

Research on Debt Financing Efficiency and Influencing Factors of SMEs in China

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Abstract. The development of small and medium-sized enterprises is of great significance to the growth of the national economy. The efficiency of debt financing reflects the efficiency of enterprises' comprehensive utilization of debt funds, and is an important indicator to reflect the operation and development of enterprises. Taking Chinese listed SMEs as a sample, this paper measures the efficiency of corporate debt financing through the traditional DEA model and the Malmquist index model, then constructs a Tobit model to empirically analyze the factors that affect the efficiency of debt financing. The research shows that: the overall debt financing efficiency of SMEs is low, and pure technical inefficiency is the main reason for restricting the efficiency of debt financing. The solvency, operating ability, profitability, growth ability and R&D investment of SMEs have a significant positive impact on debt financing efficiency, while enterprise scale, debt financing amount and equity concentration have a significant negative impact on debt financing efficiency.

Keywords: Debt Financing Efficiency; DEA Model; Malmquist.

1. Introduction

As an important pillar of China's economy, SMEs have created many jobs, relieved people's living pressure to a large extent, improved people's livelihood, and enabled the healthy development of society. In recent years, China's economy has achieved rapid growth, and SMEs have also contributed a lot. Therefore, SMEs are the mainstay of ensuring the healthy and sustainable development of the economy and society, and it is of great economic significance to solve their development problems. Due to the limitations of their own conditions, SMEs mainly obtain funds through debt financing. Many scholars have carried out relevant research on this, to explore how to increase the scale of debt financing of enterprises. The current policy orientation is mainly based on different financing methods, relaxing the financing requirements for SMEs, and improving the financing capacity of enterprises. In fact, the increased scale of debt financing does not mean that companies can effectively use these funds. Increasing the financing scale of enterprises is the first step for SMEs. To truly solve financing and development problems, more attention should be paid to the efficiency of corporate debt financing. Therefore, this paper selects 608 Chinese listed SMEs as a sample to conduct empirical research on their debt financing efficiency, in order to make some supplements to the research on SME financing.

The structure of this paper is as follows: The second part is the literature review. The third part is the empirical research design. The fourth part is the empirical research results of the debt financing efficiency of SMEs. The fifth part is the conclusion.

2. Literature review

2.1 Definition of related concepts

How to define financing efficiency, there is currently no unified standard in academia. Chinese scholar Zeng Kanglin (1993) put forward the concept of "financing efficiency" earlier, and he pointed out that different financing methods have different efficiencies [19]. Later, scholars defined financing efficiency from different perspectives, which can be classified into the following categories:

The first perspective understands financing efficiency as financing cost. From the perspective of capital integration, Huang Rentong (2018) proposed that financing efficiency is the ability of enterprises to obtain funds through low cost; when the solvency of the enterprise is stronger and the accounting conservatism is higher, the financing cost is lower and the debt financing efficiency is higher [8].

The second point of view is that financing efficiency is the situation in which enterprises benefit from the use of funds. Chu Liping and Su Fang (2013) mainly consider the use efficiency of funds, and point out that financing efficiency is the efficiency of enterprises using funds to create value. Their research found that the financing efficiency of Chinese property insurance companies is better than that of foreign property insurance companies [3]. Zou Huixia and Liu Yi (2015) focus on the allocation stage of funds and analyze how enterprises use the raised funds to create maximum returns. Their research shows that centrally controlled enterprises have higher financing efficiency [22].

The third perspective to define financing efficiency is based on the cost of capital integration and the benefits of using capital. Fang Fang and Zeng Hui (2005) comprehensively considered the process of raising funds and using funds, they believed that the less cost an enterprise pays in the financing process, the lower the risks it faces, and the greater the ultimate revenue, the higher the financing efficiency. Their research found that financing efficiency is proportional to ROE [5]. Liao Yan et al. (2017) also considered the cost of capital financing and the efficiency of using the financing, and found that the asset-liability ratio of SMEs on NEEQ was significantly negatively related to financing efficiency [11]. Wu Qingtian and Wang Qian (2020) believe that financing efficiency is the input-output ratio of capital, and their research found that the development quality of inclusive finance can effectively improve the financing efficiency of SMEs [17].

2.2 Financing Efficiency Measure

At present, scholars have mainly used entropy method, fuzzy evaluation method and data envelopment analysis method (DEA method) to measure financing efficiency.

Guo Ping et al (2012) comprehensively considered and determined indicators from multiple perspectives such as fundraising, fund allocation and corporate governance, and used the entropy method to study GEM companies. It is found that the level of financing efficiency is not optimistic, and the cost incurred by enterprises in the process of obtaining funds is relatively high. Large scale and low utilization of funds limit the improvement of financing efficiency [6].

