# Based on financing efficiency evaluation and influencing factors of new energy enterprises based on DEA-Malmquist-Tobit model

Maoqi Gu*

Department of Business Administration and Tourism Management, Yunnan University, Yunnan, China

*Corresponding author: 2775097078@qq.com

**Abstract.** Based on panel data of 120 new energy enterprises from 2016 to 2021, this paper studies the current situation of financing efficiency of new energy enterprises. DEA-BCC model, Malmquist index and Tobit model are used to measure the financing efficiency of additional energy enterprises and analyze its influencing factors. The results show that the proportion of new energy enterprises with effective financing does not exceed 20 %, but the proportion shows a fluctuating upward trend ; the financing efficiency of new energy enterprises decreased by 2.6 %, which was more obviously restricted by the technological progress index. The level of economic development, the quality of workers and the level of technology have a promoting effect on the financing efficiency of different energy enterprises, while the asset-liability ratio, ownership concentration and operating cost ratio have an inhibitory effect.

**Keywords:** New energy enterprises, financing efficiency, DEA model, Tobit Regression.

## 1. Introduction

On May 14,2022, the National Development and Reform Commission and the National Energy Administration issued the " Implementation Plan for Promoting the High-quality Development of New Energy in the New Era, " pointing out that improving fiscal and financial policies is one of the important measures to promote the sustainable development of new energy enterprises. The choice of financing channels, the reduction of financing costs and the utilization efficiency of financing funds is of great significance to the development of new energy enterprises. The improvement of financing efficiency will bring more opportunities for the development of new energy enterprises and improve their development efficiency.

Based on this, this paper intends to study the current situation of financing efficiency of new energy enterprises and put forward suggestions for the development of new energy enterprises. In this paper, the data envelopment analysis method is used to select the factors that reflect the solvency of enterprises as the output index to measure the financing efficiency of enterprises, and the influencing factors of financing efficiency are selected from the macro and micro perspectives to evaluate the financing efficiency more comprehensively.

## 2. Research design

### 2.1. DEA-BCC model, Malmquist index and Tobit regression model

This paper uses the BCC model in the DEA model to study the financing efficiency of new energy enterprises, and combines the Malmquist index to reflect the dynamic changes of the efficiency of decision-making units on the basis of static efficiency analysis. In order to further determine the influencing factors of financing efficiency of new energy enterprises, this paper takes the comprehensive efficiency, pure technical efficiency and scale efficiency measured by DEA model as dependent variables, and takes the influencing factors as independent variables for Tobit regression.

$$\min[\theta - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{n} s_r^+)]$$
$$\text{s.t.} \begin{cases} \sum_{j=1}^{k} \lambda_j x_{ij} + s_i^- = \theta x_{ip}, i = 1,2,\text{L},m \\ \sum_{j=1}^{k} \lambda_j y_{rj} - s_r^+ = \theta x_{rp}, r = 1,2,\text{L},n \\ \sum_{j=1}^{k} \lambda_j = 1, j = 1,2,\text{L},k \\ \lambda_j, \theta, s_i^-, s_r^+ \geq 0 \end{cases} \quad (1)$$

Formula 1 ) is the BCC model, $k$ is the decision-making unit, $s_i^-$ and $s_r^+$ are slack variables of input and output, $x_{ij}$ and $y_{rj}$ are input and output variables, $\theta$ is used to reflect the efficiency of the decision-making unit, $\varepsilon$ is a constant, $\lambda_j$ is the weight vector of input vector and output vector.

$$\begin{aligned} m(x^{t+1}, y^{t+1}, x^t, y^t) &= [\frac{d^t(x^{t+1}, y^{t+1})}{d^t(x^t, y^t)} \times \frac{d^{t+1}(x^{t+1}, y^{t+1})}{d^{t+1}(x^t, y^t)}]^{\frac{1}{2}} \\ &= L_{\text{effch}}(x_{t+1}, y_{t+1}; x_t, y_t) \times L_{\text{tech}}(x_{t+1}, y_{t+1}; x_t, y_t) \\ &= L_{\text{sech}}(x_{t+1}, y_{t+1}; x_t, y_t) \times L_{\text{pech}}(x_{t+1}, y_{t+1}; x_t, y_t) \times L_{\text{tech}}(x_{t+1}, y_{t+1}; x_t, y_t) \end{aligned} \quad (2)$$

