ANP-based fuzzy comprehensive evaluation system for electric power environment

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Abstract. In order to evaluate the environmental situation of electric power business in Lishui City, a relatively objective evaluation index system was established by using literature review method and Delphi method. The network analytic network process (ANP) and fuzzy comprehensive evaluation method are combined to comprehensively evaluate the electric power business environment in Lishui. Firstly, the weight of each evaluation index is determined by ANP method, which overcomes the defect that the analytic hierarchy process (AHP) can not reflect the mutual influence relationship between indicators. Then, the ANP-based fuzzy comprehensive evaluation model is constructed to evaluate the uncertain electric power business environment and calculate with the help of Super Decisions software. The results show that the electricity business environment in Lishui is better. Finally, some measures to improve the electricity business environment were proposed based on the corresponding indicators.

Key words: ANP, Fuzzy comprehensive evaluation, Power resources.

1. Introduction

The business environment is the sum of a series of comprehensive development environments that affect the behavior of regional market entities, including political environment, economic environment, social and cultural environment, etc., and is the result of interaction between the market and the government and society. A good business environment is not only an important manifestation of the economic soft power of a country and a region, but also an important part of improving comprehensive competitiveness. In recent years, international competition has intensified, and countries around the world have attached great importance to the improvement of the business environment.

There are many versions of the business environment assessment at present, and the World Bank's evaluation system is more representative. The World Bank has been able to assess the business environment of 190 economies around the world for 15 consecutive years. According to the "2019 Business Environment Report" published by the World Bank, the global ranking of China's business environment has jumped rapidly from the 78th place in the previous year to the 46th place, ranking among the top 50 economies in the world. Among them, China has achieved remarkable results in reforms in improving the efficiency of its power business processes. It ranks 14th in the global ranking of the “Get Power” index and 84 places in 2017. Electricity belongs to an important basic industry that
affects the national economy and the people's livelihood. It is related to the overall situation of economic and social development, is the forerunner of economic development, and is an important guarantee for the people to pursue a better life. The importance of electricity to the business environment is far more than many people imagine.

However, by combining the World Bank's business environment ranking with the actual situation of national economic development, it is not difficult to find that the World Bank's business environment indicator system has certain limitations, including: (1) Limited coverage. The World Bank only conducts index calculations for the largest and second largest cities in the world. For China, only Beijing and Shanghai are included in the indicator system. Therefore, it is impossible to obtain the business environment of other cities in China from the available data. (2) The evaluation system is complex. The World Bank's business environment consists of two parts. The first part is the situation stipulated by the regulations. It is often conducted in the form of complex case questions. The respondents cannot guarantee the detailed judgment after answering due to time and energy constraints. The second part is the actual implementation, which involves questionnaire surveys of a large number of SMEs, and the breadth and accuracy of data samples have certain limitations. (3) The data cannot fully and fully reflect the actual situation in China, nor can it be fully and fully estimated.

At the beginning of this year, Lishui, located in the mountainous area of southwestern Zhejiang, put forward the goal of accelerating high-quality green development, and promoted the “maximum run once” reform to upgrade the quality and expand the face, and strive to create a “lishui model” for the reform of the value realization mechanism of ecological products. Promoting high-quality development is inseparable from a high-quality business environment. As the engine of economic development, electric power plays an important role in industrial upgrading, people's livelihood improvement and various social undertakings. The strong grid structure and reliable power supply capacity are the basis for building a good electricity business environment. The level of construction of the electricity business environment has profoundly affected the development of social economy. The electricity business environment is the sum of a series of comprehensive development environments that affect the behavior of regional market players. This paper evaluates the electricity business environment in Lishui, not only can objectively understand the environmental conditions of Lishui's electricity business, but also effectively propose optimization suggestions, and can provide reference for other areas of power camp mountain environment evaluation. This paper firstly based on the results of domestic and international business environment case studies, combined with the connotation and characteristics of the business environment, in accordance with the principles of science, comprehensiveness and feasibility. Based on the actual situation in Lishui, the Lishui City Electric Business Environment Evaluation Index System was constructed. Secondly, a fuzzy comprehensive evaluation model of electric business environment based on ANP (analytic network process) [1] is established. That is to say, the network analytic hierarchy process is used to determine the weights of each index, and the fuzzy comprehensive evaluation method is used to evaluate each indicator, which can truly and accurately reflect the actual situation of the electricity business environment in Lishui.

