An Empirical Study on Financing Efficiency of Information Service Enterprises Listed on GEM in China Based on DEA Model

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Abstract. This paper use the data envelopment analysis (DEA) method to analyze the financing efficiency of 77 enterprises listed on GEM in China's information service industry. The empirical results show that financing efficiency of these enterprises is generally low, the financing situation is not matched with the development degree of enterprises, the low scale efficiency is the most obvious problem, the regional distribution is not balanced, and the capital utilization efficiency is not high. According to the empirical results, it is suggested that enterprises should reduce operating costs, optimize financing structure, allocate resources rationally, and select financing opportunities and channels reasonably. Regulators should strengthen information disclosure and policy support.

1. Introduction

Small and medium-sized enterprises (SMEs) are an important part of China's economic system. The number of SMEs accounts for 99% of China's total enterprises, contributing 60% of China's GDP, 50% of Taxation and 80% of urban employment. But SMEs have their own problems, such as high production costs, short life cycle and weak anti-risk ability, which greatly restrict their development. For solving SMEs' financing difficulties, China has successively established multi-level capital markets. GEM was set up in 2009, which is a stock exchange market that provides financing channels for SMEs and high-tech industries that temporarily can not be listed on the main board. GEM is an important addition to the main board.

Information service industry uses computer and communication network, to produce, collect, store, transmit, and utilize information and provide services with information products. It has characteristics of rapid technological updating, high added value of products, and wide application fields, playing an important supporting and leading role in economic and social development. China's information service industry is developing rapidly. The financing efficiency affects the lifeline of an enterprise, researching the financing efficiency of information service industry is necessary.

Based on relevant financing theory, this paper uses data envelopment analysis (DEA) to construct a model for evaluating financing efficiency, using total assets, asset liability ratio and main business cost as input index, growth rate of main business income, return on net assets and turnover rate of total assets as output index. It makes an empirical study on the sample of information service industry listed on GEM in China, and puts forward relevant countermeasures in view of the existing problems to promote the sound development of capital market, perfect the multi-level capital market and improve the financing efficiency of information service industry listed on GEM.

2. Literature review

Early scholars' research was in the definition stage. Most of them thought that financing efficiency was the efficiency of resource allocation. Gregory, Stusrt (1990) considered that financing efficiency referred to how to use the funds effectively[1]. Lipoy (1996) defined financing efficiency based on the social funds allocation, if corporate financing reached Pareto optimum state, financing was efficient[2]. Sumueolson (1999) believed that financing efficiency was the efficiency of allocation . If funds were effectively used in the production and operation, the financing efficiency was relatively high[3]. In subsequent studies, scholars began to discuss the influencing factors of financing efficiency. Thomas (2005) believed that financing efficiency should be separated into two aspects: use efficiency and

allocation efficiency. Only when the two aspects are high, can the overall level of financing efficiency be high[4]. Bynum (2006) used quantitative analysis method and the results show that financing efficiency is impacted by the transparency of financing information[5].

Professor Zeng (1993) was the first person in China to use the concept of financing efficiency, but he did not give a specific definition[6]. Song (1998) formally studied the concept of "financing efficiency" firstly. He believed that efficiency included transaction efficiency and allocation efficiency[7]. Xiao (2004) pointed out that the financing efficiency meant the ability to create maximum benefits for enterprises. It depends on two sides: the obtaining cost of funds and the effective use of funds[8]. Chinese scholars also carried out empirical research on financing efficiency. Zeng and Chen (2008) used DEA model to evaluate the debt financing efficiency of SMEs. They proved that enterprises with long operation time were easy to obtain loans from banks[9]. Liu and Han (2012) constructed panel data regression model to analyze the relationship between financing efficiency and financing modes of SMEs in Liaoning Province. Results show that equity financing reduces financing efficiency, debt financing improves financing efficiency[10].

3. Research design

3.1 Research method

This paper mainly uses data envelopment analysis (DEA) to evaluate the financing efficiency of information service enterprises. DEA model was put forward by American scholar Charnes in 1978. It is an decision-making method based on relative efficiency, evaluating the relative efficiency of several decision-making units (DMUs) with the same type of multi-input and multi-output[11].

