Research on evaluation model of equipment research project procurement based on structural equation

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Abstract—This paper analyzes the problem that the variables that may be encountered in the procurement process of equipment research projects are difficult to measure directly and accurately. A bid evaluation model based on structural equation with 30 evaluation indexes is established, and a set of bid evaluation methods more suitable for equipment scientific research projects is proposed. Through the combination of factor analysis, path simulation test, multi group comparison and causality analysis of structural equation model, the data analysis and processing of the relationship between variables, indicators and variables are realized, and the continuous fitting test makes the model more accurate and effective.

1. Introduction
With the introduction of competition mechanism in the procurement process of equipment scientific research projects, it will be more and more common to carry out bidding in the procurement of scientific research projects. For the tenderer of scientific research project, the premise to ensure the quality of scientific research project, shorten the implementation period of the project and save the project funds is to select a research unit with strong scientific research technology strength, high personnel quality and rich research experience, and with excellent management organization related system and ability, which can effectively carry out the project, continuously improve the work and the satisfaction, so as to achieve the purpose of jointly improving the effect, efficiency and benefit. However, in the actual bidding of scientific research projects, how to comprehensively evaluate and select the bidders is the primary task of successful bidding of scientific research projects[1].

2. Establishment of evaluation index system for equipment scientific research project

2.1 Analysis on the background of current evaluation index system of equipment scientific research project procurement
The evaluation of military equipment research projects mainly involves three categories: materials, engineering and services. Under the supervision of the relevant functional departments of the military, the evaluation is open and transparent. In addition, the military has issued a series of laws and regulations to ensure the fairness and rationality of the evaluation process in accordance with the national laws and regulations and its own procurement characteristics.

At present, the main method of evaluation of military equipment scientific research project is the comprehensive evaluation method. The evaluation standard is composed of technical performance and price. The calculation method is weighted synthesis. The data processing is based on the score, with 2-3
decimal places remaining and rounding. The current scoring method is simple, easy to operate and comprehensive to a certain extent. It is suitable for equipment scientific research projects and engineering projects with comparative test.

However, with the advancement of military reform and the in-depth development of civil military integration, the evaluation of equipment research projects not only has powerful state-owned enterprises, but also has dynamic social forces. The current price and technology based index system is not only rough and lack of pertinence and dynamic, but also difficult to quantify index score processing and calculation, and the subjective deviation and calculation error of the method will have a negative impact on the evaluation results. Therefore, it is necessary to establish a comprehensive and accurate evaluation index system of equipment scientific research projects, which takes innovation and effectiveness into account, so as to evaluate equipment scientific research projects more scientifically.

In the actual operation of equipment scientific research project evaluation, the selection of multiple index systems and methods can be more suitable for the increasingly complex evaluation of equipment scientific research projects. The index system and methods established in this paper are oriented to the overall evaluation of equipment scientific research projects, and have adaptability for mainstream projects, aiming at specific projects involving physical, engineering and service In bid evaluation, the project's own characteristics and needs can be combined with the index system and methods established in this paper to weigh the current main standards and methods for bid evaluation.

### 2.2 Construction of evaluation index system of equipment scientific research project

Based on a comprehensive analysis of a large number of documents related to the evaluation of scientific research projects, and combined with the requirements of various documents prepared by the Ministry of Finance and the Procurement Management Bureau of the logistics support department of the CMC, this paper first draws up a draft of indicators, after extensive consultation with experts, repeated exchange of views, unified treatment and comprehensive induction, taking into account the confidentiality, technology, actual combat and The differences between quality requirements and social bid evaluation are guided by the optimization of function cost and the core idea of value engineering theory, and guided by the dynamic perspective of game theory in bid evaluation and the pursuit of comprehensive balance of participants in competitive procurement of scientific research projects. Try to reduce the deviation of subjective judgment, introduce the indexes that can be objectively calculated, and build the evaluation index system table 1.

| Target                                      | Dimension                                                                 | First level indicators | Secondary index                                                                 |
|---------------------------------------------|---------------------------------------------------------------------------|------------------------|--------------------------------------------------------------------------------|
| Satisfactory research institutions (A)      | Economic dimension (B₁)                                                   | Project benefits (C₁)  | Quotation saving rate (F₁)                                                   |
|                                             |                                                                           |                        | Quotation ratio (F₂)                                                         |
|                                             |                                                                           |                        | Duration reduction rate (F₃)                                                  |
|                                             |                                                                           |                        | Value of subsidiary commercial terms (F₄)                                    |
|                                             | Technology dimension (B₂)                                                 | Institutional benefits (C₂) | Current ratio (G₁)                                                        |
|                                             |                                                                           |                        | Cost profit margin (G₂)                                                      |
|                                             |                                                                           |                        | Return on assets (G₃)                                                        |
|                                             |                                                                           |                        | Reasonable applicability of the plan (H₁)                                   |
|                                             |                                                                           |                        | Allocation of scientific research personnel (H₂)                            |
|                                             |                                                                           |                        | Level of supporting facilities (H₃)                                         |
|                                             |                                                                           |                        | Experience rate of related projects (H₄)                                    |
3. Evaluation methods and comparison of current equipment research projects

