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중국 중소기업 재무구조가 혁신 효율성에 미치는 영향

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The Impact of Chinese SMEs' Financial Structure on Innovation Efficiency

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요 약 본 논문은 2010년부터 2020년까지 중국 중소기업협회에 등재된 중소기업의 패널 데이터를 연구 표본으로 하고, 계량경제학 모형을 이용하여 금융구조가 중소기업의 혁신효율성에 미치는 영향을 살펴보았다. 확률 변경 분석법(SFA)에 의해 측정된 중소기업의 혁신효율성을 측정하고, Tobit 모형으로 중소기업의 자금조달구조와 혁신효율성의 관계를 살펴보고, 이에 상응하는 이질성 분석을 하였다. 마지막으로, 모델의 견고성을 테스트하였다. 부채와 주식금융이 혁신의 양적 효율성에 미치는 영향은 비선형적이고, 주로 반전된 "U"자형 관계를 나타낸다는 결론이 나왔다. 혁신의 질적 효율성을 위한 채권재무는 긍정적으로 기여한 반면에 주식재무는 부정적으로 나타났다.

주제어 부채재무, 주식재무, 혁신효율성, 재무구조, SFA

Abstract This paper examined the impact of financing structure on the innovation efficiency of SMEs by constructing an econometric model using panel data of SMEs listed on the SME board from 2010 to 2020 as the research sample. The innovation efficiency of SMEs was measured by the Stochastic Frontier Analysis (SFA), the relationship between financing structure and innovation efficiency of SMEs was examined with the help of the Tobit model, and the corresponding heterogeneity analysis was conducted. Finally, the robustness of the model was tested. It was concluded that the effects of debt and equity financing on the quantitative efficiency of innovation were non-linear and mainly showed an inverted "U" shaped relationship. For innovation quality efficiency, bond financing could positively contribute, while equity financing negatively inhibits. Finally, the corresponding advice was given.

Key Words Debt financing, Equity financing, Innovation Efficiency, Financial Structure, Stochastic Frontier Analysis (SFA)

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1. Research Background

In the face of the world economic trends and the current situation, China has put forward the "innovation-driven development strategy". SMEs occupy an important position in China's enterprises and are an important platform for the implementation of China's innovation-driven strategy. However, due to the lack of long-term financial security, the investment in innovation has increased the cost of enterprises, resulting in huge business risks for them. Financing is the basis for firms to carry out innovative activities, and there are differences in the role of different financing structures and different sources of financial capital on firms' innovative activities. SMEs have always been the fresh blood in the market economy and have made important contributions to promoting economic growth and boosting employment. Innovation is a sufficient condition to maintain the rapid development of SMEs, and the current promotion of SME development is bound to improve innovation capacity. Therefore, under such circumstances, it is of great theoretical and practical significance to study the impact of the financial structure of SMEs on the innovation capability of enterprises, which can further optimize the financial structure and improve the innovation vitality.

2. Literature Review

After the 1970s, the theory of technological innovation has been developed comprehensively, and the issues of motivation and sources of innovation, resistance to innovation and environmental factors, and diffusion of innovation have been studied more intensively. From the late 1980s scholars generally agreed that innovation runs through the whole process of product development, production, and distribution. And by the early 1990s, information sharing between firms and external agencies such as customers, suppliers, government, and intermediaries gained importance.

The financial structure of a company is also called Capital Structure Theory, which focuses on the factors influencing the capital structure, the relationship between the capital structure, and the value and cost of capital of a company. Jensen and Meckling(1976) studied the financial structure from the perspective of agency costs and correlated the theory of financial structure with information economics to propose the theory of agency costs. The theory divides the principal-agent cost into equity agency cost and debt agency cost. In the mid-to-late 1970s, the new financial structure theory introduced information asymmetry, signaling theory, and life cycle theory in terms of influencing factors, and the governance within the firm was also examined to achieve a multi-faceted analysis and study of corporate financial structure.

