Evaluation of Equipment Competitive Acquisition Management Based on Entropy Theory

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Abstract. Aiming at the evaluation of equipment competitive acquisition management, the paper proposes an evaluation method based on entropy theory. First, the concept of equipment competitive acquisition management entropy is defined. Second, the conceptual model, mathematical model, and evaluation index system of equipment competitive acquisition management entropy are constructed. Finally, taking policy and regulatory entropy as an example, the paper has calculated and analyzed its evaluation results to prove the effectiveness of the method.

Keywords: equipment competitive acquisition management, entropy theory, management entropy

1. Introduction

Strengthening the evaluation of equipment competitive procurement management is of great significance for accurately grasping the problems and deficiencies in equipment procurement reform, which will help all types of enterprises participate in competition fairly, and improve the modernization of weapons and equipment[1][2]. The paper evaluates equipment competitive procurement management based on entropy theory. According to the entropy change principle of equipment competitive procurement management, the paper establishes the conceptual model, mathematical model, and evaluation index system of equipment competitive procurement management entropy, which provides a quantitative method for the evaluation of equipment competitive procurement management.

2. Entropy theory and the concept of management entropy
2.1. Entropy theory
Entropy is defined to describe the state of energy spontaneously changing from "ordered" to "disordered" in an isolated system. Entropy is a state function whose value change has nothing to do with the thermodynamic path but only depends on the initial state and the final state.

2.2. Equipment competitive procurement management entropy
RenPeiyu[3] defined the concept of management entropy, that is, organization, mechanism, policy, and method of any kind of management in a relatively closed system, always present an irreversible status that effective energy gradually decreases, while ineffective energy gradually increases. Therefore we get the concept of equipment competitive procurement management entropy, that is, in the relatively closed equipment market, the management of equipment competitive procurement will gradually show a state of lagging behind the demand for equipment modernization. The flexibility and effectiveness of policies, systems, and mechanisms have gradually decreased, and the constraints on equipment modernization have gradually increased[4-6].

3. Model of equipment competitive procurement management entropy

3.1. Conceptual model of equipment competitive procurement management entropy
Schrodinger, a physicist of Austria, pointed out that all living things must absorb energy from the external and obtain negative entropy to survive. The same is true for various management activities. If they are in a closed operating environment for a long time and do not exchange energy with the outside world, the positive entropy flow will gradually increase and the negative entropy flow will gradually decrease, which will make the efficiency of management low. Therefore, in management activities, it is necessary to continuously exchange materials, energy, and information with the external environment, and by introducing new ideas, new knowledge, new technologies, new systems, and new talents, to inject new blood and energy into management activities. The change principle of equipment competitive procurement management entropy is shown in Fig.1.

![Fig. 1] the change principle of equipment competitive procurement management entropy

The main factors that cause the changes in equipment competitive procurement management entropy are strategic planning, policies and regulations, organizational structure, and mechanism.

1) Strategic planning entropy. The development of equipment construction involves a wide range of fields, multiple subjects, and complex relationships between each other. It requires scientific and
reasonable strategic planning for guidance. The strategic planning factors refer to development strategy, mid-term plan, and short term plan of equipment construction. The strategic planning entropy measures the forward-looking, guiding, and innovative nature of the development strategy, the effectiveness of the development plan, the feasibility of planned measures, and the ability to meet military needs.

(2) Policies and regulations entropy. The guidance and guarantees caused by policies and regulations are not permanent. In order to ensure policies and regulations scientific and advanced, we must keep pace with the times and insist on the combination of establishment, reform, and abolition. Policies and regulations entropy measures the rationality of the competitive procurement policy and regulations system’s framework, the comprehensiveness of the coverage, and the coordination of laws and regulations[7].

(3) Organizational structure entropy. Equipment procurement agencies and personnel are the most fundamental elements of equipment procurement operations, and they are the decision-makers, organizers, and implementers of equipment procurement activities. Since the effectiveness of the organizational structure will gradually weaken over time, adjustments and innovations must be made in the development process time to ensure the organizational structure rational and scientific that will keep organizational structure entropy.in a low level. Organizational structure entropy measures the scientificity and rationality of organization settings and division of duties and powers.

(4) Mechanism entropy. The effectiveness of the mechanism will also gradually weaken over time, and continuous innovation and development are required. It needs to introduce negative entropy by the reform of the old system and the establishment of a new system. Mechanism entropy measures the soundness of the mechanism and the rationality of the process. The conceptual model of equipment competitive procurement management entropy is shown in Fig. 2.