Huang Qiong (2014) considered costs, risks and benefits when selecting factors, and used the fuzzy comprehensive evaluation method to study the difference between the efficiency of project financing and traditional financing. The results found that in most cases, the project financing method is more efficient [7]. Zhu Yaqin (2016) comprehensively considered the capital integration and output, selected multiple indicators such as capital cost, and used the fuzzy comprehensive evaluation method to analyze the SMEs in Liaoning Province. The results show that the internal financing efficiency of enterprises is the highest and the equity financing efficiency is the lowest [20].

Ren Haizhi and Xu Bingyu (2019) used the DEA-Malmquist index method to study the financing efficiency of biosmart industry companies, and found that the financing efficiency of biomass energy companies was decreasing [15]. Wu Yangfen and Zeng Fanhua (2019) used the DEA model to measure the financing efficiency of innovation-level companies on NEEQ, and the results showed that most companies have serious redundancy in investment, resulting in low financing efficiency^[18]. Bi Chao and Li Xiaowen (2019) also used the DEA model to study NEEQ companies, and found that after equity financing, the financing efficiency of the company has improved [1]. Deng Yingchun and Huang Xiaojun (2019) used the new energy enterprises in Jiangsu Province as a sample to conduct research through the DEA model and found that the level of financing efficiency is low, but the degree of utilization of funds by enterprises is constantly improving [4].

2.3 Factors affecting debt financing efficiency

At present, there are few studies on the influencing factors of debt financing efficiency in the literature, and most scholars study the influencing factors of financing efficiency. Therefore, this paper sorts out the literature in both aspects to provide reference for this study.

Through theoretical analysis, Zhu Yao (2013) pointed out that enterprise scale, growth ability, financing cost, financing structure and profitability will affect the debt financing efficiency of listed coal enterprises, but did not explore the specific impact of each factor through empirical evidence [21]. Liu Renqi (2018) conducted an empirical study on energy-saving and environmental protection enterprises, and found that the scale of the enterprise, the proportion of bank loans, the growth ability, the level of profitability and the operating period will have a positive impact on the efficiency of debt financing, while the scale of debt funds and the degree of majority shareholder control will have a negative impact on the efficiency of debt financing [14].

Lin Yan et al. (2019) explored the relationship between corporate credit, profitability and financing efficiency, and found that corporate credit rating, profitability and financing efficiency showed positive changes. The improvement of credit rating could increase the positive effect of profitability on financing efficiency [12].

Liu Chao et al. (2019) studied artificial intelligence industry companies through the DEA model and the Tobit model, and found that the profit level, capital structure, and growth ability of the company have a significant impact on the financing efficiency of the company [13]. Huang Yongfu (2020) also conducted research on listed logistics enterprises through DEA method and Tobit model, and found that capital utilization, growth ability, financing structure, profitability and operating ability have a significant positive impact on the financing efficiency of enterprises [9].

By reviewing the above literature, it can be found that there is no unified view on the definition of financing efficiency in academia. As for the measurement method of financing efficiency, the DEA model has gradually become the mainstream in recent years, and many scholars have used the traditional DEA model to measure and analyze the financing efficiency of companies in different industries. However, in the existing literature, there are few studies on the efficiency of corporate debt financing. Most of the literature only analyzes through the traditional DEA model, and there is a lack of quantitative research on the influencing factors of debt financing efficiency. Therefore, this paper refers to scholars' research on financing efficiency, pays attention to the integration and use of funds, and defines debt financing efficiency as the ability of enterprises to obtain debt funds at the lowest cost and use funds to obtain benefits. In the process of capital integration, the cost of debt capital and the ability to obtain capital are mainly considered, while the effect of capital use is comprehensively considered in the process of capital allocation. Based on the above definitions, this paper uses the traditional DEA model and the Malmquist index model to measure and analyze the debt financing efficiency of SMEs, then constructs a regression model to study its influencing factors to provide reference for SMEs.

3. Empirical Research Design

3.1 Research hypothesis

In order to facilitate the measurement of indicators to better carry out empirical work, this paper considers the influencing factors of debt financing efficiency from the enterprise level.

3.1.1 Scale

In this paper, total asset is used to measure the size of an enterprise. Generally speaking, if the scale of an enterprise is relatively large, it means that the overall strength of the enterprise is relatively strong, the ability to resist risks is relatively strong, and the default risk faced by debt investors is lower, so they will be more willing to invest in large-scale enterprises. Besides, when banks and other financial institutions issue loans, they have stricter financing requirements for small-scale enterprises, which will invisibly increase the capital cost of enterprises. Therefore, it is more convenient for larger

enterprises to carry out debt financing, and the cost of capital is also lower, which is conducive to improving the efficiency of debt financing. Formulate research hypothesis 1.

H1: The debt financing efficiency of SMEs is proportional to the size of the enterprise.

3.1.2 Debt financing amount

The amount of debt financing refers to the amount of funds an enterprise obtains through debt financing. This paper uses the asset-liability ratio to measure it. According to the trade-off theory, when a company has less debt, the tax shield effect can reduce the capital cost of the company. At this time, increasing the debt level is conducive to improving the debt financing efficiency of the company; but with the continuous increase of the debt ratio, the financial risk faced by the company is greater, the resulting negative effects will gradually offset the benefits brought by the tax shield effect. At this time, if the debt level is increased, the company will face financial difficulties and reduce the efficiency of debt financing. Due to their own conditions, SMEs are not easy to obtain equity financing, and relatively rely on debt financing, so they are prone to excessive debt. Research hypothesis 2.