2. Fuzzy comprehensive evaluation based on ANP

2.1. Evaluation steps
Because of the mutual influence between the indicators of the electric business environment, the ANP method can effectively reflect these effects. People's evaluation of things is usually subjective and ambiguous [2], and there is a certain difference in the understanding of the electricity business environment. Therefore, the fuzzy comprehensive evaluation method is more effective in this evaluation. The ANP-based fuzzy comprehensive evaluation method is an evaluation method that combines the ANP method with the fuzzy comprehensive evaluation method.

The basic steps of the method are:
(1) Based on ANP, construct a suitable evaluation index system;
(2) Determine the set of factors and the evaluation set according to the ANP model;
(3) Using the ANP method, calculate and determine the weight of each factor;
(4) Determining the membership function or membership degree of each evaluation index;
(5) Take appropriate fuzzy operators for comprehensive evaluation and obtain the evaluation results.

2.2. Evaluation process

2.2.1. Establishment of evaluation index system. This paper summarizes the index factors that may affect the business environment of Lishui Electric Power, and sends a letter of advice to experts using Delphi method. According to the expert opinion, the important first-level evaluation indicators and second-level evaluation indicators are selected according to the ranking method, and on this basis, the evaluation index system of the electric business environment is established, as shown in Table 1.

| Lishui City Electric Business Environment Evaluation Index | Primary evaluation index | Secondary evaluation index |
|----------------------------------------------------------|--------------------------|---------------------------|
| Access to electricity (C1)                               | (1) Procedures for connecting to the grid (C11) | (1) Rule of law construction environment (C21) |
|                                                          | (2) Time required to connect to the grid (C12) | (2) Policy Support (C22) |
|                                                          | (3) Power cost (C13) | (3) Local government executive capacity (C23) |
|                                                          | (4) Power supply reliability (C14) | (1) Employee comprehensive ability (C31) |
|                                                          | (5) Fee standard transparency (C15) | (2) Assessment, supervision, incentives (C32) |
| social support (C2)                                      |                          | (3) Service mode (C33) |
| Electricity market service level (C3)                    | (1) Internet bonding ability (C41) | (1) Internet bonding ability (C41) |
|                                                          | (2) Innovative mobile application (C42) | (2) Innovative mobile application (C42) |
|                                                          | (3) Power grid planning and construction (C43) | (3) Power grid planning and construction (C43) |
| Change and innovation ability (C4)                       |                          |                          |

2.2.2. Establishing a set of factors and evaluation sets. According to the operational planning capability evaluation index system constructed in this paper, the factor set U of fuzzy comprehensive evaluation is established. Determine the evaluation set of the electricity business environment factor set as V = {v1, v2, v3, v4, v5} = {very good, better, average, poor, very poor}.

2.2.3. Determine the weight of evaluation indicators based on ANP method. Due to the high complexity of the ANP model, its weight calculation is facing great difficulties. Currently, related weight calculations are usually performed by means of Super Decisions. Launched in the US by Rozann W. Satty and William Adams, the SD software is based on the ANP theory and is primarily used for ANP modeling and calculations. It is a powerful ANP calculation software. The specific process is as follows:

First, based on the interdependence and mutual influence between the evaluation indicators, the relationship between the indicators is analyzed and listed. Enter the built network model into the Super Decisions software to get the power business environment. The ANP structure model is shown in Figure 1. The arrow pointing in the figure represents the interaction of elements in the two-element set, and the circular arrow represents the influence between the elements inside the element set.
After all the network models are built and constructed, the comparison between the elements can be performed, and the judgment matrix is established to determine the dominance between the elements, and the supermatrix is calculated based on the basis. First enter the score of an expert and build a judgment matrix for this model in Super Decisions software. The Super Decisions software uses the nine-point assignment method for constructing the judgment matrix. The meanings of the representations are shown in Table 2.

| Score | Meaning                                                   |
|-------|-----------------------------------------------------------|
| 1     | The contribution of the two indicators is of equal importance |
| 3     | Experience judgment shows a slight agreement with a certain indicator |
| 5     | Empirical judgment shows that it clearly agrees with an indicator |
| 7     | The facts show a strong agreement with a certain indicator |
| 9     | There is enough evidence to agree with an indicator       |
| 2, 4, 6, 8 | Between the above assessment criteria                    |

The two-two judgment matrix score interface between the indicators provided in the Super Decisions software is shown in Figure 2.

