Research on Weapon Equipment Storage Structure Optimization Model Based on Improved ABC Classification Method

Xiaosong Li¹*, Zenghua Li¹, Xinran Peng¹ and Zhenhua Xiao²

¹ Military Science Information Research Center PLA Military Science, Beijing, 100142, China
² Military Commission Equipment Development Department, Beijing, China

*Corresponding author’s e-mail: 164832732@qq.com

Abstract. Weapon equipment storage is an important part of weapon equipment supply support. In this paper, we analysed the related concepts of weapon equipment storage, introduced the ABC classification method, proposed the steps to construct the optimization model of the weapon equipment storage structure, studied the influencing factors of the weapon equipment storage structure, and constructed a storage structure optimization model based on the improved ABC classification. The optimal weapon equipment storage structure and strategy were obtained, and a case analysis was carried out. The research conclusions can provide reference for the practical work of weapon equipment storage.

1. ABC classification
The ABC classification is derived from Pareto law, which is based on the distribution of social wealth, known as the rule of majority. Therefore, the core of the ABC classification method is to require managers to focus their management resources on the key “minority” rather than the minor “majority”, and spend 80% of their time and energy on the most important 20% to get good results[4-6].

Table 1. ABC classification

| Storage class | Quantity ratio | Value ratio | Importance       | Control method |
|---------------|----------------|-------------|------------------|----------------|
| Class A       | 10%            | 70%         | Extremely important | Key control    |
| Class B       | 20%            | 20%         | Medium important | Medium control |
| Class C       | 70%            | 10%         | Not important    | Simple control |

1.1. Class A storage
Class A contains "minority" and “key control” resource. This type of resource is extremely important, usually the storage quantity is small (about 10% of all resources), and high value (about 70% of the total value).

1.2. Class C storage
Class C contains "majority" resource and do not require strict control. This type of resource is “not important”, with a large amount of storage (about 70% of all resources), and low value (about 10% of the total value).
1.3. Class B storage
Class B is between Class A and C, and the control level is also between Class A and C. The importance of this type of resource is medium, storage quantity is average (about 20% of all resources), and the value is moderate (about 20% of the total value).

2. Weapon equipment storage structure optimization model construction steps
The traditional ABC classification method only considers two factors that affect the storage structure. It does not consider the impact of other factors on the storage structure. Therefore, this article improves the traditional ABC classification method. During the optimization, the concept of storage intensity is introduced, and the factors affecting the storage structure such as support objects, equipment importance, equipment economy are considered comprehensively. Weapon equipment storage structure optimization model construction steps in this paper based on the improved ABC classification method are shown in Figure 1.

Figure 1. Weapon equipment storage structure optimization model construction steps

2.1. Influencing factors analysis
Analyse the factors influencing the structure of weapon equipment storage, and summarize the factors.

2.2. Storage intensity analysis
Using the expert survey method, judge the influencing factors of various weapon equipment storage structure, and score each factor. On this basis, according to the weight of various factors, determine weapons equipment storage intensity.

2.3. Storage structure analysis
Put forward the weapon equipment storage ABC classification standard, sort the weapon equipment according to the weapon equipment storage intensity, and according to the ABC classification standard, classify the weapon equipment storage, so as to obtain the optimized storage structure.

2.4. Propose storage strategy
According to the optimized weapons equipment storage structure, various storage strategies such as A, B, and C are proposed.
3. Optimal weapon equipment storage structure model

3.1. Weapon equipment storage structure influencing factors
The factors that affect the weapon equipment storage structure mainly include support objects importance, equipment importance, equipment accessibility, equipment economy.

3.1.1. Equipment support objects importance
Weapon equipment support objects refer to the support objects of weapon equipment storage. Set the support objects importance as $X_i$, and divide them into 3 categories. The first category $X_1$ is used to support main weapon, with a score of 1; the second category $X_2$ is used to support the secondary weapon, with a score of 0.6; the third category $X_3$ is used to support general weapon, score 0.4.

3.1.2. Equipment importance
Set the equipment importance as $Y_i$, which is divided into three categories. The first category $Y_1$, means that the equipment failure leads to complete loss of weapon function, with a score of 1; the second category $Y_2$, means that the equipment failure leads to a significant weapon dysfunction, with a score of 0.6; the third category $Y_3$, means the equipment failure has no effect on weapon functions, with a score of 0.4.

3.1.3. Equipment accessibility
Set the equipment accessibility as $Z_i$, which is divided into 3 categories. The first category $Z_1$, means non-standard equipment, which is difficult to produce and supply, rely on foreign-produced equipment, etc., with a score of 1; the second category $Z_2$, represents equipment that only a few contractors can produce, with a score of 0.6; the third category $Z_3$ represents equipment with a wide range of market sources, with a score of 0.4.

