Quality Control Model of Military Camouflage Materials Research and Development Project Based on C2GS2

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Abstract

Aiming at the subjectivity in quality control and the unilateralism of material management information in the research and development of military camouflage materials, the C2GS2 quality control model is established to improve the scientific management level. Firstly, by establishing a quality control index system, according to the characteristics of all its output indicators, Output-DEA model is established to evaluate the management level. Secondly, In order to further improve the radial and non-radial detection information, the non-Archimedes infinitesimal quantity is introduced to form C2GS2 quality control model. Finally, an example is used to verify that quality control model can significantly improve the R & D level of camouflage materials and provide more detailed management information.

Keywords

Camouflage materials; quality control; DEA; C2GS2 model; non-Archimedean infinitesimal.

1. Introduction

Camouflage is an important means of covert military targets and military operations. The purpose is to confuse the enemy's reconnaissance of our troops, weapons and operations. Camouflage materials are used in a variety of ways on the surface of the target, such as spraying, covering and adhering, etc., so that the camouflage target cannot be recognized or detected in a certain electromagnetic wave band [1]. At present, despite the increasing understanding of quality management and working methods in the camouflage materials development department, there are still phenomena such as unsound design process monitoring mechanism, cooperative dispersion in production departments, uncontrollability towards input-output ratio, rehandling and internal friction. It's often just a qualitative prediction of quality control of camouflage material R & D project. The quantitative analysis method of the system is remained to be resolved [2].

For the evaluation methods and mathematical models of engineering quality, the main research is based on the theory of fuzzy mathematics nowadays, such as fuzzy comprehensive evaluation, etc. [3]. Some scholars also use AHP to build the index system and model, however, there is still subjectivity in the empowerment of evaluation indicators, with the index information overlaps. DEA(Data Envelopment Analysis)is a nonparametric method for evaluating the relative effectiveness of decision making units. It is an important analytical tool and research tool in common use. It does not take into account the impact of the evaluation indicator dimension, so the mutual constraints between input and output indicators can be avoided. The relative validity of the decision making unit can be judged, also be used as a good modeling tool in the field of quality control [4].

Traditional DEA mode can easily make a simple sort towards Quality Management of R & D projects, thus providing radial improvement information for input or output indicators, while the improved information often can not meet the need of quality control. The C2GS2 model can overcome the disadvantages of the traditional DEA model. Its input and output indicators are provided with radial and non-radial improvement information, so it has better quality control ability.[5]

2. Index system of quality control

Index system of quality control is the basis of establishing the quality control model of the R & D project of military camouflage materials, is also an important part of evaluating its management quality. The aim is to objectively reflect the current situation of project quality management, providing effective information and decision - making to the quality supervision and management of administrative departments at all levels, so as to improve the scientific nature and effectiveness of management.[6] Therefore, the index system can be divided into three levels, as shown in figure 1.