Studies on the impact of financing structure on innovation efficiency have not reached a consensus. Some scholars believe that financial structure can promote the efficiency of corporate innovation. Brown and Petersen(2009) conducted an empirical study of U.S. SME data and concluded that equity financing is more conducive to innovation. The study of Ling and Li(2010) concluded that exogenous financing is an important way of funding sources and significantly contributes to the efficiency of technological innovation. Relevant findings by Wu et al.(2014) and Gong et al.(2015) both suggest that equity financing funds can promote R&D efficiency. Another view is that corporate finance inhibits firms' innovation efficiency, or that the two exhibit a relatively complex relationship. Zhu and Zhou(2016) suggest that higher equity checks and balances help improve corporate innovation efficiency, while there is a significant non-linear relationship between executive shareholding ratio and corporate innovation efficiency. Wang and Zhang(2014) selected data from a sample of listed A-share firms in Shanghai and Shenzhen, China from 2008-2017, and the test results showed that debt financing had a significant inhibitory effect on firms' innovation efficiency.

Most scholars measure innovation efficiency by the parametric method of the Stochastic Frontier Analysis h (SFA). Han et al.(2019) and Xie(2019) chose SF as the A method based on CD prod the auction function or beyond logarithmic production function. Based on the summary of existing related literature, Xu et al.(2015) took the number of invention patents applied for, the number of invention patents owned, and the proportion of new product sales revenue to main business income as innovation output variables. Zhan and Wang(2019) selected the SFA method based on the CD production function or beyond the logarithmic production function.

Scholars mainly classify financial structures according to equity and debt financing and measure them by a single indicator or the ratio of equity and debt. Gu and Zhai(2014) choose the ratio of the sum of equity and capital stock of a firm to its total assets to represent equity financing. Most scholars use a firm's gearing ratio to measure debt financing. Qian Yan et al.(2019) use the ratio of the sum of long- and short-term borrowings to total assets as corporate debt financing.

3. Empirical Analysis

This paper examines the impact of financial structure on the innovation capability of SMEs by constructing an econometric model using the panel data of SMEs listed on the SME board from 2010 to 2020 as the research sample. In this chapter, the innovation efficiency of SMEs measured by stochastic frontier analysis (the SFA) is used as a measure of innovation efficiency, and the relationship between financial structure and innovation efficiency of SMEs is examined with the help of the Tobit model, and correspond heterogeneity analysis is conducted.

3.1 Research Design

3.1.1 Research Hypothesis

Under China's current financing pattern, increased R&D investment must be leveraged by capital. Moderate leverage can have a positive effect on corporate innovation through the path of providing capital support and improving investment efficiency; while too much leverage can increase the risk of corporate innovation activities, reduce investment in high-risk and long-cycle projects, and negatively affect corporate innovation (Wang et al. 2019). At the level of innovation quality efficiency, the negative factors such as bankruptcy costs, financing costs, and financing constraints may not be significant when SMEs engage in debt financing, while the marginal effects of their reverse incentives, behavioral constraints, and positive signals are greater than their negative factors. Therefore, this paper proposes the hypothesis that :

H1: Debt financing will show a significant inverted "U" shaped relationship with innovation quantity efficiency.

H2: Debt financing will be positively related to innovation quality efficiency.

And according to the attributes of equity financing, firms that focus on innovation are often able to attract investors with potentially high returns from new technologies, and are firms with certain funds to carry out long-cycle innovation activities, while after the innovation activities are carried out, as analyzed in the previous section, problems such as principal-agent of equity financing can negatively affect corporate innovation. At the level of innovation quality and efficiency, with the expansion of equity financing, the conflict of interests of shareholders and stakeholders may intensify, investors are prone to short-sighted behavior (Feng et al.2017), and the "ownership substitution effect" and "operation The "tunneling effect" of equity financing on firms will also be detrimental to corporate innovation. Therefore, the following hypotheses are proposed :

H3: Equity financing will has a significant inverted "U" shape relationship with innovation quantity efficiency.

H4: Equity financing will has a negative relationship with innovation quality efficiency.

3.1.2 Sample selection and data sources

This chapter takes the small and medium-sized listed enterprises from 2010 to 2020 as the research object. Because of the difference of asset-liability structure between listed companies in financial industry and other industries, ST-share companies have delisting risk and other reasons, which will cause deviation to the research conclusion., the sample is screened as follows: (1) excluding the ST class enterprises; (2) excluding the enterprises with serious missing data of core variables; (3) excluding the financial enterprises; (4) excluding the enterprises with obvious abnormal data (such as asset-liability ratio greater than 100%). After the above exclusion, a total of 7,231 firm-annual data were obtained in this paper. The data in this paper are obtained from CSMAR and Wind databases and are calculated and organized accordingly. To avoid the influToreme values on the study, the author has performed 1% and 99% tailing for continuous variables in the paper, and the treated data are used in the subsequent analysis, and the software tool used for the empirical analysis is Stata15.1.

