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# Research on Operational Efficiency Evaluation of Provincial Power Grid Enterprise Based on DEA

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**Abstract.** This paper takes the 18 power grid enterprises in Henan Province as the research object, and evaluates the operational efficiency of Henan power grid by using data envelopment analysis (DEA) which could evaluate relative efficiency effectively. According to the analysis of the problems existing in these power grid enterprises, the key factors that restrict the improvement of operational efficiency have been found. Finally corresponding countermeasures and suggestions have also been put forward.

## 1. Introduction

The traditional methods of evaluating business efficiency include financial ratio method, fuzzy comprehensive evaluation method, and balanced scorecard method. These methods are mainly qualitative analysis, relying on the subjective judgment of the analyst which could inevitably affect the accuracy of evaluation result to some extent. DEA is a quantitative calculation method to analyze the economic efficiency of several decision making units (DMUs) with multiple inputs and outputs [1, 2]. It has an absolute advantage in the efficiency evaluation of multiple DMUs for it does not need to set the function form and weight-coefficients. This paper selects a provincial power grid enterprise as the research object and conducts operational efficiency calculation based on DEA. It has guiding significance for grid enterprises to optimize operational decisions and achieve sound development.

## 2. Evaluation Model Construction

### *2.1. Introduction of the DEA*

The Variable Returns to Scale (VRS) model in the DEA method is selected. The model assumes that the returns to scale (RTS) are variable, more in line with objective facts, and meet the need to measure the relative efficiency of different return states of scale. Besides, the output orientation has been chosen, focusing on the extent to which the output should increase when the technology is effective without increasing the input. The linear programming form of the model is:

$$\begin{cases} \min[\theta - \varepsilon(\hat{e}^T s^- + e^T s^+)] \\ s.t. \sum x_{ij} \lambda_j + s^- = \theta x_0, (i = 1,2, \dots, m) \\ \sum y_{rj} \lambda_j - s^+ = y_0, (r = 1,2, \dots, q) \\ \sum \lambda_j = 1, \lambda_j \geq 0, (j = 1,2, \dots, n) \\ s^+ \geq 0, s^- \geq 0 \end{cases} \quad (1)$$

In this formula, $x_{ij}$—The number of i-th inputs required for the jth decision unit; $y_{rj}$—Number of r-th outputs required for the jth decision unit; $\lambda_j$—The combined ratio of the jth decision unit constructed as a valid DMU by linear combination; $s^-$, $s^+$—Relaxation variable; ε—Non-Archimedean infinitesimal; θ— Efficiency value of the jth decision unit. In order to ensure the ability of the DEA model to distinguish the efficiency of the DMU, it is generally required that the number of DMUs should not be less than the product of the number of input and output indicators, and not less than three times the sum of the input and output indicators[3]. That is:

$$n \geq \max\{m \times q, 3 \times (m + q)\} \quad (2)$$

The linear programming problem is solved after the above formula being solved several times.

### *2.2. Indicator Selection and Data Source*

In the DEA model, the indicators should be selected objectively and typically which could directly affect the accuracy of the results [4, 5]. In order to accurately measure the operational efficiency of Henan Power Grid, truly reflects the effectiveness of management and technological progress, the indicator system is constructed and shown in Table 1. All data are from the "Henan Province Power Statistics Compilation".

**Table 1.** The indicator system for evaluating operational efficiency

| Indicator attribute | Indicator selection | Evaluation purpose |
|---|---|---|
| Input indicators | Power grid engineering investment | Capital investment |
| | 110 kV and above common substation capacity | Capital stock |
| Output indicators | Maximum load of power supply | Power supply apability |
| | Electricity sold | Marketing level |

## 3. Model Application and Result Analysis

### *3.1. DEA Validity Analysis*

The comprehensive efficiency (CRSTE), pure technical efficiency (VRSTE) and scale efficiency (SCALE) of 18 grid enterprises in Henan Province in 2016 were calculated. The results are shown in Table 2.

The CRSTE reflects the overall level of business management, which is equal to the product of VRSTE and SCALE. The average CRSTE of the 18 grid enterprises is 0.776, and the average VRSTE is 0.838, which is less than the average SCALE which is 0.928. It shows that the pure technical inefficiency leads to a lower comprehensive efficiency than the scale inefficiency.

Among the 18 grid enterprises, the CRSTE of Luoyang and Anyang equals 1, and the overall operational efficiency has reached a relatively optimal level.The remaining 16 grid enterprises are not in the DEA effective state, and two situations have emerged: Firstly, the CRSTE of Zhengzhou, Hebi and Jiyuan is not 1 but the VRSTE is 1. It shows that the production technology and management level of the enterprise is effective, but the current enterprise scale has not reached the optimal state.Secondly, the VRSTE and SCALE of the remaining 13 grid enterprises such as Kaifeng, Pingdingshan and Xinxiang are all less than 1. The reason for invalid DEA is as follows: first, the scale is not good, so it needs to be solved by long-term scale adjustment; second, the pure technology is inefficient, and the input factors are not effectively utilized.