H2: The debt financing efficiency of SMEs is inversely proportional to the amount of debt financing.

3.1.3 Solvency

The company's strong solvency means that the company has more liquidity and is not easy to fall into debt crisis. This sends a message to debt investors: the money they put in can be paid back on schedule, so investors are willing to provide capital. Enterprises with sufficient operating funds can better avoid financial risks caused by capital turnover problems, thus forming a virtuous circle, which has a positive effect on improving the efficiency of debt financing. In this paper, the current ratio is used to measure the solvency of the enterprise, and the research hypothesis 3 is put forward.

H3: The debt financing efficiency of SMEs is proportional to their solvency.

3.1.4 Operating capacity

Operating capacity represents the degree of capital utilization. The strong operating ability indicates that the enterprise has a high degree of capital utilization and reduces the waste of resources, which obviously has a positive impact on improving the efficiency of debt financing. This paper chooses the total asset turnover rate to measure it, and puts forward the research hypothesis 4.

H4: Debt financing efficiency of SMEs is proportional to operating capacity.

3.1.5 Profitability

Profitability reflects the company's ability to generate income, which is measured by ROE in this paper. Enterprises with strong profitability are more likely to obtain bank loans and attract debt investors to invest, which ensures that enterprises have sufficient funds and is conducive to improving the efficiency of debt financing. Formulate research hypothesis 5.

H5: Debt financing efficiency of SMEs is proportional to profitability.

3.1.6 Growth ability

Growth ability represents the development potential of an enterprise, which is measured by the growth rate of operating income in this paper. The current business situation of a company with strong growth potential may not be optimistic, so the cost of investing in the company at this time is low. Due to the good development prospects of the company, the current investment can get more returns in the future, which is very attractive to investors. Therefore, even if the current profit situation is not very good, growing enterprises can still obtain considerable funds, then use these funds to expand their productivity, and finally get a good return. Formulate research hypothesis 6.

H6: The debt financing efficiency of SMEs is proportional to their growth ability.

3.1.7 Innovation ability

Innovation ability reflects the market competitiveness of enterprise products. This paper selects the proportion of R&D investment to measure it. If a company has strong innovation capability, its products will be difficult to replicate in the short term, and it can monopolize the entire market, create huge profits for the company, and improve the efficiency of debt financing. Formulate research hypothesis 7.

H7: Debt financing efficiency of SMEs is proportional to innovation capability.

3.1.8 Ownership concentration

The ownership structure has an important impact on corporate governance. When the shareholding is too concentrated, it is difficult for small shareholders to exercise their power, and it is impossible to form effective supervision and management of large shareholders. At this time, the controlling shareholder may arbitrarily change the use of debt funds for personal gain and reduce the utilization efficiency of debt funds. This paper selects the shareholding ratio of the top ten shareholders to measure the shareholding concentration of the company, and puts forward the research hypothesis 8.

H8: Debt financing efficiency of SMEs is inversely proportional to equity concentration.

3.2 Empirical models

3.2.1 DEA model

The DEA model can deal with the efficiency evaluation problem of multiple inputs and multiple outputs. Compared with the single-index evaluation method, the DEA model is more comprehensive. The weights of each index are calculated by the model, and the results are more objective. Therefore, it is widely used in the research on efficiency. The measurement principle is to linearly program the input-output indicators of all individuals to obtain the effective frontier, and then calculate the relative efficiency according to the distance between each individual and the effective frontier.

The traditional DEA model includes the CCR model and the BCC model. The CCR model calculates the comprehensive technical efficiency value (TE), which in this paper represents the debt financing efficiency of the enterprise. The model assumes that the return to scale remains unchanged, that is, the manufacturer's input and output will increase year-on-year, which is obviously unsatisfied in reality. In this regard, the BCC model is supplemented, and the pure technical efficiency (PTE) is calculated under the condition of variable returns to scale, which in this paper represents the technical and management level of the enterprise. The specific form of the BCC model is as follows:

$$\min \left[\theta - \varepsilon \left(\sum_{i=1}^m s_i^- + \sum_{r=1}^s s_r^+ \right) \right] \quad (1)$$

$$\text{s.t.} \begin{cases} \sum_{j=1}^n x_{ij} \lambda_j + s_i^- = \theta x_{ij_0}, i \in (1, 2, \dots, m) \\ \sum_{j=1}^n y_{rj} \lambda_j - s_r^+ = y_{rj_0}, r \in (1, 2, \dots, s) \\ \sum_{j=1}^n \lambda_j = 1 \\ \theta, \lambda_j, s_i^-, s_r^+ \geq 0, j \in (1, 2, \dots, n) \end{cases} \quad (2)$$

x_{ij} is the i -th input of the j -th enterprise, y_{rj} is the r -th output of the j -th enterprise, s_i^- and s_r^+ is the slack variable and the residual variable, respectively, θ is pure technical efficiency value, ε is infinitesimal. λ_j is the weight of the j -th enterprise, and its specific value can be calculated through the model.