The basic principle is as follows: suppose there are n decision-making units $DMU_j (j=1,2,...n)$, whose input and output vectors are respectively: $X_j = (x_{1j}, x_{2j}, ..., x_{mj})^T > 0$, $Y_j = (y_{1j}, y_{2j}, ..., y_{sj})^T > 0$, $j = 1,2,...n$. Assuming that the weights of input indices are vectors $v = (v_1, v_2, ..., v_m)^T$, the weights of output indices are vectors $w = (w_1, w_2, ..., w_s)^T$, then the efficiency evaluation index of the jth DMU can be expressed as $\theta_j = \frac{u^T Y_j}{v^T X_j} = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}$, $j = 1,2,...n$ [12].

DEA model can be separated into variable returns on scale (VRS) and constant returns on scale (CRS) by the nature of returns on scale, which are called BCC model and CCR model respectively.

(1) CCR model

$$\min \theta$$

$$s.t. \sum_{j=1}^{n} \lambda_j x_j + s^+ = \theta x_0$$

$$\sum_{j=1}^{n} \lambda_j y_j - s^- = \theta y_0$$

$$\lambda_j \geq 0,\ j = 1,2,...n$$

$$\theta \text{ is unconstrained}, s^+ \geq 0, s^- \leq 0$$

CCR model evaluates the efficiency of DMU under the CRS condition. If $\theta^* = 1, s^+ = 0, s^- = 0$, the DMU is efficient. That means on the basis of existing scale of input and output, the optimal output has been achieved, and both technology and scale are efficient at the same time; if $\theta^* = 1, s^+ \neq 0, s^- \neq 0$, the DMU is called DEA weak efficiency, if the input variables are reduced and the output remains unchanged, the optimal structure will be achieved, or keeping input unchanged to achieve the best output; if $\theta^* < 1$, the DMU is ineffective, neither technical efficiency nor scale efficiency is the best.

(2) BCC model

In reality, DMU can not be produced under the CRS condition due to the surrounding factors. There will be increasing or decreasing scale reward. Charnes and Cooper improve the CCR model by adding variable scale reward (VRS). The model is as follows:

$$\min[\theta-\varepsilon(\sum_{i=1}^{m}S_i^-+\sum_{r=1}^{m}S_r^+)]$$

$$s.t.\sum_{j=1}^{n}X_{ij}\lambda_j+S_i^-=\theta X_{ij0}$$

$$\sum_{j=1}^{n}Y_{rj}\lambda_j+S_r^+=Y_{rj0}$$

$$\sum_{j=1}^{n}\lambda_j=1$$

$$\theta,\lambda_j,S_i^-,S_r^+\geq 0,\ j=1,2,...,n$$

$$(i=1,2,...,m;r=1,2,...,s)$$

Among them, m and s are the number of input and output indicators respectively. Vectors X and Y represent input and output variables. If $\theta=1,s^+=0,s^-=0$, it is efficient, indicating that the technical efficiency of *DMU* is the best; if $\theta<1,s^+\neq 0,s^-\neq 0$, the *DMU* is ineffective, $s^-\neq 0$ indicates that there is surplus input, $s^+\neq 0$ indicates that the output is still surplus; if $\theta\in(0,1)$, it means that the *DMU* input is ineffective, it has not reached the maximum efficiency in both input and output.

3.2 Sample Selection and Data Sources

3.2.1 Sample selection

This paper chooses data in 2014 and 2015 as input indicators. In order to study the long-term impact of input indicators, the average data of three years after input indicators is selected as output indicators. Since many enterprises have not published annual reports in 2018, the data of 2018 are selected as semi-annual reports. According to these indicators, 82 Enterprises were screened out, but 5 enterprises have data loss, after eliminating them, 77 sample enterprises were obtained.

3.2.2 Data sources

This paper chooses total assets, operating costs, asset-liability ratio as input indicators, return on net assets, growth rate of main business income and turnover rate of total assets as output indicators. Specific data is from the annual reports issued by various enterprises and the CSMAR database.

Table 1. Definition of Input-Output Indicators.

