Financing Efficiency Evaluation of Chinese New Energy Enterprises based on Three-stage DEA-Malquist

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Abstract. A three-stage DEA model was used to measure the financing efficiency of 102 listed new energy enterprises in China. It is found that the new energy enterprises have higher technical efficiency and scale efficiency, and lower comprehensive technical efficiency. By analyzing the change of efficiency in Malquist dynamics, we found that the total factor productivity of the sample enterprises decreased by 2%, the change of pure technical efficiency contributed 1.1% to total factor productivity. The index of technical progress is low, and there is much room for improvement in the use and application of existing technologies. The inefficiency of scale is the main reason that affects the efficiency of financing. In the empirical model of factors affecting financing efficiency, we find that there is scale diseconomy effect in financing efficiency of new energy enterprises. The influence of institutional ownership on financing efficiency is significantly negative, which indicates that institutional investors are irrational in financing decision-making.

Keywords: new energy enterprises; three-stage DEA; Malquist; scale efficiency; institutional ownership.

1. Introduction

As of 2018, there are 166 listed new energy enterprises in China. New energy enterprises play an increasingly important role in the process of social and economic development. Because of the weakness of the new energy enterprises and the restriction of the external environment, the external financing is also more difficult, and the low efficiency of the financial management and the insufficiency of the technical level of the enterprises lead to the decrease of the financing efficiency. Therefore, it is worthwhile to study the influencing factors of financing efficiency of new energy and seek the way to improve the efficiency. Based on the measurement of the financing efficiency of enterprises, this paper discusses the main factors that affect the financing efficiency of new energy enterprises, such as the proportion of institutional ownership, etc. And gives the corresponding countermeasure and the suggestion.

2. Literature Review

At present, the discussion on financing efficiency mainly focuses on the connotation, measurement and influencing factors of financing efficiency. This article mainly aims at the latter two contents to carry on the analysis.

In the aspect of financing efficiency measurement model, most of the existing researches measure efficiency from the static aspect. Foreign scholars measure the financing efficiency of new energy enterprises less, while domestic scholars focus on the study of more subsectors (these subsectors are also new energy industries) . John K. Mullen studied the total factor productivity of American manufacturing between 1919 and 1991, estimating the effects of output and cost[1]. In China, using Malmquist index method, Chengxuan found that the financing efficiency of listed companies in Jiangsu Machinery Manufacturing Industry increased from 2009 to 2014, which benefited from the improvement of technological progress, but the scale efficiency of sample enterprises changed little .Using DEA-Logit model, Sumei and others analyzed the efficiency of 30 new energy automobile companies in China for 8 years[2]. As for the evaluation methods there are also the mold and analysis method, analytic hierarchy process,and stochastic frontier method[3] . To sum up, domestic scholars mostly focus on the financing efficiency of a certain industry (and new energy

industry is rarely studied) , mostly focus on the static financing efficiency or two-stage financing efficiency.

In the financing efficiency of the impact of factors analysis, mainly from the enterprise's internal operating conditions and external macro-environment two aspects. The internal operating condition includes the enterprise growth ability, the enterprise scale, the enterprise profit ability as well as the equity structure and so on. External factors mainly include consumer price index, GDP growth rate, interest rate and so on. The above-mentioned factors are mainly applied to the financing efficiency of various industries, and there are few studies on the financing efficiency of application and new energy enterprises. Therefore, in the past, the research on the factors affecting the efficiency of financing mostly considered from two aspects: the financial status and growth ability of enterprises themselves, as well as the macro-economic environment that enterprises face .Views from the angle of institutional shareholding proportion and the large shareholder shareholding proportion are few.

Through combing the previous research methods and achievements, this paper will make innovations from the following aspects.

The first is the innovation of the research sample. Domestic research on the new energy industry is less, research for the new energy industry financing efficiency is even less. In recent years, the number of new energy companies listed on the stock market is increasing rapidly, so this paper obtains 102 new energy companies from choice financial terminal, the study period is 2011-2018. Therefore, it has great advantages in sample size, study period span and study period effectiveness.

The second is the innovation of financing efficiency model measurement. In terms of input-output indicators, total operating costs, total assets, annual growth rate of total operating income and other indicators can better reflect the overall operation of enterprises. In the aspect of model selection, this paper chooses three-stage DEA model to measure the financing efficiency statically, and uses Malquist to analyze the change of efficiency dynamically. At present, three-stage DEA and Malquist index methods are rarely used to measure the financing efficiency of new energy enterprises.