The comprehensive technical efficiency (TE) can be decomposed into pure technical efficiency (PTE) and scale efficiency (SE), namely $TE = PTE * SE$. Scale efficiency reflects the production scale of the enterprise. If the scale efficiency is effective, it means that the enterprise does not have redundant input and insufficient output [10]. When the pure technical efficiency and scale efficiency are both 1, the debt financing efficiency of the enterprise is in the optimal state, indicating that the enterprise has carried out effective debt financing.

3.2.2 Malmquist index model

The traditional DEA model can measure the relative efficiency to evaluate the efficiency of corporate debt financing. However, the effective frontier is different in different years. Therefore, the calculated debt financing efficiency values of each year are not convenient for direct comparison, and it is impossible to effectively analyze the year-on-year change trend of corporate debt financing efficiency. The Malmquist index model uses the ratio of the distance function at different times to measure the changes in productivity, so it can explore the dynamic changes in the efficiency of debt financing. In this model, changes in total factor productivity (tfpch) can be decomposed into changes in technical efficiency (effch) and changes in technological progress (techch), the specific forms are as follows

$$tfpch = \frac{D_0^{t+1}(x_{t+1}, y_{t+1})}{D_0^t(x_t, y_t)} \times \sqrt{\frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_{t+1}, y_{t+1})} \times \frac{D_0^t(x_t, y_t)}{D_0^{t+1}(x_t, y_t)}} \quad (3)$$

$$\frac{D_0^{t+1}(x_{t+1}, y_{t+1})}{D_0^t(x_t, y_t)} \text{ represents changes in technical efficiency, and } \sqrt{\frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_{t+1}, y_{t+1})} \times \frac{D_0^t(x_t, y_t)}{D_0^{t+1}(x_t, y_t)}}$$

represents changes in technological progress.

When the returns to scale are variable, the change in technical efficiency can be decomposed into pure technical efficiency change (pech) and scale efficiency change (sech), that is, $tfpch = techch \times effch = techch \times pech \times sech$ [13]. When these indices are greater than 1, it indicates that the corresponding efficiency has improved compared to last year, if it is less than 1, it indicates a decrease, and if it is equal to 1, it means that it is basically unchanged.

3.2.3 Tobit model

Since the efficiency value in this paper is between 0 and 1, which belongs to censored data, the OLS estimation will produce bias, while the Tobit model estimated by the maximum likelihood method can effectively solve this problem. Its basic form is as follows:

$$y_i^* = \beta X_i + \varepsilon_i \quad (4)$$

$$y_i = \begin{cases} 0 & \text{if } y_i^* \leq 0 \\ y_i^* & \text{if } y_i^* > 0 \end{cases} \quad (5)$$

y_i is the explained variable, X_i is the explanatory variable, and ε_i is the random disturbance term.

3.3 Variables and data

3.3.1 Input indicators

(1) Total asset

Total asset reflects the business scale of an enterprise. When the scale of the enterprise is large, the debt investors are more willing to provide funds, so the total asset reflects the debt financing ability to a certain extent.

(2) Asset-liability ratio

The asset-liability ratio reflects the scale of debt financing. When the scale of corporate debt financing is large, it needs less self-owned funds. If the business is in good condition, it can effectively use financial leverage to create profits, but it will also make the company face relatively large financial risks at the same time. Once there is a problem with capital turnover, it will inevitably have an adverse impact on the enterprise. Therefore, the asset-liability ratio also reflects the risk of debt financing to a certain extent.

(3) Debt ratio of financial expenses

Financial expenses debt ratio reflects the cost of obtaining and using debt funds [16]. If the cost is too large, it will seriously reduce the operating efficiency of the enterprise and make financing activities meaningless.

3.3.2 Output indicators

(1) Return on equity

ROE reflects profitability and evaluates the use effect of funds from the current period.

(2) Growth rate of operating income

The growth rate of operating income reflects the change in the revenue created by the company compared to the previous period, and evaluates the operating efficiency of the company from a long-term perspective.

(3) Total asset turnover ratio

The total asset turnover rate reflects the turnover capacity of the enterprise and evaluates the utilization of funds as a whole.

