Evaluation and Analysis of Total Factor Input and Output of Power Grid Enterprises under the New Situation

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Abstract: The current economic and social development and changes in internal and external environments have brought severe challenges to the operation of power grid companies. By studying the input-output relationship of all factors in power grid companies, from the perspective of effectiveness, efficiency, and benefit, this paper constructs an input-output evaluation index system, introduces analytic hierarchy process and entropy method for weight calculation, uses weighted average method to construct input-output evaluation model, and conducts empirical research with relevant data and information in a certain area as an example. The research results can provide auxiliary decision-making support for the scientific and reasonable allocation of resources, and realize the clarity of input and output effects of power grid enterprises, scientific and rational investment arrangements, and lean business management.

1. Introduction
At present, China is in a period of continuous deepening of the impact of the "three-phase superposition". Coupled with the new crown pneumonia epidemic which has caused a greater impact on the global economy, the production and operation of power grid companies are facing many challenges. In addition, the new crown pneumonia epidemic has caused a greater impact on the global economy, and the production and operation of power grid enterprises are facing many challenges. Therefore, carrying out research on the evaluation of input-output benefits of power grid companies is of great significance for improving the level of power grid companies' operating benefits.

In recent years, relevant experts and scholars have done more research on the input-output evaluation of power grid companies. Literature [1] takes distribution network investment management as the research object, and designs a distribution network input-output benefit evaluation system based on correlation analysis. Literature [2] combines the relevant evaluation system and development needs of power grid companies to build a power grid investment efficiency benefit evaluation index system. Literature [3] proposes a power grid investment benefit evaluation method based on decision tree model. Literature [4] puts forward a new method of quantitative evaluation of comprehensive benefits based on improved QPA in view of the shortcomings of existing smart grid construction project investment benefit evaluation methods.

In summary, the current relevant research has not conducted in-depth research on the integration of input factors and output indicators, and there are certain shortcomings. Therefore, this article combines the input factor analysis of power grid companies and considers output effects from the three dimensions of efficiency, effectiveness and benefit, and builds a full-factor input-output evaluation
system for power grid companies under the new situation to support the realization of development needs and business performance goals of power grid companies.

2. Construction of input-output indicator system
The construction index system is shown in Table 1 below.

| Serial number | First indicator | Secondary indicators |
|---------------|-----------------|----------------------|
| 1             | efficacy        | Power grid quality operation index |
| 2             | Get power index | Conversion rate of scientific and technological achievements |
| 3             | Overall labor productivity |
| 4             | Power supply per unit asset |
| 5             | Asset turnover   | Return On Total Assets |
| 6             | ROE              | EBITDA growth rate per asset |
| 7             | Socioeconomic contribution rate |

Comprehensively construct an output indicator system, with the main principle of highlighting efficiency, efficiency, and guiding power grid companies to accelerate the transformation of development methods, optimize resource allocation, and continuously improve economic benefits, capital return levels, labor output efficiency and value creation capabilities, and achieve higher quality, Development with better efficiency and better structure.

3. Construction of input-output evaluation model
This article is based on the construction of a total factor output indicator system, combined with indicator data collection, using scientific methods to non-dimensional and normalizing indicator data, and using entropy weight method to calculate objective weights, analytic hierarchy process method to calculate subjective weights, and comprehensive Calculate the comprehensive weight, and finally, use the linear weighting method to obtain the final evaluation result based on the calculation result of the comprehensive weight and the dimensionless and normalized value of the data.

3.1. Ideas for building evaluation models
The construction idea of the evaluation model is shown in Figure 1 below.

Figure 1. Evaluation model construction ideas.
3.2. Principle of weight calculation method

3.2.1 Basic principles and steps of AHP

1) First, build a hierarchical structure, decompose the decision-making problem in detail, and structure it into a top-to-bottom hierarchical structure. Complex problems are decomposed into multiple core elements. When applying AHP to analyze decision-making problems, the responsible problem is first decomposed into multiple elements, and then the elements are decomposed into several levels according to the attributes of the elements, and finally a hierarchical problem structure model is constructed as the basis of the analytic hierarchy process.

2) Construct a judgment matrix

In order to reflect the weight correspondence between the elements, a judgment matrix needs to be constructed. Generally, the 1-9 scale method is used, and the numbers 1-9 and their reciprocals are used as the scale to evaluate the correspondence between the elements.