![Network model diagram of electric business environment indicator evaluation in Super Decisions software](image1)

**Figure 1.** Network model diagram of electric business environment indicator evaluation in Super Decisions software

**Table 2.** ANP scale evaluation form

![Example of the evaluation index of the two-two judgment matrix in the Super Decisions software](image2)

**Figure 2.** Example of the evaluation index of the two-two judgment matrix in the Super Decisions software

Figure 3 shows the weights and corresponding limits for each level 2 evaluation indicator output by Super Decisions software. Since the limits are convergent and unique, the weights obtained are stable weights.
2.2.4. Determining the membership degree of the indicator. In the form of questionnaire survey, a total of 30 survey objects were selected from enterprise users and relevant experts to judge and evaluate the various indicators in the Lishui Electric Business Environmental Assessment Index. The questionnaires were all recovered.

Based on the statistics and collation of the questionnaire survey results, the evaluation results of each sub-factor are obtained, as shown in Table 3. The factor set corresponds to the first-level evaluation index, and the sub-factor set corresponds to the second-level evaluation index. Through the single factor evaluation of each element of the sub-factor set, the corresponding single-factor fuzzy evaluation matrix $R_i, i=1,\ldots, 5$ is obtained.

**Table 3.** Evaluation index weights and evaluation results of each sub-factor set

| Factor set | Weights | Subfactor set Weights | Evaluation results |
|------------|---------|------------------------|--------------------|
| C1         | 0.233   | C11 0.11826            | well 2 | better 16 | general 7 | Poor 5 | Very poor 0 |
|            |         | C12 0.05478            |        |           |           |       |               |
|            |         | C13 0.16149            |        |           |           |       |               |
|            |         | C14 0.48555            |        |           |           |       |               |
|            |         | C15 0.17993            |        |           |           |       |               |
| C2         | 0.497   | C21 0.32522            |        |           |           |       |               |
|            |         | C22 0.49568            |        |           |           |       |               |
|            |         | C23 0.17910            |        |           |           |       |               |
| C3         | 0.120   | C31 0.33736            |        |           |           |       |               |
|            |         | C32 0.27953            |        |           |           |       |               |
|            |         | C33 0.38311            |        |           |           |       |               |
| C4         | 0.150   | C41 0.49389            |        |           |           |       |               |
|            |         | C42 0.14637            |        |           |           |       |               |
|            |         | C43 0.35974            |        |           |           |       |               |

**Figure 3.** Super Decisions calculates the weight of each indicator.
2.2.5. Comprehensive evaluation. As can be seen from Table 3, the weight of the factor set is \( W_c = [0.233, 0.497, 0.120, 0.150] \). The weight of the sub-factor set is \( W_1 = [0.11826, 0.05478, 0.16149, 0.48555, 0.17993] \), \( W_2 = [0.32522, 0.49568, 0.17910] \), \( W_3 = [0.33736, 0.27953, 0.38311] \), \( W_4 = [0.49389, 0.14637, 0.35974] \).

Through the fuzzy statistical method, the fuzzy evaluation matrix \( R_1 \) is obtained.

\[
R_1 = \begin{bmatrix}
0.067 & 0.533 & 0.233 & 0.167 & 0 \\
0.167 & 0.633 & 0.2 & 0 & 0 \\
0.1 & 0.433 & 0.367 & 0.1 & 0 \\
0.133 & 0.467 & 0.3 & 0.1 & 0 \\
0.233 & 0.467 & 0.267 & 0.033 & 0
\end{bmatrix}
\]

The weighted average \( (\cdot, +) \) operator is used to perform fuzzy operation on \( R_1 \), and the comprehensive evaluation vector \( B_1 \) of \( C_1 \) is obtained.

\[
B_1 = W_1 \circ R_1 = \begin{bmatrix}
0.11826^T \\
0.05478 \\
0.16149 \\
0.48555 \\
0.17993
\end{bmatrix} \circ \begin{bmatrix}
0.067 & 0.533 & 0.233 & 0.167 & 0 \\
0.167 & 0.633 & 0.2 & 0 & 0 \\
0.1 & 0.433 & 0.367 & 0.1 & 0 \\
0.133 & 0.467 & 0.3 & 0.1 & 0 \\
0.233 & 0.467 & 0.267 & 0.033 & 0
\end{bmatrix}
\]