Variable name	Unit	Meaning
Input variables		
Total assets	yuan	Including current assets and non-current assets, reflects the financing scale of enterprises.
Main business cost	yuan	Resources invested by enterprises in the process of production and operation.
Asset-liability ratio	/	The ratio of corporate liabilities to assets, reflecting the impact of capital structure on equity financing efficiency.
Output assets		
Return on equity	/	The percentage of net profit and average shareholder's equity, which measures the profitability of an enterprise and reflects the ability to integrate capital into output.
Growth rate of main business income	/	Represents the growth rate of the company's sales and judges the development of main business of the enterprise.
Total assets turnover rate	/	The ratio of main business income divided by total assets, reflects the turnover capacity of an enterprise.

3.2.2 Sample data processing

DEA model requires that all input-output indices are positive, while y_1 and y_2 may be less than 0. Therefore, the dimensionless treatment of DEA model is carried out, and the formula is as follows:

$$x_{ij}^{*}=0.1+\frac{x_{ij}-\min(x_{ij})}{\max(x_{ij})-\min(x_{ij})}\times 0.9$$

After dimensionless processing, all the data fall into the range of 0.1 to 1, which still meets the requirements of DEA model for index properties and has no substantial impact on the results .

4. Empirical research results

4.1 Overall efficiency analysis

After sorting out the results, the financing efficiency of samples are as shown in Table 2.

Table 2. Sample Enterprises' Overall Financing Efficiency.

		Vrste	Crste(CCR)	Scale(BCC)
In 2014	Effective	16 (20.78%)	8 (10.39%)	8 (10.39%)
	Ineffective	61 (79.22%)	69 (89.61%)	69 (89.61%)
	Efficiency average	0.869	0.489	0.548
In 2015	Effective	15 (19.48%)	7 (9.09%)	8 (10.39%)
	Ineffective	62 (80.522%)	70 (90.91%)	69 (89.61%)
	Efficiency average	0.867	0.457	0.514
	To improve	33 (42.86%)	32 (41.56%)	30 (38.96%)
	To reduce	36 (46.75%)	40 (51.95%)	42 (54.55%)
	The same	8 (10.39%)	5 (6.49%)	5 (6.49%)

Among the 77 enterprises, only 8 reaches efficient vrste and scale at the same time in 2014, accounting for only 10.39% of the total, proving that the level of input and output of these enterprises is reasonable, there is no surplus input or insufficient output; 8 achieved efficient vrste, but did not achieve efficient scale, indicating that they may not have redundant input or insufficient output, but because of the insufficient or excessive financing scale, which does not match their technical level, the scale efficiency is ineffective. 61 enterprises have not achieved either vrste or scale effectiveness, accounting for 79.22% of the total. It shows that these enterprises have excessive or insufficient financing scale, and need to adjust the proportion of input and output to achieve the optimal state.

The empirical results in 2015 show that 15 enterprises have achieved efficient vrste, which is 1 less than that in 2014. According to the change of financing efficiency, there are 33 enterprises with vrste improved, 8 with effective efficiency unchanged, 30 with scale efficiency improved, and 5 with efficient scale unchanged. It can be seen that more than half of enterprises achieve the improvement of vrste or maintain effectiveness, indicating that the financing efficiency of these information service industry is in an improved or effective state without considering scale factors, and the utilization efficiency of funds is improved as a whole. However, from the scale efficiency perspective, 54.55% of the enterprises' financing scale efficiency is in a declining state, indicating that the mismatch between capital scale and enterprise scale of these information service industry has deteriorated. The overall financing efficiency of enterprises fluctuates greatly, indicating that some enterprises' financing strategies do not change with the transformation of surrounding factors. Generally speaking, the financing efficiency of information service enterprises listed on GEM in China is low, financing efficiency fluctuates greatly, and the enterprise funds do not play a full role.

From the analysis of the change of scale reward, most of the enterprises that have not reached the effective scale are in the increasing phase of scale reward, showing that the production scale has not reached the optimal level, enterprises can continue to expand the scale and increase investment; but there is also an enterprise in the declining stage of scale reward, which shows that the investment of this enterprise is redundant and should be reduced appropriately.

4.2 Level distribution of financing efficiency

The empirical results can be integrated into Table 3.