Table 1. Indicator Description

Indicator type	Indicator name	Calculation	Indicator meaning
input indicator	Total asset	The natural logarithm of total asset	Debt financing capacity
	Asset-liability ratio	Total Liabilities/Total Assets	Debt financing size and risk
	Debt ratio of financial expenses	Finance Charges/Liabilities	Debt financing costs
output indicator	Return on equity	Net Profit/Shareholders' Equity	corporate profitability
	Growth rate of operating income	(Operating income of the current period - operating income of the previous period)/operating income of the previous period	business growth
	Total asset turnover ratio	Operating Income/Average Total Assets	Efficiency of the use of funds

3.3.3 Variables

Table 2. Variable Description

variable name	Variable symbols	Calculation	Variable meaning
Comprehensive technical efficiency	TE	Comprehensive technical efficiency	Debt Financing Efficiency
Total assets	SIZE	The natural logarithm of total assets	Enterprise size
Asset-liability ratio	LEV	Total Liabilities/Total Assets	Debt financing amount
current ratio	Current	Current assets/current liabilities	solvency
Total asset turnover ratio	AT	Operating Income/Average Total Assets	Operating capacity
Return on equity	ROE	Net Profit/Shareholders' Equity	Profitability
Growth rate of operating income	Growth	(Operating income of the current period - operating income of the previous period)/operating income of the previous period	growth ability
R&D investment	RD	R&D expenditure/operating income	Innovation ability
Shareholding ratio of the top ten shareholders	Top10	Top 10 Shareholder Shares/Total Shares	Ownership concentration

This paper chooses the comprehensive technical efficiency value (TE) as the explained variable. According to the above analysis of the factors affecting the efficiency of debt financing, we select the total asset, asset-liability ratio, current ratio, total asset turnover ratio, return on equity, operating income growth rate, R&D investment ratio and shareholding ratio of top ten shareholders as explanatory variables. The specific meaning of each variable is shown in Table 2.

3.3.4 Data

Based on the consideration of data availability and sample representativeness, this paper selects listed A-share companies in China as a sample of SMEs in accordance with the "Regulations on the Classification of Small and Medium-Sized Enterprises", and the sample interval is from 2017 to 2020. After screening out financial companies, ST companies and companies with serious data missing, there are a total of 608 companies.

The use of the DEA model needs to meet the conditions that the input and output indicators are all positive, and the above indicators such as return on equity, financial expenses, operating income growth rate and other indicators will inevitably have negative values. At the same time, due to the large difference in magnitude between absolute indicators such as total asset and other relative indicators, there may be large errors in the calculation of debt financing efficiency. Therefore, this paper refers to the practice of Cao Weixing (2020), and performs dimensionless processing on the original data without changing the original data relationship, so that all of them become positive values in the range of 0-1 [2]. The specific processing method is as follows:

$$\bar{X}_{ij} = 0.1 + 0.9 \times \frac{X_{ij} - m_j}{M_j - m_j} \quad (6)$$

$\bar{X}_{ij}$ is the processed data, X_{ij} is the original data, and M_j and m_j represent the maximum and minimum values of the j th indicator, respectively. In order to avoid the influence of extreme values, this paper performs 1% tail reduction processing on both ends of all continuous variables.

4. Results

4.1 Debt financing efficiency measurement results

4.1.1 Static analysis

Based on the above input-output indicators, the debt financing efficiency of the sample companies from 2017 to 2020 is estimated. Referring to the research of Wu Yangfen (2019) [18], the measured debt financing efficiency values are divided, as shown in Table.3.

Table 3. Classification of Debt Financing Efficiency Levels

Financing Efficiency Value	$0 < e < 0.5$	$0.5 \leq e < 0.8$	$0.8 \leq e < 1$	$e = 1$
Financing efficiency division	ineffective	less efficient	high efficiency	optimal efficiency

According to the division of financing efficiency value in the above table, the calculation results of corporate debt financing efficiency are sorted out, see Table.4. for details.

Table 4. Debt financing efficiency measurement results

2017	TE		PTE		SE	
	Number	proportion	Number	proportion	Number	proportion
$0 < e < 0.5$	213	35.03%	195	32.07%	2	0.33%
$0.5 \leq e < 0.8$	333	54.77%	324	53.29%	18	2.96%
$0.8 \leq e < 1$	41	6.74%	50	8.22%	540	88.82%
$e = 1$	21	3.46%	39	6.42%	48	7.89%
Total	608	100%	608	100%	608	100%
mean	0.577		0.604		0.960	
2018	TE		PTE		SE	
	Number	proportion	Number	proportion	Number	proportion
$0 < e < 0.5$	355	58.39%	312	51.32%	8	1.32%
$0.5 \leq e < 0.8$	187	30.76%	216	35.53%	48	7.89%
$0.8 \leq e < 1$	41	6.74%	34	5.59%	506	83.23%
$e = 1$	25	4.11%	46	7.56%	46	7.56%
Total	608	100%	608	100%	608	100%
mean	0.506		0.542		0.935	
2019	TE		PTE		SE	
	Number	proportion	Number	proportion	Number	proportion
$0 < e < 0.5$	306	50.33%	270	44.41%	8	1.32%
$0.5 \leq e < 0.8$	242	39.80%	254	41.78%	41	6.74%
$0.8 \leq e < 1$	36	5.92%	34	5.59%	516	84.87%
$e = 1$	24	3.95%	50	8.22%	43	7.07%
Total	608	100%	608	100%	608	100%
mean	0.532		0.568		0.941	
2020	TE		PTE		SE	
	Number	proportion	Number	proportion	Number	proportion
$0 < e < 0.5$	283	46.55%	237	38.98%	6	0.98%
$0.5 \leq e < 0.8$	258	42.43%	278	45.72%	64	10.53%
$0.8 \leq e < 1$	42	6.91%	45	7.40%	490	80.59%
$e = 1$	25	4.11%	48	7.90%	48	7.90%
Total	608	100%	608	100%	608	100%
mean	0.544		0.585		0.935	