3.1.4. Equipment economy
Set the equipment economy as $R_i$, divided into three categories. The first category $R_1$ means that the equipment purchase price and the storage cost is high, with a score of 1. The second category $R_2$ means the equipment purchase price and the storage cost is medium, with a score of 0.6; the third category $R_3$, means the equipment purchase price and storage cost is low, with a score of 0.4.

3.2. Equipment storage intensity
Set the storage intensity of the j-th weapon equipment is represented by $q_j$. The calculation formula is as follows:

$$q_j = w_a \times X_j + w_b \times Y_j + w_c \times Z_j + w_d \times R_j$$

In the formula, $w_a, w_b, w_c, w_d$ respectively indicate the equipment support object, equipment importance, equipment accessibility, equipment economy.

Assuming there are n equipment, the storage intensity is: $Q = \{q_1, q_2, \ldots, q_n\}$. Sort the weapon equipment according to the storage intensity formula:

$$D = \{d_1, d_2, \ldots, d_n\}, \quad d_i = \max Q, \quad d_n = \min Q$$

$d_i$ represents the weapon equipment with the highest storage intensity, $d_i$ represents the weapon equipment with the i-th highest storage intensity, and $d_n$ represents the weapon equipment with the lowest storage intensity.

3.3. Weapon equipment storage structure
According to the ABC classification standard, the weapon equipment storage structure is divided into three categories: A, B, and C. The specific standards are as follows: the first 20% of weapon equipment
are class A, the middle 50% of weapon equipment are class B, and the remaining 30% are class C. According to Formula 1 and Formula 2, the classification standard of weapon equipment storage is obtained, as shown in Table 1.

Table 2. Weapon equipment storage level classification standard

| Weapon equipment storage level | Weapon equipment storage Intensity | Storage level |
|-------------------------------|-----------------------------------|---------------|
| A                             | $\{d_1, d_2, \ldots, d_i\}, i \approx 0.2 \times n$ | Key control  |
| B                             | $\{d_i, d_{i+1}, \ldots, d_j\}, i \approx 0.2 \times n, j \approx 0.7 \times n$ | Secondary control |
| C                             | $\{d_j, d_{j+1}, \ldots, d_n\}, j \approx 0.7 \times n$ | General control |

3.4. Weapon equipment storage strategy

After determining the storage level of weapon equipment, should take corresponding strategies to conduct effective management and control of weapon equipment and resources, as shown in Table 2.

Table 3. Weapon Equipment Storage Strategy

| Class A       | Class B                               | Class C                               |
|---------------|---------------------------------------|---------------------------------------|
| Key points of management | Key control. | Secondary control. | General control. |
| Ordering      | Control the order quantity strictly, predict the demand accurately | General control. Order when the storage drops to the lowest point. | Use centralized procurement, increase the amount, and reduce the number of orders accordingly. |
| Storage       | Implement key control and keep as little storage as possible. | Implement general control, properly store. | To maintain a high storage amount. |

4. Case analysis

Take the weapon equipment storage in a certain case as an example to analyse the weapon equipment storage level. The relevant data of known weapon equipment storage, see Table 3.

Table 4. Weapon equipment storage data

| Equipment                          | Equipment support objects importance | Equipment importance | Equipment accessibility | Equipment economy |
|------------------------------------|--------------------------------------|----------------------|-------------------------|-------------------|
| Electromechanical equipment 1     | category 1                           | category 2           | category 3              | category 1        |
| Electromechanical equipment 2     | category 2                           | category 1           | category 3              | category 2        |
| Electromechanical equipment 3     | category 2                           | category 1           | category 1              | category 2        |
| Testing equipment 1               | category 1                           | category 1           | category 1              | category 1        |
| Testing equipment 2               | category 1                           | category 2           | category 1              | category 2        |
| Testing equipment 3               | category 1                           | category 1           | category 3              | category 2        |
| Instrumentation 1                 | category 2                           | category 2           | category 3              | category 2        |
| Instrumentation 2                 | category 2                           | category 2           | category 3              | category 1        |
| Instrumentation 3                 | category 2                           | category 2           | category 1              | category 2        |
| Meteorological equipment          | category 2                           | category 3           | category 3              | category 2        |
Use the analytic hierarchy process to determine the weights of the influencing factors of weapon equipment storage, \( w_a = 0.3, w_b = 0.3, w_c = 0.2, w_d = 0.2 \). According to Table 3 and Formula 1, the weapons equipment storage intensity scores and rankings are obtained, as shown in Table 4.

