

The Influence of Financing Constraints on the Improvement of Enterprise Technical Efficiency-An Empirical Study Based on Micro-Data of Grain and Oil Processing Industry

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Received: 9 March 2024; Accepted: 23 March 2024; Published: 11 April 2024

Abstract:

Based on the financial data of grain and oil processing enterprises listed on A-shares in China from 2003 to 2020, this paper uses stochastic frontier model to measure the technical efficiency of grain and oil processing enterprises, and explores the influence of financing constraints on the technical efficiency of grain and oil processing enterprises. It is found that financing constraint is a problem widely faced by enterprises at present, which has a significant inhibition effect on the technical efficiency of grain and oil processing enterprises. Therefore, solving the problem of enterprise financing constraint is of great significance for the efficient transformation and development of grain industry. After the classification and discussion of the samples, it is found that there is significant heterogeneity in the negative impact of financing constraints on the technical efficiency of grain and oil processing enterprises.

Keywords:

Grain and Oil Processing Enterprises, Technical Efficiency, Stochastic Frontier Model, Financing Constraint

1. Introduction

Grain, the foundation of people's livelihood, is also the main raw material of modern industry. Grain and oil processing industry is the core industry connecting agriculture and modern industry [1]. In recent years, China's grain and oil processing industry has been developing and growing, and the overall production capacity of grain and oil processing enterprises has been greatly increased [2]. In 2021, the National Food and Strategic Reserves Administration said that China's food emergency processing capacity in one day can meet the needs of the people of the whole country for 2 days. However, grain and oil processing enterprises generally

have problems such as too short processing industry chain, and even some grain and oil processing enterprises have poor operating performance and losses [3]. How to improve the production performance of grain and oil processing enterprises and what factors affect the technical efficiency of enterprises have been concerned by scholars. Grain and oil processing enterprises are a special kind of manufacturing enterprises, and the factors affecting their technical efficiency are similar to those of manufacturing enterprises. Many scholars have studied and analyzed the influencing factors, but few studies have discussed the influence on the technical efficiency of grain and oil processing enterprises from the perspective of capital and finance.

It is of great theoretical and practical significance to study the influence of financing constraints on the technical efficiency of grain and oil processing enterprises [4]. First of all, as a special manufacturing enterprise, grain and oil processing enterprises, like general manufacturing enterprises, have their technical efficiency affected by macro-environment and micro-enterprise individual factors, which have been discussed and studied by many scholars, while there is still a lot of room for research in terms of financial financing and other factors. The research on the influence of financing constraints on the technical efficiency of grain and oil processing enterprises can enrich the research on the influencing factors of technical efficiency to a certain extent and broaden the research horizon. Secondly, financing constraints are a practical problem faced by many small, medium and micro enterprises in China [5]. Financing difficulties and high financing costs make many small, medium and micro enterprises unable to obtain sufficient funds in time, which affects normal operation and scale expansion and has a significant negative impact on the technical efficiency of enterprises. The research in this paper can help enterprises, especially small, medium and micro enterprises, to improve their business performance and provide some policy suggestions. In addition, grain and oil processing enterprises are an important part of the grain industry chain[6]. For enterprises, the level of technical efficiency determines the level of output to a large extent and greatly affects the business performance. Studying the impact of financing constraints on the technical efficiency of grain and oil processing enterprises can help improve the technical efficiency level of grain and oil processing industry and improve the business performance. Thus to realize the grain processing of deep processing and industrial chain extension.

This paper intends to take financing constraints as the core factor affecting the technical efficiency of grain and oil processing enterprises, and further investigate how financing constraints and other factors affect the technical efficiency and business performance of grain and oil processing enterprises. The arrangement of this paper is as follows: This part is divided into the introduction, starting from the research background and research significance, leading to the research content of this paper; The second part is literature review, sorting out and analyzing the existing literature research. The third part is the theoretical analysis of the influence of financing constraints on the technical efficiency of grain and oil processing enterprises. The fourth part is the empirical analysis of the impact of financing constraints on the technical efficiency of grain and oil processing enterprises, using the data to build an econometric model for regression analysis; The last part is the conclusion and policy suggestions, from the whole point of view, gives the conclusion of this paper and feasible policy suggestions.

2. Literature Review

There are quite a number of literatures that have analyzed the factors affecting enterprise technical efficiency and the impact of financing constraints on enterprise performance and achieved significant research results. This paper will sort out the writing ideas and literature basis of this paper from four aspects, namely, the measurement of technical efficiency, the research on the factors affecting the technical efficiency of enterprises and grain and oil processing enterprises, and the research on the impact of financing constraints on enterprise performance [7]. To establish a mechanism framework for discussing the influence of financing constraints on the technical efficiency of grain and oil processing enterprises.

2.1. *Research on the measurement of technical efficiency*

The measurement of technical efficiency was first proposed by Farrell, and the enterprise's ability to reduce the cost of input as much as possible under the given output is regarded as the enterprise's technical efficiency, which is defined from the perspective of input. From the perspective of output, technical efficiency is the ability of a firm to produce as much output as possible given the given input cost. On this basis, Afriat combines technical efficiency and production possibility boundary, comparing the actual output with the maximum output, the smaller the output difference, the greater the technical efficiency [8].