Formula 2 ) is the Malmquist index. $(x^t, y^t)$ and $(x^{t+1}, y^{t+1})$ represents the input and output of periodt and periodt+1. Among them. $L_{\text{effch}}$ is the efficiency index, $L_{\text{tech}}$ is the technological progress index, and efficiency index can be decomposed into $L_{\text{pech}}$ pure technical efficiency index and $L_{\text{sech}}$ scale efficiency index.

$$y_{ij} = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \beta_4 x_{4ij} + \beta_5 x_{5ij} + \beta_6 x_{6ij} + u_{it} \quad (3)$$

In the formula 3 ), $y$ is the comprehensive efficiency, pure technical efficiency or scale efficiency, $i$ is the companies in the sample, $j$ is the year, $\beta_0$ is the constant term, $\beta_1$-$\beta_6$ is the coefficient term, $x_{1ij}$-$x_{6ij}$ is the independent variable that may affect the financing efficiency, and $u$ is the random interference term.

### 2.2. Input-output index selection

Based on the relevant literature, this paper considers the input indicators from three aspects of endogenous financing, equity financing and debt financing, and selects the output indicators of the aspects of profitability, operating capacity, growth capacity and solvency. See Table 1 for details.

**Table 1.** Input-output index selection

| Index types | Primary indicators | Secondary indicators |
|---|---|---|
| Input indicators | Endogenous financing | $X_1$ surplus reserve |
| | | $X_2$ undistributed profits |
| | | $X_3$ accounts receivable |
| | Equity financing | $X_4$ received capital |
| | | $X_5$ capital reserve |
| | Debt financing | $X_6$ non-current liabilities |
| | | $X_7$ financial expenses |
| Output indicators | Profitability | $Y_1$ return on net assets |
| | Operating capacity | $Y_2$ total asset turnover rate |
| | Growth ability | $Y_3$ operating income growth rate |
| | Solvency | $Y_4$ times interest earned |

### 2.3. Data Sources and Processing

The research sample of this paper is taken from the new energy concept stock section of Oriental Fortune Chioce.After excluding ST, ST * and data missing enterprises, a total of 120 eligible research objects were chosen. Input-output index data and Tobit micro-factor data come from Oriental wealth Chioce, and Tobit macro-factor data come from the National Bureau of Statistics. In order to avoid the negative number in the input-output index, the original data has been standardized to make sure that the index value is fixed between 0.1 and 1. The original data is standardized by formula 4). $i$ is the decision making unit,$i = 1,2, \mathrm{L}, 120, j$ is the indicator, $j = 1,2, \mathrm{L}, 11, x_{ij}$ indicates the original value of the $i$ index of the $j$ decision unit.$a_i = \max(x_{i1}, x_{i2}, \mathrm{L}, x_{ij})$, $b_i = \min(x_{i1}, x_{i2}, \mathrm{L}, x_{ij})$.

$$y_{ij} = 0.1 + 0.9 \times \frac{x_{ij} - b_i}{a_i - b_i} \quad (4)$$

## 3. Analysis of empirical results

### 3.1. Static Analysis of financing efficiency based on BCC model

Based on the data of 120 additional energy enterprises, this paper uses DEAP 2.1 software to calculate the financing efficiency. When the comprehensive efficiency = 1, financing is relatively effective. Owing to the limitation of space, this paper conducts relevant statistics based on the DEA efficiency measurement value. The results are shown in Table 2 and Table 3.

From the perspective of the average value of corporate financing efficiency, the improvement of financing efficiency and industrial scale efficiency in the new energy industry is significantly related to the macroeconomic trend. This shows that most enterprises are committed to improving their innovation level and comprehensive strength, optimizing resource allocation, and improving the input factors of financing activities in order to achieve scale returns and achieve full and effective financing. The average value of pure technical efficiency has been at a high level and fluctuates smoothly, reflecting that the decision-making ability and management level of the new energy industry are at a high level under the condition of constant returns to scale, which is conducive to improving the financing efficiency of the industry. The average scale efficiency increased dramatically from 2016 to 2021, and was higher than the average pure technical efficiency after 2019. This shows that before 2019, scale efficiency is the key factor restricting the improvement of financing efficiency. After 2019, the improvement of financing efficiency needs the cooperative drive of pure technical efficiency and scale efficiency.