Table 5. Weapon equipment storage intensity scores and ranking

| Equipment                        | Objects importance | Importance | Accessibility | Economy | Score | Ranking |
|----------------------------------|--------------------|------------|---------------|---------|-------|---------|
| Electromechanical equipment 1    | 1                  | 0.6        | 0.4           | 1       | 0.76  | 3       |
| Electromechanical equipment 2    | 0.6                | 1          | 0.6           | 0.6     | 0.72  | 5       |
| Electromechanical equipment 3    | 0.6                | 1          | 1             | 0.6     | 0.8   | 2       |
| Testing equipment 1              | 1                  | 1          | 1             | 1       | 1     | 1       |
| Testing equipment 2              | 1                  | 0.6        | 1             | 0.6     | 0.8   | 2       |
| Testing equipment 3              | 1                  | 1          | 0.4           | 0.6     | 0.8   | 2       |
| Instrumentation 1                | 0.6                | 0.6        | 0.4           | 0.6     | 0.56  | 10      |
| Instrumentation 2                | 1                  | 0.6        | 0.4           | 1       | 0.76  | 3       |
| Instrumentation 3                | 0.6                | 0.6        | 1             | 0.6     | 0.68  | 6       |
| Meteorological equipment         | 0.6                | 0.4        | 0.4           | 0.6     | 0.5   | 11      |
| Equipment 1                      | 0.6                | 1          | 0.6           | 0.4     | 0.68  | 6       |
| Equipment 2                      | 0.6                | 0.4        | 1             | 0.4     | 0.58  | 9       |
| Equipment 3                      | 1                  | 0.4        | 0.6           | 1       | 0.74  | 4       |
| Communication equipment 1        | 0.6                | 0.6        | 0.6           | 0.6     | 0.6   | 8       |
| Communication equipment 2        | 0.4                | 0.6        | 0.6           | 0.4     | 0.5   | 11      |
| General vehicle equipment        | 0.4                | 0.6        | 0.4           | 0.6     | 0.5   | 11      |
| Measuring equipment 1            | 0.6                | 0.6        | 1             | 1       | 0.76  | 3       |
| Measuring equipment 2            | 0.6                | 0.4        | 1             | 0.6     | 0.62  | 7       |

According to the data in Table 4 and comparing with Table 2, we can get the level of weapon equipment storage, see Table 5.
Table 6. Weapon equipment storage level

| Weapon equipment storage level | Weapon equipment(resource) | Storage level |
|-------------------------------|----------------------------|---------------|
| A                             | Testing equipment 1, electromechanical equipment 3, testing equipment 2, testing equipment 3 | Key control |
| B                             | Electromechanical equipment 1, electromechanical equipment 2, instrumentation 2, instrumentation 3, equipment 1, equipment 3, communication equipment 1, measurement equipment 1, measurement equipment 2 | Secondary control |
| C                             | Instrumentation 1. Meteorological equipment, equipment 2, Communication equipment 2. General vehicle equipment | General control |

It can be seen from the table that the storage level of testing equipment 1, electromechanical equipment 3, testing equipment 2, and testing equipment 3 is A; the storage level of electromechanical equipment 1, electromechanical equipment 2, instrumentation 2, instrumentation 3, equipment 1, equipment 3, communication equipment 1, measurement equipment 1 and measurement equipment 2 is B; the storage level of instrumentation 1, meteorological equipment, equipment 2, communication equipment 2 and general vehicle equipment is C.

5. Conclusion
In this paper we used the ABC classification method to analyse the structure of weapon equipment storage. As the storage of weapon equipment involves complex environment, factors, and uncertain demand, the next step is to build a quantitative analysis model to study the demand of weapon equipment and their resources, and the location of the weapon equipment storage warehouses. The research conclusion is expected to provide theoretical and methodological support for equipment storage system construction.

Project fund
National Natural Science Foundation of China (72074219), National Natural Science Fund Emergency Consultation Project (Project Number: 71841052), National Social Science Foundation Project (Project Number: 19BGL294)

References
[1] Sun Zheng, Shi Quan, Wang Qiang, etc. Modeling and simulation of maintenance equipment configuration based on subsequent sharing [J]. Computer Simulation, 2019, 36(06): 5-9+336.
[2] Teng Shangru, He Chengming, Cong Bin. Two-stage heuristic algorithm for production route decision of equipment maintenance equipment[J]. Journal of National University of Defense Technology, 2020, 42(05): 126-135.
[3] Chen Yukun, Gao Qi, Chen Jian, etc. Decision-making method for equipment maintenance equipment support during the initial support period[J]. Firepower and Command Control, 2020, 45(02): 23-27.
[4] Yu Zhijing, Wang Keping, Zheng Jianwen, etc. Improve the ABC classification management method of navigation aid lighting spare parts management [J]. Computer Applications and Software, 2019, 36(07): 59-64.
[5] Li Hongwen, Li Chengbiao, Cao Qiong. Research on ABC classification of petroleum production equipment based on fuzzy analytic hierarchy process [J]. Logistics Technology, 2013, 32(21):227-229.
[6] Yang Xiaolou. The application of ABC classification management method in the field of logistics [J]. Logistics Technology, 2013, 32(21): 67-69.