There are two main methods to measure technical efficiency. One is the parameter estimation method, which regards the part of the production function that cannot be explained by the production factors as the technical efficiency of the enterprise, represented by stochastic frontier production function analysis (SFA). For example, Li Gang used stochastic frontier model (SFA) and C-D production function through empirical calculation and found that collective cooperation of farmers can significantly help improve farmers' technical efficiency. The second is non-parametric estimation method, which measures the technical efficiency by the input that can be saved under the same output, represented by data envelopment analysis (DEA). For example, Chen Xiulan used data envelopment method (DEA) to find that enterprise size has a significant positive impact on technical efficiency, and Yang Xue et al. used DEA-Malmquist index method to reach a similar conclusion.

2.2. *Research on influencing factors of enterprise technical efficiency*

As the most basic economic individual unit, enterprise management is often affected by many factors. At the macro level of enterprises, the ownership structure of enterprises often directly affects the business objectives of enterprises, and non-state-owned enterprises usually have higher technical efficiency than state-owned enterprises. Similarly, large enterprises are more likely to have economies of scale and have higher technical efficiency. In addition, the government's economic policies constitute an important part of the market economy environment, and fiscal and tax policies also have a significant impact on the technical efficiency of enterprises.

At the micro level of enterprises, technology level, informatization level and human capital status of employees can directly affect the total factor productivity and technical efficiency of enterprises, and R&D investment can directly affect the technological progress of enterprises, thus helping to improve the technical efficiency of enterprises. However, this influence is heterogeneous among different industries and regions. The ability of enterprises to control their own industrial chain can help

enterprises fight against the risk of economic fluctuations and help improve technical efficiency. In addition, some scholars have found that the greater the financing constraints on enterprises, the more difficult it is for enterprises to obtain funds, which inhibits the technical efficiency.

2.3. Study on influencing factors of technical efficiency of grain and oil processing enterprises

For grain and oil processing enterprises, due to the particularity of grain, cost plays a decisive role in it, and technological progress and enterprise scale that can help reduce costs have a significant role in promoting technical efficiency. Wu Wentan et al. used the three-stage DEA model to measure the technical efficiency of listed grain and oil processing enterprises in China, and found that ownership concentration, diversification and financial subsidies had significant effects on technical efficiency. Further, Yan Han et al. found through empirical research that the implementation of the minimum purchase price policy can help improve the technical efficiency of the grain processing industry, but this impact has regional heterogeneity.

2.4. The impact of financing constraints on firm performance

Financing constraints refer to the fact that an enterprise cannot obtain sufficient financial support from the outside in a timely manner. Generally, the financing constraints and the degree of constraints imposed on an enterprise cannot be directly reflected in financial statements, but they can be indirectly reflected by some financial data. Whether external funds will choose to invest in the enterprise determines whether the enterprise will be affected by financing constraints. Investors or financial institutions usually consider the business performance and financial status of the enterprise when making decisions, that is, the scale of the enterprise, leverage ratio, age of the company, whether financial institutions hold shares, net cash flow and other financial data. Therefore, these financial data can be used as proxy variables to reflect the financing constraints of enterprises. In addition to these proxy variables, models such as investment-cash flow sensitivity (FC index), SA index, WW index and KZ index can also be used to measure financing constraints.

The financing constraint problem of enterprises indicates that enterprises cannot obtain sufficient financial support, so they may be forced to give up some projects that may incur losses in the short term but will help improve production efficiency in the long run, and cannot purchase more efficient production machines, thus inhibiting the improvement of production efficiency. This is a view widely recognized by many scholars. However, some scholars hold the opposite view. Ju Xiaosheng et al. used the data of non-listed enterprises in China from 1998 to 2008 and the SA index method to measure the degree of financing constraints on enterprises, and found that the stronger the external financing constraints on enterprises, the more prominent the role of internal working capital on enterprise innovation. In other words, enterprises can realize innovative activities through internal capital turnover under the condition of financing constraints.

2.5. A review of the existing literature

Through the collation and analysis of the existing literature, it can be found that since the concept of technological efficiency was put forward, the measurement of technological efficiency and the research on influencing factors of technological efficiency have achieved a wealth of theoretical research results. From

macroeconomic environmental factors to individual internal factors of enterprises, the factors affecting enterprise technological efficiency are complex and diverse. As a kind of special manufacturing enterprises, grain and oil processing enterprises have obtained abundant results in the research on their technical efficiency. However, the existing literature may also have some deficiencies in the research on technical efficiency, and the research on the impact of financial financing on technical efficiency is slightly insufficient. And financing constraints are exactly the problems faced by many small, medium and micro enterprises, which has certain practical guiding significance for invigorating enterprise vitality from the outside. In view of this, on the basis of existing relevant literature, this paper intends to study the determinants of technical efficiency of grain and oil processing enterprises from the perspective of financing constraints, and explore ways for enterprises to improve technical efficiency.

