Research on Input-Output Benefit Evaluation Technology for Power Grid Asset Production Based on Production Function Theory

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Abstract. In recent years, the development of power grid companies is in an important stage from the pursuit of scale speed to focus on quality and efficiency. Under high-quality development, because of the complex relationship between input and output, there are many factors that affect the effectiveness of investment can not be accurately evaluated. Therefore, grid companies need to build a perfect input-output index evaluation system based on industry financial integration, which is conducive to objectively quantifying the input-output benefits of resource factors, in order to solve the problems of low efficiency of input-output and low utilization of assets in power grid company, the closed-loop management and control of the whole process of resource input before, during and after can be realized, promote accurate allocation of resource elements and improve quality and efficiency.

Keywords: power grid assets, production function, input-output benefit, evaluation technology

1 Introduction

At present, there are some problems in the current situation of power grid construction investment decisions, especially in the aspect of efficiency and benefit evaluation, there is a lack of reasonable methods and measures to support power grid enterprises to improve investment decisions and improve investment efficiency and efficiency.

In terms of grid asset management: Literature [1] analyzes the current situation and problems of power grid construction investment decision, and discusses how to improve the accuracy and scientificity of decision-making. Literature [2] uses the dynamic investment payback period calculation method to analyze the investment benefit.

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In terms of grid asset input assessment: Literature [4] analyzes the current situation and development needs of power grid investment, and puts forward suggestions for the implementation of power grid investment benefit evaluation from the aspects of power grid asset division, cost and income collection, data collection, etc. Literature [5] overall power grid enterprise development multiple goals, the detailed input-output analysis carrier, combing curing input on the basis of the pooling rules, using multiple perspective integration mapping and management link simulation technology, the system built with "quantifiable, assessment, easy to choose" as the characteristics of "five force three effect" input and output evaluation system. Literature [6] analyzes the economic evaluation content of power grid engineering, and puts forward the evaluation methods and parameter optimization suggestions based on the background of electricity transmission and distribution price reform, so as to ensure that the calculated project benefits meet the input-output requirements of enterprises. Based on the functional positioning of power grid assets, literature [7] proposes to establish a five-dimensional efficiency evaluation index system and evaluation model for the company's power grid assets to promote the operation and management of power grid assets to be leaner. Literature [8] effectively manages and evaluates the relationship between the value of power grid enterprises and the influencing factors, so that power grid enterprises can dynamically track the uncertainty caused by the influencing factors of power grid asset value and form risk control decision-making responses.

Suggestions for improving investment in power grid assets: Literature [9] Starting from the needs of power grid enterprises to strengthen the benefit control of investment projects, they put forward mechanism optimization suggestions from the aspects of pre-decision-making, in-process implementation and post-evaluation respectively, in order to expect to benefit the improvement of the efficiency control level of power grid investment projects. Literature [10] constructs a control mechanism from three dimensions: project plan management, execution process management, and data sharing management, and proposes safeguard measures.

To sum up, the current research on power grid investment benefit is more based on the analysis of the current situation of investment management, the construction of evaluation index system and the improvement suggestions, while the relevant research on investment benefit evaluation model is relatively weak. So this paper puts forward the input-output benefit evaluation model based on the production function and Malmquist index, realize the input-output benefit evaluation, its purpose is to power grid enterprise currently input-output benefit of comprehensive, scientific, targeted strategy, help to power grid enterprise optimize input-output resources and improve the resource utilization and economic benefits of productivity.

2 Model Building

2.1 Construction of the Evaluation Index System

The evaluation index system of power grid investment benefit constructed in this paper is shown in Table 1 below:

Table 1. Evaluation index system.

Order number	Indicator type	Metric
1	Investment index	Investment in infrastructure project (ten thousand yuan)
2		Investment in technical transformation project (ten thousand yuan)
3		Investment of overhaul project (ten thousand yuan)
4		Marketing project investment (ten thousand yuan)
5		Investment in science and technology project (ten thousand yuan)
6	Output indicators	Equipment quality failure (times)
7		Average power outage time of users (h)
8		Voltage failure time (h)
9		line loss rate (%)
10		Electricity sold (billion kWh)
11		Electricity sales income (ten thousand yuan)

As can be seen from Table 1, the index system mainly includes input index and output index, including: infrastructure project investment, technical renovation project investment, overhaul project investment, marketing project investment and science and technology project investment; the output index includes equipment quality failure, average power failure time, voltage failure time, line loss rate, electricity sales and electricity sales income.