3.1.3 Variable selection and description

(1) Dependent variable

In this paper, the dependent variable is innovation efficiency, and the existing literature usually uses stochastic frontier analysis (SFA) to measure innovation efficiency. SFA belongs to the parametric method, and although it relies on a specific production function, it takes into account the influence of random factors, the measurement results are less influenced by special points, and there is generally no situation where the efficiency values are the same and 1. Comprehensive of the above analysis, this paper adopts SFA for the measurement of innovation efficiency. The general function of SFA can be set as follows :

$$y = f(x)\exp(v-\mu) \quad (1)$$

Drawing on the existing literature, a stochastic frontier production function in the form of the Cobb-Douglas production function is set for efficiency measurement, and the specific model is set as follows :

$$\ln y = \beta_0 + \Sigma_{k=1} \ln x_{kit} + v - \mu, \mu \geq 0 \quad (2)$$

Where, y is innovation output, f measure of innovation quantity efficiency, innovation output is the number of patents granted, fonumbermeasure of innovation quality efficiency, innovation output is the net intangible assets; xkit indicates the input mix, in the text, it is mainly R&D expenditure (RD) and the number of R&D personnel (RDE); μ is the "inefficiency term ", i.e., efficiency loss, obeys the broken-tailed normal distribution, and μ ≠ 0, which means there is efficiency loss and is suitable for SFA model; v is the random disturbance term, obeys the normal distribution with 0 mean and variance of 〖σ_v〗^2. The inefficiency term is obtained through equation (2), and the innovation efficiency can be obtained according to the formula.

$$Te = \exp(\mu)$$

(2) Independent variables

The core explanatory variable in this paper is financial structure. The paper measures financial structure in terms of both equity financing (Eqf) and debt financing (Debtf). According to the research of Gu and Zhai(2014) and Qian et. al (2019), in this paper, equity financing refers to the financing obtained by firms through equity transactions, which is quantified in the paper using the share of a firm's equity and capital stock in total assets, and debt financing refers to the financing obtained through loans from banks or other financial institutions or the issuance of debentures, which mainly includes long- and short-term loans and bonds issued by enterprises.

(3) Control variables

To control for the influence of other factors on the study, the paper draws on previous work and controls for variables that may affect innovation output in several dimensions. The main variables include net profit margin on total assets (ROA), which reflects the profitability of the firm; sales revenue growth rate (SG), which reflects the future growth capability of the firm; cash flow level (Cash), which reflects the cash flow of the firm; current ratio (Liq) and equity ratio (Eqr) the above two variables reflect the short- and long-term solvency of the firm; independent (IBR), which reflects the corporate governance of the firm; executive compensation (Dpay), which reflects the incentive of executive compensation; dual role (Dual), which reflects the leadership structure of the board of directors; whether the firm is audited by four accounting firms (Big4), which reflects the quality of the firm's internal audit; the age of the firm (Age), which reflects the firm's Age, which reflects the firm's characteristics; and Staff, which reflects the firm's size. To more intuitively reflect the variable measures in this paper have been drawn in Table 1.

<Table 1> Variable measurement

Variable Type	Variable Name	Abbreviations	Variable Description
Dependent variable	Innovation Quantity Efficiency	NTe	Measured by stochastic frontier analysis (SFA) to obtain
	Innovation Quality Efficiency	QTe	
Independent variable	Debt Capital	Debtc	Debt ratio = (Long-term borrowing + short-term borrowing + bond issuance)/total assets
	Equity Capital	Eqc	Equity ratio = (Total equity + capital surplus)/total assets
Control variables	Total assets net profit margin	ROA	Net profit/total assets
	Growth	SG	Sales revenue growth rate
	Cash Flow Level	Cash	Net cash flow from operating activities/total assets
	Current Ratio	Liq	Current assets/current liabilities
	Equity Ratio	Eqr	Total liabilities / Shareholders' equity
	Ratio of Independent Directors	IBR	Number of independent directors / Number of board members
	Executive Compensation	Dpay	Natural logarithm of the average compensation of the top three executives
	Two positions in one	Dual	Whether the chairman and CEO are concurrently appointed, yes takes the value of 1, otherwise takes the value of 0
	Internal Audit Quality	Big4	The enterprise has 4 big accounting firm audit take the value of 1, otherwise take the value of 0
	Employee size	Staff	Natural logarithm of the number of employees at the end of the year
	Age of business	Age	Natural logarithm of the number of years of business establishment