**Table 2.** Results of operational efficiency of 18 power grid enterprises in Henan Province in 2016

| Decision making unit (DMU) | comprehensive efficiency (CRSTE) | pure technical efficiency (VRSTE) | scale efficiency (SCALE) | returns to scale (RTS) |
|---|---|---|---|---|
| Zhengzhou | 0.842 | 1 | 0.842 | drs |
| Kaifeng | 0.631 | 0.651 | 0.97 | irs |
| Luoyang | 1 | 1 | 1 | - |
| Pingdingshan | 0.706 | 0.714 | 0.988 | irs |
| Anyang | 1 | 1 | 1 | - |
| Hebi | 0.832 | 1 | 0.832 | irs |
| Xinxiang | 0.74 | 0.747 | 0.991 | irs |
| Jiaozuo | 0.812 | 0.837 | 0.97 | irs |
| Puyang | 0.706 | 0.734 | 0.962 | irs |
| Xuchang | 0.631 | 0.657 | 0.961 | irs |
| Luohe | 0.764 | 0.877 | 0.871 | irs |
| Sanmenxia | 0.791 | 0.918 | 0.862 | irs |
| Nanyang | 0.491 | 0.591 | 0.832 | drs |
| Shangqiu | 0.93 | 0.951 | 0.978 | irs |
| Xinyang | 0.708 | 0.737 | 0.961 | irs |
| Zhoukou | 0.77 | 0.805 | 0.957 | irs |
| Zhumadian | 0.823 | 0.863 | 0.953 | irs |
| Jiyuan | 0.781 | 1 | 0.781 | irs |
| mean | 0.776 | 0.838 | 0.928 | |

### *3.2. Analysis of the RTS*

The results of the RTS measure the trend of enterprise benefits with scale. Table 2 shows the following contents:

The SCALE of Luoyang and Anyang are effective, and RTS are unchanged. It also means that the output and investment will change in the same proportion, and the scale is in the best state without adjustment required.

In the grid enterprises with ineffective scale, the RTS of Zhengzhou and Nanyang are diminishing. If the scale continues to expand, the proportion of output increase will be less than the input ratio, indicating that the current grid size is too large. It is necessary to properly integrate input resources and reduce the current scale to achieve the optimal scale.

The RTS of other 14 grid enterprises are increasing, such as Kaifeng and Pingdingshan. If the scale is expanded, the proportion of output increase will be greater than the input ratio, indicating that the current scale is small and the enterprises have large growth potential. It is necessary to further increase the input and expand the current scale to achieve the optimal scale and improve operational efficiency.

### *3.3. Projection Analysis*

The non-effective DMU can be an effective unit by adjusting the original input and output. The adjusted point is the "projection" of each DMU on the production frontier. The gap between the actual input, output and ideal value can be defined as the input redundancy ratio and the output shortage ratio [6, 7].

The cities with VRSTE equal to 1 are Zhengzhou, Luoyang, Anyang, Hebi and Jiyuan. At the current technical level, the use of their input resources is efficient, and there is no need to adjust the input and output.

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Other 13 cities such as Kaifeng, Pingdingshan and Xinxiang with VRSTE less than 1 are not on the production frontier. There are gaps between the projected values of the input-output indicators and the actual values. The inputs are redundant and the outputs are insufficient. It needs to be adjusted according to Table 3.

**Table 3.** Projection Analysis of 18 Power Grid Enterprises in Henan Province in 2016

| DMU | VRSTE | Input Redundancy Ratio | | Output Shortage Ratio | |
|---|---|---|---|---|---|
| | | Power grid engineering investment | 110 kV and above common substation capacity | Electricity sold | Maximum load of power supply |
| Zhengzhou | 1.000 | 0.00% | 0.00% | 0.00% | 0.00% |
| Kaifeng | 0.651 | 9.46% | 0.00% | 53.67% | 53.67% |
| Luoyang | 1.000 | 0.00% | 0.00% | 0.00% | 0.00% |
| Pingdingshan | 0.714 | 16.67% | 0.00% | 40.05% | 40.05% |
| Anyang | 1.000 | 0.00% | 0.00% | 0.00% | 0.00% |
| Hebi | 1.000 | 0.00% | 0.00% | 0.00% | 0.00% |
| Xinxiang | 0.747 | 5.25% | 0.00% | 33.87% | 33.87% |
| Jiaozuo | 0.837 | 0.00% | 0.00% | 19.45% | 33.21% |
| Puyang | 0.734 | 0.00% | 0.00% | 36.24% | 36.24% |
| Xuchang | 0.657 | 23.93% | 0.00% | 55.96% | 52.16% |
| Luohe | 0.877 | 4.14% | 0.00% | 22.72% | 14.04% |
| Sanmenxia | 0.918 | 0.00% | 0.00% | 8.99% | 8.99% |
| Nanyang | 0.591 | 31.64% | 0.00% | 87.16% | 69.20% |
| Shangqiu | 0.951 | 34.27% | 0.00% | 5.13% | 5.13% |
| Xinyang | 0.737 | 17.54% | 0.00% | 62.29% | 35.72% |
| Zhoukou | 0.805 | 47.68% | 0.00% | 63.42% | 24.29% |
| Zhumadian | 0.863 | 36.71% | 0.00% | 28.16% | 15.91% |
| Jiyuan | 1.000 | 0.00% | 0.00% | 0.00% | 0.00% |

## 4. Conclusion

This paper uses the DEA method and the data of "Henan Province Power Statistics Compilation"in 2016 to analyze the operational efficiency of 18 grid enterprises in Henan. First of all, from the perspective of DEA effectiveness, the CRSTE of Luoyang and Anyang is 1, and the overall operational efficiency has reached a relatively optimal level, which is in the DEA effective state. Secondly, from the perspective of the RTS, the scale efficiency of Luoyang and Anyang is in the best state. The RTS of Zhengzhou and Nanyang are diminishing, and it is necessary to integrate the input resources and reduce the current scale to reach the optimal scale. The other 14 grid enterprises are increasing, and it is necessary to further increase the input factor and expand the current scale to achieve the optimal scale. Thirdly, from the perspective of projection analysis, the inputs and outputs of Zhengzhou, Luoyang, Anyang, Hebi and Jiyuan are proper and located on the production frontier. Other 13 grid enterprises need to adjust according to the input redundancy ratio and the output shortage ratio obtained by the projection analysis.

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