2.2 Model Construction

(1)Cobb Douglas production function

Based on the actual economic benefits of power grid finance, based on the production function expression, Y = Af (L, K):

$$Y = Ae^{rT+u}K^{\alpha}L^{\beta} \tag{1}$$

Where, Y is the economic benefit; A is constant, represents the comprehensive technical level K represents the total capital input; L is the total labor input; r is the coefficient of T; u is a random error item; α and β are output elasticity, respectively represent the share of the total economic benefit, the time of the agent variable, to avoid heteroscedastic conditions, it is necessary to take logarithm of the variables on both sides of the function.

(2)DEA model

This article constructs the C^2R model. Assuming there are a total of r decision-making units, each with l types of investment types (I) and output types (O), with inputs and outputs $I_a = (I_{a1}, I_{a2}, ..., I_{al})^T$, $O_a = (O_{b1}, O_{b2}, ..., O_{bq})^T$, and $a, b = 1, 2, L, r$.

$$\begin{cases} \max \dfrac{f^T O_0}{e^T I_0} \\ s.t. \dfrac{u^T y_j}{v^T x_j} \leq 1 \\ f \geq 0, e \geq 0 \end{cases} \quad (2)$$

Where, $e = (e_1, e_2, L, e_m)^T$ and $f = (f_1, f_2, L, f_l)^T$ is the weight coefficients of m inputs and s outputs respectively.

$$\begin{cases} \min \theta \\ s.t. \sum_{j=1}^{n} x_j \lambda_j \leq \theta x_0 \\ \sum_{j=1}^{n} y_j \lambda_j \geq v_0 \\ \lambda_j \geq 0, j = 1,2, L, n, \theta \in E_1^{-} \end{cases} \quad (3)$$

By processing the above model with infinitesimal (ε), it can be concluded that:

$$\begin{cases} \min \left[\theta - \hat{e}^{T} S^{-} + \hat{e}^{T} S^{+} \right] \\ s.t. \sum_{j=1}^{n} x_j \lambda_j + S^{-} = \theta x_0 \\ \sum_{j=1}^{n} y_j \lambda_j - S^{+} = y_0 \\ \lambda_j \geq 0, j = 1,2, L, n, \theta \in E_1^{+}, S^{-} \geq (\end{cases} \quad (4)$$

Where $\hat{e}^{T} = (1,1,L,1)^T$, if $\theta_0 = 1$, $S^- = 0$ and $S^+ = 0$ are met, DWU_{j0} is said to be DEA effective.

Let the optimal solution of the model be $\theta^0, \lambda^0, S^{0-}, S^{0+}$,if $\theta^0 = 1$, $S^{0-} = 0$ and $S^{0+} = 0$, call DMU DEA valid; if $\theta^0 = 1$, $S^{0-} \neq 0$ and $S^{0+} \neq 0$, call DMU weak DEA valid, if $\theta^0 < 1$, call DMU non-DEA valid.

3 Empirical Analysis

The following is the basic data of the input and output index of a power grid company in the past 10 years:

Table 2. Basic data sheet.

time	Investment in infrastructure project (ten thousand yuan)	Investment in technical transformation project (ten thousand yuan)	Investment of overhaul project (ten thousand yuan)	Marketing project investment (ten thousand yuan)	Investment in science and technology project (ten thousand yuan)	Equipment quality failure (times)	Average power outage time of users (h)	Voltage failure time (h)	line loss rate (%)	Electricity sold (billion kWh)	Electricity sales income (ten thousand yuan)
2013	1206766.25	70297.5	123426.25	254622.5	378322.5	23.75	4.625	7.125	0.625	985	5418750
2014	706113.75	57370	98182.5	377697.5	563782.5	1.25	3 9	3.625	0.75	537.5	7037500
2015	815396.25	111926.25	401995	275198.75	128211.25	26.25	7.5	24.125	1.125	861.25	7801250
2016	986951.25	107463.75	251955	133175	251847.5	10	7	21.625	1.25	1203.75	12042500
2017	296192.5	71213.75	128211.25	651370	402368.75	7.5	9.125	6.125	1.25	1252.5	8278750
2018	157370	122301.25	570401.25	790225	1143618.75	18.75	4.375	5.125	1.125	2632.5	118130000
2019	407122.5	67661.25	127997.5	515048.75	378211.25	16.25	3.875	2.625	1.25	1208.75	11057500
2020	182035	196227.5	501611.25	986891.25	908731.25	11.25	2.5	4.75	1	4151.25	43637500
2021	320497.5	182370	378372.5	823426.25	1150183.75	40	6.25	4.625	1.25	3238.75	33641250
2022	1119592.5	204980	140711.25	1205650	873426.25	46.25	8.375	12.375	0.375	1295	8111250