Bid evaluation method refers to the specific method of using bid evaluation standard and comparing bid documents. In practice, there are generally percentage system method (i.e. comprehensive scoring method), lowest quotation method, expert evaluation method, priority relationship comparison method, AHP, fuzzy comprehensive evaluation method, entropy based multi criteria comprehensive evaluation method and grey evaluation method. After long-term practice, these methods are proved to be subjective. There are disadvantages in tendency and actual workload demand. Based on the above analysis, in the bid evaluation stage of bidding, if there is not a set of scientific evaluation methods, it is difficult to select the real excellent in the bidding unit. Due to the influence of various internal and external factors, the traditional measurement method can not control the error of independent variable and dependent variable well, and the independent variables have mutual influence relationship. Structural equation model is used to clearly analyze the effect of single index on the overall and the relationship between single index. For the analysis and evaluation of abstract concepts, it has advantages to process multiple data, and at the same time, it can deal with multiple data. By adjusting multiple dependent variables to allow greater flexibility, a special factor structure is proposed to test whether the data match or not, and the bidirectional

| Management dimension \((B_3)\) | Advanced technology \((D_2)\) | Technological innovation \((D_2)\) | Comprehensive management ability \((E_1)\) | Growth ability \((E_2)\) | Operation capacity \((E_3)\) |
|--------------------------------|--------------------------------|--------------------------------|---------------------------------|----------------|----------------|
| Advanced rate of achievements \((J_1)\) | Span of technical field \((I_2)\) | Referential degree \((I_1)\) | Technical uniqueness \((J_1)\) | Knowledge management system \((J_1)\) | Technology accumulation reserve \((J_3)\) |
| Qualification credit of research undertaking unit \((K_1)\) | Dynamic performance capability \((K_2)\) | Quality assurance and after sales capability \((K_3)\) | Confidentiality management level \((K_4)\) | Technology input ratio \((L_1)\) | Technological innovation mechanism \((L_2)\) |
| Growth rate of total assets \((L_3)\) | Organizational change and innovation capability \((L_4)\) | Project risk control level \((M_1)\) | Operation and maintenance capacity of key projects \((M_2)\) | EHS management \((M_3)\) | Key business process optimization \((M_4)\) |
| Key business process optimization \((M_4)\) | Internal audit system \((M_5)\) |
feedback of data method is realized. Therefore, it will be more effective to judge the unit of satisfactory undertaking research by establishing structural equation model.

4. Evaluation model based on structural equation

4.1 Model building

The measurement equation is used to describe the relationship between indicators and latent variables, which is represented by the following model:

\[
\begin{align*}
X_m &= AX + \delta \\
Y_n &= AY + \varepsilon
\end{align*}
\]

Here, \( X \) is a column vector composed of \( m \) exogenous indexes, \( \eta \) is a column vector composed of \( u \) exogenous latent variables; \( A \) is an \( m \times u \)-dimensional matrix, called factor load matrix of \( X \) on \( \eta \); \( \delta \) is the error column vector of \( m \) dimension; \( Y \) is a column vector composed of \( n \) endogenous indexes, \( \xi \) is a column vector composed of \( v \) endogenous latent variables; \( A \) is a \( n \times v \)-dimensional matrix, called \( y \) factor load matrix on \( \xi \); \( \varepsilon \) is the error column vector of \( n \) dimension.

It includes the system modeling, determination of simulation algorithm, establishment of simulation model, design of simulation program, operation of simulation program and output of simulation results analysis. Structural equation is used to describe the relationship between exogenous latent variable and endogenous latent variable, which is expressed by the following model:

\[
\eta = B\xi + \Gamma + \gamma[2]
\]

Here, \( \eta, \xi \) are defined as above; \( B \) is a matrix of \( v \times v \) dimension, which describes the relationship between endogenous latent variables; \( \gamma \) is a matrix of \( v \times u \), which is the load of \( \eta \) on \( \xi \), which describes the influence of exogenous latent variables on endogenous latent variables; \( \varepsilon \) is the column vector of the residual term of a \( v \)-dimensional structural model, which reflects the part of the model that fails to interpret \( \eta \). Because the existing empirical research results show that the satisfaction of the first level indicators under the three dimensions has a significant impact on the satisfactory research units, this paper assumes that \( H_1 \) to \( H_{11} \) are respectively project benefits, institutional benefits, technological reliability, advanced technology, technological innovation, comprehensive management, growth ability, operation ability, economic dimensions, technological dimensions and management dimensions, which are significantly positive to the satisfactory research units To.

