Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Research on Equipment Procurement Contract Performance Evaluation

To cite this article: Mingxing Yuan *et al* 2021 *J. Phys.: Conf. Ser.* **1757** 012188

View the article online for updates and enhancements.

IOP ebooks™

Bringing together innovative digital publishing with leading authors from the global scientific community.

Start exploring the collection–download the first chapter of every title for free.

This content was downloaded from IP address 223.237.52.81 on 22/06/2021 at 11:49

Research on Equipment Procurement Contract Performance Evaluation

Mingxing Yuan, Xinran Peng, Xiaosong Li*

Military Science Information Research Center, Academy of Military Sciences, PLA, Beijing 100142, China

*164832732@qq.com

Abstract. The equipment procurement contract performance evaluation is an important means to effectively solve the problem like “inefficient progress”, “low targets”, and “increased costs" in equipment procurement. This paper defined the concept and connotation of the performance of equipment procurement contract, and proposed the equipment procurement contract performance evaluation, including influence factors analysis, evaluation indicators establishment, evaluation model construction, calculating results, etc., constructed four-dimension equipment procurement contract performance evaluation indicator system consisting of quality, schedule, funding, and service, and constructed the equipment procurement contract performance evaluation model based on BP neural network, and carried out a case analysis. The research conclusions provide a reference for the evaluation practices of equipment procurement contract performance.

Keywords: Equipment procurement contract; contract performance evaluation; BP neural network.

1. Introduction

In order to fully understand the status of the equipment procurement contract, accurately discover the problems and weaknesses in the performance of the equipment procurement contract, and improve the performance of the equipment procurement contract, it is urgent to carry out evaluation research on the performance status of the equipment procurement contract. This paper put forward the general idea of equipment procurement contract performance evaluation, established the evaluation indicator system of the equipment procurement contract performance, built the evaluation model based on BP neural network, and conducted case analysis, in order to provide a reference for equipment procurement contract evaluation.

2. The guideline of equipment procurement contract performance evaluation

2.1. The definition of equipment procurement contract performance evaluation

The equipment procurement contract performance refers to the equipment contractor abides by the equipment procurement contract, fulfills the contract obligations, and provides high-quality weapon and equipment. The fulfillment of the equipment procurement contract is an important part of equipment procurement contract management. It is crucial for the military and contractors to execute the

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

contract and fulfill contract rights and obligations in accordance with the law. It is significant for improving the quality and efficiency of equipment procurement.

The equipment procurement contract performance evaluation refers to methods including both qualitative and quantitative to make objective and scientific value judgments on the equipment procurement contract performance based on the terms and objectives of the equipment procurement contract and evaluation indicators and standards, provides a quantitative reference basis for decision-making. Weapon and equipment have the characteristics of complex technology, complex objective, an inefficient system, prolonged lifecycle, and huge investment, which cause great risks in the performance of equipment procurement contracts. Therefore, it is urgent to carry out the equipment procurement contract performance evaluation, supervise the equipment procurement contract performance from multiple dimensions, and improve the quality and efficiency of equipment procurement contract management.

2.2. The process of equipment procurement contract performance evaluation

The process of equipment procurement contract performance evaluation includes: analyzing influencing factors, establishing an evaluation indicator system, constructing an evaluation model, and calculating evaluation results, as shown in Fig.1.