3. Theoretical Analysis

Financing constraints refer to the inability of enterprises to obtain adequate financial support from the outside in a timely manner due to some macroeconomic environmental factors or internal financial difficulties. This phenomenon is a problem widely faced by small and medium-sized enterprises in our country, and the main causes of financing constraints are: because of information asymmetry makes banks and other financial institutions can not fully understand the financial situation of enterprises, so as to put forward higher interest requirements or guarantee conditions, improve the financing cost of enterprises; The financial institutions of banks are more inclined to provide loans to large enterprises with stronger repayment ability within the limited total loan amount, and it is difficult for small, medium and micro enterprises to obtain loan support. Due to economic fluctuations, the company has been poorly operated in the near future and suffered serious financial losses (Figure 1). As a result, the company cannot jump into credit through banks and other financial institutions and thus cannot obtain financial support. Due to the imperfection of the financial money market, the channels for enterprises to obtain financial support from the outside are limited, and it is difficult for enterprises to obtain external funds.

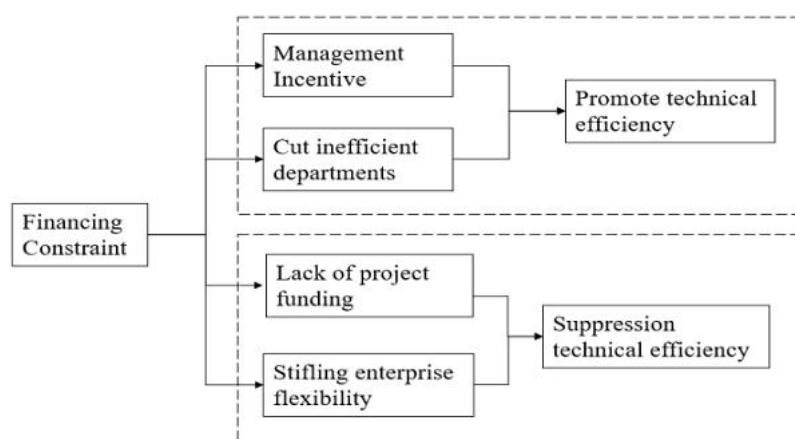


Figure 1. Mechanism diagram of the impact of financing constraints on technical efficiency.

By combing relevant theories and existing literature, this paper believes that the impact of financing constraints on enterprise technical efficiency can be described from the following two aspects. On the one hand, financing constraints mean that enterprises cannot normally obtain sufficient funds from the outside, which may disrupt the business plan of enterprises, making enterprises unable to carry out some

projects with large short-term investment but which will improve the production efficiency of enterprises in the long run, which is not conducive to the improvement of long-term technical efficiency of enterprises. Affected by financing constraints, enterprises are unable to further develop new production departments, purchase new production equipment, and introduce advanced management and technical talents, and are restricted in existing fields, unable to enter areas with stronger profitability, and thus unable to improve the overall technical efficiency of enterprises. On the other hand, when an enterprise is subject to relatively severe financing constraints, it may cause serious financial crisis, which is very unfavorable to the management of the enterprise. In order to obtain normal salary conservatism, the managers will also consider solving this problem and maintain the normal operation of the enterprise by stimulating their managers. Managers will think more carefully about the use and flow of funds to improve the production efficiency of enterprises as much as possible. Some production departments of enterprises may have problems such as low production efficiency. In the case of financing constraints, enterprises can reduce unnecessary personnel expenses, shut down some inefficient departments, relieve internal capital pressure, and better invest in technological innovation, so as to improve the technical efficiency of enterprises.

4. Model and Variable Setting

With reference to the municipal process in previous literatures and the theoretical analysis above, this paper carries out empirical research design, including data selection, variable setting and model setting, and analyzes the final empirical results.

4.1. Data source and description

Based on the consideration of data availability and model setting, this paper selects the annual financial data of A-share listed grain and oil processing enterprises from 2003 to 2020, and the data is from the CSMAR database of Guotai 'an. This paper studies the impact of financing constraints on the technical efficiency of grain and oil processing enterprises. For grain and oil processing enterprises, this paper selects them from the CSMAR database of Guotai 'an, and selects the enterprises engaged in grain and vegetable oil production and processing and liquor brewing as grain and oil processing enterprises in the business scope. After sorting out, enterprises with short listing time and other abnormal enterprises are excluded. Finally, 87 sample enterprises were obtained, with a total of 1075 sample data.

4.2. Variables and indicators

This paper studies the impact of financing constraints on the technical efficiency of grain and oil processing enterprises. Based on the reference of relevant literature, this paper selects the core explained variable as technical efficiency, adopts the translog-stochastic frontier production function method (SFA) for calculation, and selects the core explanatory variable as the degree of financing constraints of enterprises. At the same time, other relevant financial data such as net operating cash flow and whether financial institutions hold shares are selected as control variables.

In this paper, the core explanatory variable is selected as financing constraint, but the degree of financing constraint faced by enterprises cannot be directly reflected in the financial data of enterprises. Therefore, three proxy variables and indicator methods are selected in this paper to indirectly reflect the degree of financing constraint faced by enterprises. The first is the proxy variable method. This paper

selects enterprise size (size), leverage ratio (r_{lev}) and company age (age) as proxy variables of financing constraints. It is generally believed that the larger the scale of the enterprise, the stronger the capital of the enterprise, usually has better operation ability, banks and other financial institutions and investors are more willing to lend or invest in it, the lower the degree of financing constraints the enterprise is subject to. In addition, in order to reduce the variance between sample data and reduce the impact of outliers, logarithm processing ($\ln size$) was performed for enterprise size. The leverage ratio reflects the overall debt level of the company. The lower the leverage ratio, the lower the debt level of the company, the smaller the financial risk it faces and the lower the default risk. Banks and other financial institutions are more willing to issue loans for the company, and the lower the financing constraint the company is subject to. The age of the company refers to the time when the company was established. Generally speaking, the longer the company is established, the more and better market trading relationships can be formed, the lower the operating risk, the stronger the profitability of the company, the easier it is to obtain external financial support, and the lower the degree of financing constraints it is subject to.