3.1.4 Research model

In this paper, the stochastic frontier model (SFA) is used to measure the quantity of innovation efficiency innovation quality efficiency, and innovation performance as an explanatory variable can be considered as a restricted explanatory variable, the use of OLS estimation may lead to bias, therefore, the panel Tobit model constructed to examine the impact of financial structure on innovation performance.

The specific model is set up as follows:

$$Te=\alpha_0+\alpha_1 FinS+\alpha_2 FinS^2+cX+\Sigma\in d\_dummy+\Sigma Year\_dummy+\epsilon$$

Where Teit is the innovation efficiency of the firm I in period t, which includes innovation quantity efficiency (NTe) and innovation quality efficiency (QTe), respectively. finS are the financial structure, which is debt financing (debtf) and equity financing (eqf), respectively, in the paper. Since the financial structure and innovation quantity efficiency may show a non-linear relationship, the quadratic term of the financial structure is introduced in the paper. If the coefficient of the primary term is significantly positive and the coefficient of the quadratic term is significantly negative, it means that the financial structure and the innovation quantity efficiency show a significant inverted "U" type relationship; if the coefficient of the primary term is significantly negative and the coefficient of the quadratic term is significantly positive, it means that the financial structure and the innovation quantity efficiency show a "U" If the primary coefficient is significantly negative and the second coefficient is significantly positive, it means that the financial structure and innovation quantity efficiency have a "U" shape relationship. Since financial structure shows a linear relationship with innovation quality efficiency, only the primary term of financial structure is considered in the Tobit regression. x is a control variable to control for the effect of other factors on the study, which in the text are total net asset margin (ROA), sales revenue growth rate (SG), cash flow level (Cash), current ratio (Liq), equity ratio (Eqr), independent director ratio (Ibr), executive compensation (Dpay), audit quality (Big4), employee size (Staff), and firm age (Age). ind_dummy is an industry dummy and year_dummy is a year dummy to control for the effect of industry and year. ε it is a random disturbance term.

3.2 Innovation efficiency measurement results and evolutionary analysis of small and medium-sized listed enterprises

Table 2 reports the estimation results of the stochastic frontier model, the first column for the innovation quantity efficiency model, and the second column for the innovation quality efficiency model. The coefficients of both innovation inputs in Table 2 are significantly positive, indicating that innovation inputs show a significant positive correlation with innovation efficiency. The λ in both the innovation quantity efficiency equation and the innovation quality efficiency equation is significant, indicating the existence of the inefficiency term and the suitability of using the stochastic frontier to measure innovation efficiency. The measurement results of innovation quantity efficiency and innovation quality efficiency can be obtained by equations (1) and (2) and combined with equation (2).

〈Table 2〉 SFA estimation results

	(1) Patl	(2) Unform
LnRD	0.284***	0.261***
	(12.76)	(39.44)
LnRDE	0.015***	0.051***
	(3.21)	(19.16)
σ_u	0.446***	0.676***
	(14.52)	(56.38)
σ_v	0.514***	0.147***
	(25.97)	(15.44)
λ	0.868***	4.587***
	(17.72)	(242.16)
N	4039	6153
Log-Likelihood	-4085.79	-6443.25

Note: λ=σ_u/σ_v, used to determine the presence of the inefficiency term. ***,**,* indicate significant at 1%, 5%, and 10% significance levels, correspondingly.

To further portray the dynamic evolution law of innovation efficiency of SMB-listed enterprises, the following simulation is conducted by estimating the dynamics of innovation efficiency distribution through kernel density. The density function f(x) of the random variable X can be expressed as:

$$f(x)=\frac{1}{Nh}\Sigma_{i=1}^{N}K=\left(\frac{X_i-x}{h}\right) \quad (3)$$

Where N is the number of observations; K(•) denotes the kernel function; Xi is the independent identically distributed observations; x is the mean; h is the bandwidth, which determines the accuracy of the

Kernel density estimation and the smoothness of the curve, and choosing the optimal bandwidth h is the key to get the optimal fitting results. The larger the number of samples, the lower the bandwidth requirement, but the following conditions must be satisfied.