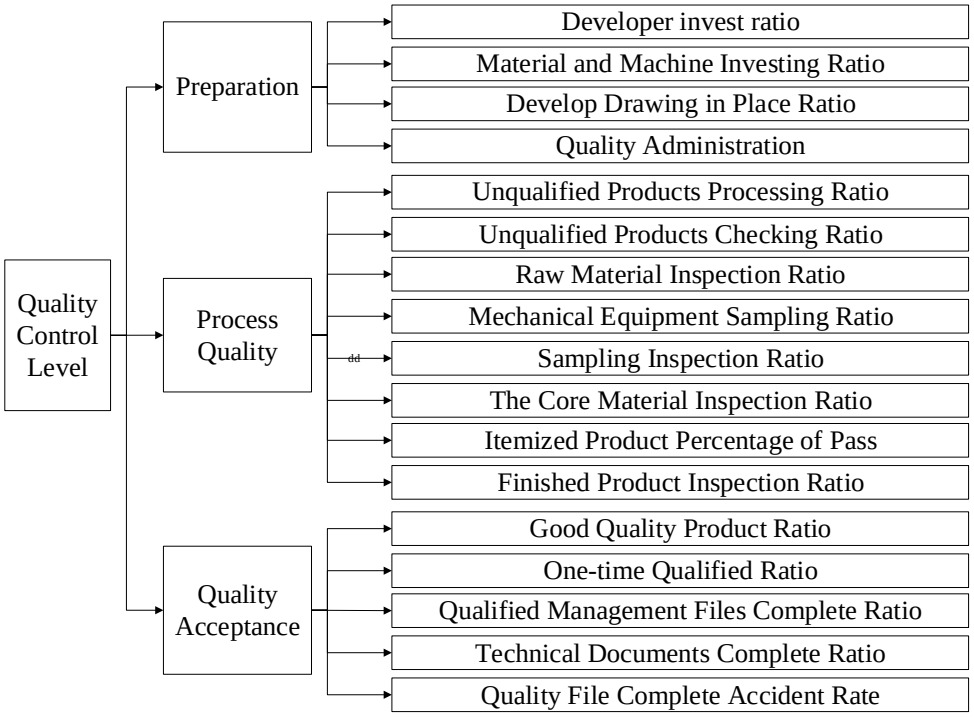

Fig.1 Index system of quality control of the R & D project of military camouflage materials

3. Output-DEA control model

DEA is developed by the concept of relative efficiency Evaluation in the system analysis theory, it uses a mathematical programming model with multiple input and multiple output (DMU) between the relative effectiveness of the department. According to the data of each DMU to observe whether it is DEA efficient, is essentially to determine whether a DMU in production possibility set production frontier [7]. DEA model is created by Charnes Cooper and Rhodes, can be used directly for input and output data, to make sure production frontier to the structure, characteristics and construction method. However, in view of the characteristics of the quality control of the R & D project of military camouflage materials, the bigger the output index, the better the quality evaluation is.[8] Therefore, we need to reconstruct the index data structure of DEA model. If the number of DMU is n, the number of input index is m, the output index is s. $X_j = (x_{1j}, x_{2j}, \cdots, x_{mj})^T$ is the input data set, and $Y_j = (y_{1j}, y_{2j}, \cdots, y_{sj})^T$ is the output data set, $j = 1, 2, \cdots, n$. Establish input data set $X_j = (1, 1, \cdots, 1)_{1\times n}$, that is $m = 1$ and $x_{mj} = 1$, $j = 1, 2, \cdots, n$; the output data set is $Y_j = (y_{1j}, y_{2j}, \cdots, y_{sj})^T$, y_{sj} is the s quality indicator corresponding index system, in which, $s = 17$, $j = 1, 2, \cdots, n$, the data structure is as follows:

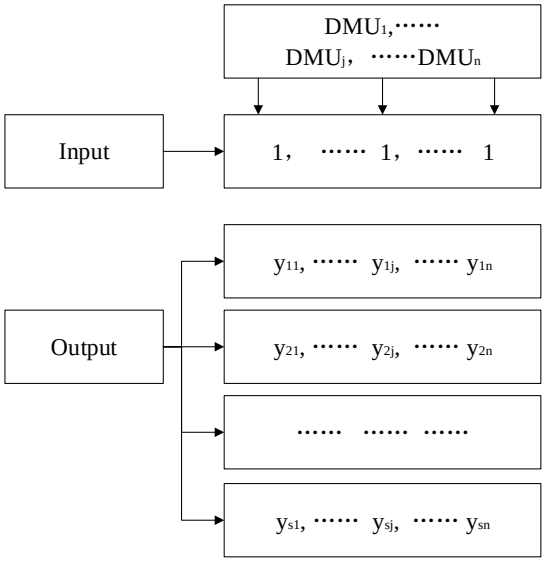

Fig.2 Output-DEA model data structure

The Output-CCR model is in Eq.1, the optimal solution is λ^*, σ^*, in which σ^* is efficiency value of Output-CCR and $\sigma^* \geq 1$.