In 2017, only 21 SMEs were able to obtain effective debt financing, accounting for only 3.46%. The average comprehensive technical efficiency of SMEs is 0.577, and the overall level is low, indicating that the debt financing efficiency of most enterprises is not high, and they need to improve in terms of capital operation management and allocation of input resources. The mean of pure technical efficiency is 0.604, which is lower than scale efficiency, indicating that pure technical efficiency mainly limits the efficiency of debt financing.

In 2018, the number of sample companies that were able to carry out effective debt financing became 25, a slight increase compared to 2017. The number of companies with low pure technical efficiency changed greatly, and their proportion changed from 32.07% to 51.32%. The number of SMEs with optimal scale efficiency and high scale efficiency has decreased compared to last year, but the overall change is not large, with a change ratio of 5.92%. It can be seen that the average decrease in debt financing efficiency in 2018 was jointly affected by pure technical efficiency and scale efficiency, and pure technical efficiency had a greater impact. Observing the mean can also find that the pure technical efficiency of SMEs in 2018 is still low, which is the main reason for restricting the improvement of debt financing efficiency.

In 2019, the number of sample enterprises capable of effective debt financing became 24, a slight decrease compared with 2018; the number of SMEs with pure technical efficiency reaching DEA

effectiveness increased compared with last year, while the number of SMEs with scale efficiency reaching DEA efficiency has decreased. This shows that the decline in scale efficiency has resulted in fewer SMEs with effective debt financing in the year. However, the mean of scale efficiency is still higher than the pure technical efficiency, which shows that although some enterprises have improved their management level, the overall level of pure technical efficiency is still low due to the small improvement, which inhibits the improvement of debt financing efficiency.

In 2020, the number of sample enterprises that can carry out effective debt financing became 25, a slight increase compared with 2019; the number of enterprises whose pure technical efficiency has reached DEA effectiveness has decreased, and the number of enterprises whose scale efficiency has reached DEA effectiveness has increased. The overall change is not significant. Pure technical efficiency is still the main factor restricting the efficiency of debt financing.

Looking at the 4-year data, it can be seen that the debt financing efficiency of SMEs from 2017 to 2020 has always been relatively low. On one hand, the poor internal management of the enterprise and insufficient technological innovation ability lead to the decline of pure technical efficiency; on the other hand, the scale efficiency declines due to the unreasonable scale of input and output. Observing the mean value, it can be seen that the overall scale efficiency level of SMEs is stable at a high level, while the pure technical efficiency level is low. Therefore, improving the management and technical level of SMEs has become the key to improving their financing efficiency. Further analysis shows that from 2017 to 2019, the number of SMEs that have achieved scale efficiency has a downward trend year by year, and this trend will also have a qualitative impact on the efficiency of debt financing to a certain extent. Therefore, while improving the internal management of the enterprise, the scale of input and output should also be adjusted accordingly, and the efficiency of the utilization of funds should be improved, thereby improving the overall debt financing efficiency of the enterprise.

4.1.2 Dynamic Analysis

In order to further explore the year-by-year change trend of SMEs' debt financing efficiency, this paper uses the Malmquist index model to decompose the changes in debt financing efficiency. The results are shown in Table.5.

Table 5. Malmquist results

years	effch	techch	pech	sech	tfpch
2017—2018	1.076	0.905	1.015	1.059	0.973
2018—2019	1.06	1.092	1.081	0.981	1.158
2019—2020	1.054	0.85	1.053	1.001	0.896
mean	1.063	0.944	1.049	1.013	1.003

From the end of 2017 to the end of 2018, the total factor productivity change index of SMEs was 0.973, indicating that the overall debt financing efficiency of SMEs declined in 2018. By observing the results of its decomposition, the technical efficiency change index is 1.076, indicating that the technical efficiency level of SMEs has increased in this year; the technological progress change index is 0.905, indicating that the overall technical level of the enterprise has declined, resulting in a decrease in the efficiency of debt financing for SMEs in the year.

From the end of 2018 to the end of 2019, the total factor productivity change index of SMEs was 1.158, indicating that the debt financing efficiency of SMEs increased during 2019. Observing the results of its decomposition, the technical efficiency change index and the technological progress change index are both greater than 1, indicating that the improvement of the efficiency of debt financing of SMEs is affected by the progress of both, and the positive impact of technological progress is greater. Observing the decomposition results of the technical efficiency change index, it can be seen that the scale efficiency change index is less than 1, indicating that the unreasonable production scale of enterprises in 2019 is the main reason for limiting the improvement of their technical efficiency.

