Selection of Input-Output Factors for Total Factor Productivity Evaluation of Chinese Power Grid Enterprises

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Abstract. In response to the call of the 19th CPC National Congress, China's large-scale power grid companies have proposed in recent years to improve total factor productivity. Based on the analysis of the problems existing in the traditional efficiency evaluation methods of power grid enterprises and the importance of the evaluation of total factor productivity, combined with literature research, this paper focuses on the input-output factors with characteristics of power grid companies.

1. Introduction
In October 2017, the report of the Nineteenth National Congress of the Communist Party of China proposed that "the quality change, efficiency change, and power change of economic development should be promoted to improve total factor productivity." As key state-owned key enterprises that have a bearing on national energy security and the lifeblood of the national economy, power grid companies have emphasized in recent years that they "improve total factor productivity." In view of the characteristics of multi-input and multi-output of power grid enterprises, most of the related researches use the DEA-based Malquist index method constructed by Fare et.al (1994), such as Liang Zhihong et al. (2007), Zhang Gexing et al. (2012), Lu Qiang et al. (2019 all used this method to study the total factor productivity of some provincial grid companies in China. However, these literatures lack of research on why grid companies attach importance to the evaluation of total factor productivity and the study of input-output factors.

2. Traditional Efficiency Evaluation Methods and Problems of Power Grid Enterprises
From the perspective of SASAC's assessment of grid companies, the main assessments are grid construction indicators such as line length and transmission capacity, as well as operating performance indicators such as operating income, profit, electricity sales, and labor productivity. Although total labor productivity is a commonly used indicator for assessing productivity, as the average product output of each employee in a unit of time calculated based on the value of the product, it only measures the input and output of a single labor factor effectiveness. Within the power grid company, its traditional performance evaluation is mainly based on the above indicators for measuring grid construction and operating performance, and has been appropriately expanded according to its own situation. Generally, it also involves the return on net assets, which is an efficiency indicator based on value. However, the return on net assets, as a percentage of net profit and average shareholder equity,
reflects the level of return on shareholder equity, and is only used to measure the efficiency of the company's use of its own capital. Therefore, no matter from the perspective of SASAC assessment or from the perspective of internal performance evaluation of power grid companies, the current performance evaluation system cannot fully reflect the input-output efficiency of power grid companies. In the practice of performance evaluation, according to the characteristics of multiple inputs and multiple outputs of power grid companies, productivity measurement will often have a large deviation if it uses only a single labor productivity measure, potentially distorting the performance of power grid companies. In order to more objectively and comprehensively measure the production efficiency of grid companies, it is necessary to measure the output that can be obtained from all observable combinations of factor inputs, that is, total factor productivity (TFP) as the ratio of total output to total input. As an important method for evaluating input-output efficiency, total factor productivity can enrich the performance evaluation index system of power grid companies and fill the related efficiency evaluation gaps.

3. Significance of grid companies' emphasis on total factor productivity evaluation in the new situation

3.1. Helps to actively implement the new central development concept and promote high-quality development

As a central enterprise related to national economy and people's livelihood, power grid companies need to better implement the new development concept, actively implement the central government's call for "improving total factor productivity" in the report of the 19th National Congress of the CPC, attach importance to the evaluation and research of total factor productivity, and guide and promote enterprises to improve input-output efficiency, better play the role of the power grid's basic platform in the allocation and conversion of energy resources, and promote high-quality economic development.

3.2. It is helpful to adapt to the deepening of power system reform and the increasingly strict government supervision

China's power system reform has continued to deepen, and a scientific, standardized and transparent transmission and distribution price supervision system is gradually being established. As the profit margins of power grid companies continue to narrow, their input-output efficiency will surely receive more and more government attention and become the core content of subsequent supervision. Many foreign countries that have adopted market-oriented reforms have introduced efficiency factors in the calculation of transmission and distribution prices, taking the input-output efficiency of transmission and distribution enterprises as the core parameter for checking their permitted income. Among them, power regulatory agencies in countries such as Australia, New Zealand, the United Kingdom, and Canada take total factor productivity as an important method for evaluating the input-output efficiency of transmission and distribution enterprises. Therefore, in order to proactively adapt to the requirements of the continuous deepening of the reform of the power system and the increasingly stringent government supervision, China's power grid companies need to plan ahead and start the evaluation of total factor productivity as soon as possible.