As can be seen from Table 2, in the past 10 years, the investment in infrastructure projects of the power grid company showed a fluctuation downward trend; technical renovation projects, overhaul projects, technology projects and marketing projects showed a fluctuation upward trend. Output index: the equipment failure shows a rising trend; the average power outage time and line loss rate of users remain stable; the voltage failure time index shows a trend of first increase and then decrease; due to the influence of national supervision and economic downturn, the electricity sales and sales income show first increase and then decrease.

Table 3. DEA input-output measurement results.

time	Comprehensive technical efficiency	pure technical efficiency	Scale efficiency	return of scale
2013	0.3883	0.4818	0.4159	Dec ↓
2014	0.4818	0.5983	0.4634	Dec↓
2015	0.4334	0.7784	0.2787	Dec↓
2016	0.3883	1.0347	0.7783	Inc↓
2017	0.6187	0.3883	0.4088	Dec↓
2018	0.7236	0.5983	1.0538	Inc↓
2019	0.5844	0.5141	0.3104	Dec↓
2020	0.9714	0.9043	0.4978	Dec↓
2021	1.0887	1.0643	1.0747	Inc↓
2022	1.1502	0.7336	0.9411	Inc↓
average value	0.6829	0.7096	0.6223	-

According to Table 3, the comprehensive technical efficiency values of power grid enterprises from 2013 to 2022 are analyzed. Overall, the comprehensive efficiency was significantly improved. Increase, especially after 2019, the comprehensive technical efficiency value is significantly improved; the average comprehensive technical efficiency is 0.65036, during the study period. In 2016, the lowest TE value reached the highest in 2022, except for less than 1 in 2021 and 2022. Combined with the economic meaning of comprehensive technical efficiency, analysis of the power grid enterprise comprehensive technical efficiency value change characteristics, the research period, power grid enterprises did not realize the optimal ratio, the vast majority of the comprehensive technical efficiency value invalid state, resource waste phenomenon, but according to its change trend, after 2020, comprehensive technical efficiency value rising steadily, the allocation of resources gradually tend to the optimal state.

According to Table 3, the pure technical efficiency value of power grid enterprises from 2013 to 2022 is analyzed. Overall, technical efficiency is basically consistent with the trend of comprehensive efficiency, and the change characteristics of technical efficiency value are similar to that of comprehensive efficiency value, that is, during the study period, the initial efficiency value is low and the efficiency value increases significantly after 2019; second, the average value of technical efficiency value is 0.7096, which is the lowest in 2016 and the highest in 2022. Combined with the economic meaning represented by technical efficiency, it shows that the effective utilization degree of the input elements of famous power grid enterprises is not high in the research period.

According to Table 3, the scale efficiency value of power grid enterprises from 2013 to 2022 is analyzed. The scale efficiency of power grid enterprises fluctuates greatly, increasing at the end of the decade compared with the beginning; the average scale efficiency in the ten years is 0.6223, with the lowest value appearing in 2015 and the highest value appearing in 2021. Combined with the economic meaning represented by the scale efficiency, it shows that the investment scale of the power grid enterprises is unreasonable at the beginning of the research period, but the investment scale of the power grid enterprises gradually tends to be reasonable, and the output level also increases compared with the beginning of the period.

4 Conclusion

In order to improve the investment efficiency and efficiency of power grid enterprises, this paper puts forward the technical model of investment benefit evaluation based on production function on the basis of fully combining the characteristics of power grid investment, and verifies the effectiveness of the model through empirical analysis. Due to the influence of time and other factors, this paper also has the following deficiencies: Considering the different focus of investment benefits of power grid enterprises in different periods and in different environments, it is necessary to gradually improve the evaluation index system according to the actual needs of enterprises.

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