From the end of 2019 to the end of 2020, the total factor productivity change index of SMEs was 0.896, indicating that the overall level of debt financing efficiency of SMEs decreased in 2020. By observing the results of its decomposition, the change index of technological progress is 0.85, which indicates that the technological level of enterprises has declined greatly, which reduces the efficiency of debt financing.

Observing the three-year average, the change index of total factor production efficiency is greater than 1, indicating that the overall efficiency of debt financing of enterprises is on the rise. The change index of technological progress is 0.944, indicating that the overall technical level of enterprises has declined. The mean of the scale efficiency change index is 1.013, indicating that the enterprise is constantly optimizing its own input-output scale and improving the utilization efficiency of funds. However, if only focus on adjusting the scale of the enterprise without improving the technical level, it will lead to a mismatch between the technical level and the scale of the enterprise, resulting in a waste of resources. Therefore, in order to better improve the debt financing efficiency of SMEs, we should focus on improving the technical level of enterprises while optimizing the scale of enterprises, so as to ensure that resources can be effectively used.

4.2 Empirical results of factors affecting debt financing efficiency

4.2.1 Descriptive analysis

Descriptive statistics are carried out on the above variables, and the results are shown in Table.6.

Table 6. Descriptive Statistics

VARIABLES	N	mean	sd	min	max
TE	2,432	0.540	0.185	0.107	1
SIZE	2,432	2.040e+09	2.021e+09	3.719e+08	1.317e+10
LEV	2,432	0.304	0.170	0.048	0.768
Current	2,432	3.635	3.129	0.579	18.180
AT	2,432	0.566	0.380	0.091	2.493
RD	2,432	6.325	5.285	0.100	28.320
ROE	2,432	0.048	0.157	-0.988	0.310
Top10	2,432	60.500	13.460	23.690	84.450
Growth	2,432	0.322	0.785	-0.748	5.410

According to the results of descriptive statistics, it can be seen that:

(1) The mean of total assets is 2.04e+09, indicating that the scale of sample enterprises is small. The average comprehensive technical efficiency is 0.54, indicating that the overall debt financing efficiency of SMEs is low.

(2) The maximum value of the asset-liability ratio is 0.768, and the minimum value is 0.048, indicating that SMEs have a certain degree of debt, and the debt levels of different enterprises vary greatly, and some enterprises have excessive debt problems.

(3) The mean of the current ratio is 3.635, which means that the company has strong capital liquidity and strong ability to resist risks. The mean of the turnover rate of total assets is 0.566, indicating that the operating ability of the enterprise is not strong, and the utilization of funds is low.

(4) The return on equity has a negative value, indicating that the operating conditions of different enterprises are quite different. Some enterprises have good operating conditions and benefit more, which can reduce the demand for debt funds, while some enterprises are in a state of loss and need more external financing. The average return on equity is 0.048, indicating that the overall profitability of SMEs is not optimistic.

(5) The average growth rate of operating income is 0.322, indicating that most enterprises have strong growth ability and considerable development prospects.

(6) The average ratio of R&D investment is 6.325%, indicating that most SMEs have a low level of investment in innovation.

(7) The average shareholding ratio of the top ten shareholders is 60.5%, indicating that the equity distribution of the enterprise is relatively balanced.

4.2.2 Regression results

In this paper, an individual random effect Tobit model is established in the following form:

$$TE_{it} = \beta_0 + \beta_1 SIZE_{it} + \beta_2 LEV_{it} + \beta_3 Current_{it} + \beta_4 AT_{it} + \beta_5 RD_{it} + \beta_6 ROE_{it} + \beta_7 TOP10_{it} + \beta_8 Growth_{it} + \varepsilon_{it} \quad (7)$$

β_0 is a constant term, $\beta_1 \sim \beta_8$ is the coefficient of each explanatory variable, and ε_{it} is a random disturbance term.

Regression is performed according to the established model, and the results are shown in Table.7.

Table 7. Regression Results

	Coef.	Std. Err.	z	P> z
lnSIZE	-0.104***	0.004	-27.730	0.000
LEV	-0.134***	0.019	-7.060	0.000
Current	0.028***	0.001	27.710	0.000
AT	0.138***	0.007	19.170	0.000
ROE	0.157***	0.012	13.370	0.000
RD	0.001***	0.000	2.670	0.008
Growth	0.074***	0.002	32.570	0.000
Top10	-0.001***	0.000	-7.400	0.000
cons	2.654***	0.081	32.920	0.000

Note: ***, **, * indicate significant at the 1%, 5%, and 10% significance levels, respectively, the same below.

From the regression results, it can be seen that each explanatory variable has passed the test at the 1% significance level, indicating that these factors can have a significant impact on the debt financing efficiency of enterprises. Among them, current ratio, total asset turnover ratio, ROE, R&D investment ratio, operating income growth rate have a positive relationship with debt financing efficiency, while total asset, asset-liability ratio, top ten shareholders' shareholding ratio have a negative relationship with debt financing efficiency.