Table 3. Distribution of financing efficiency levels of samples.

		Vrste		Scale(BCC)	
		Number	Proportion	Number	Proportion
In 2014	Poor efficiency $0<x<0.5$	0	0%	39	50.65%
	Lower efficiency $0.5\leq x<0.8$	22	28.57%	19	20.68%
	Higher efficiency	39	50.65%	11	14.28%

	0.8≤x<1				
	Optimum efficiency x=1	16	20.78%	8	10.39%
In 2015	0<x<0.5	0	0%	41	53.25%
	0.5≤x<0.8	24	31.17%	23	29.87%
	0.8≤x<1	38	49.35%	5	6.49%
	x=1	15	19.48%	8	10.39%

From the perspective of vrste, sample enterprises are mainly concentrated in the higher efficiency stage (0.8≤x<1), and the sum of number of enterprises in the higher and the optimum efficiency stage exceeds 65% of the total sample. Compared with 2014, the number of enterprises in the higher and the optimum stage of financing efficiency in 2015 has decreased by 2.6%. Without considering the factors of scale, the vrste of these enterprises is relatively high as a whole, but some enterprises' efficiency has decreased. It shows that the funds obtained by enterprises in GEM have been effectively used in their development.Simultaneously, some enterprises should pay attention to the adjustment of financing structure and time to avoid the reduction of financing efficiency.

From the scale efficiency perspective, the number of enterprises is mostly concentrated in the poor efficiency stage (0 < x < 0.5), and enterprises in the poor and the lower efficiency stage are more than 70% of the total. Scale efficiency means the impact of the size of an enterprise on its input and output efficiency.It shows that there is a mismatch between the size of information service enterprises and their input and output levels. Enterprises should expand or reduce the enterprises size appropriately to make more effective use of the funds obtained from financing.

4.3 Regional distribution of financing efficiency

The distribution of information service enterprises has obvious characteristics, among which the top four areas are Beijing (39), Guangdong (32), Shanghai (18) and Zhejiang (11). From Figure 1, it shows that information service industry are mainly distributed in the economically developed areas, which have a good economic foundation, a high degree of openness, strong policy support, a high level of education, and are suitable for the development of information service industry.

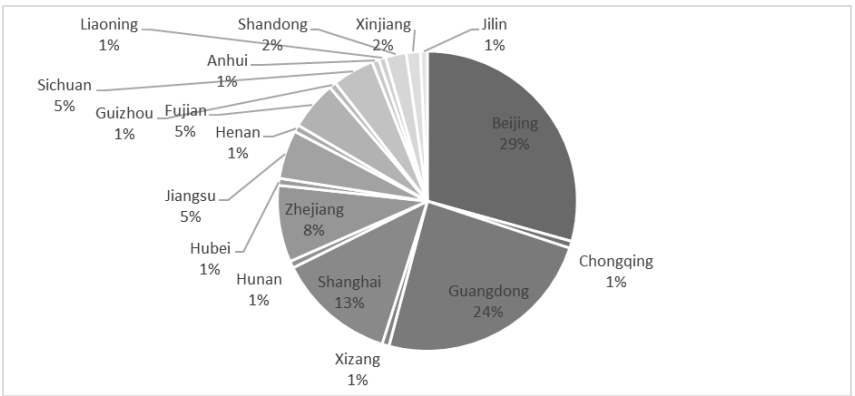

Fig 1. Regional distribution of information service enterprises listed on GEM in China.

The data of enterprises with effective financing and their regions (taking 2014 data as an example) can be summarized in the following table (Table 4).

Table 4. Regional distribution of financing efficiency.