Secondly, in order to solve the problem that regression results between different proxy variables may not be uniform, referring to relevant literature studies, the financing constraint index SA index is constructed from company size and company age:

$$SA = -0.737 \ln size + 0.043 \ln^2 size - 0.04 age \quad (1)$$

Here, SA index and financing constraint change in the opposite direction, that is, the greater the SA index, the lower the degree of financing constraint of the company (the specific proof process can be seen in the appendix at the end of the paper).

In addition, this paper also chooses WW index to measure the degree of financing constraints, and the data is from the CSMAR database of Guotai 'an. Here, WW index and financing constraints change positively, that is, the larger the WW index is. The more constrained a company is by financing.

4.3. Model design

In order to study the impact of financing constraints on the technical efficiency of grain and oil processing enterprises, it is necessary to first measure the technical efficiency of the enterprises, refer to the practice of previous literature, adopt the translog-stochastic frontier production function (SFA) method to measure the technical efficiency, and then empirically investigate the impact of financing constraints on the technical efficiency. The stochastic frontier production function can be expressed as:

$$\ln Y_{it} = \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 (\ln K_{it})^2 + \beta_4 (\ln L_{it})^2 + \beta_5 \ln K_{it} \ln L_{it} + f_i + v_{it} - u_{it} \quad (2)$$

Where, Y is the total annual output of the enterprise (million yuan), equal to the sum of the main business taxes and their surcharges, total pre-tax profits, financial expenses and cash paid to employees; K is the net fixed assets of the enterprise (million yuan); L for the enterprise labor input (100 people); f_i is the company's fixed effect; u_{it} is the technical non-efficiency term, which follows a truncated normal distribution, and the relationship between u_{it} and the technical efficiency term te_{it} is as follows: $u_{it} = -\ln te_{it}$; v_{it} is a random disturbance term.

When empirically investigating the influence of financing constraints on technical efficiency, the function of technical non-efficiency term is set as:

$$u_{it} = \alpha_0 + \alpha_1 \text{Financial_Constraint}_{it} + \alpha_2 X_{it} \quad (3)$$

Among them, $\text{Financial_Constraint}_{it}$ is a variable that measures the degree of financing constraints on enterprises, including proxy variables, SA index and WW index, and X_{it} is a series of control variables.

4.4. Descriptive statistical analysis

Figure 2 and Figure 3 show the kernel density maps of SA index and WW index in different years respectively, and Table 1 shows the descriptive statistical table of variables in this paper. As can be seen from Table 1, the age of grain and oil processing enterprises is generally relatively high, with an average of 16 years, indicating that enterprises generally have a good business foundation. The average leverage ratio reached 0.415, which is at a high level, indicating that grain and oil processing enterprises generally have a high level of debt. 81.6% of grain and oil processing enterprises have financial institutions (Table 1).

Table 1. Descriptive statistics of variables.

Variable name	Variable	Observed number	Mean value	Standard deviation	Minimum value	Maximum value
Annual output (million Yuan)	Y	1,075	1,991.191	6,605.361	8.970	98,024.820
Total fixed assets (million Yuan)	K	1,075	2,174.365	4,956.481	1.349	99,550.929
Number of employees (hundred)	L	1,075	70.130	122.040	0.200	1,375.200
Enterprise size (million Yuan)	size	1,075	8,841.046	21,026.416	238.420	255,168.195
Company age	age	1,075	16.014	6.072	1.000	37.000
Leverage ratio	r_lev	1,075	0.415	0.192	0.028	1.158
Shareholding by financial institutions	finance	1,075	0.816	0.388	0.000	1.000
Net operating cash flow (million Yuan)	cash_flow	1,075	987.960	3,981.912	-2,910.856	64,028.676

As can be seen from Figure 2, the mean value of SA index of grain and oil processing enterprises continues to decrease over time, and the distribution is more and more inclined to the left. It can be said that the SA index of grain and oil processing enterprises continues to decline, while the SA index changes in the opposite direction with financing constraints, indicating that the degree of financing constraints of grain and oil processing enterprises continues to increase. As can be seen from Figure 3, the WW index of grain and oil processing enterprises is generally inclined to the right, and the WW index is positively correlated with financing constraints, which also indicates that enterprises are generally under serious financing constraints at this stage.

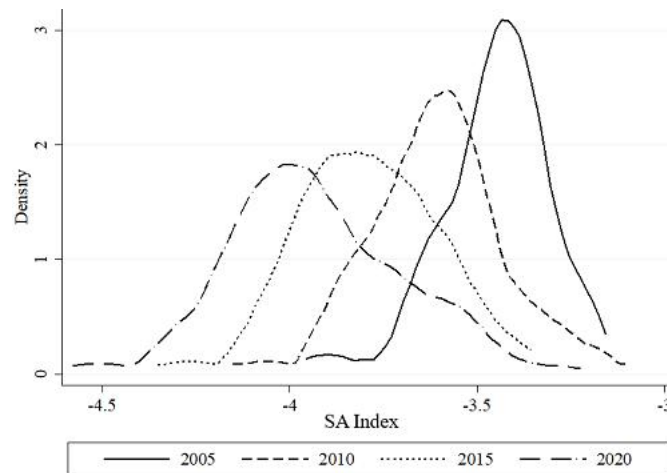


Figure 2. Nuclear density map of SA index in different years.