**Table 2.** The average financing efficiency of new energy enterprises in 2016-2021

| Year | Combined efficiency | Pure technical efficiency | Scale efficiency |
|---|---|---|---|
| 2016 | 0.749 | 0.944 | 0.792 |
| 2017 | 0.793 | 0.928 | 0.854 |
| 2018 | 0.846 | 0.924 | 0.915 |
| 2019 | 0.849 | 0.919 | 0.924 |
| 2020 | 0.854 | 0.911 | 0.938 |
| 2021 | 0.883 | 0.919 | 0.961 |
| Mean value | 0.829 | 0.924 | 0.897 |

From the perspective of comprehensive efficiency, the effective number of comprehensive efficiency of new energy enterprises in 2016-2021 did not exceed 20%, indicating that the overall financing efficiency of new energy enterprises was not high. The reason may be that most of the extra energy enterprises are in the initial or growth period of the life cycle. The comprehensive management level, technical level, management consciousness and decision-making ability of the enterprises needs to be improved. The strength and effectiveness of government policy support need to be improved. Many factors make the financing activities unreasonable and effective, which leads to low financing

efficiency. In terms of trend changes, the overall efficiency of new energy enterprises is on the rise, and the proportion of effective financing enterprises has increased by nearly 10% in 6 years. This shows that in recent years, China's macroeconomic trend is getting better and better, and policy support has increased the financing efficiency of enterprises. The joint improvement of pure technical efficiency and scale efficiency has increased the number of enterprises with operational financing.

From the perspective of pure technical efficiency, the proportion of pure technical efficiency effective enterprises in 2016-2021 is more than 27 %, indicating that the management level and decision-making ability of some new energy enterprises can meet the needs of enterprise development under the condition of constant returns to scale, but the comprehensive management ability of most enterprises needs to be improved. In terms of trend changes, the effectiveness of pure technical efficiency is not stable. The number of effective enterprises in 2017,2019 and 2020 has decreased. The reason may be that the management ability and specialized level of new energy enterprises cannot adapt to the expanding scale of enterprises in the process of development. The comprehensive management ability lags behind the scale expansion speed of enterprises. Excessive expansion leads to low decision-making efficiency and low financing efficiency. In addition, the decline in the proportion of pure technical efficiency operative enterprises in 2020 may be related to the outbreak of the epidemic. The attack of the epidemic not only leads to a downturn in the national economy, but also may frustrate the previous decisions of enterprise managers, severely test the decision-making efficiency and management level, and seriously impact some extra energy enterprises.

From the perspective of scale efficiency, the proportion and change trend of scale efficiency effective enterprises in 2016-2021 is basically consistent with the comprehensive efficiency, both at a low level and fluctuating upward trend. This shows that the scale efficiency of most new energy enterprises is an ineffective state and there is much room for improvement. The decline in the proportion of effective enterprises with scale efficiency in 2018 shows that most enterprises lack the ability of resource allocation and the corresponding output, and have not reached the optimal production scale. The severe economic situation in 2020 has caused some enterprises to fail to meet the returns to scale between resource input and output, and there is a great amount of input redundancy or insufficient output. Therefore, enterprises should improve the efficiency of resource allocation while increasing operational input factors, so as to maximize output and achieve economies of scale.