$$(D^O CCR)\begin{cases} \max \sigma \\ \sum_{j=1}^{n} X_j \lambda_j \leq X_0 \ , \ \sum_{j=1}^{n} Y_j \lambda_j \geq \sigma Y_0 \\ \lambda_j \geq 0, \ \ j = 1,2,\cdots,n \end{cases} \tag{1}$$

Therefore, in order to get the best solution, we only need to transform the output index of radial improvement Information Y_0 into extended output value σ^* to achieve the best. But for a valid Output-DEA DMU, It cannot provide non-radial improvement information. Therefore, it can solve computational and technical problems by the introduction of the concept of Archimedes infinitesimal.

4. C^2GS^2 control model

Make $\varepsilon > 0$ is an non-Archimedean infinitesimal, ε is less than any number of positive and greater than zero, the output-DEA model which has an non-Archimedean dimensionless is as follows （Output-C^2GS^2）[9]:

$$\begin{cases} \max [\sigma + \varepsilon(\hat{e}^T S^- + e^T S^+)] \\ \sum_{j=1}^{n} X_j \lambda_j + S^- = X_0 \quad , \quad \sum_{j=1}^{n} Y_j \lambda_j - S^+ = \sigma Y_0 \\ \lambda_j \geq 0, \ \ j = 1,2,\cdots,n \ \ S^- \geq 0 \ , \ S^+ \geq 0 \end{cases} \tag{2}$$

1) If efficiency value $\sigma^* > 1$, the DMU0 is Output-C^2GS^2 invalid;

2) If efficiency value $\sigma^* = 1$, $\hat{e}^T S^{-*} + e^T S^{+*} > 0$, which is S^{-*} and S^{+*} are not all 0, the DMU0 is weak Output-C^2GS^2 effective;

3) If efficiency value $\sigma^* = 1$, $\hat{e}^T S^{-*} + e^T S^{+*} = 0$, the DMU0 is Output- C^2GS^2 effective, that is based on the original output shows that the DMU input is optimal.

By introducing Output-C2GS2 model into the index system of quality control, we can get the optimal solution by size of research and development project quality management level of the pros and cons of sorting[10], which is smaller, then the DMU quality level is higher. At the same time, through the optimal solution, can further understand DMU in the radial direction of improving information, the management information is rich in more details.

5. Application example

Now, there are 10 cases of military camouflage material R & D projects, Based on the quality evaluation indicator system described above, we build the quality control model of C2GS2. $X_j = (1,1,\cdots,1)_{1\times 10}$ as input indicators, output indicators basis for quality assessment of 17 indicators data, as shown in table 1.

Table 1 Camouflage materials research and development project quality indicator data

DMU j	DMU 1	DMU 2	DMU 3	DMU 4	DMU 5	DMU 6	DMU 7	DMU 8	DMU 9	DMU10
x1	1	1	0.9	0.95	1	0.92	1	0.98	1	1
y1	0.85	0.75	0.65	0.60	0.90	0.65	0.88	0.78	0.65	0.80
y2	0.90	0.95	0.75	0.65	0.85	0.78	0.95	0.69	0.82	0.82
y3	0.56	0.50	0.65	0.75	0.72	0.64	0.85	0.78	0.80	0.95
y4	0.65	0.58	0.65	0.65	0.70	0.65	0.85	0.80	0.95	0.95
y5	0.88	0.80	0.70	0.78	0.89	0.85	0.92	0.69	0.80	0.95
y6	0.78	0.75	0.70	0.72	0.82	0.70	0.95	0.75	0.65	0.85
y7	0.65	0.65	0.75	0.70	0.65	0.75	0.95	0.78	0.78	0.89
y8	0.85	0.58	0.65	0.75	0.70	0.65	0.88	0.80	0.82	0.80
y9	0.85	0.78	0.80	0.79	0.82	0.82	0.90	0.75	0.95	0.95
y10	0.78	0.89	0.65	0.68	0.70	0.65	0.85	0.70	0.78	0.92
y11	0.82	0.88	0.75	0.80	0.82	0.82	0.85	0.56	0.64	0.97
y12	0.65	0.90	0.75	0.69	0.68	0.80	0.88	0.65	0.65	0.82
y13	0.89	0.89	0.78	0.75	0.95	0.75	0.82	0.78	0.95	0.88
y14	0.82	0.85	0.72	0.78	0.95	0.65	0.90	0.78	0.90	0.85
y15	0.65	0.78	0.80	0.80	0.85	0.80	0.85	0.65	0.85	0.95
y16	0.70	0.66	0.75	0.85	0.65	0.69	0.89	0.87	0.65	0.80
y17	0.88	0.95	0.65	0.70	0.78	0.75	0.88	0.70	0.70	0.83