The weighted average \( (\cdot, +) \) operator is used to perform fuzzy operation on \( R_1 \), and the comprehensive evaluation vector \( B_2 \) of \( C_2 \) is obtained:

\[
B_2 = W_2 \circ R_2 = \begin{bmatrix}
0.2114 & 0.4769 & 0.2686 & 0.0433 & 0
\end{bmatrix}
\]

\[
B_3 = W_3 \circ R_3 = \begin{bmatrix}
0.1069 & 0.4471 & 0.2717 & 0.1352 & 0.0391
\end{bmatrix}
\]

\[
B_4 = W_4 \circ R_4 = \begin{bmatrix}
0.1613 & 0.5008 & 0.2870 & 0.0506 & 0
\end{bmatrix}
\]

A fuzzy comprehensive evaluation matrix of the first hierarchical factor set can be obtained from \( B_1, B_2, B_3, \) and \( B_4 \). \( R_C \):

\[
R_C = \begin{bmatrix}
B_1 & 0.1397 & 0.4784 & 0.2915 & 0.0904 & 0 \\
B_2 & 0.2114 & 0.4769 & 0.2686 & 0.0433 & 0 \\
B_3 & 0.1069 & 0.4471 & 0.2717 & 0.1352 & 0.0391 \\
B_4 & 0.1613 & 0.5008 & 0.2870 & 0.0506 & 0
\end{bmatrix}
\]

The \( (\cdot, +) \) operator is used to perform the fuzzy operation on \( R_C \), and the comprehensive evaluation vector \( B_C \) of the electricity business environment of Lishui City is obtained:

\[
B_C = W_C \circ R_C = \begin{bmatrix}
0.1746 & 0.4773 & 0.2771 & 0.0664 & 0.0047
\end{bmatrix}
\]

2.2.6 Analysis of evaluation results. The above calculation results are summarized, and the first-level evaluation results and the second-level evaluation results are generated by each index fuzzy operation, as shown in Tables 4 and 5.
Table 4. Results of the first-level evaluation of fuzzy comprehensive evaluation

| well  | better | general | Poor | difference |
|-------|--------|---------|------|------------|
| 0.1746 | 0.4773 | 0.2771  | 0.0664 | 0.0047     |

Table 5. Results of the second-level evaluation of fuzzy comprehensive evaluation

| index | Evaluation results |
|-------|--------------------|
|       | well | better | general | Poor | difference |
| C1    | 0.1397 | 0.4787 | 0.2915  | 0.0904 | 0          |
| C2    | 0.2114 | 0.4769 | 0.2686  | 0.0433 | 0          |
| C3    | 0.1069 | 0.4471 | 0.2717  | 0.1352 | 0.0391     |
| C4    | 0.1613 | 0.5008 | 0.2870  | 0.0506 | 0          |

According to the principle of maximum membership degree, it can be seen from Table 4 that the evaluation result of the customer satisfaction of the power enterprise is the largest among the five levels of membership, and the value of 0.4773 is the largest. Therefore, the comprehensive membership value of the electricity business environment in Lishui City is 0.4773, the comment value is "better". Explain that the customer's evaluation of the city's electricity business environment is generally satisfactory.

According to Table 5, the evaluation results were converted into scores and total sorting was performed. Set the comment set $V = \{\text{very good, better, average, poor, very poor}\} = \{100, 80, 60, 40, 0\}$. The scores and ranking results of each indicator are shown in Table 6. It can be seen that these four indicators are all up to 75 points, indicating that the overall level of the electricity business environment in Lishui is good, but there is room for improvement.

Table 6. Scores and ranking results of each indicator

| index | C1    | C2    | C3    | C4    |
|-------|-------|-------|-------|-------|
| Score | 73.372 | 77.14 | 68.168 | 75.438 |
| Sort  | 3     | 1     | 4     | 2     |

3. Suggestions

3.1. Improve the level of access to electricity

(1) Further streamline the formalities. Comprehensively streamline the power-making process, can be simple and simple, can be combined, cancel the ordinary customer design review and intermediate inspection links, merge site investigation and power supply program reply links, completion acceptance and loading and receiving.

(2) Further compression of the power-on time. Perform a one-time notification obligation, that is, guide the client to prepare the information and then submit the formal power application. The implementation of the limited time contract service, the high-voltage (10 kV), low-voltage (excluding batch residents) customers average control time is controlled within 35 days and 15 days.

(3) Reduce the cost of electricity. Implement the national policy of canceling the temporary electricity fee and provide free services throughout the process. Optimize the power supply mode and connect to the public power grid according to the nearest access principle.