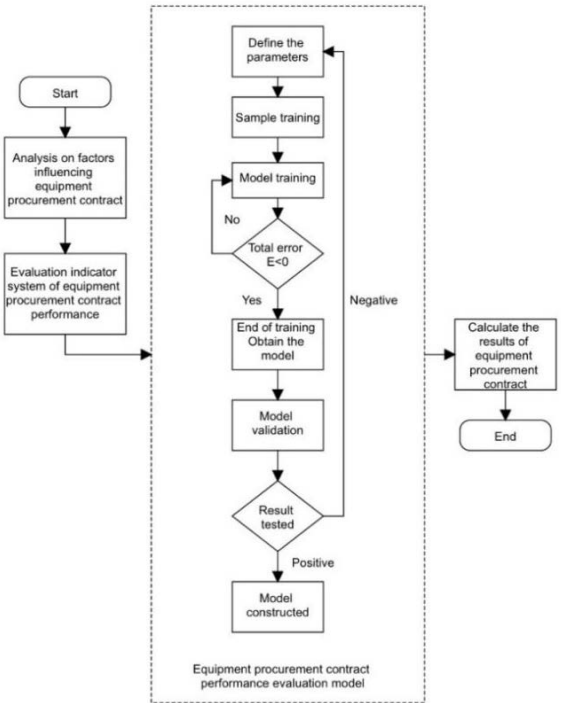

Fig.1 The main steps of equipment procurement contract fulfillment evaluation

2.2.1. Analysis of the factors influencing equipment procurement contract performance

From multiple dimensions, multiple perspectives, and multiple levels, this paper analyzed factors affecting the performance of equipment procurement contracts, including personnel, quality, progress, risks, costs, etc., provides a reference for building an evaluation indicator system.

2.2.2. Evaluation indicator system of equipment procurement contract performance

This paper constructed an indicator system for equipment procurement contract performance evaluation in terms of quality, progress, funding, and services.

2.2.3. Construct an evaluation model for equipment procurement contract performance

This paper constructed an equipment procurement contract performance evaluation model based on BP neural network, including defining parameters, training models, and validate models. (1) Define the parameters, determine the number of layers of the BP neural network model, the number of nodes in each layer, and the corresponding transfer function and training function; (2) Train the model, establish a training sample set to train the model, and calculate the weight values and thresholds of each layer to obtain a well-trained model; (3) Test the model, establish a validation sample set to validate the model, and validate the result of the model. If the results are positive, the model is established; if the results negative, the model needs to be retrained and adjusted.

2.2.4. Calculate the result of equipment procurement contract performance

According to the equipment procurement contract performance evaluation model, estimate the equipment procurement contract performance result find out the problems or weaknesses.

3. Equipment procurement contract performance evaluation indicator system

Evaluation indicator is an important parameter for understanding the performance of equipment procurement contracts and helps to strengthen the management of equipment procurement contracts. Geng Weibo et al. [1] (2020), Cai Wanqu et al. [2] (2018), Song Cuiwei et al. [3] (2014), proposed an evaluation indicator system for the performance of equipment procurement contract and conducted case analysis. Ji Lichao et al. [4] (2019), Li Zhengying et al. [5] (2019) analyzed the problems and risks in the performance of equipment procurement contracts and put forward countermeasures and suggestions. The equipment procurement contract performance evaluation indicator system constructed in this paper included 4 primary indicators and 8 secondary indicators, such as quality, progress, funding, and service, as shown in Tab.1.

Serial number	Primary indicators	Secondary indicators
1	Quality A	Quality assurance A1
2		Quality process A2
3		Quality result A3
4	Progress B	Progress completion result B1
5	Funding C	Funding management C1
6		Result of expenditure C2
7	Service D	After-sales service D1
8		Contract service D2

Tab.1 evaluation indicator system of equipment procurement contract

3.1. Quality evaluation indicator

Equipment quality evaluation indicator A refers to the process of fulfilling the equipment procurement contract and the quality of the equipment after completion, which includes three secondary indicators: quality assurance, quality process, and quality results.

3.1.1. Quality assurance evaluation indicator

The equipment quality assurance evaluation indicator A1 focuses on the quality management system, quality assurance program, and equipment production readiness status. This indicator is a qualitative indicator, obtained through expert scoring, with a score of 0 to 1.

3.1.2. Quality process evaluation indicator

The equipment quality process evaluation indicator A2 focuses on the management of equipment procurement supporting equipment, equipment research and production process management, and substandard product management. This indicator is a qualitative indicator, obtained through expert scoring, with a score of 0 to 1.

3.1.3. Quality result evaluation indicator

The equipment quality result evaluation indicator A3 focuses on the equipment qualification rate (key parts qualification rate, important parts qualification rate, and general parts qualification rate). This indicator is a quantitative indicator, calculated by Formula 1, with a score of 0 to 1.

$$x_{A3} = \frac{x_1 + 0.6 \times x_2 + 0.4 \times x_3}{3} \tag{1}$$

Among them, x_{A3} represents the evaluation score of equipment quality results, x_1 represents the pass rate of key parts, x_2 represents the pass rate of important parts, and x_3 represents the pass rate of general parts.