3.2. The mathematical model of equipment competitive procurement management entropy

3.2.1. Mathematical model
According to the entropy theory, the formula for calculating the entropy of equipment competitive procurement management can be obtained as follows:
$S = \sum k_i S_i$ (1)

$i$ is the serial number of the index item that affects the management entropy value in the index system; $k_i$ is the weight of the index; $S_i$ is the entropy value generated by the index $i$, which can be calculated according to formula (2).

$$S_i = -K_\beta \frac{X_i}{\bar{X}_i} \ln \frac{X_i}{\bar{X}_i}$$ (2)

$K_\beta$ is the management entropy coefficient, which represents the additional cost value required for increasing unit revenue in a specific equipment procurement field, that is $\frac{\Delta C}{\Delta E}$; $X_i$ is the actual value of the indicator $i$ in the indicator system; $\bar{X}_i$ is the standard value of the indicator $i$, that is the ideal value of the index $i$. The value of $X_i$ and $\bar{X}_i$ is obtained by experts scoring.

### 3.2.2. Calculation of management entropy

The calculation of management entropy is divided into the following steps[6]:

1. According to the conceptual model of equipment competitive procurement management entropy, the evaluation index system can be established as shown in Tab.1.

| First-level index                                           | Second-level index                   | Third-level index                                                                 |
|-------------------------------------------------------------|--------------------------------------|-----------------------------------------------------------------------------------|
| Evaluation of equipment competitive procurement management   | Strategic planning entropy            | Long-term development strategy: forward-looking, guiding and innovative             |
| entropy                                                     | Policies and regulations Entropy     | Mid-term development plan: level and efficiency                                     |
|                                                             |                                      | Short-term planning measures: feasibility, ability to meet military needs           |
|                                                             |                                      | The formulation of basic laws: the coverage of equipment procurement basic laws     |
|                                                             |                                      | (such as equipment procurement law, contract law, talent team law, etc.), lack of |
|                                                             |                                      | items, and progress in advancement, etc.                                           |
|                                                             |                                      | The formulation of special laws and regulations: the number and coverage of        |
|                                                             |                                      | special laws and regulations for equipment procurement, the cohesion, matching,    |
|                                                             |                                      | coordination with basic laws, lack of items, and progress in advancement, etc.     |
|                                                             |                                      | The formulation of normative policies and measures: the coverage of normative      |
|                                                             |                                      | policies and measures for equipment procurement, the cohesion, matching,          |
|                                                             |                                      | coordination, and                                                                |
| Organization entropy | Institutional setting: it is compatible with the procurement environment or not, it is suitable for the procurement activities or not, the elements are complete or not, the hierarchy is reasonable or not, etc. |
|----------------------|----------------------------------------------------------------------------------------------------------|
| Division of responsibilities and authorities: the function arrangement is reasonable or not, the relationship of power and responsibility is clear or not, communication and coordination are smooth or not, etc. |
| Mechanism entropy     | Access mechanism: the setting of access threshold, review content, access process, market openess, etc. is reasonable or not |
| Exit mechanism: the conditions for the enterprise to exit from the equipment market, the responsibilities to be assumed are clear or not, the exit process is set up reasonable or not, etc. |
| Competition mechanism: the scope of the classification, level and phased competition of weapons and equipment is clear or not, and the competition subjects enjoy the same status in terms of tax incentives, financial support, and information acquisition or not, etc. |
| Demand docking mechanism: the demand docking platform construction, the demand docking program design is complete or not, the demand release channels are diversified or not, etc. |

**Tab.1 Evaluation index system of equipment competitive procurement management entropy**

② Construct level matrix $A$ of the index system.

$$A = (a_1, a_2, \ldots, a_n)$$

$a_i$ is the entropy value produced by the indicator $i$.

③ Construct the interaction force matrix $N$ of each index. The mutual influences among the sub-indexes are different. Therefore, the mutual influence needs to be considered when calculating the management entropy. In this paper, an interaction force matrix $N$ is constructed to express the interaction force between the three-level indicators, and the matrix $N$ is determined by the interaction prediction method. The specific process is as follows:

a. Judge the direction of the mutual influence between the three-level indicators, quantify it, and record it as $K_{ij}$, which represents the direction of the indicator $j$ influence on the indicator $i$.

$$K_{ij} = \begin{cases} 
1 & \text{positive influence} \\
0 & \text{no influence} \\
-1 & \text{negative influence} 
\end{cases} \quad i \neq j; i, j = 1, 2, \ldots, n$$

