

Index System for Overall Benefit of Equipment Repair Costs and Its Fuzzy Comprehensive Evaluation

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Abstract. In order to improve the evaluation for overall benefit of equipment repair costs and provide a good management and decision-making for equipment repair costs, the fuzzy Comprehensive evaluation method is introduced to quantitatively evaluate the overall benefit of equipment repair costs. First the index system for overall benefit evaluation of equipment repair costs is built on the basis of detailed factor analysis, and then Fuzzy theory is used to process the qualitative indices and AHP is used to calculate the weight of each index, finally the three-level fuzzy synthetic evaluation model is established. The example shows that the evaluation method is feasible and effective.

Introduction

The benefit in the use of equipment repair cost is the comparison between the results achieved by repair use spending and the investment amount of used repair cost. Repair activities results may manifest as the physical form and value form. The physical form refers to the quantity and quality of repaired equipment. The value form refers to the improvement of the repair support ability or combat effectiveness, namely military value. It can use the degree that meet the requirement of support capability to measure. The benefit of repair use can be represented by the formula:

$$E = V / C$$

where E is the using benefit of repair cost, V is the repair activities result, C is repair cost spending.

Under the condition of achieved same results, less the used repair cost, higher the benefit; in the case of certain repair cost expense, more the achievements, higher the benefit. So the using benefit of repair cost has 2 forms; one is to use the same repair cost to obtain greater achievements of repair activities; one is to use the smaller repair cost to achieve the same repair activities results. The using benefit of repair cost is to comprehensive, integrated analyze the gain and loss of the repair expenses in all aspects of the evaluation criteria, and use the comprehensive evaluation method to seek the optimal scheme for repair cost expenditure. Research developed by USA, Japan and Russia and other countries on this field is relatively early, and these countries all have a set of complete benefit evaluation method and program for repair costs. In recent years, our country also pays the attention to the benefit evaluation of equipment repair cost, which starts the implementation phase of the "transformation" strategy.

The overall benefit evaluation of equipment repair costs is a complicated system engineering that includes many uncertain factors. The paper introduces fuzzy theory and uses fuzzy comprehensive evaluation method to analyze the overall benefits of equipment repair costs on the basis of further quantification from the aspects of using benefit of overall repair costs, using benefit of medium repair costs, using benefit of small repair costs, using benefit of equipment costs, using benefit of professional training costs, using benefit of repair management costs.

Index system for overall benefit evaluation of equipment repair costs

Setting principle.

1. Comprehensiveness

From the overall perspective of equipment repair system, every index of the system should be considered from many aspects in order to fully reflect the overall benefit of repair costs in equipment repair system.

2. Rationality

To enhance the working efficiency of equipment repair system, the index system for overall benefit evaluation of repair costs should reasonable set the evaluation parameters for outstanding emphasis, and distinguishing between primariness and secondariness.

3. Scientificity

The size of index system for overall benefit evaluation of repair costs should be appropriate, clear define the connotation of various describing parameters, and exclude the compatibility between the indices. To reduce the workload of the evaluation system and ensure the scientificity of evaluation, the indices that have an important impact on the overall benefit of repair costs should be subdivided, other indices should be appropriately divided in the coarse form.

Establishment of index system.

Considering a good many factors of overall benefit of equipment repair costs, we can establish the evaluation system as shown in Fig. 1.

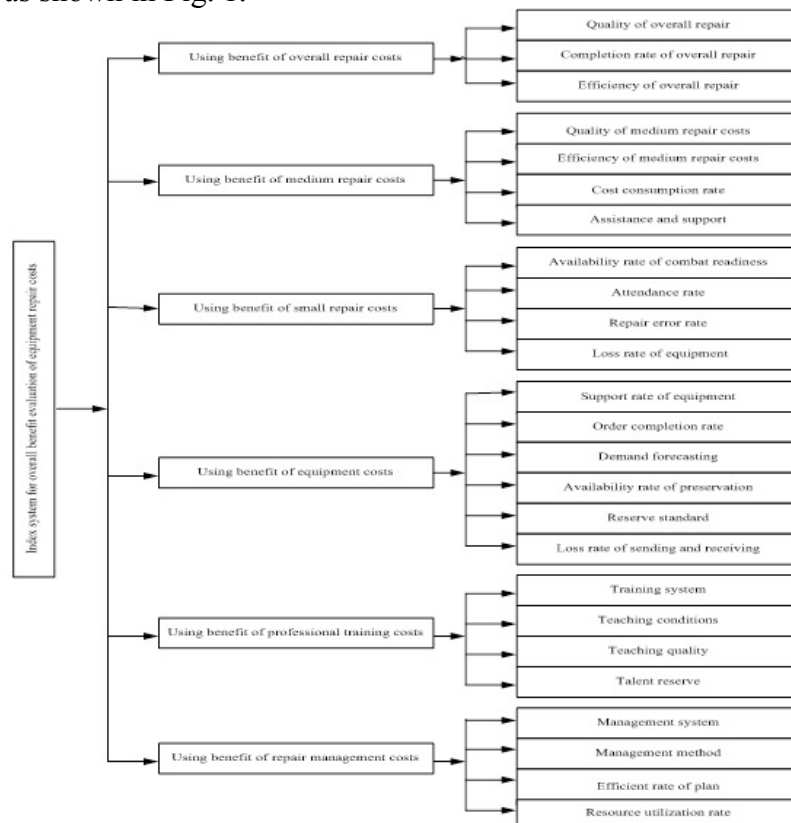


Fig. 1 Index evaluation system for overall benefit of equipment repair costs

Fuzzy comprehensive evaluation method for overall benefit of equipment repair costs