The third is the innovation of factor influencing the financing efficiency . In this paper, institutional ownership and large shareholder ownership can represent the corporate governance structure of factors[4], which rarely appear in the past research. At present, the research on the impact of equity governance structure on financing efficiency of domestic new energy enterprises is relatively scarce.

3. Construction of Evaluation Model of Financing Efficiency

3.1 Sample Selection and Treatment of New Energy Enterprises

New energy Concept Enterprises are extracted from choice financial terminal,.In order to ensure that the enterprises have enough growth period before listing, the enterprises listed before January 1,2009(the research period of this paper is 2011-2018) are screened out, and the enterprises treated by St, * St are excluded. There are a total of 102 samples of enterprises. The data obtained in this paper are mainly the annual reporting period data.

In order to ensure that the input-output variables included in the DEA model are all positive, the data need to be standardized:

$Y=0.1+0.9\dfrac{X-\text{MIN}}{\text{MAX - MIN}}$, where Min, Max is the minimum and maximum value of the variable X in the current period.

3.2 Input-output Index and Environment Variable Selection

The input indicators selected in this paper are total assets, ratio of assets to liabilities and total operating cost, while the output indicators are yield valve, turnover ratio of total assets and growth rate of total operating income. The environmental variables are annual GDP and the investor sentiment index (CICSI) . The index derives monthly data from the CSMAR database and uses the average of 12 monthly data as the annual index of investor sentiment.

3.3 The Setting of Three-stage DEA Model

The traditional DEA model is influenced by environmental factors and random noise, and can not separate environmental factors, random perturbation and efficiency redundancy. THREE-STAGE DEA takes environmental factors and random noise into account, and adopts SFA to carry on regression analysis to the first-stage relaxation variables, so that DMUS can measure efficiency level again under the same external environment .Thus it eliminates the environmental factor to the efficiency influence. The three-stage DEA and later Malquist index are realized by using DEAP2.1 FRONTIER4.1 software (for length reason, this paper only gives the adjusted DEA efficiency of the third stage).

3.3.1. Phase I

The basic models include CCR model and BCC model. CCR model calculates DEA efficiency under the assumption that scale returns are constant, while BCC model assumes scale returns are variable. In the first stage, this paper selects the BCC model and measures the financing efficiency based on the output orientation.The BCC model divides technical efficiency into pure technical efficiency and scale efficiency under the assumption of variable scale reward.
The envelope can be expressed as:

$$S.T. \qquad \min_{P,\alpha} \Phi,$$
$$-b_i + B\alpha \geq 0,$$
$$Ba_i - A\alpha \geq 0,$$
$$E_1^*\alpha = 1,$$
$$\alpha = 0,$$

(where E_1 is the variable scale reward, $E*1$ is the Matrix,1 is the total factor.)
The CCR model was defined as the comprehensive technical efficiency (CRSTE), and the BCC model was defined as the pure technical efficiency (VRSTE), where the comprehensive technical efficiency was equal to the pure technical efficiency multiplied by the scale efficiency(scale).
The formula is:

$$CRSTE = VRSTE \times SCALE$$

3.3.2 Phase II

The second stage is to use SFA to separate out environmental factors, random disturbances and management inefficiencies for the relaxation variables of the first stage. Before performing the regression with Frontier4.1, the input relaxation variable or the output relaxation variable need to be adjusted. Since the first stage of this paper is output-oriented calculation efficiency, the second stage is to adjust the output slack variables. Finally, the output variables are separated by efficiency redundancy. Space is limited,and we no longer give a detailed introduction for the specific calculation formula of the second phase.

3.3.3. Phase III

After SFA regression analysis, the adjusted input or output variables eliminates the effects of managerial inefficiency, environmental factors and random disturbances. The decision-making units (this paper for the annual cross-section of each enterprise) is for the DEA efficiency measurement again, in the first phase of the variable environment.

3.4 Malquist Index Method

By constructing the best edge of industry financing efficiency in each period, the paper compares the financing efficiency of each enterprise with the best edge, and then dynamically measures the technical progress and total factor productivity of sample enterprises. In this paper, we use Malquist's index to measure the progress of t period efficiency compared with t + 1 period efficiency.
Formula of MALQUIST:

$$tfpch=effch(technical\ efficiency)\times techch(technical\ progress)Total\ factor$$
$$productivity(tfpch)=\ technical\ progress\ (techch)\times Change\ in\ pure\ technical\ efficiency\ (pech)\times$$
$$Change\ in\ scale\ efficiency(sech)$$

If tfpch is equal to 1, the efficiency is not changed. If tfpch is less than 1, the efficiency is not enough.