**Table 3.** Effective financing efficiency of new energy enterprises in 2016-2021

| Year | Enterprise quantity | Comprehensive efficiency | Pure technical efficiency | Scale efficiency |
|---|---|---|---|---|
| 2016 | Effective /Number | 13 | 38 | 13 |
| | Non-effective/Number | 107 | 82 | 107 |
| | Proportion of effective enterprises | 10.83% | 31.67% | 10.83% |
| 2017 | Effective /Number | 17 | 33 | 17 |
| | Non-effective/Number | 103 | 87 | 103 |
| | Proportion of effective enterprises | 14.17% | 27.5% | 14.17% |
| 2018 | Effective /Number | 16 | 43 | 16 |
| | Non-effective/Number | 104 | 77 | 104 |
| | Proportion of effective enterprises | 13.33% | 35.83% | 13.33% |
| 2019 | Effective /Number | 18 | 42 | 19 |
| | Non-effective/Number | 102 | 78 | 101 |
| | Proportion of effective enterprises | 15% | 35% | 15.83% |
| 2020 | Effective /Number | 15 | 35 | 15 |
| | Non-effective/Number | 105 | 85 | 105 |
| | Proportion of effective enterprises | 12.5% | 29.17% | 12.5% |
| 2021 | Effective /Number | 24 | 42 | 28 |
| | Non-effective/Number | 96 | 78 | 92 |
| | Proportion of effective enterprises | 20% | 35% | 23.33% |
| Total | Average efficiency | 0.829 | 0.924 | 0.897 |

### 3.2. Dynamic Analysis of financing efficiency based on the Malmquist index

In order to evaluate the financing efficiency of new energy enterprises more comprehensively, based on the static analysis of financing efficiency, this paper further analyzes the Malmquist index of the input-output data of the sample companies, and the results are detailed in table 4.

**Table 4.** The Malmquist index of new energy enterprises in 2016-2021

| Year | Technical efficiency index | Technological progress index | Pure technical efficiency index | Scale efficiency index | Total factor productivity index |
|---|---|---|---|---|---|
| 2016-2017 | 1.055 | 0.781 | 0.978 | 1.078 | 0.824 |
| 2017-2018 | 1.072 | 1.175 | 0.994 | 1.079 | 1.260 |
| 2018-2019 | 1.001 | 0.834 | 0.993 | 1.009 | 0.835 |
| 2019-2020 | 1.005 | 1.133 | 0.988 | 1.017 | 1.138 |
| 2020-2021 | 1.038 | 0.858 | 1.013 | 1.024 | 0.891 |
| Mean value | 1.034 | 0.943 | 0.993 | 1.041 | 0.974 |

From Table 4, it can be seen that the average value of the total factor productivity index is 0.974, and the overall financing efficiency of new energy enterprises in 2016-2021 decreased by 2.6%. Specifically, the decline in total factor productivity in the three periods of 2016-2017, 2018-2019 and 2020-2021 led to a decline in the five-year average. The change of total factor productivity is determined by the technical efficiency index and the technological progress index. The mechanical efficiency index of the six years is greater than 1, which shows an upward trend. Therefore, the main reason for the decline in corporate financing efficiency is the decline in technological development. On the one hand, it shows that the management level of China's new energy enterprises has been continuously improved in the past six years. Although the overall technical level has decreased by 0.7%, the scale economic benefits have increased by 4.1%, so the overall technical efficiency has increased by 3.4%, and the efficiency of enterprise factor allocation has increased. On the other hand, it also shows that new energy enterprises need to use the improvement of technological progress to improve financing efficiency. That is, to improve the quality of factors and accelerate the progress of science and technology. The elements include technological advance, organizational innovation, specialization and production innovation.

### 3.3. Analysis of influencing factors of financing efficiency based on Tobit model

On the basis of reference to relevant literature [ 3,5 ], this paper chooses the per capita GDP of the location of the enterprise to represent the level of economic development, the average number of students in colleges and universities per 100,000 population to represent the quality of workers, the R & D funds of industrial enterprises above designated size to represent the technical level, asset-liability ratio, the shareholding ratio of the top ten shareholders and the concentration of equity, operating cost rate as independent variables, comprehensive efficiency, pure technical efficiency and scale efficiency as dependent variables, three regressions. At the same time, in order to eliminate the impact of dimensional inconsistency, macro indicators were logarithmically processed, and the regression results are shown in Table 5.