From the above results, it can be seen that, except Hypothesis 1, all the other hypotheses have been verified. According to the analysis of the debt financing efficiency of SMEs above, the pure technical efficiency of debt financing of SMEs is currently low, while the scale efficiency is high. Therefore, this situation may be due to the fact that many enterprises do not pay attention to improving the management level of enterprises and blindly expand their scale to pursue economies of scale, resulting in serious redundancy in investment and ineffectiveness of economies of scale.

4.3 Robustness check

In order to further verify the reliability of the regression results, this paper refers to the research of Li Dan (2020) [10], and selects pure technical efficiency (PTE) instead of comprehensive technical efficiency (TE) to measure debt financing efficiency, and other explanatory variables remain unchanged. The comparative regression results are shown in Table.8.

Table 8. Robustness Test Results

VARIABLES	TE	PTE
lnSIZE	-0.104*** (-27.73)	-0.094*** (-19.58)
LEV	-0.134*** (-7.06)	-0.065*** (-2.65)
Current	0.028*** (27.71)	0.031*** (23.82)
AT	0.138*** (19.17)	0.227*** (23.61)
ROE	0.157*** (13.37)	0.102*** (6.76)
RD	0.001*** (2.67)	0.003*** (5.13)
Growth	0.074*** (32.57)	0.086*** (27.93)
Top10	-0.001*** (-7.40)	-0.002*** (-7.10)
Constant	2.654*** (32.92)	2.398*** (23.25)

Compared with the regression results of the original model, the signs of the regression coefficients have not changed, and the influence of each explanatory variable is also significant, so the regression results of the original model are robust and reliable.

5. Conclusions

This paper uses the traditional DEA model and the Malmquist index model to measure the debt financing efficiency of SMEs, and then constructs a regression model to empirically study its influencing factors, and draws the following conclusions:

(1) At present, the overall debt financing efficiency of SMEs is relatively low. There are few enterprises that can achieve optimal efficiency, and most enterprises still have a lot of room for improvement.

(2) From the decomposition results of comprehensive technical efficiency, the scale efficiency of SMEs is much higher than pure technical efficiency, indicating that the input-output scale of most enterprises is in a relatively good state, while the management and technical level of enterprises still need to be improved. The low pure technical efficiency limits the improvement of corporate debt financing efficiency.

(3) Judging from the dynamic changes in the past four years, the overall debt financing efficiency of SMEs shows an upward trend, and the advancement or regression of the overall technology of SMEs will have a co-directional impact on the efficiency of debt financing.

(4) From the perspective of influencing factors, solvency, growth ability, operating ability, profitability, and R&D investment are positively related to debt financing efficiency, while the scale of enterprises, the amount of debt financing and the degree of majority shareholder holding are negatively related to debt financing efficiency.

Based on the above results, this paper puts forward the following countermeasures and suggestions:

First, SMEs should focus on improving their own management level. Due to the particularity of SMEs, their scale limits the development of enterprises, so most SMEs are very concerned about the expansion of scale, but at the same time they ignore the importance of internal management of enterprises. In fact, the difficulty in improving the efficiency of SMEs in debt financing is mainly due to the limitation of pure technical efficiency. Therefore, while focusing on economies of scale,

enterprises should also strengthen the management of corporate financing and improve the efficiency of capital utilization, thereby improving the efficiency of corporate debt financing.

Second, strengthen the technological innovation of enterprises. The study found that the technological change of SMEs is the main reason affecting the change of debt financing efficiency, and increasing R&D investment has a positive effect on improving debt financing efficiency. Therefore, SMEs should increase investment in technological innovation, cultivate innovative talents, and improve the core competitiveness of products, thereby improving the profitability of enterprises and promoting the improvement of debt financing efficiency.

Third, pay attention to controlling the ownership structure of the company. Research shows that the equity concentration of SMEs is negatively related to the efficiency of debt financing, indicating that the equity of the company is too concentrated, and the decision-making power of the company will fall in the hands of a few shareholders. These controlling shareholders may arbitrarily change the use of debt funds for their own interests, reducing the utilization efficiency of funds, resulting in waste of resources, thereby increasing the cost of enterprises and reducing the efficiency of debt financing. Therefore, enterprises should control the equity concentration to a reasonable level according to their own conditions.

Last, improve the financing structure of enterprises and carry out moderate debt financing. The empirical results show that the higher the debt ratio of SMEs, the lower the level of debt financing efficiency, which indicates that the excessive borrowing of SMEs increases the financial risks and the cost of various aspects, and reduces the debt financing efficiency. Therefore, enterprises should adopt diversified financing methods to obtain the funds and reduce their dependence on debt financing. By continuously optimizing the financing structure of the enterprise, the enterprise can make the debt level reach the optimal state, maximize the benefits brought by the tax shield effect, and improve the debt financing efficiency of the enterprise.

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