(4)
b. Quantify the size of the influence and record it as $E_{ij}$, which represents the size of the index $j$ influence on the index $i$. The value range of $E$ is $[1,2]$. The specific situation is shown in Tab. 2.

| Values of $E$ | 1   | 1.2 | 1.4 | 1.6 | 1.8 | 2    |
|---------------|-----|-----|-----|-----|-----|------|
| Influence     | no  | influence | weaker | influence | weak | influence | strong | influence | stronger | influence | very strong | influence |
| Tab.2 Values of $E$ |

Use expert opinion method to evaluate the influence of the indicators, and its value is the average of the expert evaluation results.

c. The calculation formula of interaction force is:

$$N = K_{ij} \times E_{ij} = \begin{bmatrix} n_{11} & K & n_{ij} \\ K & K & K \\ n_{ni} & K & n_{nn} \end{bmatrix}, \quad (i, j = 1, 2, K n)$$

(5)

4. Construct the weight matrix $C_i$ of each index.

$$C = \begin{bmatrix} c_1 \\ K \\ c_n \end{bmatrix}, \quad \text{And} \quad c_1 + c_2 + L + c_n = 1.$$  

(6)

5. The calculation formula of management entropy is:

$$S = A \times N \times C = (a_1, K, a_n) \times \begin{bmatrix} n_{11} & K & n_{ij} \\ K & K & K \\ n_{ni} & K & n_{nn} \end{bmatrix} \times \begin{bmatrix} c_1 \\ K \\ c_n \end{bmatrix}$$

(7)

3.3. The connotation of management entropy

Equipment competitive procurement management entropy is closely related to the efficiency of equipment competitive procurement management:

If $S > 0$, it means that the negative entropy flow generated by the exchange with the outside is not big enough to offset the positive entropy, and the competitive equipment procurement management shows a lack of vitality and low efficiency;

If $S = 0$ it means that positive entropy and negative entropy are relatively flat, equipment competitive procurement management has reached the best state of the orderly structure, and the equipment market is full of vitality. However, due to the lack of more negative entropy flow, the evolutionary strength of equipment competitive procurement management is not enough to transform it into a higher-level dissipative structure;
If $S < 0$, it means that the positive entropy generated spontaneously in the management process is less than the negative entropy, and the total entropy of management was negative. The management of equipment for competitive procurement is relatively orderly. Under the effects of dissipation and fluctuations, equipment competitive procurement management will generate self-organization, and leap up to a higher-order structure.

4. Evaluation results and analysis

Taking policy entropy, for example, calculate and analyze its evaluation results.

4.1. Evaluation results

Since the evaluation indicators of policies and regulations entropy are qualitative indicators, use expert scoring method to quantify them. Design a questionnaire according to the evaluation criteria of policy and regulation entropy, and invite 20 experts to score the evaluation indicators. Using the "descriptive statistics" function in the SPSS software to analyze the validity of the sample data, the results prove that the collected sample data are all valid data. The scoring results of the questionnaire are averaged as the final score of the index.

In order to analyze the results, this paper will normalize the entropy value obtained. Since $K_\beta$ is a constant, in order to simplify the calculation, the value of $K_\beta$ is taken as 1. The entropy calculation results of policies and regulations entropy are shown in Tab.3.

| Indicator | Actual value | Standard value | Actual value/standard value | Entropy value | Normalization result of entropy value | Weight |
|-----------|--------------|----------------|----------------------------|---------------|---------------------------------------|--------|
| The formulation of basic laws | 50 | 100 | 0.5 | 0.3466 | 0.9421 | 0.33 |
| The formulation of special laws and regulations | 70 | 100 | 0.7 | 0.2497 | 0.6787 | 0.33 |
| The formulation of normative policies and measures | 83 | 100 | 0.83 | 0.1547 | 0.4205 | 0.33 |

Tab.3 Values of policies and regulations entropy

Then we can get $A = (0.9421, 0.6787, 0.4205)$.

| Index | $B_{11}$ | $B_{12}$ | $B_{13}$ |
|-------|----------|----------|----------|
| $B_{11}$ | 1        | 2        | 2        |
| $B_{12}$ | 1.8       | 1        | 2        |
| $B_{13}$ | 1.8       | 1.8      | 1        |

Tab.4 Interaction force evaluation of each sub-indicator of policy entropy

Then the interaction force matrix $N$ of each sub-indicator of policy entropy is:
Therefore, the value of policies and regulations entropy is \( S = A \times N \times C = 3.2678 \). Its normalizing value is 0.6876. The result indicates that the construction of policies and regulations for equipment competitive procurement management needs to be further improved.

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