If techch >1 ,this indicates that this efficiency promotes TFP, while less than 1 this indicates that techch suppresses total factor productivity.

3.5 Empirical Analysis of Three-stage DEA Model

From 2011 to 2018, the comprehensive technical efficiency of new energy enterprises in China is 0.717125, which indicates that the contribution of scientific and technological progress to the financing efficiency is insufficient, and the scientific and technological capability and the application of science and technology in enterprise management need to be strengthened. The technical efficiency is higher, the scale efficiency also obtains the certain achievement, but is not very high. It shows that the R & D capability of Chinese new energy enterprises is insufficient due to the limitation of scale and resources. There is no waste of capital and low utilization rate in China's new energy enterprises, but the financing technology needs to be improved.

Table 1. Empirical Results of THREE-STAGE DEA

year	crste	vrste	scale
2011	0.7436765	0.8784215	0.8424118
2012	0.6422451	0.7294902	0.8739902
2013	0.7510687	0.9101471	0.8225392
2014	0.7531078	0.9482353	0.7918823
2015	0.7056961	0.8322059	0.843353
2016	0.7228922	0.8284902	0.8607157
2017	0.7199608	0.8544608	0.8323236
2018	0.6983529	0.8865	0.784951
Average value	0.717125	0.8584939	0.8315209

3.6 Empirical Analysis of Malquist Index Model

Table 2.Empirical results of the Malquist Index

year	effch	techch	pech	sech	tfpch
2	0.849	0.816	0.808	1.050	0.692
3	1.185	1.243	1.282	0.924	1.473
4	0.996	1.036	1.045	0.953	1.032
5	0.943	0.849	0.871	1.082	0.800
6	1.016	0.950	0.993	1.023	0.965
7	0.990	0.973	1.032	0.959	0.963
8	0.971	1.142	1.039	0.934	1.109
Geometric mean	0.989	0.991	1.011	0.988	0.980

As can be seen from the table above, the enterprise financing efficiency (tfpch) improved greatly in the 3rd and 4th years, and then decreased slightly. By the eighth year, the improvement is 10.9% , which is mainly due to the promotion of scientific and technological progress (pech) . But China's new energy companies' total factor productivity underperformed throughout the entire sample period, eventually falling by 2 percent. This shows that companies need to continue the progress of 2018 and improve the financing efficiency. The change in pure technical efficiency has been better in recent years, with a 1.1% boost to total factor productivity. In 2017 and 2018, in particular, the total factor productivity achieved a 3.2% , 3.9% boost. It shows that the scientific and technological progress level of new energy enterprises is relatively high. The overall performance of scale efficiency is not good, the financing efficiency is obviously restricted by scale, and the scale efficiency is restrained

by 1.2% . In conclusion, the progress of science and technology promotes the efficiency of enterprise financing most obviously. But because of the lack of financing technology (effch, sech) , total factor productivity doesn't make progress.The lack of scale efficiency is the main reason for the decrease of financing efficiency in China.

4. Regression Model Setting

4.1 Variable Selection

All variables are obtained from the choice financial terminal. The ownership concentration degree reflects the ownership governance structure of the enterprise, and we take the largest shareholder's ownership proportion as the proxy variable of the ownership concentration degree. The annual growth rate of operating income represents the growth ability of enterprises. The total assets represent the size of the enterprise. In order to eliminate the influence of dimension difference on empirical results, the variables were standardized by DZ-SCORE.

4.2 Model Setting

After the F test and Housman test, this paper selects the fixed effect model to carry on regression analysis to the panel data.

