Evaluation Model and Algorithm of Water Resources and Hydropower Based on ANP

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Abstract. The tendering and evaluation of water conservancy projects is an important part of China's infrastructure construction, and the evaluation of bidding is also a key link in the construction of water conservancy projects. In view of the problems in the bidding evaluation process for projects of water conservancy and hydropower in a certain province, the proportion of subjective elements is large, the proportion of bidding factors is not fixed, the randomness is large, and the external obstacle factors are large. This paper proposes the use of network analysis in the bidding evaluation process. The method (ANP) considers the mutual influence and dependence of each index, and establishes a multi-index comprehensive scoring criteria model for the nonlinear combination of indexes. Based on the model establishment process, the algorithm of ANP evaluation model was implemented using C# and applied to the bidding evaluation process, which made the evaluation process more scientific and rational.

Introduction

Water conservancy construction is the basic construction of our country and it is related to the long-term stability of the country⁷. The evaluation of water conservancy projects is the core link in the construction of water conservancy projects. The openness and fairness of evaluation work are largely related to the development and stability of the national economy. However, at the present stage, there is a large subjective component in the bidding evaluation process for projects of water conservancy and hydropower in a certain province⁸, and the proportion of evaluation factors is not fixed, the randomness is large, and external factors are large. Therefore, the analysis of the influence factors of a province's water conservancy and hydropower rating criteria, the scientific construction based on the ANP theory of the scoring criteria model⁹, the model is implemented by the algorithm and the algorithm is applied to the water conservancy department's bidding evaluation system¹⁰, through computer assistance, to create a fair and efficient electronic bidding evaluation system makes the bidding evaluation system more scientific, practical and operational.

Analytic Network Process(ANP)

The Concept of ANP

The Analytic Network Process (ANP) is a scientific decision-making method proposed by Thomas L. Saaty in 1996 for complex systems⁵. It comprehensively considers the dependence and feedback of system factors. Network analysis method divides the system into control layer and network layer⁴. The control layer includes the objectives and decision criteria of the decision problem. The network layer includes the element groups and elements that are controlled by the control layer. And the element groups and the elements influence or relate to each other to form a network structure⁸. The typical ANP structure is shown in Figure 1.
Basic Steps of ANP

(1) Analysis problem
Analysis of decision-making issues, the formation of element sets, analysis of whether the internal level of the element is independent, whether there is dependency and feedback, analysis methods similar to the ANP method\(^3\), can be used in the form of meeting methods, experts fill in forms.

(2) Constructing a typical structure of ANP
Firstly construct the control layer, define the decision objectives and criteria, and then construct the network hierarchy. Analyze the network structure\(^4\) and mutual influence relationship of each element set. After determining the relationship between element sets, the corresponding ANP network can be constructed. Basic practical problems are both There is an internal and cyclic ANP network hierarchy\(^2\).

(3) Constructing ANP Super matrix Computation Weights.

Establishment of ANP Evaluation Model

Determination of Evaluation Factors
According to the experts’ discussions and resolutions, they finally reached a consensus on the factors of evaluation, and finally determined the performance, corporate reputation, financial capabilities, the company's implementation capabilities, technical capabilities, the degree of compliance with the tender, production capacity, and price. A detailed description of each factor is shown in Table 1:

<table>
<thead>
<tr>
<th>Target index</th>
<th>First level index</th>
<th>Two level index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best bid unit A</td>
<td>Business factors(B)</td>
<td>Corporate reputation(B1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Performance(B2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Financial ability(B3)</td>
</tr>
<tr>
<td></td>
<td>Technical factors(T)</td>
<td>Delivery and execution capabilities(B4)</td>
</tr>
<tr>
<td></td>
<td>The degree of compliance with the bid(T1)</td>
<td></td>
</tr>
<tr>
<td>Price factor (P)</td>
<td>Technical skills(T2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Price factor (P)</td>
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</tbody>
</table>