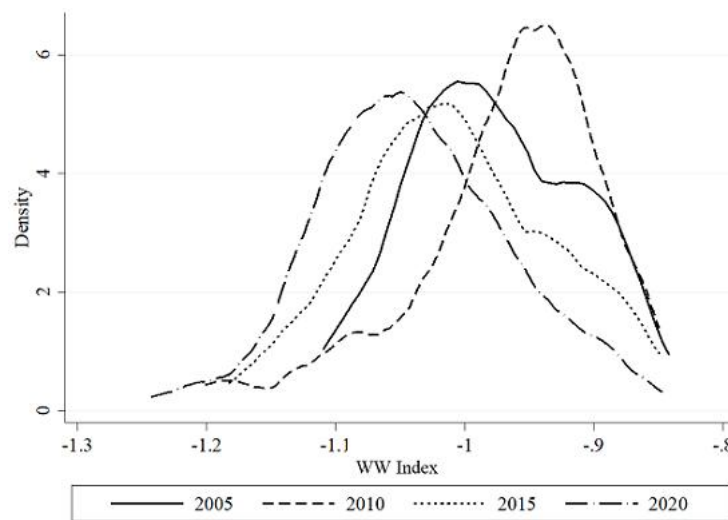


Figure 3. WW index kernel density map in different years.

5. Empirical Analysis

5.1. Technical efficiency measurement results

Before studying the influence of financing constraints on the technical efficiency of grain and oil processing enterprises, it is necessary to measure the technical efficiency of grain and oil processing enterprises. The calculated results based on equation (2) are shown in Table 2. Among them, (1) is listed as the calculation result of Cobb-Douglas (C-D) production function, that is, the calculation result obtained by excluding quadratic terms and interaction terms on the basis of equation (2), and (2) is listed as the calculation result of translog-random frontier production function of equation (2).

Table 2. Technical efficiency measurement results table.

Stochastic frontier production function	(1)	(2)
	C-D function	Transcendental logarithm
LnK	0.557*** (17.745)	-0.129 (-0.546)
LnL	0.380*** (9.860)	0.381* (1.843)
LnK_2		0.058**

		(2.118)
LnL_2		0.036*
		(1.861)
LnKLnL		-0.030
		(-0.698)
Constant	3.373***	5.317***
	(2.664)	(5.204)
Observed number	1,075	1,075
Firm fixed effect	YES	YES
μ	2.188*	1.977**
$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$	0.783	0.781

Note: The corresponding z values are in parentheses. *, ** and *** are significant at the level of 10%, 5% and 1% respectively.

As can be seen from Table 2, γ in the results obtained by the translogarithm function is 0.781, indicating that about 78.1% of the gap between the actual output and the optimal output of grain and oil processing enterprises is caused by technical inefficiency, and γ in the results of Cobb-Douglas (C-D) function is also 0.783, indicating that the model can better estimate the technical efficiency of grain and oil processing enterprises. In terms of regression coefficient, the labor input LnL and its secondary term LnL_2 and the capital input second term LnK_2 in the translogarithm function are significant at different significance levels, and the coefficients are all integers, indicating that increasing labor and capital input can help improve the output of grain and oil processing enterprises. In Cobb-Douglas (C-D) function, both labor and capital input have a positive impact on enterprise output at the significance level of 1%, and capital input has a greater impact on output than labor. At the same time, the sum of the two coefficients is 0.937, which is slightly less than 1, indicating that China's grain and oil processing enterprises are still in the stage of diminishing returns to scale, and have not achieved significant economies of scale effect.

5.2. Regression results of the influence of financing constraints on technical efficiency of grain and oil processing enterprises

After calculating the technical efficiency of grain and oil processing enterprises, combined with the technical inefficiency function of equation (3), OLS model was used to empirically analyze the influence of financing constraints on the technical efficiency of grain and oil processing enterprises, and the results were shown in Table 3. Among them, (1) is listed as the result of regression between the three financing constraints of company size, leverage ratio and age and the technical efficiency of grain and oil processing enterprises; (2) is listed as the result of regression between SA index and the technical efficiency of grain and oil processing enterprises; (3) is listed as the result of regression between WW index and the technical efficiency of grain and oil processing enterprises. The firm fixed effect was added to all three regression models.

Table 3. Regression results of financing constraints on technical efficiency of grain and oil processing enterprises.

Technology is not an efficiency function	(1)	(2)	(3)
	Proxy variable	SA Index	WW Index
lnsize	-0.010***		
	(-4.449)		
r_lev	0.019**		
	(2.109)		

age	0.002***		
	(5.356)		
SA		-0.012**	
		(-2.267)	
WW			0.002***
			(3.406)
cash_flow	0.000	-0.000	0.000
	(0.499)	(-0.253)	(0.417)
finance	-0.007**	-0.008***	-0.006**
	(-2.236)	(-2.627)	(-1.947)
Constant	2.154***	2.076***	2.115***
	(149.479)	(100.467)	(278.674)
Observed number	1,075	1,075	941
Firm fixed effect	YES	YES	YES
R-squared	0.997	0.997	0.997
Note: The corresponding z values are in parentheses. *, ** and *** are significant at the level of 10%, 5% and 1% respectively.			