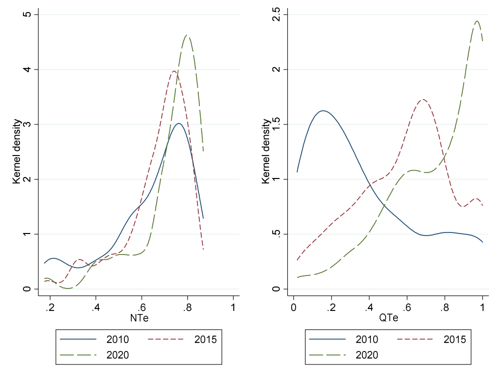
$$\lim_{N\to\infty} h(N)=0; \lim_{N\to\infty} N\,h(N)=N\to\infty \quad (4)$$

In which, h is a function of N. The kernel function can be regarded as a form of weighting function or smoothing function, and the Gaussian kernel function is the most widely used among the common kernel functions, so this paper selects the Gaussian kernel function to estimate the dynamic evolution trend of the distribution of innovation efficiency. The expression is:

$$K(MC)=\frac{1}{2\pi}\exp\left(-\frac{MC^2}{2}\right) \quad (5)$$

The kernel density function estimation is a nonparametric estimation method, which does not require a specific functional form in fitting, and ultimately presents the comparison results in the form of an image to examine the information characteristics such as location, shape, and extension of the distribution of the random variables.

For comparison, the kernel density estimates of innovation quantity efficiency (NTe) and innovation quality efficiency (QTe) for three representative years, 2010, 2015, and 2020, are selected in this paper, and the kernel density curves are plotted in Figure 6. From the left panel. The center of the innovation quantity efficiency kernel density curve shifts first to the left and then to the right, and overall the innovation quantity efficiency curve from 2010 to 2020 shows a rightward shift, indicating that the innovation quantity efficiency of SME Board listed enterprises shows an upward trend during the sample period. The innovation quantity curves all show a single wave within the sample period, the steepness of the wave shows an increasing trend, and the width of the curve opening shows a decreasing trend, which indicates that the gap in innovation quantity efficiency among SME Board listed enterprises is gradually narrowing. From the right panel, the center of the innovation quality efficiency kernel density curve shows a shift from left to right, and the steepness of the crest gradually increases, especially after 2015, indicating that the innovation quality efficiency shows an upward trend during the sample period, and the gap of innovation quality efficiency among SME Board listed enterprises is gradually narrowing, especially after 2015, the speed of the enterprises with low innovation quality efficiency catching up with the enterprises with high innovation quality efficiency more rapidly.



[Fig. 1] Innovation efficiency representative year kernel density curve

3.3 Regression analysis of the effect of financial structure on innovation efficiency

3.3.1 Regression results of financial structure on innovation quantity efficiency

Since the financial structure and control variables in this chapter are essentially the same as in the previous chapter, the results of the descriptive analysis of the variables are not disclosed in this chapter for brevity, and the regression analysis is performed directly.

Table 3 reports the results of the panel Tobit regression of financial structure on innovation quantity efficiency, controlling for industry and year effects. The coefficient of debtf in the first column of Table 3 is positive at the 10% significance level, and the quadratic term debtf2 is significantly negative at the 5% significance level, indicating that debt financing has an inverted "U" shaped relationship with innovation quantity efficiency, and there is an inflection point for the effect of debt financing on innovation quantity efficiency. Further, we can obtain the critical value of 0.1618 by taking the partial derivative of equation (1) concerning debtf, which indicates that when the scale of debt financing is lower than 16.18%, debt financing shows a significant promotion effect on innovation quantity efficiency, and when it is higher than the critical value, debt financing shows a suppression effect on innovation quantity efficiency. To further reflect the relationship between debt financing and innovation quantity objectively, and to verify whether the inverted "U" shape relationship between the debt financing curve and innovation quantity is within the value range of debt financing (0.5), I further plot the inverted "U" shape curve in Figure 2. The solid red vertical lines on the left and right are the critical range of debtf. The existence of the inverted "U" type relationship is verified.