3) Single ranking consistency test

Generally, the consistency index CI is used to test whether the judgment matrix is reasonable in design and whether there are logical errors. It is generally believed that when CI<0.10, the judgment matrix is reasonable.

4) Total ranking consistency test

After the consistency of a single sort meets the requirements, the consistency test of the total sort is needed. If the test passes, the current weight ranking results can be used as the final decision basis.

3.2.2 Basic principles and steps of entropy method

1) Suppose that n evaluation indicators are used to make and evaluate m candidates.

\[ x_{ik}^* \]: The estimated value of the evaluation index \( i \) of the candidate option \( k \).

\[ x_{i}^* \]: The ideal value of the evaluation index \( i \). The value of \( x_{i}^* \) varies with the characteristics of evaluation indicators. For profitability indicators, the larger \( x_{i}^* \) is, the better; for loss indicators (inverse indicators), the smaller \( x_{i}^* \) is, the better (it can also be converted to positive indicators first).

2) Define the proximity \( D_{ik} \) of \( x_{ik} \) to \( x_{i}^* \):

\[
D_{ik} = \begin{bmatrix}
\frac{x_{ik}}{x_{i}^*} & x_{i}^* = \max \{x_{ik}\} \\
\frac{x_{ik}}{x_{i}^*} & x_{i}^* = \min \{x_{ik}\}
\end{bmatrix}
\]  

(1)

3) \( D_{ik} \) normalization processing:

\[
d_{ik} = D_{ik} \left/ \sqrt{\sum_{i=1}^{n} \sum_{k=1}^{m} D_{ik}^2} \right.
\]  

(2)

4) Overall entropy: using \( n \) evaluation indicators to evaluate the entropy \( E \) of \( m \) candidate options:

\[
E = -\sum_{i=1}^{n} \sum_{k=1}^{m} d_{ik} \ln d_{ik}
\]  

(3)

5) The overall entropy when the indicator has nothing to do with the plan:

If the relative importance of the evaluation index has nothing to do with the alternatives, the entropy is calculated by the following formula:

\[
E = -\sum_{i=1}^{n} d_{i} \ln d_{i}
\]  

(4)
Where:

\[ d_i = \sum_{k=1}^{n} d_{ik} \]  

(5)

In this way, the uncertainty of the relative importance of the evaluation index \( i \) of the decision-making evaluation to be selected can be determined by the following conditional entropy.

6) Conditional entropy of evaluation index \( i \):

\[ E_i = -\sum_{k=1}^{m} \frac{d_{ik}}{d_i} \ln \frac{d_{ik}}{d_i} \]

(6)

It can be seen from the extreme value of entropy that \( \frac{d_{ik}}{d_i} \), that is, \( d_{i1} \approx d_{i2} \approx \ldots \approx d_{ik} \), the closer to the same, the greater the conditional entropy, and the greater the uncertainty of the evaluation index for the evaluation and decision-making of the selected program.

7) By normalizing the above formula, the entropy value that characterizes the importance of the evaluation decision of the evaluation index \( i \) is obtained.

\[ e(d_i) = -\frac{1}{m \sum_{k=1}^{n} \frac{d_{ik}^2}{d_i}} \]

(7)

3.2.3 Combination weight calculation process

In order to ensure the accuracy of weight determination and input and output evaluation goals, this paper adopts the method of combining entropy weight method and analytic hierarchy process to determine the weight of each indicator. The comprehensive weight is the weighted average of the subjective and objective weights. The determination of the comprehensive weight can be sufficient It reflects the scientific nature of the index weight setting, and provides support for ensuring the accuracy of decision-making.

4. Empirical analysis

Selecting 10 power grid companies as the research object, combined with data collection to achieve full-factor input-output evaluation and analysis, can effectively evaluate and analyze the current situation of different companies, and clarify the shortcomings and advantages of different companies. details as follows:

Table 2. Table of original statistics.

