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## Comprehensive Evaluation of County-Level Power Supply Companies Based on Total Factor Production Efficiency

To cite this article: Wenjie Zhao *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **252** 032053

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# Comprehensive Evaluation of County-Level Power Supply Companies Based on Total Factor Production Efficiency

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**Abstract.** Total Factor Productivity (TFP) is a productivity indicator that measure the total output of a unit's total input. This paper explores the use of total factor production efficiency analysis model to comprehensively evaluate the power grid development and production and operation of 107 county-level power supply enterprises in Henan province. At the same time, it puts forward relevant countermeasures and suggestions for the development of various county level power supply enterprises.

## 1. Overview of total factor productivity

Total Factor Productivity (TFP) refers to the "efficiency of production activities within a certain period of time", which is the Productivity index to measure the total input and total output of a unit.

Total factor productivity (TFP) = technical change (techch) \* integrated technical efficiency change (effch);

Total technical efficiency change (effch) = pure technical efficiency change (pech) \* scale efficiency change (sech).

**Table 1.** Main indicators of the Total Factor Productivity.

total factor productivity	technical change	Integrated technical efficiency changes	Pure Technical Efficiency Change	Scale Efficiency Change
TFP	techch	effch	pech	sech

The measurement methods of total factor production efficiency are mainly divided into parameter method and non-parameter method, among which the non-parameter method is mainly stochastic frontier method (SFA) and parameter method is mainly data envelopment analysis (DEA).

### 1.1. Stochastic frontier method

In general, this method is based on the estimation of a production or cost frontier function, and then USES regression analysis to determine the parameters in the expression.

The model can be basically expressed as:

$$y=f(x, \beta) \cdot \exp(v-u) \quad (1)$$



Among,  $y$  stands for output,  $x$  stands for input of a set of vectors, and is a set of undetermined vector parameters. For the error term, the first part of  $v$  is subject to the  $N(0, \sigma_v^2)$  distribution,  $\in \text{lid}$ . Part two:  $u \gg 0$ , Used to represent the impact on only one individual; Therefore, the technical efficiency state of the individual is expressed in terms of  $TE = \exp(-u)$ . If so, When  $u=0$ , the manufacturer is right on the production frontier ( $y = f(x, \beta) \cdot \exp(v)$ ); If  $u > 0$ , the manufacturer is below the upper production frontier, that is, in the state of non-technical efficiency.

Advantages: 1. the frontier is random, and each production unit does not need to share one frontier. 2. Can distinguish error terms and accurately reflect actual efficiency level. 3. Can conduct hypothesis testing for practical results.

Shortage: 1. large sample size is required for statistical methods. 2. The parameter method requires a strict production function form. 3. The processing of multi-output production process is difficult and the statistical calculation is complex.

### 1.2. Data envelopment analysis

DEA is a quantitative calculation method for economic effectiveness analysis of several Decision Making units (DMU) with multiple inputs and outputs. The basic principle is to keep the input or output of DMU unchanged, use mathematical programming and statistical data to determine the relatively effective production frontier surface, project each DMU onto the production frontier surface, and evaluate the relative effectiveness of the decision unit by comparing the degree of DMU deviating from the production frontier surface. This method does not need to set the function form and assumed weight, but can point out the optimization approach to improve efficiency for the inefficient DMU. Meanwhile, it has the advantages of avoiding subjective factors, simplifying the algorithm, reducing errors and other aspects, and enriches the production function theory in microeconomics and its application technology.

DEA method mainly includes two basic models: CRS model and VRS model. Among them, the CRS (Constant Returns to Scale, CRS) model is based on the assumption that Scale return is fixed, the VRS (Variable Returns to Scale, VRS) model takes into account Variable Scale compensation. The latter is more in line with the objective facts in reality and meets the analysis needs to measure the relative efficiency value under different Scale Returns. The DEA model selected in this paper is the VRS (Variable Returns to Scale) model. This model assumes that the return on scale is variable, which is more consistent with objective facts, meets the measurement of relative efficiency under different return on scale, and chooses the output orientation. It focuses on the degree to which the effective output of technology should be increased without increasing input. The linear programming form of this model is:

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

Among,  $x_{ij}$  represents the number of inputs of type  $i$  required for the  $j_{th}$  decision unit,  $y_{rj}$  represents the output of the  $r_{th}$  type required for the  $j_{th}$  decision unit,  $\lambda_j$  represents the composition proportion of the  $j_{th}$  decision unit when the effective DMU is constructed by linear combination,  $s^-$  and  $s^+$  represent relaxation variables,  $\varepsilon$  is the infinitesimal amount of non – Archimedes,  $\theta$  is the efficiency value of  $j_{th}$  decision unit. In order to ensure the differentiation ability of DEA model on DMU efficiency, it is generally required that the number of DMU should not be less than the product of the number of input and output indicators and at the same time not less than 3 times of the number of input and output indicators, as:

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

The linear programming problem expressed in the above equation is solved  $n$  times, and the efficiency value of each DMU can be obtained. Specifically, it is divided into the following three situations:

When  $\theta = 1, s^- = s^+ = 0$ , the decision unit is called DEA effective, that is, it is located at the production frontier, and the output is optimized relative to the input.