By calculation, we get the improved information of evaluation efficiency values and quality indicators of 10 R & D projects, as shown in Table 2.

Table 2 C^2GS^2 model quality control evaluation results

DMU j	DMU 1	DMU 2	DMU 3	DMU 4	DMU 5	DMU 6	DMU 7	DMU 8	DMU 9	DMU10
σ_j^*	1	1	0.9	0.95	1	0.92	1	0.98	1	1
S1+	0	0	0.1073	0.2518	0	0.1443	0	0.0821	0	0
S2+	0	0	0.0325	0.2694	0	0.0702	0	0.2441	0	0
S3+	0	0	0.2010	0.0647	0	0.1581	0	0.0521	0	0

S4+	0	0	0.2010	0.1694	0	0.1538	0	0.0316	0	0
S5+	0	0	0.1677	0.1033	0	0.0000	0	0.2141	0	0
S6+	0	0	0.1083	0.1961	0	0.1489	0	0.1828	0	0
S7+	0	0	0.0806	0.2171	0	0.0981	0	0.1521	0	0
S8+	0	0	0.1073	0.0947	0	0.1305	0	0.0616	0	0
S9+	0	0	0.0510	0.0728	0	0.0181	0	0.1328	0	0
S10+	0	0	0.1804	0.1380	0	0.1704	0	0.1339	0	0
S11+	0	0	0.1044	0.0124	0	0.0000	0	0.2771	0	0
S12+	0	0	0.0106	0.1575	0	0.0000	0	0.2151	0	0
S13+	0	0	0.0000	0.0347	0	0.0320	0	0.0221	0	0
S14+	0	0	0.0706	0.0833	0	0.1793	0	0.1021	0	0
S15+	0	0	0.0354	0.0124	0	0.0079	0	0.1851	0	0
S16+	0	0	0.0000	0.0000	0	0.1001	0	0.0000	0	0
S17+	0	0	0.1279	0.1471	0	0.0609	0	0.1639	0	0

As can be seen from table 2, the efficiency value of quality evaluation of six R & D projects DMU1, DMU2, DMU5, DMU7, DMU9 and DMU10 is 1, effective for Output-C2GS2; DMU3， DMU4， DMU6. The quality evaluation efficiency of four DMU8 R & D projects is less than 1, invalid for Output-C2GS2. For example, DMU3, $\sigma_3^* = 0.9$, $S_1^+ = 0.1073$, $S_2^+ = 0.0325$. Therefore, in order to achieve an optimal level of quality management, DMU3 research and development staff should make the radial expansion of 0.9 times and 0.1073 of non-radial increase, its material equipment input should make the radial expansion of 0.9 times and 0.0325 times of non-radial increase.

6. Conclusion

On the basis of the reconstruction of the military camouflage material R & D projects of quality control in DEA model data structure, the Output-DEA control model is established to provide richer management information, further provide quality control information to managers as well as the introduction of Archimedes infinitesimal. The quality control model of C2GS2 camouflage material R & D project is established, which can be a radial and non-radial output index. In case of the quality control for C^2GS^2 model of efficiency value is 1, and the Output-C^2GS^2 is effective, in this way, how to sort DMU completely and effectively will be the direction of further research.

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