As can be seen from column (1) of Table 3, the regression results of the three proxy variables are generally significant, and the company size is significantly negatively correlated with technical inefficiency factors, that is, the larger the company size, the higher the technical efficiency. The leverage ratio is positively correlated with technical inefficiency factors, that is, the higher the leverage ratio, the lower the technical efficiency. There is a significant positive correlation between company age and technical inefficiency factors, that is, the older the company, the lower the technical efficiency. It is generally believed that the larger the size and age of the company and the lower the leverage ratio, the lower the degree of financing constraints of the company. This indicates that the regression results of the company size and leverage ratio support that financing constraints inhibit the improvement of the technical efficiency of the grain and oil processing enterprises, while the regression results of the company age believe that financing constraints will promote the improvement of the technical efficiency of the grain and oil processing enterprises. The results obtained by different proxy variables are contradictory, one possible reason is that these proxy variables can not well reflect the degree of financing constraints of enterprises. In column (2), SA index is significantly negatively correlated with technical inefficiency factors, that is, the higher the SA index is, the higher the technical efficiency is, while SA index is negatively correlated with financing constraints, indicating that the regression results of SA index support the view that financing constraints will inhibit the improvement of technical efficiency of grain and oil processing enterprises. In column (3), WW index is significantly positively correlated with technical inefficiency factors, and WW index is positively correlated with financing constraints, indicating that the regression results of WW index also support the view that financing constraints are not conducive to improving the technical efficiency of grain and oil processing enterprises, which is consistent with the regression results of SA index, which also indicates that the regression results have certain robustness to a certain extent. In addition, in the regression results of the three groups, whether or not financial institutions hold shares has a significant negative correlation with technical inefficiencies. Generally speaking, enterprises with financial institutions hold shares have a lower degree of financing constraints, indicating that financial institutions hold shares can help reduce the degree of financing constraints of enterprises, thereby improving the technical efficiency of grain and oil processing enterprises.

5.3. Robustness test

In order to further test the stability of the regression results of the model, some adjustments were made to the above model Settings. Specifically, an important assumption of the original model is that the enterprise technical efficiency does not change with time and is basically fixed, but this assumption may not be accurate. For this reason, the time trend term t and its interaction terms $tLnK_{it}$ and $tLnL_{it}$ are introduced into equation (2), that is, the enterprise technical efficiency will change with time, and a new translog-random frontier production function is obtained:

$$\ln Y_{it} = \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 t + \beta_4 (\ln K_{it})^2 + \beta_5 (\ln L_{it})^2 + \beta_6 \ln K_{it} \ln L_{it} + \beta_7 t \ln K_{it} + \beta_8 t \ln L_{it} + f_i + v_{it} - u_{it} \quad (4)$$

In formula (4), except for the newly added time trend term t and its interaction term t and its interaction terms $tLnK_{it}$ and $tLnL_{it}$, the rest of the Settings are the same as in formula (2). The calculated results of time-varying technical efficiency are shown in Table 4. It can be seen that γ in the regression results reaches 0.828, indicating that 82.8% of the gap between the actual output and the optimal output of grain and oil processing enterprises is caused by technical inefficiency, which is close to 1, and the coefficient of each variable is significant at the significance level of 1%, indicating that the model fits well. The technical efficiency of grain and oil processing enterprises can be measured more accurately.

Table 4. “Time-varying” technical efficiency measurement results table.

Stochastic frontier production function	(1) Coefficient	(2) Z value
LnK	52.766***	(5.438)
LnL	-77.786***	(-7.996)
t	0.008***	(5.340)
LnK ²	0.088***	(3.524)
LnL ²	0.068***	(3.862)
LnKLnL	-0.124***	(-3.160)
tLnK	-0.026***	(-5.451)
tLnL	0.039***	(8.039)
Constant	-0.822	(.)
Observed number	1,075	
Firm fixed effect	YES	
μ	10.895***	
$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$	0.828	

Note: *, ** and *** are significant at the 10%, 5% and 1% levels respectively.

After calculating the “time-varying” technical efficiency of grain and oil processing enterprises, equation (3) is used for regression to analyze the influence of financing constraints on the technical efficiency of grain and oil processing enterprises, and the regression results are shown in Table 5. Among them, (1), which is similar to the above, is the regression result of the three proxy variables of financing constraints. It can be seen that the directivity of the regression coefficient is consistent with that in Table 3 above, but the overall regression result is still inconsistent. The regression results of company size and leverage ratio support the inhibitory effect of financing constraints on the improvement of technical efficiency of grain and oil processing enterprises. The regression results of firm age suggest that financing constraints will promote the improvement of technical efficiency of grain and oil processing enterprises. The regression results in columns (2) and (3) are all significant, and the regression coefficients are consistent with those in Table 3, which support the view

that financing constraints are not conducive to improving the technical efficiency of grain and oil processing enterprises. Consistent with the above point of view, it shows that the model established in this paper has a certain robustness.

Table 5. Regression results of financing constraints on technical efficiency of grain and oil processing enterprises.