〈Table 3〉 Regression results of financial structure and quantitative efficiency of innovation

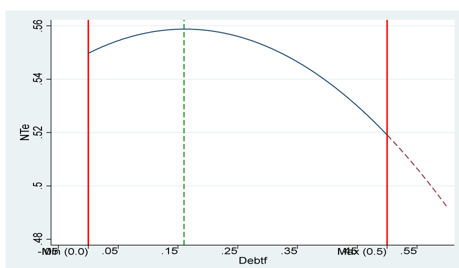
	(1) NTe	(2) NTe
Debtc	0.112* (1.71)	
Debtc2	-0.346** (-2.09)	
Eqc		0.383*** (4.13)
Eqc2		-0.829*** (-4.66)
Age	0.022** (2.05)	0.024** (2.19)
ROA	-0.017 (-0.28)	-0.014 (-0.24)
SG	-0.000** (-2.47)	-0.000** (-2.16)
Cash	-0.081* (-1.79)	-0.098** (-2.17)
Liq	0.001 (0.75)	0.001 (0.63)
Eqr	-0.001 (-0.21)	-0.001 (-0.29)
IBR	-0.028 (-0.57)	-0.020 (-0.41)
Dpay	0.004 (0.92)	0.006 (1.19)
Big4	-0.001 (-0.08)	0.003 (0.14)
Staff	0.002 (0.50)	0.002 (0.53)
_cons	0.550*** (5.76)	0.489*** (5.06)
Inddutry FE	Yes	Yes
Year FE	Yes	Yes
N	3801	3801

Log-Likelihood	1839.595	1848.537

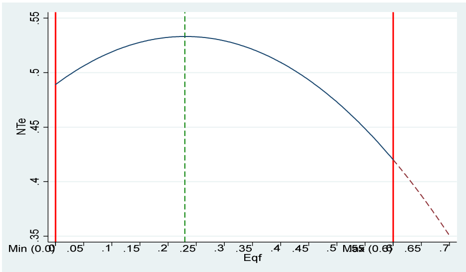
t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The coefficient of eqf in the second column of Table 19 is positive at a 1% significance level, and the quadratic term eqf2 is negative at a 1% significance level, indicating that equity financing has an inverted "U" type relationship with innovation quantity efficiency. The critical value of 0.231 can be obtained by taking the partial derivative of equation (2) concerning eqf, which indicates that equity financing has a significant role in promoting innovation quantity efficiency when the scale of equity financing is below 23.1% and inhibits innovation quantity efficiency when it is above the critical value.

To further reflect the relationship between equity financing and innovation quantity efficiency objectively, and to verify whether the inverted "U"-shaped relationship between the equity financing curve and innovation quantity is within the value range of debt financing (0.03 0.57), I further plot the inverted "U"-shaped curve in Figure 3. In the curve in Figure 8, the solid red vertical lines on the left and right are the critical range of eqf, and I notice that in this value range, the equity financing and innovation quantity efficiency show a complete inverted "U" type relationship, and the critical value falls within the value range, which verifies the existence of the inverted "U ". The hypothesis H1, H3 passes the test.



[Fig. 2] Fitted curve of debt financing and innovation quantity efficiency



[Fig. 3] Fitted curve of equity financing and innovation quantity efficiency

3.3.2 Regression results of financial structure and innovation quality efficiency

Further panel Tobit regressions are conducted below to examine the relationship between financial structure and innovation quality efficiency. The coefficient of debtf in the first column of Table 4 is positive at the 10% significance level, indicating that debt financing in presents a weak contribution to innovation quality efficiency. The coefficient of eqf in the second column is significantly negative, indicating that equity financing presents a significant inhibitory effect on innovation quality efficiency, verifying hypotheses H2, and H4. From the control variables, firm age and employee size present a significant positive effect on innovation output quality, while the current ratio and equity ratio present a significant negative effect on innovation output quality.