| Output index                        | Unit  | A    | B    | C    | D    | E    | F    | G    | H    | I    | J    |
|-------------------------------------|-------|------|------|------|------|------|------|------|------|------|------|
| Power grid quality operation index  | %     | 99.79| 99.37| 98.80| 98.18| 98.75| 98.71| 97.46| 98.74| 98.67| 98.95|
| Get power index                     | -     | 3.00 | 2.61 | 2.76 | 2.54 | 2.41 | 2.12 | 1.83 | 1.96 | 1.96 | 2.19 |
| Conversion rate of scientific and   | a/100 million | 1400.05 | 1032.05 | 1868.57 | 1649.63 | 4284.60 | 1972.45 | 3807.96 | 3738.00 | 1710.75 | 1101.23 |
| technological achievements          |       |      |      |      |      |      |      |      |      |      |      |
| Overall labor productivity          | 100 million yuan/per persons | 0.0076 | 0.0191 | 0.0144 | 0.0075 | 0.0033 | 0.0057 | 0.0048 | 0.0055 | 0.0066 | 0.0199 |
| Power supply per unit asset         | 10,000 kWh/Billion | 10080.9 | 9361.87 | 9707.13 | 9897.48 | 10774.6 | 8218.55 | 8592.95 | 10111.5 | 11929.6 | 4310.51 |
### 4.1 Weight calculation

Combining subjective and objective weight calculations, further determine the comprehensive weight level of indicators to provide support for the next step of benchmarking calculation analysis and comparative research.

Comprehensive weight = 0.7 * subjective weight + 0.3 * objective weight.

| Secondary indicators                                      | Subjective weight | Objective weight | Comprehensive weight |
|-----------------------------------------------------------|-------------------|------------------|---------------------|
| Power grid quality operation index                        | 0.12              | 0.01             | 0.08                |
| Get power index                                           | 0.15              | 0.12             | 0.14                |
| Conversion rate of scientific and technological achievements | 0.05              | 0.26             | 0.11                |
| Overall labor productivity                                | 0.1               | 0.01             | 0.07                |
| Power supply per unit asset                               | 0.12              | 0.01             | 0.09                |
| Asset turnover                                            | 0.06              | 0.23             | 0.11                |
| Return On Total Assets                                    | 0.05              | 0.09             | 0.06                |
| ROE                                                       | 0.05              | 0.20             | 0.10                |
| EBITDA growth rate per asset                              | 0.05              | 0.06             | 0.06                |
| Socioeconomic contribution rate                           | 0.25              | 0.01             | 0.18                |

### 4.2 Comprehensive evaluation results

Combining the above basic theories and technical routes, the evaluation results of each company's input-output indicators are calculated and analyzed according to the linear weighting method, and the evaluation results are as follows.

| output index                                            | A     | B     | C     | D     | E     | F     | G     | H     | I     | J     |
|---------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Power grid quality operation index                       | 8.00  | 7.97  | 7.92  | 7.87  | 7.92  | 7.91  | 7.81  | 7.92  | 7.91  | 7.93  |
| Get power index                                          | 14.00 | 12.18 | 12.88 | 11.85 | 11.25 | 9.89  | 8.54  | 6.11  | 9.15  | 10.22 |
| Conversion rate of scientific and technological achievements | 3.59  | 2.65  | 4.80  | 4.24  | 11.00 | 5.06  | 9.78  | 9.60  | 4.39  | 2.83  |
| Overall labor productivity                               | 2.66  | 6.70  | 5.04  | 2.62  | 1.16  | 1.99  | 1.70  | 1.94  | 2.30  | 7.00  |
| Power supply per unit asset                              | 7.61  | 7.06  | 7.32  | 7.47  | 8.13  | 6.20  | 6.48  | 7.63  | 9.00  | 3.25  |
| Asset turnover                                           | 9.19  | 6.10  | 6.02  | 7.60  | 9.36  | 6.79  | 11.00 | 7.22  | 4.45  | 1.88  |
| Return On Total Assets                                    | 4.30  | 3.65  | 6.00  | 5.57  | 4.31  | 1.73  | 2.38  | 1.63  | 4.06  | 1.40  |
| ROE                                                      | 7.10  | 8.39  | 10.00 | 9.53  | 6.54  | 3.26  | 0.00  | 3.66  | 6.93  | 3.93  |
5. Conclusion

This paper proposes a method for calculating index weights based on analytic hierarchy process and entropy method, finally realizes the comparative analysis of evaluation results through linear weighting method, and clarifies the business shortcomings and development needs of different companies. The research results of this paper can provide auxiliary decision-making support for the scientific and reasonable allocation of resources of power grid enterprises, realize clarification of input and output effects, scientific and rational investment arrangements, and lean business management.

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