At the macro level, the level of economic development has a promoting effect on the financing efficiency of enterprises, but the statistics are not significant, and has a negative impact on pure technical efficiency at the 1 % level, which is positively related to scale efficiency. The reason may be that the higher the level of local economic development, the larger the scale of enterprises, the higher the scale efficiency, but because the original technology and management level lags behind the expanding production scale, the overall efficiency of enterprises has not been significantly improved. The quality of workers is significantly positively correlated with comprehensive efficiency and scale efficiency at the 1% level, and the promotion effect on pure technical efficiency is not significant. As the core factor of enterprise development, human resources, the higher the quality of

workers, can provide high-quality talent reserve for the development of enterprises, the better the development prospects of enterprises, the greater the demand for high-quality talents, and the natural improvement of financing efficiency. The technical level is positively correlated with comprehensive efficiency and pure technical efficiency at the 5% and 1% level, respectively, and the positive impact on scale efficiency is not significant. The more R & D funds for industrial enterprises above designated size, the greater the intensity of scientific research investment and the higher the technological level, the more conducive to the improvement of financing efficiency. However, there is no significant correlation between nominal level and enterprise scale. Some enterprises with higher mechanical level do not need too much labor force, and the expansion of enterprise scale may be ineffective.

At the micro level, the asset-liability ratio of the enterprise is significantly negatively correlated with the comprehensive efficiency at the 5% level, and the negative impact on pure technical efficiency and scale efficiency is not significant. The higher the debt ratio, the lower the financing cost, but the higher the financial risk of the enterprise, which may affect the financing decision of the enterprise, resulting in lower financing efficiency. Ownership concentration is negatively correlated with comprehensive efficiency and pure technical efficiency at the level of 5% and 1% respectively, and has no significant positive impact on scale efficiency. The more concentrated the power of the enterprise, the more likely there will be a dominant or inappropriate control situation, which can not brainstorm, resulting in financing decisions or other major decision-making errors. At the same time, the extreme concentration of equity will also affect the management level and technical level of enterprises through the decision chain. The operating cost rate is negatively correlated with comprehensive efficiency and scale efficiency at the level of 1% and 5%, respectively, and the promotion effect on pure technical efficiency is not significant. The higher the operating cost rate, the lower the level of capital utilization of the enterprise, and the efficiency of capital allocation needs to be strengthened. Once the funds can not be fully utilized, it will affect the efficiency of enterprises, and then affect the financing strategy of enterprises, including the choice of financing channels, the allocation of financing structure, etc., which have a significant impact on financing efficiency.

**Table 5.** Tobit regression results

| Variables | Overall efficiency | Pure technical efficiency | Scale efficiency |
|---|---|---|---|
| Level of economic development | 0.0014 | -0.2268*** | 0.1409*** |
| Quality of workers | 0.1898*** | 0.0332 | 0.1601*** |
| Technical level | 0.0355** | 0.0552*** | 0.0095 |
| Asset-liability ratio | -0.0011** | -0.0004 | -0.0006 |
| Ownership concentration | -0.0015** | -0.0014*** | 0.0002 |
| Operating cost rate | -0.2228*** | 0.0246 | -0.1816** |

## 4. Conclusion and suggestion

Based on the above analysis, this paper draws the following main conclusions: Firstly, the overall financing efficiency of new energy enterprises is not high. From 2016 to 2018, it is more restricted by scale efficiency, and from 2019 to 2021. It is more significantly affected by pure technical efficiency. Secondly, overall financing efficiency of new energy enterprises shows a downward trend, with a decrease of 2.6%, and the restrictive effect of the decline of technological progress index is significant. Thirdly, the level of economic development, the quality of workers and the level of technology have a promoting effect on the financing efficiency of enterprises, while the asset-liability ratio, ownership concentration and operating cost ratio have an inhibitory effect on the financing efficiency of enterprises.

Based on this, the following three suggestions are proposed: 1) Optimize the financing structure and moderately weigh the benefits and risks. Reasonable financing structure helps to improving

financing efficiency. Enterprises should maintain a tolerable proportion of equity financing, debt financing and internal financing, optimize capital structure, and control financial risks within an acceptable range while minimizing the comprehensive capital cost rate to reduce financing costs and financing risks. 2) Strengthen the independent research and development of core technology. China's new energy enterprises have moved towards the development path dominated by technical resources. The improvement of technological level and the introduction of high-quality talents will provide strong intellectual support for the development of enterprises, thus improving the financing efficiency of enterprises. 3) Government departments should strengthen the guidance and policy support for new energy enterprises, and improve the effectiveness of such guidance and support. The government's financial subsidies, tax incentives, credit policies should seize the opportunity, timely supply, while optimizing the support object, improve the efficiency of financial support.

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