When  $\theta = 1$ , and  $s^- \neq 0$  or  $s^+ \neq 0$ , the decision unit is called DEA weak and effective, which can increase part output under the condition of constant input amount.

When  $\theta < 1$ , called decision making units DEA is invalid.

## 2. Total factor production efficiency evaluation

Compared with the stochastic frontier estimation (SFA) method, the data envelopment analysis (DEA) method is more suitable for multi-input and multi-output situations. Besides, it does not need to set the function form, and the physical quantity of factor input and output can be directly used. There are many input and output factors of county-level power supply companies in Henan province, so data envelopment analysis (DEA) is adopted to measure the production efficiency of 107 county-level power supply enterprises in Henan province in 2017, to measure the grid operation efficiency of Henan county-level power supply companies, and to reflect the effectiveness of management and technological progress.

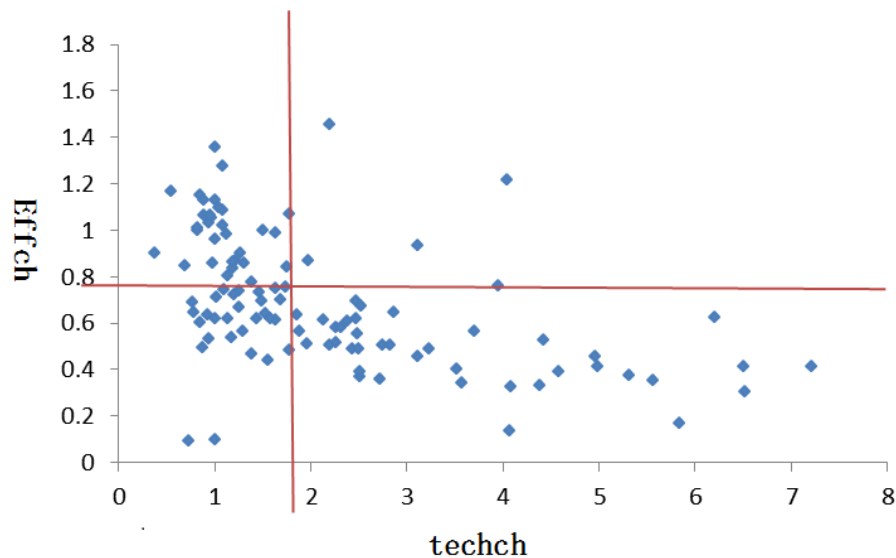
Input factor: select "110kV capacity ratio", "per unit distribution variable capacity", "average power supply radius of 10kV line", "operating life of 110kV main transformer", "operating life of 110kV line", "power supply reliability rate", "and power information acquisition system coverage rate".

Output factor: select "comprehensive line loss rate", "total profit" and "load of unit assets".

**Table 2.** Index system of input and output.

Index attribute	Index selection	
Input	Power supply capacity	110 kv capacity load ratio
		Housing allocation to change capacity
	Electric power network composition	Average power supply radius of 10kV line
	Technical equipment	110kV principal variable operating life
		Operation life of 110kV line
	Power supply quality	Electric reliability
Output	Intelligentize	Electricity information collection system coverage rate
	Business performance	Composite line loss rate
		Total profit
	Quality of assets	Load on unit assets

The county-level power supply companies are classified and made scatter diagram according to the comprehensive technical efficiency change and technical change, as shown in figure 1.



**Figure 1.** Total factor production efficiency classification of 107 county-level power supply companies in Henan province.

### 3. Conclusion

According to the figure, 107 county-level power supply companies can be roughly divided into four categories:

The first I class: There are 6 county-level power supply companies in Yongcheng, Xinan, Yichuan and Changyuan in the upper right, the comprehensive technical efficiency and technical changes are higher than the average level of 107 county companies, the highest total factor productivity;

The first II classes: The technical efficiency of 36 county-level power supply companies in the lower right is higher than average while the comprehensive technical efficiency is lower than average.

The first III classes: The technical efficiency of 36 county-level power supply companies in the lower right is higher than average while the comprehensive technical efficiency is lower than average.

The first IV classes: The comprehensive technical efficiency change and technical change of 30 county-level power supply companies located at the lower left are lower than the average level of 107 county-level power supply companies, with the lowest total factor production efficiency.

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