3.3. Helps improve the level of precision investment and lean management of grid companies

Under the new situation, grid companies need to promote innovation in management methods and management methods to provide good management support for the high-quality development of the grid and the companies themselves. As an important method of measuring input-output efficiency, total factor productivity involves the effectiveness of input factors such as human and financial resources, and these input factors are the main aspects of precision investment advocated by grid companies. Carrying out the research and application of total factor productivity evaluation and accurately measuring the input-output efficiency of power grid companies will help to strengthen the effectiveness of incentives and constraints, find and solve the management shortcomings that restrict
the sustainable and healthy development of enterprises, and improve operational efficiency, and improve lean management.

4. Selection of input and output factors of power grid enterprises

The output indicators usually required for classical total factor productivity measurement in economics are output value added (Y), and the input indicators are generally capital (K) and labor (L). However, the research and selection of key input-output factors with characteristics of power grid companies is very important for the evaluation of the total factor productivity of power grid companies.

In terms of the selection of output elements, Neuberg (1977) first proposed the use of four output indicators: power sales, number of customers, line length, and power supply area of transmission and distribution companies. In this regard, based on 20 literatures on power grid enterprise efficiency compiled by Jamasb and Pollitt (2001), this paper sorts out 6 domestic literatures on power grid efficiency (as shown in Table 1), and statistically obtains 26 domestic and foreign papers on power grid The input-output elements commonly used in corporate efficiency research (shown in Table 2).

It can be seen that the electricity sales and the number of customers (especially the former) proposed by Neuberg (1977) are widely used as output indicators in the current research, while the latter two indicators are relatively less applied. At the same time, because the power grid enterprises output power supply products and services, some scholars have also proposed that service capacity and service quality are also important factors to measure output, which can be measured by the highest power load and power supply reliability indicators. However, it can be seen from Table 2 that the relevant literature uses the highest power load more frequently than the power supply reliability.

### Table 1. Input-output elements of the literature on the efficiency of grid companies in China

| Literature | Input factor | Output factor |
|------------|--------------|---------------|
| Tian Zhenzhen (2015) | Number of employees, line length | Power sales, number of customers |
| Zhang Gexing and Xia Dawei (2012) | Number of employees, line length | Power sales, number of users |
| Huang Wenfeng et al. (2014) | Number of employees, capital investment | electricity sales |
| Zheng Shilin and Wang Yanan (2015) | Capital stock, number of employees, input of intermediate products | Output value added |
| Li Shulin (2018) | Grid investment, line length, transformer capacity | Operating income, total profit, electricity sales, maximum load |
| Lu Qiang et al. (2019) | Number of employees, total costs, total fixed assets | Operating income, electricity sales, maximum power load, power supply reliability |

With regard to the selection of input factors, as shown in Table 2, most of the literature considers the labor input that affects the efficiency of grid companies, and is usually measured by the number of employees or the number of employees used in relevant domestic literature (as shown in Table 1). At the same time, most literatures consider line length and transformer capacity as two important input factors to replace the capital investment of grid companies. Of course, there are some literatures that start from traditional enterprise investment, use capital investment as input elements, and use different indicators to measure. For example, Huang Wenfeng et al. (2014) used the year-end total assets, Li Shulin (2018) used the amount of grid investment, and Lu Qiang et al. (2019) used the total fixed assets to characterize capital investment. But the choice of capital investment did not take into account the characteristics of power grid companies.
### Table 2. Common input-output factors for efficiency research of domestic and foreign power grid companies

| Input factor                  | Output factor                  |
|------------------------------|--------------------------------|
| Power sales (2)              | Power sales (17)               |
| line length (14)             | line length (4)                |
| Substation capacity (12)     | Number of customers (13)       |
| Service area (2)             | Service area (6)               |
| Number of employees (20)     | Operating income (3)           |
| Capital investment (4)       | Maximum power load (6)         |
| Power supply reliability     |                                |

Note: Only the input-output variables with a frequency of 2 or more are counted.

## 5. Conclusion

Based on the analysis of the problems existing in the traditional efficiency evaluation methods of Chinese power grid enterprises and the importance of attaching importance to the evaluation of total factor productivity under the new situation, this paper focuses on the selection of input-output factors that are critical to the evaluation of total factor productivity of power grid enterprises. The results show that for the evaluation of total factor productivity of power grid enterprises, the number of employees, line length, and transformer capacity can be selected as input factors, and the amount of electricity sold, number of customers, and maximum power load can be selected as output factors. For the specific researched grid companies, comprehensive consideration of the needs of research methods and the availability of data, input and output factors can be adjusted appropriately.

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