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Research on Probability Estimation Method of Investment Cost of Water Conservancy Construction Project

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Abstract. The construction period of water conservancy construction project is long, and the project cost is affected by many uncertain factors. There is a great difference between the final account value after the completion of the project and the budget value before the commencement.Therefore, this paper considers the complexity and variability of the project cost, analyzes and constructs the probability estimation theory of investment cost from the perspective of system analysis, and applies it to the estimation of the investment cost of the construction project of Matan River miaotazi hydropower station, and calculates the probability distribution of the total cost change.The research results can provide a new idea for the estimation of investment cost of water conservancy projects, and also provide valuable reference for the estimation of investment cost of Matan River miaotazi hydropower station.

Keywords: Water Conservancy Construction Project; Investment Cost; Probability Estimation.

1. Introduction

The estimation of the investment cost of water conservancy project is similar to that of other construction projects. The method of referencing the preliminary budgeting and the method of expanding index estimation[1-2] are adopted. The estimated investment cost value is a definite value. However, the general construction period of water conservancy construction projects is relatively long, and the project cost is affected by many uncertain factors. The final account value after the project is completed differs greatly from the budget value before the project starts. There are many reasons for this difference. For example, the cost of materials and labor varies, and the hydrological and climatic conditions such as rainstorm, flood and freezing during the construction period cause the cost to change. The above uncertainties can make the investment cost of the project change. However, these uncertainties have a certain randomness, which can be measured by probability.

The purpose of this paper is to project cost due to the complexity and variability, in the budget compilation directions and expand index estimation, on the basis of the construction cost estimates from the viewpoint of system analysis, the basis system of gradation and decomposability, engineering cost the complex system is decomposed into several subsystems . The expected value and variance of the random change of each sub-cost are obtained, and the expected value and variance of the total cost change are obtained with the help of the probability theory, so as to obtain the probability distribution curve of the total cost change. The estimation of investment cost of water conservancy project has certain reference value.

2. Probability Estimation Method of Investment Cost

Probability estimation of sub-costs. By combining the sub-cost value obtained by the expanded index estimation method and the estimate and budget method with the expert investigation method, three characteristic values of the sub-cost estimation can be obtained, namely, the minimum value (small risk), the most possible value (normal situation) and the maximum value (high risk). The objective estimate obtained according to the standard of budget preparation is taken as the most likely value, and on this basis, the fluctuation is made up and down according to the information of relevant experts. The floating limit value is taken as the maximum value and the minimum value. The expected

value E(x) and variance D(x) of the change of subcost are deduced by using the theory of triangle distribution. Triangular distribution is a simple form of distribution, which is suitable for the lack of data, but the highest, lowest and most likely values of variables can be obtained. The numerical characteristics of triangular distribution are as follows:

$$E(x) = \frac{1}{3}(a+b+c) \tag{1}$$

$$D(x) = \sigma^2 = \frac{1}{18}\left[(b-a)^2 + (c-a)(c-b)\right] \tag{2}$$

Probability estimate of the total cost. According to the characteristic parameters of each sub-cost to deduce the distribution of the total cost of the project, there are mainly two methods: one is the Monte Carlo simulation method; One is statistical parameter analysis. This paper mainly studies and discusses the calculation principle and steps of statistical parameter analysis method here.

Assume that the total cost of the project k consists of n subcosts, and its expression is as follows:

$$k = x_1 + x_2 + \cdots\cdots + x_n \tag{3}$$

Since $x_i (i = 1,2,\cdots\cdots n)$ is a variable, their expected values and variances have been determined in the above sub-cost estimates, then the total cost k is a function of the variable. According to the relevant theories of multivariate random variables, the mathematical expected values of both sides of Equation (3) are taken to obtain:

$$E(k) = E(x_1) + E(x_2) + \cdots\cdots + E(x_n) \tag{4}$$

It can also be calculated that its variance is:

$$D(k) = \sigma_k{}^2 = \sum_{i=1}^{n}\sigma_i^2 + 2\sum_{i<j}(\rho_{ij}\cdot\sigma_i\cdot\sigma_{j\,\mathrm{j}}) \quad (i, j = 1,2,\cdots\cdots n) \tag{5}$$

Where: σ_k mean square error of the total cost; σ_i Mean square error of sub-expenses; ρ_{ij} Is the correlation coefficient of and.