〈Table 4〉 Regression results of financial structure and innovation quality efficiency

	(1) QTe	(2) QTe
Debtc	0.077* (1.84)	
Eqc		−0.284*** (−7.45)
Age	0.039*** (2.65)	0.042*** (2.85)
ROA	−0.093 (−1.32)	−0.177** (−2.49)
SG	0.000 (0.62)	0.000 (0.24)
Cash	−0.035 (−0.57)	−0.005 (−0.07)
Liq	−0.009*** (−5.88)	−0.010*** (−6.52)
Eqr	−0.022*** (−3.07)	−0.024*** (−3.93)
IBR	0.036 (0.53)	0.049 (0.73)
Dpay	−0.004 (−0.61)	−0.004 (−0.71)
Big4	−0.017 (−0.73)	−0.014 (−0.62)
Staff	0.024*** (5.23)	0.015*** (3.18)
_cons	0.425*** (3.48)	0.537*** (4.40)
Inddutry FE	Yes	Yes
Year FE	Yes	Yes
N	5887	5887
Log-Likelihood	−320.303	−294.378

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

3.4 Robustness test

3.4.1 Substitution of core variables

To test the robustness of the model, the paper changes the measure of innovation efficiency by adding government subsidies as input variables and re-runs the estimation of the SFA model to measure innovation quantity efficiency and innovation quality efficiency, denoted as Te1 and Te2, respectively. In addition, as a robustness check, the paper uses OLS estimation for regressions controlling for industry and year and puts debt financing and equity financing into the same regressions for estimation. From Table 5, changing the measure of innovation efficiency and putting financial structure and equity structure into the same equation, the relationship between debt financing and equity financing and innovation efficiency remains unchanged, but the significance of debt financing in the innovation quantity equation decreases, indicating that there is some bias in the problem of using OLS estimation of restricted explanatory variables and the selection of Tobit model is necessary.

〈Table 5〉 Regression results for replacing core variables

	(1) te1	(2) te2
Debtc	0.076 (1.12)	0.070* (1.66)
Debtc2	−0.296* (−1.65)	
Eqc	0.382*** (3.69)	−0.281*** (−6.61)
Eqc2	−0.822*** (−3.97)	

Age	0.024**	0.037**
	(2.20)	(2.46)
ROA	-0.020	-0.192**
	(-0.31)	(-2.53)
SG	-0.000*	0.000
	(-1.94)	(0.40)
Cash	-0.098**	0.014
	(-1.96)	(0.21)
Liq	0.001	-0.009***
	(0.76)	(-5.88)
Eqr	0.003	-0.032***
	(0.45)	(-3.96)
IBR	-0.021	0.063
	(-0.41)	(0.96)
Dpay	0.006	-0.004
	(1.26)	(-0.62)
Big4	-0.000	-0.008
	(-0.00)	(-0.33)
Staff	0.001	0.013***
	(0.32)	(2.61)
_cons	0.478***	0.564***
	(6.13)	(5.53)
N	3786	5868
F	2.536	11.824
r2_within	0.011	0.026
Industry FE	Yes	Yes
Year FE	Yes	Yes

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

3.5 Empirical Summary

This chapter takes the panel data of SMEs listed on the SME Board from 2010 to 2020 as the research sample, measures innovation quantity efficiency and innovation quality efficiency by using stochastic frontier analysis (SFA), and analyzes the dynamic evolution pattern of innovation efficiency by kernel density estimation, and the results show that both innovation quantity efficiency and innovation quality efficiency show an upward trend during the sample period, and the gap of innovation efficiency among SMEs is gradually decreasing, especially after 2015, the enterprises with low innovation quality efficiency quickly catch up with the enterprises with high innovation quality efficiency. The results show that debt financing, equity financing, and innovation quantity efficiency have an inverted U-shaped relationship, and debt financing has a significant positive effect on innovation quality efficiency, while equity financing has a significant inhibitory effect on innovation quality efficiency.

5. Conclusions and Suggestions

5.1 Strengthen the guiding demonstration of government capital

The positive promotion effect of debt financing on innovation quality and efficiency originates from the information asymmetry among market players. According to the theory of financing preference, enterprises will prefer debt financing to avoid equity fragmentation, which will release positive signals to investors. Conversely, equity financing will increase investors' suspicion about the financial and operational status of the firm. Therefore, information asymmetry can hinder the optimization of SME financial structure, and the role of government capital needs to be strengthened to compensate for market deficiencies. Government capital can play a role in three ways to strengthen the role of guidance demonstration: government guidance funds, tax incentives, and policy support. Therefore, a special guide fund to support the innovative development of SMEs can be established to leverage social capital to support it. At the same time, tax concessions should be given to investors of SMEs for scientific research and innovation, so as to encourage more investment institutions or companies to invest their capital in the innovative development of enterprises and alleviate the innovative capital dilemma of SMEs.