Network Level Model Construction
In this bid evaluation model, the target criteria of the control layer are the best bid units, the network layer includes the price, business evaluation factors, and technical rating factors. The technical rating factors will affect the business rating factor, and at the same time, it will be the business rating factor. Affected by the existence of external dependencies between them, the internal factors in the business scoring factor will also affect each other, and there is internal dependence among them, thus forming a hierarchical network model. It is difficult to consider the impact between these internal and external influences on the general bid evaluation scheme, and the results of the bid evaluation will be slightly inappropriate. The model of the evaluation network layer is shown in Figure 2.
The Structure of the Judgment Matrix

In this bid evaluation model, there are internal dependencies on the commerce scoring factors. Here, under the B1 criterion, B1, B2, B3, and B4 influence each other on B1. Under the B2 criterion, B1, B2, B3, and B4 are mutually exclusive. The influence of B2, the commerce scoring factors on the technical indicators of the scoring factors are interdependent, mutual influence, so in this list under the T1 criteria, B1, B2, B3, B4 mutual influence on T1, enumerated under the C1 criteria, B1, B2, B3, and B4 influence each other on C1. Due to space limitations, only a part of the judgment matrix is listed here, and the structure of the judgment matrix is shown in Figure 3.

Construction of a Super Matrix

In the process of forming an unweighted super matrix, all the judgment matrices of all elements with internal dependence and elements with external dependence and elements of the control layer are placed in the super matrix in an appropriate order to form weighted hyper matrix. In this super matrix, each column is relative to the weight of the influence that represents the head of the table. For example, B1 has an influence weight of 0.25 on the target, and so on. T1 has an impact weight of 0.33 on the target and has no effect. The weight is 0, as shown in Figure 4.
Figure 4. Construction of a super matrix.

Construction of Weighted Super Matrix

Based on the unweighted super matrix, multiplies it by a weight vector to form a weighted super matrix. In the weighted super matrix, each column represents the absolute weight relative to the header elements. The example shows the business factor B1 relative to the control layer. The absolute weight of the target element is 0.08. The weighted super matrix is shown in Figure 5.
Construction of Limit Super Matrix

Multiply the weighted super matrix by the weighted hyper matrix until the value of the matrix reaches a stable value, then the limit hypermatrix is constructed, so as to obtain the best bidding company, i.e., the optimal solution. In the limit super matrix, each row's relative weight of a column and the head of the table is the final weight ratio. Compare the weight values and get the corresponding result. The limit super matrix is shown in Figure 6.

![Figure 5. Construction of weighted super matrix.](image)
ANP Evaluation Model Algorithm Implementation and Application

ANP Evaluation Model Algorithm Implementation

The bidding modeling process in the above section is based on the .net as a development platform and the C# language coding design is used to implement the ANP evaluation process. The implementation process of the algorithm is shown in Figure 7.

![Figure 6. Construction of a limit super matrix.](image-url)

### Table: Limit Super Matrix

<table>
<thead>
<tr>
<th>Aim</th>
<th>Business factors</th>
<th>Technical factors</th>
<th>Price</th>
<th>Programme</th>
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</tbody>
</table>
Application of ANP Algorithm in Bid Evaluation System

The implementation of the ANP algorithm and the water conservancy and hydropower evaluation system, based on the data input by experts, through the calculation of the ANP algorithm, and finally give the best bid unit. The core component of the bid evaluation system is shown in Figure 8.

The Matrix.cs file implements the output of the largest weight value, the ANP.cs file implements the operation of various algorithms such as feature values, feature vectors, and merging of data, and the DecisionInpt.aspx.cs file realizes data input, editing, saving and transfer.
Conclusion

This paper makes use of the network analysis theory ANP, considers the mutual influence and restriction relationship between various factors of hydropower evaluation, establishes the evaluation model, and uses the c# language to code design based on the model establishment process, and realizes the ANP evaluation and construction. The algorithm of the model and the application of the algorithm to the water conservancy and hydropower evaluation system make the evaluation more fair and efficient.

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References