When determining the correlation coefficient, it can be selected from 0.1 to 1.0 according to the correlation between sub-items.

The above formula deduced the mathematical expectation $E(k)$ and variance $D(k)$, The mathematical expectation reflected the distribution center of the random change of the total cost, and the variance reflected the uneven degree of the change of the total cost. To derive the probability relation curve of the total cost, it is necessary to reveal the change rule of the total cost by means of a theoretical distribution function. According to the number and change characteristics of the influencing factors, normal or P-III distribution theory is usually used to describe the change law of the total cost. Literature [3] believes that the total cost of engineering projects is affected by many uncertain factors, and the influence of each factor is usually difficult to determine. In most cases, the change of K follows a normal distribution.

If the cost of water conservancy project is a random variable and the probability distribution obeys a normal distribution, its probability density function is expressed as:

$$f(k) = \frac{1}{\sqrt{2\pi}\sigma_k}\exp\left\{-\frac{1}{2\sigma_k{}^2}\left[k - E(k)\right]^2\right\} \tag{6}$$

In the formula: $E(k)$ — mathematical expectation;B — mean square error;

It can be deduced that the probability of being less than any cost value K is:

$$P(k \le K) = \int_{-\infty}^{k} \frac{1}{\sqrt{2\pi}\sigma_k} \exp\left\{ -\frac{1}{2\sigma_k^2}[k - E(k)]^2 \right\} dk \tag{7}$$

Transform Equation (7) into a standard normal distribution:

$$\Phi(Z) = \int_{-\infty}^{\frac{K-E(k)}{\sigma_k}} \frac{1}{\sqrt{2\pi}} \exp(-\frac{Z^2}{2}) dz = P(k \le K) \tag{8}$$

Assuming a set of appropriate K and a corresponding set of Z, the probability relation curve of total cost value K ~P can be obtained by looking up the standard normal distribution table.

3. Engineering Applications

Project overview. Matan River belongs to the first tributary of Jinqian River. The whole section of the main stream of Matan River is located in Shanyang County, starting from Sehepu and descending to the confluence of Matan River and Jinqian River. The river course is 33.6km long, with a total drop of 176. The water energy resources are abundant and have the conditions for development. The proposed miaotaizi power station is located on the matan river in the southwest of shanyang county, belonging to the third stage of hydropower cascade development in the matan river basin, the project is located at 200m upstream of baitouzhai, slanyan town, with 302 provincial roads running through the project area, and the traffic is very convenient. The main task of the construction of Miaotaizi Hydropower Station is hydropower generation. The installed capacity is 3000KW, and there is no flood control, water supply, irrigation and other tasks. Therefore, all the electricity generated is connected to the Internet.

Cost probability calculation. The main task of Matan Hemiaotaizi Hydropower Station is to generate electricity. According to its total cost, the total cost is divided into six sub-costs, which mainly include the main project, the power station (electromechanical equipment and installation), flood control works, water and soil conservation, environmental protection, management and other expenses.

Table 1. Miaotaizi hydropower station cost estimates Unit: million yuan

Eigenvalu / sub-costs		Minimum Values *a*	Possible Values *c*	Maximum Values *b*	Expected Values *E*(*x*)	Mean Square error σ
Main works	x_1	1190	1280	1380	1283.3	38.80
Power station	x_2	650	675	700	675	10.21
Flood control works	x_3	570	596	630	598.7	12.28
Water and soil conservation	x_4	27	27	27	27	0
Environmental protection engineering	x_5	20	20	20	20	0
Management and other related matters	x_6	180	190	210	194	6.16
Total		/	/	/	2798	/

Combining the objective calculated value of the above six sub-expenses obtained by the method of preparing budget estimates with the objective estimated value of the expert group, and giving three characteristic values of the minimum value, the most possible value and the maximum value of each sub-expense, the expected value and variance of each sub-expense can be calculated according to the

triangular distribution mentioned above. According to the above theory and the actual situation of Miaotaizi Hydropower Station on Matan River, the estimation table of its sub-cost can be obtained, and the expected value and mean square error of its characteristic parameters can be calculated (see Table 1).