	Enterprises		Vrste		Scale(BCC)	
	Sample size	Proportion of samples	Sample size	Proportion of samples	Sample size	Proportion of samples
Beijing	23	30%	6	26.09%	5	21.74%
Guangdong	19	25%	4	21.05%	1	5.26%
Shanghai	11	14%	3	27.27%	2	18.18%
Zhejiang	7	9%	1	14.29%	0	0%
Jiangsu	5	6%	0	0%	0	0%
Fujian	4	5%	0	0%	0	0%
Sichuan	2	3%	1	50%	0	0%
Shandong	2	3%	0	0%	0	0%

Chongqing	1	1%	0	0%	0	0%
Henan	1	1%	1	100%	0	0%
Guizhou	1	1%	0	0%	0	0%
Liaoning	1	1%	0	0%	0	0%

From Table 4, it shows that the distribution of financing efficiency of information service enterprises in different regions is basically consistent with the regional distribution of information service enterprises. Enterprises with effective financing are mostly concentrated in Beijing, Shanghai and Guangdong. The proportion of samples which achieve both vrste and scale effectiveness in Beijing and Shanghai exceeds the whole proportion. The proportion of efficient vrste enterprises in Guangdong is also higher than the overall proportion, which shows that the financing efficiency of these three regions is higher than the overall level of the whole country. The information service industry in these three regions is more mature, and the funds can be used to a greater extent.

To be specific, among the three cities, the financing efficiency of information service enterprises in Beijing is the best, followed by Shanghai, and there are some problems in the scale efficiency of Guangdong. Beijing has the first national hi-tech industrial development zone, which is the most intensive area of science and education and talent resources in China. The information service industry has developed for a long time, and has a good financing situation. Shanghai is one of the financial centers in China, with a high degree of openness and a good financing environment with Shanghai Stock Exchange. Guangdong has a good economic foundation, is adjacent to Hong Kong and Macao, the information service industry develops rapidly and has a good financing environment with Shenzhen Stock Exchange. However, compared with Beijing and Shanghai, the university resources in Guangdong are slightly weaker, and the development of information service industry starts later. Enterprises should pay attention to the control of financing scale in future financing.

At the same time, we can see that the number of information service enterprises in the central and western regions of China is small and the financing efficiency is low. These enterprises should fully combine the regional characteristics to seek suitable financing channels, and pay attention to the matching of financing scale and enterprise scale.

4.4 Analysis of causes of empirical results

Combining with the empirical research above, we can see that the financing efficiency of information service industry listed on GEM is low and the financing scale does not match the enterprise scale. The possible causes are the following two aspects.

Firstly, information service enterprises lack financial awareness and have a single financing channel. At present, the information service industry is dominated by high-tech talents, lacking of high-quality financial talents, resulting in the lack of financing channels and low financing efficiency.

Second, the efficiency of the use of funds is low. Generally speaking, the standard value of enterprise capital turnover rate is 80%, but the average asset turnover rate of 77 sample enterprises in this paper is only 21.49% from 2014 to 2018, which is far below the standard level. The low efficiency of fund use also affects the improvement of financing efficiency.

5. Basic conclusions

In this paper, 77 information service enterprises listed on GEM are selected as research samples, and DEA model is used to conduct empirical research on the financing efficiency of enterprises. The conclusions are as follows:

(1) The financing efficiency of information service enterprises listed on GEM in China is generally low. There are insufficient or excessive input and output, inadequate or excessive financing scale, which is incompatible with their own technical level.

(2) The problem of financing efficiency focuses more on the problem of low scale efficiency, which reflects that the scale of information service enterprises does not match the input and output level seriously. Enterprises should expand or reduce the scale of financing appropriately so as to make more effective use of the funds obtained from financing.

(3) In terms of regional distribution, the regional distribution of financing efficiency is consistent with that of the industry. The financing efficiency of Beijing, Shanghai and Guangdong is higher than

the overall level of the whole country, and Beijing has the highest financing efficiency.

(4) The inefficiency of information service industry is closely related to the lack of financial awareness and inefficient use of funds. In future financing, attention should be paid to multi-channel financing and improve the efficiency of the funds use.

For the information service enterprises themselves, they should reduce their operating costs, use the raised funds to the development of their main business and prevent corruption; optimize the financing structure and maintain a reasonable asset-liability ratio; rationally allocate resources, increase scientific and technological input and talent introduction, and increase innovation; rationally select financing timing and channels, combine direct financing with indirect financing, optimize the capital structure, make full use of bills financing, financial leasing and other methods. For regulators, they should promote the construction of multi-level capital market system, strengthen information disclosure, increase financial and policy support to promote enterprises to strengthen innovation.

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