3.2. Progress evaluation indicator

The equipment procurement progress evaluation indicator B refers to the completion result of the equipment procurement contract fulfillment schedule. This indicator is a quantitative indicator, calculated by Formula 2, with a score of 0 to 1.

$$x_B = \begin{cases} \dfrac{x_{contract} - x_{actual}}{x_{contract}} & x_{actual} \le x_{contract} \\ 0 & x_{actual} > x_{contract} \end{cases} \tag{2}$$

Among them, x_B represents the evaluation score of equipment procurement progress, x_{actual} represents the actual value of equipment procurement progress, and $x_{contract}$ represents the value of equipment procurement progress agreed in the contract.

3.3. Funding evaluation indicator

Equipment procurement expenditure evaluation indicator C refers to the funding management and use after the completion of the equipment procurement contract, which includes two secondary indicators: funding management and funding expenditure.

3.3.1. Funding management evaluation indicator

The evaluation indicator C1 of equipment procurement expenditure management focuses on the special situation of equipment procurement expenditures, the rationality of expenditure, and the timeliness of payment of contract expenditures. This indicator is a qualitative indicator, obtained through expert scoring, with a score of 0 to 1.

3.3.2. Expenditure evaluation indicator

The evaluation indicator C2 of equipment procurement expenditures focuses on the relationship between actual expenditures of equipment procurement expenditures and contractual expenditures. This indicator is a quantitative indicator, calculated by Formula 3, with a score of 0 to 1.

$$x_{C2} = \begin{cases} \dfrac{x_{contract} - x_{actual}}{x_{contract}} & x_{actual} \le x_{contract} \\ 0 & x_{actual} > x_{contract} \end{cases} \tag{3}$$

Among them, x_{C2} represents the evaluation score of equipment procurement expenditure, x_{actual} represents the actual value of equipment procurement expenditure, and $x_{contract}$ represents the value of equipment procurement expenditure agreed in the contract.

3.4. Service evaluation indicator

Equipment procurement service evaluation indicator D refers to the performance of the equipment procurement contract, including two secondary indicators: after-sales service and contract service.

3.4.1. After-sales service evaluation indicator

The equipment procurement after-sales service evaluation indicator D1 focuses on the inspection of equipment delivery to the army after the completion of the equipment procurement contract, training, equipment instruction manuals, and technical information, equipment problem handling, and technical support for special tasks in wartime and emergency. This indicator is a qualitative indicator, obtained through expert scoring, with a score of 0 to 1.

3.4.2. Contract service evaluation indicator

Equipment procurement contract service evaluation indicator D2 focuses on contract management such as contract signing, modification, dispute settlement, and contract information management. This indicator is a qualitative indicator, obtained through expert scoring, with a score of 0 to 1.

4. Evaluation model of equipment procurement contract performance based on BP neural network

4.1. Fundamental

In 1986, Rumelhart, Hinton, and Williams proposed an artificial neural network error backpropagation training algorithm (referred to as BP (Back Propagation) algorithm). The BP neural network is a complex nonlinear system composed of a large number of simple neurons interconnected, as shown in Fig.2.

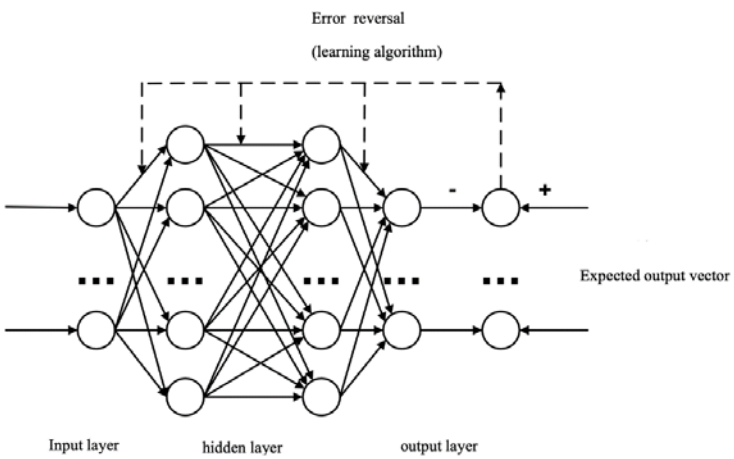

Fig.2 BP neural network structure

Suppose the BP neural network includes *n* input neurons, *m* hidden layer neurons, and *p* output layer neurons. The transfer function of the hidden layer adopts the Sigmoid function, and the output layer transfer function adopts the linear function. The mathematical description formula is:

(1) hidden layer: $$x_i = \sigma(\sum_{j=1}^{n} w_{ij}^0 \times x_j + w_{i0}^0) \qquad i = 1,2,\mathrm{L}\ m; j = 1,2,\mathrm{L}\ n$$

(2) output layer: $y_h = \sum_{k=1}^{m} w_{hk}^0 \times x_k + w_{h0}^0) \quad h = 1,2,\mathrm{L}\ p; k = 1,2,\mathrm{L}\ m$

Among them, x_i and y_h respectively represent the output value of the *i*-th hidden layer neuron and the *h*-th output layer neuron; w_{ij}^0 and w_{hk}^0 respectively represent the weight between the two layers of neurons; σ represent the Sigmoid function.

4.2. Evaluation model of equipment procurement contract performance

4.2.1. The basic structure of BP neural network

Establish a three-layer BP neural network model for the equipment procurement contract performance evaluation. The number of nodes in the input layer is 8, which is the eight secondary evaluation indicators for the equipment procurement contract performance, and the number of nodes in the output layer is 1, which is the evaluation value of the equipment procurement contract performance result, the hidden layer nodes are set to 17, and the topological structure is 8-17-1, as shown in Fig.3.

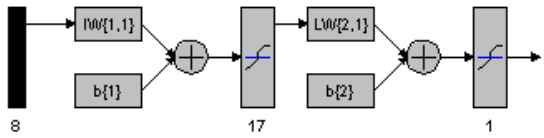

Fig.3 Neural network topology structure of the evaluation model

A total of 25 samples for the equipment procurement contract performance evaluation are selected, 80% of the samples are randomly selected as training samples (20 samples), and 20% of the samples are test samples (5 samples). Known 20 sets of training sample data, see Tab.2.

	1	2	3	……	18	19	20
Quality assurance A1	0.8	0.7	0.5	……	0.5	0.68	0.88
Quality process A2	0.85	0.75	0.6	……	0.55	0.56	0.85
Quality result A3	0.75	0.6	0.7	……	0.52	0.6	0.86
Progress completion result B1	0.9	0.8	0.85	……	0.46	0.72	0.9
Funding management C1	0.86	0.59	0.35	……	0.75	0.68	0.86
Result of expenditure C2	0.95	0.68	0.68	……	0.56	0.68	0.8
After-sales service D1	0.82	0.72	0.72	……	0.35	0.75	0.82
Contract service D2	0.84	0.65	0.58	……	0.52	0.78	0.72
Evaluation results	0.88	0.7	0.62	……	0.55	0.66	0.82

Tab.2 Sample data table

4.2.2. Training result

Run the BP neural network model to reach the allowable error of the network after 50 iterations of training, and the model construction is completed. The error change process during model training is shown in Fig.4.