After estimating the sub-costs of Miaotaizi Hydropower Station on Matan River, the mean square error of characteristic parameters can be calculated by combining with the correlation coefficient matrix of the sub-costs given by the expert group through analysis and judgment. The correlation coefficient matrix of each sub-cost is as follows:

$$\rho_{ij} = \begin{array}{c} \\ x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \end{array} \begin{array}{c} \begin{array}{cccccc} x_1 & x_2 & x_3 & x_4 & x_5 & x_6 \end{array} \\ \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0.2 \\ & 1 & 0 & 0 & 0 & 0 \\ & & 1 & 0 & 0 & 0.1 \\ & & & 1 & 0 & 0 \\ & & & & 1 & 0 \\ & & & & & 1 \end{bmatrix} \end{array}$$

Based on the estimated sub-cost data in Table 1, the mathematical expected value E(k) of the total cost can be calculated through Formula (4) as follows:

$$E(k) = \sum_{i=1}^{6} E(x_i) = 1283.3+675+598.7+27+20+194=2798 \text{ (million yuan)}$$

The variance D(k) of the total cost can be calculated by formula (5) as follows:

$$D(k) = \sum_{i=1}^{6} \sigma_j^2 + 2\sum_{i<j} (\sigma_{ij}\ \sigma_i \sigma_j)$$

$$=38.8^2+10.21^2+12.28^2+0+0+6.16^2+2\times(0.2\times38.8\times6.16+0.1\times12.28\times6.16)=1853.98$$

So the mean square error is:

$$\sigma_k = \sqrt{D(k)} = 43.06 \text{ (million yuan)}$$

According to the above method, the relationship between the total cost present value K and P can be obtained. Let 1 = 2, suppose a set of cost values K, then we can find the corresponding set of Z, and then look up the normal distribution probability table respectively to get the K ~ p relationship, as follows:

Table 2. The hydropower total cost of Miaotaizi K ~ P relationship

K (million yuan)	2700	2750	2780	2798	2800	2825	2850	2900
P(%)	98.9	86.9	66.3	50	48.1	26.4	11.3	7.9

According to Table 2, the probability distribution curve of the total cost of the hydropower station can be depicted as follows:

From Table 2, the K-P relationship of the total cost of the Matan River Miaotaizi Hydropower Station, and Figure 1, the probability distribution curve of the total cost, it can be seen that the total cost of the hydropower station project generally fluctuates between 27 million and 29 million yuan. The probability of less than or equal to 27 million yuan is 1.1%, while the probability of less than or equal

to 29 million yuan is 92.1%, and the probability of greater than 2900 yuan is 7.9%. Therefore, the probability of the cost between 27 million and 29 million yuan is 91%.

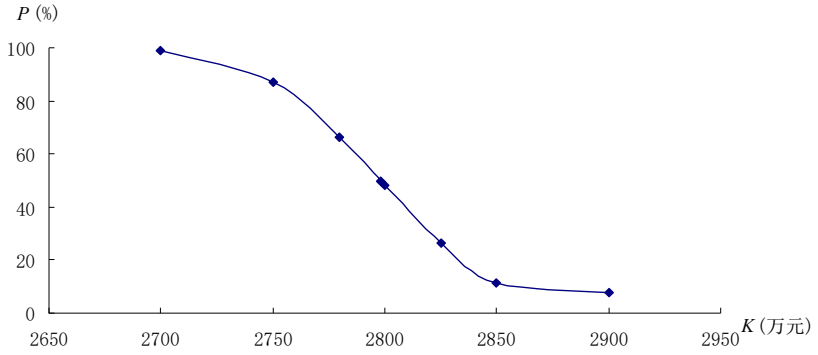

Fig 1. The hydropower total cost of Miaotaizi probability distribution curve

4. Conclusion

In this paper, the probability estimation method of investment cost is applied to estimate the investment cost of the construction project of miaotaizi hydropower station on Matan river. In the probability estimation of investment cost, the random variation characteristics of the future actual project cost are considered. Compared with the current deterministic calculation method, it is more objective and can reflect the variation characteristics of the future project cost more practically, It can provide more accurate and reliable scientific basis for decision-making of water conservancy construction project investment scheme.

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