Technology is not an efficiency function	(1)	(2)	(3)
	Proxy variable	SA Index	WW Index
lnsize	-0.004***		
	(-4.456)		
r_lev	0.008**		
	(2.116)		
age	0.001***		
	(5.359)		
SA		-0.005**	
		(-2.267)	
WW			0.001*
			(3.406)
cash_flow	0.000	-0.000	0.000
	(0.501)	(-0.253)	(0.417)
finance	-0.003**	-0.004***	-0.003**
	(-2.416)	(-2.627)	(-1.947)
Constant	11.090***	11.056***	11.073***
	(1,757.603)	(1,217.800)	(3,319.724)
Observed number	1,075	1,075	941
Firm fixed effect	YES	YES	YES
R-squared	0.999	0.999	0.997
Note: The corresponding z values are in parentheses. *, ** and *** are significant at the level of 10%, 5% and 1% respectively			

5.4. Endogeneity problem

We have discussed the inhibitory effect of financing constraints on the technical efficiency of grain and oil processing enterprises, but the model constructed in this paper may have some endogenous problems. First of all, the model may have sample selection bias. The sample selected in this paper is A grain and oil processing enterprise listed on A-shares. Generally, listed enterprises have more capital sources and better business performance than unlisted enterprises, so the estimated results may be biased when studying the impact of financing constraints on technical efficiency. Secondly, the variable of financing constraint may also be endogenous, and technical efficiency may have a counter-effect on it. Whether banks and other financial institutions will grant loans to grain and oil processing enterprises may mainly consider the recent business performance of the enterprises, that is, technical efficiency may affect the degree of financing constraint of enterprises. Finally, the model may have the problem of missing variables, and there may be some unobstructable variables that affect both financing constraints and technical efficiency, such as managerial ability, etc. These variables cannot be controlled because they cannot be numerically measured, which may lead to endogenous problems of the model.

In order to solve the endogeneity problem caused by model sample selection and missing variables, this paper uses DID to eliminate the influence of such problems by referring to previous literatures. For the specific reference to the corporate short-term financing bonds proposed by Li Ke et al., short-term financing bonds were restarted

by the People's Bank of China in 2005, allowing enterprises with credit ratings to raise funds by issuing securities in the inter-bank bond market, increasing financing channels for enterprises to reduce financing costs. It can be said that enterprises issuing short-term financing bonds are subject to lower financing constraints. The variable $fina_bond_i$ is set, and the listed grain and oil processing enterprises that issue short-term financing bonds are set as 1, and those that do not issue short-term financing bonds are set as 0. In order to measure the impact of the decline in financing constraints caused by the issuance of short-term financing bonds, the variable $time_t$ is constructed after the sample data before 2005 is eliminated, and the sample data after 2010 is set to 1, and the rest is set to 0. The construction model is as follows:

$$u_{it} = \alpha_0 + \alpha_1 fina_bond_i * time_t + \alpha_2 X_{it} + f_i + \gamma_t + v_{it} \quad (5)$$

Where u_{it} is the technical non-efficiency term, X_{it} is a series of control variables, f_i is the company fixed effect, γ_t is the year fixed effect, and v_{it} is the random disturbance term. The estimated results of the differential model (DID) are shown in Table 6, where (1) is the regression result obtained without adding control variables, and (2) is the result after adding variables.

Table 6. Results of differential estimation.

DID	(1)		(2)	
	Coefficient	T value	Coefficient	T value
fina_bond*time	-0.033***	(4.786)	-0.033***	(-4.431)
cash_flow			0.000***	(8.419)
finance			0.012	(1.348)
Constant	0.168***	(42.863)	0.144***	(18.728)
Observed number	1,010		1,010	
Firm fixed effect	YES		YES	
Time fixed effect	YES		YES	
R-squared	0.007		0.255	
Note: *, ** and *** are significant at the 10%, 5% and 1% levels respectively				

As can be seen from Table 6, when control variables are not added to column (1), the regression coefficient of the interaction term is significantly negative at the 1% level, and the regression result of column (2) is also significantly negative after the addition of control variables, indicating that enterprises capable of issuing short-term financing bonds have higher technical efficiency, and issuing short-term financing bonds can alleviate the dilemma of financing constraints to a large extent. Therefore, it can be said that the easing of financing constraints is conducive to improving the technical efficiency of grain and oil processing enterprises, which is consistent with the results obtained above.

6. Further Analysis

Enterprises with different property rights and located in different regions may have different business models and behavioral logic. In order to further explore the heterogeneity of grain and oil processing enterprises with different property rights, different regions and different scales in the face of financing constraints, with reference to existing literature, this paper divides the sample data into state-owned enterprises and private enterprises according to property rights, eastern enterprises and central and western enterprises according to their locations, and sorts them according to their scale. The first third of grain and oil processing enterprises are large-scale

enterprises, and the last third are small-scale enterprises. Based on equation (2), regression estimation is carried out respectively, and the results are shown in Table 7.

It can be seen from columns (1) and (2) of Table 7 that the regression results of private grain and oil processing enterprises are similar to the above, that is, it is believed that financing constraints will inhibit the improvement of technical efficiency of enterprises, while the regression results of state-owned grain and oil processing enterprises do not support this view. It shows that the easing of financing constraints of private enterprises has a significantly better promoting effect on technical efficiency than that of state-owned enterprises. The possible reason is that state-owned enterprises are backed by the credit of the government. Compared with private enterprises, state-owned enterprises have more abundant funds and do not have serious financing constraints.