In index system of overall benefit evaluation of equipment repair costs, there are some quantitative indices such as completion rate of overall repair, availability rate of combat readiness, attendance rate and so on. These indices not only have the different dimension and function relation without comparability, but also their types are also inconsistent. For some indices, the greater, the better. For others indices, the smaller, the better. However, some require the moderation. Thus, these indices need to implement the fuzzification process in advance. To conduct the fuzzy comprehensive

evaluation, the concept of satisfaction degree is introduced, namely, as far as the ideal system of actual system is considered, their matching degree can be defined as satisfaction degree. For example, for some indices, the greater, the better [1].

$$G_m = \begin{cases} 1 & a_m \geq S_m \\ \frac{a_m - s_m}{S_m - s_m} & s_m < a_m < S_m \\ 0 & a_m \leq s_m \end{cases} \quad (1)$$

where p_m is index value that the bigger, the better. Q_m is the ideal maximum; q_m is the ideal minimum. Similarly, we can handle the indices that the smaller, the better.

For some indexes that require moderation, we have

$$G_f = \begin{cases} \frac{2(a_f - s_f)}{S_f - s_f} & s_f \leq a_f \leq \frac{S_f + s_f}{2} \\ \frac{2(S_f - a_f)}{S_f - s_f} & \frac{S_f + s_f}{2} \leq a_f \leq s_f \\ 0 & a_f > S_f, a_f < s_f \end{cases} \quad (2)$$

where p_f is the index value that requires moderation. Other indices such as training system, teaching quality, management system and so on, can not be precisely expressed mathematically, but can use the expert scoring method to determine their value. For the evaluation set $U = \{U_1, U_2, U_3, U_4\}$, the expert can mark to a index in terms of the actual situation of the system. then we can suppose $W = \{W_1, W_2, W_3, W_4\}$, so the result of fuzzification process for the indices is $H = W_g(U)^T$, $H \in [0,1]$.

In the comprehensive evaluation, the determination of index weight is very important, directly affecting the results of the comprehensive evaluation. In the paper, Analytic Hierarchy Process (AHP) is used to determine the weight that shows the relative importance of each index corresponding to upper level index [2][3]. Because the actual system and ideal system all have some qualitative and fuzzy index requirements, the match requirements can be regarded as a fuzzy set concept, and the so-called satisfaction degree can be regarded as a fuzzy membership degree which need to carry on fuzzy comprehensive evaluation [4][5].

Validation example

According to above-mentioned fuzzy comprehensive evaluation method and AHP, we can evaluate two schemes of overall benefit of equipment repair costs for a department.

From the results shown in Table 1, It can be seen that: the satisfaction degree of Scheme 1 for overall benefit of equipment repair costs is 0.7947, obtaining a satisfactory evaluation result. The satisfaction degree of Scheme 2 is 0.6978. Consequently, for overall benefit of equipment repair costs for a department, Scheme 1 is better than Scheme 2.

Table 1. Result comparison of fuzzy comprehensive evaluation between Scheme 1 and Scheme 2

Indies of middle level	Indies weight of middle level	Indies of bottom level	Indies weight of bottom level	Fuzzy value	
				Scheme 1	Scheme 2
Using benefit of overall repair costs	0.3060	Quality of overall repair	0.4378	0.7790	0.8245
		Completion rate of overall repair	0.3226	0.9716	0.7826
		Efficiency of overall repair	0.2396	0.7853	0.5844
Using benefit of medium repair costs	0.1343	Quality of medium repair costs	0.2448	0.8932	0.8031
		Efficiency of medium repair costs	0.4097	0.8451	0.7994
		Cost consumption rate	0.2032	0.6922	0.4674
		Assistance and support	0.1423	0.7744	0.4993
Using benefit of small repair costs	0.2695	Availability rate of combat readiness	0.3578	0.7990	0.7082
		Attendance rate	0.2942	0.8941	0.7007
		Repair error rate	0.2169	0.3744	0.4550
		Loss rate of equipment	0.1311	0.4986	0.3445
Using benefit of equipment costs	0.1568	Support rate of equipment	0.2732	0.8931	0.7989
		Order completion rate	0.2432	0.9247	0.9587
		Demand forecasting	0.1813	0.6443	0.8876
		Availability rate of preservation	0.1654	0.9764	0.9428
		Reserve standard	0.0988	0.7833	0.8004
		Loss rate of sending and receiving	0.0431	0.3249	0.5560
Using benefit of professional training costs	0.0988	Training system	0.2255	0.8881	0.6940
		Teaching conditions	0.2576	0.8113	0.4472
		Teaching quality	0.3748	0.8900	0.6746
		Talent reserve	0.1421	0.7666	0.6030
Using benefit of repair management costs	0.0346	Management system	0.3572	0.5033	0.8047
		Management method	0.2028	0.6777	0.7345
		Efficient rate of plan	0.3153	0.6790	0.6802
		Resource utilization rate	0.1247	0.7661	0.6993
Fuzzy comprehensive evaluation result for overall benefit of equipment repair costs				0.7947	0.6978

Conclusions

The fuzzy comprehensive evaluation method is used to evaluate the overall benefit of equipment repair costs. First, the index system for overall benefit evaluation of equipment repair costs is established by analyzing the influence of many factors, and then the fuzzy treatment of every indies is taken into account. Actual example shows that the evaluation result for overall benefit of equipment repair costs is believable and effective.

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