4.2 Model fitting

In this study, the fitting indexes 2/DF, RMR, GFI, AGFI, NFI, IFI, CFI and RMSEA are selected. According to the previous assumptions and variable index settings, build the structural equation and bring the processed data into the structural equation model. Through Amos software and the previous assumptions, the model estimation results are as follows:
The above figure reflects the interrelationship between endogenous and exogenous variables in the model. From the criterion level to the indicator level, the standardized estimates of each index in the corresponding latitude are greater than 0.5, which shows that each topic can explain the latitude represented well. The influence of each observation variable in the model on specific structural variables is significant, which can better explain the corresponding latent variables from the table. It can be seen that the indexes of the simplicity of the evaluation model are well fitted, and the model has passed the verification[3]. Among the 11 exogenous variables in the structural equation model, the path load values are all positive, the standardized path coefficient of economic dimension is 0.328, and the rest are greater than 0.4. In general, the assumptions in this paper are all tenable[4].

### Table 2 Model fitting results

| Fit index | Reasonable scope | Result | Evaluation results |
|-----------|------------------|--------|--------------------|
| CHISQ/DF  | < 3, good model fit | 2.182  | Good               |
| GFI       | > 0.8, model fitting is reasonable; > 0.9, model fitting is good | 0.962  | Good               |
| RMR       | < 0.08, the model fitting is reasonable; < 0.05, the model fitting is good | 0.027  | Good               |
| SRMR      | < 0.08, model fitting is reasonable; < 0.05, model fitting is good; < 0.08, model fitting | 0.026  | Good               |
Table 3 Path coefficient table

| Path      | Load value | Standard deviation | Characteristic value | Significance value |
|-----------|------------|--------------------|----------------------|--------------------|
| C₁→B₁    | 0.531      | 0.107              | 4.986                | 0.000              |
| C₂→B₁    | 0.815      | 0.158              | 5.176                | 0.000              |
| D₁→B₁    | 0.627      | 0.042              | 14.816               | 0.000              |
| D₂→B₁    | 0.674      | 0.042              | 16.078               | 0.000              |
| D₃→B₁    | 0.589      | 0.041              | 14.217               | 0.000              |
| E₁→B₁    | 0.621      | 0.04               | 15.656               | 0.000              |
| E₂→B₁    | 0.702      | 0.04               | 17.655               | 0.000              |
| E₃→B₁    | 0.619      | 0.04               | 15.612               | 0.000              |
| B₁→A     | 0.328      | 0.098              | 3.359                | 0.001              |
| B₂→A     | 0.487      | 0.121              | 4.014                | 0.000              |
| B₃→A     | 0.578      | 0.139              | 4.148                | 0.000              |

It can be seen from the path coefficient table that the model and path after path analysis have achieved remarkable results, and each fitting variable conforms to the goodness of fit standard. The satisfaction of project benefit, institutional benefit, technological reliability, advanced technology, technological innovation, comprehensive management, growth ability operation ability, economic dimension, technological dimension and management dimension are all significant path coefficients of 0.531 and 0.531 respectively, 0.815, 0.627, 0.674, 0.589, 0.621, 0.702, 0.619, 0.328, 0.487, 0.578, and passed the corresponding significance test. It shows that the above variables have a positive impact on the satisfactory research units.

5. Conclusion

From the perspective of the degree of influence, institutional efficiency, growth ability and advanced technology have a high degree of relevance with satisfactory research institutions, which has a great impact on the satisfaction of research institutions. In the practice of scientific research project evaluation, it is very important to pay attention to the indicators at all levels under these three factors for the current progress and future trend of research institutions. In addition, project efficiency and technological innovation have two effects. The influence of factors is slightly weak, but in the process of evaluation of scientific research projects, the two variables are becoming more and more important in the dynamic...
environment in the actual research units. However, they are weakened by many evaluation units, or because the units participating in the evaluation are slightly inadequate in the construction and supply of these two aspects. From the perspective of dimension, the significance values of variables are all at the significance level, and the influence of b1-b3 on a is 0.3280487 and 0.578 respectively. The larger the coefficient is, the greater the influence is. Therefore, B3 > B2 > B1 indicates that the satisfied research unit should have the requirements of triple dimension. In order to improve the comprehensive strength of the research unit and the scientificity and efficiency of the evaluation of scientific research projects, the project benefits and related indicators under the economic dimension and dimension are the key factors for improvement after ensuring the construction of management and technology to a certain level. Not only in the planning, construction and implementation of this aspect, but also in the bid evaluation units, the trend, methods and ideas of bid evaluation need to be improved, updated and perfected.

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