Columns (3) and (4) of Table 7 show that in the geographical distribution of enterprises, the SA index regression coefficient of grain and oil processing enterprises in eastern China is significantly negative, indicating that enterprises in eastern China can better improve their technical efficiency when financing constraints are eased, while the SA index regression coefficient of enterprises in central and western China is not significant. This indicates that compared with enterprises in the central and western regions, enterprises in the east are subject to financing constraints, which has a greater negative impact on technical efficiency. The possible reason is that enterprises in the east have a relatively higher level of economic development and more developed financial financing channels, and enterprises in the east have a stronger ability to flow and use funds, so they can improve their technical efficiency by improving management and operation when the degree of financing constraints is eased.

Table 7. Subsample regression results.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	State-owned	Privately owned	The east	Midwest	Large enterprise	Small enterprise
SA	0.008*** (4.405)	-0.010* (-1.935)	-0.023** (-2.145)	0.021 (1.531)	-0.127*** (-6.091)	-0.003 (-0.307)
cash_flow	0.000 (0.259)	-0.000 (-0.209)	-0.000 (-0.163)	0.000 (0.308)	-0.000 (-0.617)	-0.000 (-1.219)
finance	0.005*** (4.480)	-0.007*** (-2.770)	-0.015** (-2.417)	0.023*** (2.663)	-0.034*** (-2.974)	0.007* (1.921)
Constant	2.242*** (322.305)	1.728*** (85.327)	2.035*** (48.344)	2.468*** (49.531)	1.372*** (16.254)	2.117*** (60.087)
Observed number	495	580	518	557	360	359
Firm fixed effect	YES	YES	YES	YES	YES	YES
R-squared	0.998	0.998	0.994	0.986	0.996	0.997
Note: The corresponding z values are in parentheses. *, ** and *** are significant at the level of 10%, 5% and 1% respectively.						

Among the regression results of different enterprise sizes, the regression coefficient of large-scale grain and oil processing enterprises in column (5) of Table 7 is significantly negative at the 1% level, while the regression result of small and medium-sized enterprises in column (6) is not significant, indicating that the alleviation of financing constraints of large-scale enterprises has a more effective promoting effect on technical efficiency than that of small-scale enterprises. The

possible reason is that large-scale enterprises have better management and operation ability. When the degree of financing constraint is reduced, they can make greater use of capital advantages, improve the efficiency of operation and capital flow, and thus improve the technical efficiency of enterprises.

7. Conclusions and Recommendations

Based on the financial data of grain and oil processing enterprises listed on A-shares in China from 2003 to 2020, this paper uses stochastic frontier model to measure the technical efficiency of grain and oil processing enterprises, empirically analyzes the impact of financing constraints on the technical efficiency of enterprises from a micro perspective, and finds that financing constraints are not conducive to improving the technical efficiency of grain and oil processing enterprises. Moreover, after testing the stability of the model and solving the endogenous problem, the conclusion is still reached that the easing of financing constraints is conducive to improving the technical efficiency of grain and oil processing enterprises. Shortage of funds and financing constraints are widely faced by most enterprises at present. Financing constraints mean that enterprises cannot normally obtain financing from the outside world, which will greatly hinder the normal business plan of enterprises and interrupt the process of market expansion. Shortage of funds makes enterprises unable to invest in research and development to improve production efficiency.

In addition, after discussing the classification of samples into different categories, it is found that the inhibition effect of financing constraints on technical efficiency is heterogeneous due to factors such as economic and financial environment and enterprise management skills. Specifically, the production technical efficiency of enterprises in the central and western regions and small-scale grain and oil processing enterprises is not significantly affected by financing constraints. When the financial pressure is relieved and the degree of financing constraints is reduced, private grain and oil processing enterprises, grain and oil processing enterprises in the eastern region and large-scale grain and oil processing enterprises can better realize the capital value and help improve the production technical efficiency. To a certain extent, this reflects that enterprises of different regions, different property rights and different scales have certain differences in operation and management capabilities, and there are differences in the utilization capacity of capital resources.

In view of the above conclusions, this paper believes that the current efforts should be made to solve the financing problems of grain and oil processing enterprises, starting from the market mechanism, reduce the financing cost of enterprises, establish a more perfect financial credit system, eliminate the information asymmetry between lenders and borrowers as much as possible, improve the degree of marketization, and expand financing channels. Grain and oil processing enterprises themselves should also continuously improve their management skills, should further explore the possibility of expanding the food industry chain, and grasp the improvement of production efficiency brought about by technological progress. In addition, there are significant differences in the operation and management capabilities of enterprises in different regions, different natures and different scales. Therefore, when formulating relevant policies, the government should fully consider these differences and choose appropriate policies according to local conditions.

Finally, there are certain shortcomings and limitations in this study. The samples used in exploring the impact of financing constraints on the technical efficiency of

grain and oil processing enterprises are all listed enterprises. Compared with non-listed enterprises, listed enterprises usually have better operating ability and higher technical efficiency, that is, there is a lot of room for optimization in sample selection in this paper.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

Funding

This work was supported by the Postgraduate Research & Practice Innovation Program of Jiangsu Province (KYCX22_1686).

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