5.2 Strict review of innovation support policies for technology-based enterprises

At present, China supports the innovation development of SMEs by providing different policy support at different stages of development, such as technology-based SMEs, high-tech enterprises, gazelle enterprises, science and technology board listing, main board listing, etc., and finally realize the listing and financing, and then promotes the leapfrog development of enterprise innovation strength through the optimization of financial structure. Equity financing has an inverted "U" structure for the efficiency of SMEs' innovation quantity, which has a positive promotion effect in the early stage. Moreover, the recognition of high-tech enterprises helps to improve the social image, and it is easier to play the positive role of credit financing and commercial credit in promoting innovation output and innovation efficiency.

5.3 Rational use of debt financing and control of leverage ratio

The impact of debt financing and equity financing on the efficiency of SMEs' innovation quantity shows an inverted "U" structure, therefore, enterprises should control the use of debt financing at a reasonable scale to avoid excessive indebtedness and a financial vicious circle. This requires enterprises to pay their debts on time, maintain a good credit record, use credit funds reasonably, and at the same time strengthen business contacts and maintain good cooperative relationships. This will facilitate banks and other financial institutions to deepen their understanding of the enterprise, thus facilitating debt financing.

References

[1] Jensen M C, Meckling W H. (1976) Theory of the firm: managerial behavior, agency cost, and capital structure[J]. Journal of Financial Economics, 3(4):305-360.

[2] Brown J. R., Petersen B. C. (2009) Why has the investment-cash flow sensitivity declined so sharply? Rising R&D and equity market developments. Journal of banking & finance, 33(5):971-984.

[3] Wu Y. Y., Tian L. N., Dai H. M. (2014) Impact of external equity financing on R&D efficiency of small and medium-sized enterprises. China Market, (20):39-43.

[4] Gong X. G., Yu J. F., Chen H. M. (2015) A Study on the Correlation between Equity Financing and Corporate R&D Efficiency. Accounting Friends, (24):18-20.

[5] Zhu D. S., Zhou X. P. (2016) Equity Checks and Balances, Executive Shareholding and Corporate Innovation Efficiency. Nankai Management Review, 19(03):136-144.

[6] Wang Y. F., Zhang N. (2014) Political Ties, Debt Financing and Corporate R&D Investment - Empirical Evidence from Chinese Listed Companies. Theory and Practice of Finance and Economics, (03):60-64.

[7] Han X. F., Song W. F., Li B. X. (2019) Can the Internet be the new driving force behind China's regional innovation efficiency gains? China's Industrial Economy, (07):119-136.

[8] Xie L.L. (2019) Do Industrial Agglomeration and Innovation Incentives Enhance Regional Innovation Efficiency - An Empirical Study from the Yangtze River Delta City Cluster. Economist, 8(8):102-112.

[9] Xu L. P., Jiang X. R., Yin C. (2015) search on Enterprise Innovation Ability Evaluation Index System. Research Management, (1):122-126.

[10] Zhan Y., Wang H. J. (2019) The Impact of Defense Technology Financing Methods on Innovation Efficiency--A Study Based on Panel Data of Listed Military Industry Enterprises. Economic Theory and Economic Management, (11):82-99.

[11] Gu Q., Zhai S. P. (2014) Financing Constraints, R&D Investment and Funding Sources - A Perspective Based on Heterogeneity of R&D Investment. Science and Technology Management, 35(03):15-22.

[12] Qian Y., Duan S., Zhang L. Y. (2019) The Relationship Between Financial Structure and Innovation Effciency of Technology-based Enterprises. Science and Technology Management

Research, 21:53-60.
[13] Wang Y. Z., Luo N. S., Liu W. B. (2019) What leverage is beneficial to firm innovation. China's Industrial Economy, (3):138-155.
[14] Feng G. F., Liu H., Feng Z. Z. (2017) Will stock liquidity promote technological innovation in our companies? Financial Research, 03(441):196-210.

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