Model: $FE_{i,t} = \alpha + \beta_1 LHOLD_{i,t} + \beta_2 TOP1_{i,t} + \beta_3 GROWTH_{i,t} + \beta_4 ASSET_{i,t} + \beta_5 DB_{i,t} + \varepsilon_{i,t}$

Table 3.Variable Description

Variable	Variable Meaning	Variable Symbol	Method of calculation
Explained Variable	Financing Efficiency	FE	CRSTE in three-stage DEA model
Explanatory Variable	Institutional Stake	LHOLD	Total Institutional Holdings
	Ownership Concentration	TOP1	First largest shareholder, with a stake
Control Variable	Annual growth rate of total operating income	GROWTH	Percentage increase in operating income at year-end compared to last year-end
	Total Assets	ASSET	Total current and non-current Assets
	Asstes/Liabilities	DB	Total Liabilities / Total Assets

5. Analysis of Empirical Results

Table 4.Model Test Results

crste	Coef.	t	significance(at the level of 5%)
LHOLD	-0.01728	-3.09	significant
TOP1	0.0021994	0.33	insignificant
GROWTH	0.0335331	6.94	significant
ASSET	-0.1320494	-25.56	significant
DB	-0.0610801	-12.13	significant
_cons	0.717125	149.94	significant

The effect of institutional ownership on financing efficiency is significantly negative, and the model's R^2 is 0.5917. The institutional investors can improve the financing efficiency by increasing the proportion of holding shares to participate in the decision-making of the enterprise management, but the empirical results show that the increase of institutional investors' holding shares does not improve the financing efficiency. This may have to do with the concentration of institutional investors' equity. Institutional investors can step up their intervention, but the potential for counterbalancing the power of managers, coupled with institutional investors' misunderstanding the management of business operations, is likely to result in decision-making mistakes. Another

explanation is that because a company has a large number of institutional investors, an increase in institutional ownership does not mean that the largest institutional shareholders hold a large position. It is very likely that many institutions have dispersed their ownership. This is more likely to lead to power balance and decision-making mistakes.

The proportion of large shareholders has no significant impact on financing efficiency, which may be due to the large proportion of shareholders or the limited management ability of shareholders. The annual growth rate of total operating income has a significant positive effect on financing efficiency, indicating that the growth ability has a positive effect on financing efficiency. The effect of total assets is significantly negative, which shows that small-scale enterprises have higher financing efficiency than large-scale enterprises. The influence of asset-liability ratio is obviously negative, which indicates that too much debt is not conducive to the improvement of financing efficiency.

6. Summary and Outlook

The following is a summary of static analysis and dynamic analysis of financing efficiency of new energy enterprises in China. The three-stage DEA model was used to measure the comprehensive technical efficiency, technical efficiency and scale efficiency, and their average values were 0.717125,0.858494,0.831521 respectively.

According to Malquist index model, total factor productivity, technical progress and pure technical efficiency and the change of scale efficiency is 0.980,0.991,1.011 and 0.988 respectively . We can see that the progress of science and technology (change of pure technical efficiency) is the main power to improve the efficiency of financing, and the lack of scale efficiency is the most important factor to reduce the efficiency of financing. Although China's new energy enterprises have made scientific and technological progress,   because of the size and high financing costs, it's difficult to achieve normal technological progress.

On the other hand, the influence of institutional ownership ratio on financing efficiency is significantly negative. As for other factors, the proportion of large shareholders has no significant impact on financing efficiency. The impact of the annual growth rate of total operating income was significantly positive. The total assets and the ratio of assets to liabilities have a significant negative effect on the financing efficiency, which indicates that the scale diseconomies exist in the financing efficiency of new energy enterprises.

Here are some suggestions:

Enterprises and governments should increase investment in science and technology. Pure technical efficiency plays an important role in financing efficiency. Scientific and technological progress can improve the efficiency of production, thus improving the efficiency of output variables, and ultimately improve the efficiency of financing.

Improve scale efficiency of new energy enterprises. To raise different financing policies for enterprises of different sizes, especially to provide financing preferential policies and tax exemption and reduction policies for enterprises of larger sizes, so as to improve the utilization ratio of funds. At the same time, for companies whose economies of scale are diminishing. It should be noted that the scale may have exceeded the maximum reasonable value, and industrial structure should be adjusted to reduce the scale.

Encourage institutional investors to co-ordinate and cooperate. The large proportion of institutional investors does not mean that institutional investors play a big role in the management decision-making, and the disagreement among multiple institutional investors is likely to weaken the overall position of institutional investors in the management of enterprises. At the same time, the overall holding level of institutional investors is relatively high, but the single institutional investors share a smaller proportion than the largest shareholders.Each institutional investor holds a small proportion of shares in the company, and only by cooperating can they form an effective constraint and supervision on interests of management .

We will optimize the composition of institutional investors. Promote the beneficial competition and interdependence of institutional investors, make them learn from each other to improve the

management and decision-making ability . At the present stage, China should develop diversified institutional investors to optimize the composition of China's institutional investors. Ensure that institutional investors have management expertise.

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