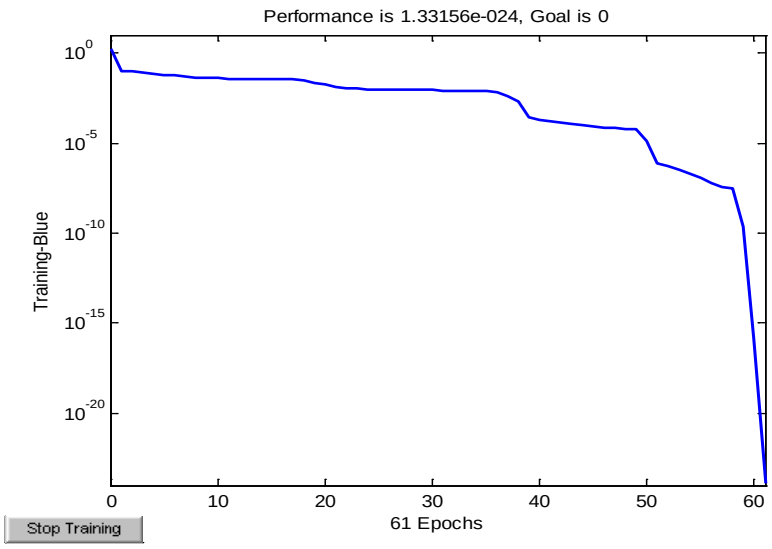

Fig.4 Training process

4.2.3. Model validation

Use 5 sets of test samples to validate the model, and the verification results obtained are shown in Tab.3. It can be seen from the table that the maximum absolute error between the calculated result and the actual value is 0.029, and the minimum error is 0.0086. Assuming that the absolute error value is less than 0.02 as the standard, and the accuracy rate reaches more than 75%, the model is established. It can be seen from the table that the accuracy rate of the equipment procurement contract performance evaluation model is 80% (only one test sample exceeds the error), which shows that the equipment procurement contract performance evaluation model is established.

	1	2	3	4	5
Actual value	0.85	0.72	0.65	0.71	0.61
Calculated	0.84137	0.69021	0.63664	0.69973	0.62647
Difference	0.00863	0.02979	0.01336	0.01027	-0.01647

Tab.3 Comparison of output results

4.3. Case study

Taking four equipment procurement contracts as an example, using the trained equipment procurement contract performance evaluation model, the performance evaluation conclusion of the equipment procurement contract is obtained. It can be seen from the Tab.4 that the performance of equipment procurement contract A is positive (0.88); the performance of equipment procurement contract D is negative (0.33). There are problems in quality results, progress completion effects, contract services, etc., leading to the negative overall evaluation result.

	Contract A	Contract B	Contract C	Contract D
Quality Assurance A1	0.75	0.35	0.85	0.42
Quality Process A2	0.85	0.45	0.85	0.55
Quality result A3	0.68	0.23	0.78	0.25
Progress completion resultB1	0.75	0.65	0.92	0.38
Fund Management C1	0.85	0.58	0.85	0.48
Result of expenditure C2	0.56	0.67	0.83	0.56
After-sales service D1	0.72	0.82	0.85	0.45
Contract service D2	0.84	0.52	0.73	0.35

Evaluation results	0.83642	0.63522	0.7839	0.33

Tab.4 Case analysis results

5. Conclusion

With the in-depth advancement of competitive equipment procurement, the performance of equipment procurement contracts has increasingly become an important aspect of inspecting the quality and effectiveness of equipment procurement. Therefore, it is particularly important to do theoretical research on the evaluation of the equipment procurement contract. In accordance with the principle of "refined, operable, and quantifiable", this paper established an evaluation indicator system for the performance of equipment procurement contract from the four dimensions of quality, schedule, cost, and service, and uses the BP neural network model to carry out the equipment procurement contract performance evaluation. In the next step, we will further study the evaluation indicators and standards of equipment procurement contract performance, establish a quantifiable evaluation indicator calculation model, and improve the credibility of equipment procurement contract evaluation.

Acknowledgments

This work was supported by 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] Weibo G, Ping X, Bing Z and Jiaoyang C 2020 The application of principal component analysis in the comprehensive evaluation of equipment procurement contract performance *J. Quality and Reliability* **02** pp56-60

[2] Wanqu C, Dong H and Hao 2018 Comprehensive evaluation method of equipment procurement contract supervision *J. Journal of Armored Forces Engineering Academy* **32** pp 16-19

[3] Cuiwei S and Zhaohui L 2014 The performance evaluation of implementation of equipment procurement contract *J. Ship Electronic Engineering* **34** pp 115-118+121

[4] Lichao J and Fangyong Z 2019 Problems and supervision suggestions on the implementation of equipment procurement contract *J. Quality and Reliability* **05** pp 54-56+61

[5] Zhengying L, Hua Z, Tielu G, Xiao C and Xing S 2019 Research on the quality supervision of equipment procurement contract implementation based on risk *J. Project Management Technology* **03** pp 64-67