(4) Improve the reliability of power supply. Optimize the operation mode of the distribution network, arrange the maintenance plan reasonably, and avoid repeated and frequent power outages. Promote the application of non-blackout operations, minimize the time and number of power outages. Actively carry out early warning analysis and judgment, implement active repairs, and reduce equipment failures. Establish tracking, statistics and analysis mechanisms for power supply reliability data of small and micro enterprises, and publish statistical results on a regular basis. In case of loss of users due to interruption of power supply, compensation shall be made in accordance with relevant state policies.
3.2. Increase social support

(1) With the improvement of people's quality of life in China, China's electric power business environment has been greatly improved and optimized, but on the overall level, the economic vitality of the power industry has not been fully released, and the overall electricity business environment still has large lifting space [2]. Therefore, government departments should establish a good awareness of the regulatory environment for electricity business. Fully aware of the importance of the electricity business environment for the release of economic vitality, form a common development awareness and rationally build a market-oriented electricity business environment with sound development. In addition, we will give full play to the potential of the private economy and promote the rationalization of the allocation of social resources. At present, the government should speed up the implementation of relevant policies, speed up the transformation of government functions, and clarify the value-oriented role of the market and the government's macro-control role.

(2) Legalization construction is the basic guarantee for optimizing the electricity business environment. Market supervision departments at all levels should adhere to the law. At the same time, it is necessary to highlight the characteristics of protecting the rights and interests of power companies, and to promote the continuous optimization of the power business environment by strengthening the construction of the government's rule of law environment. First, through legislation to promote and protect the power business environment, create a fair disputed rule of law environment, but also to determine that laws and regulations can protect the interests of social subjects. Second, the government decentralized administrative power, simplified the project approval process, and adjusted the relevant laws and regulations of the power industry. Finally, strengthen the regulation and control of the order around the power companies, make grading adjustments to various matters within the power companies, and prioritize the handling of important matters.

3.3. Continuously optimize the service level of the electricity market

At present, China has made certain achievements in the continuous optimization of the electric power business environment, but it still has a lot of backwardness compared with the developed countries. Therefore, power companies should adhere to the concept of internal and external coordination, strengthen cooperation between government and enterprises, and strictly implement various control measures. In order to further optimize the power business environment, power companies should continue to optimize the level of power supply services and adhere to the level of international power supply services. At the same time, power companies should continue to consolidate and enhance the service level of power supply companies in various regions, and promote the transformation of provincial power companies into new service models, so that users can feel the improvement and improvement of power supply services.

3.4. Actively seeking change and innovation

(1) Actively promote "Internet + power service". Customers can use the "handheld power" APP, 95598 interactive service website and other online platforms to understand the business process and submit a power application. The information that can be provided online includes the account name, address, application capacity, business license, legal person identification, real estate license, and meter installation location. Among them, the business license, legal person identification, real estate license can directly upload photos; the meter installation location is installed by mobile phone positioning or input meter, and upload photos, prompting customers to choose the electrical building exterior wall as the meter installation location. Through this measure, the staff no longer needs the cooperation of the customer during the on-site investigation, and the customer does not need to go back and forth to the business hall. Through the support of the Internet, it is possible to realize the “business online application, information online circulation, progress online inquiry, and service online evaluation”.

(2) Innovative mobile terminal applications. That is, the on-site project manager accurately locates the job site through the mobile work terminal, and configures the equipment online, automatically generates the construction design drawing and bill of materials, and simultaneously pushes the
information to the background. The back-end material department and construction department are responsible for the implementation of the materials after receiving the information, which can realize the seamless link of exploration design, material picking and project implementation.

4. Conclusion

This paper proposes an ANP-based fuzzy comprehensive evaluation system for the business environment satisfaction of the electricity market. The ANP method is used to determine the weight of the evaluation index, which can effectively solve the problem of mutual influence and mutual feedback between the indicators that are difficult to solve by the AHP method. The comprehensive evaluation of the electricity business environment by the fuzzy comprehensive evaluation method can not only comprehensively consider various factors affecting the power business environment, but also retain all the information of the evaluation indicators at all levels. The evaluation results can be easily converted into specific real scores, which solves the problem that the evaluation indicators are difficult to define accurately. Such a comprehensive and complete evaluation model is more in line with the actual situation; and the model is simpler and easier to operate, providing more scientific and reasonable decision-making for the improvement of the power business environment.

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