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The Impact of "Investment-Loan Linkage" on Technology SMEs' Time Efficiency of Technological Innovation in China – Based on the Optimal Model for Balancing Interests

Abstract. *This study incorporates multi-stakeholders into the research framework, and compares the time efficiency of technological innovation of technology SMEs under the "Investment-Loan linkage" mode with other financing modes through the optimal model for balancing interests, and uses simulation to empirical tests. It is found that under the condition of certain capital structure, technology SMEs' time efficiency of technological innovation is higher under the "Investment-Loan linkage" mode, the advantage of risk dispersion is more obvious, and the feasibility is stronger. However, the interaction between participants and policy regulation limits the effect of the "Investment-Loan linkage" mode, which can be optimised from the cooperation mode of participants and the strength of government guidance.*

Keywords: *Investment-Loan linkage, time efficiency of technological innovation, technology SMEs, China, optimal model for balancing interests.*

JEL Classification: G32, O31.

1. Introduction

Technology SMEs refers to small and medium-sized enterprises that rely on technological innovation, get independent intellectual property rights, and transform them into high-tech products or services to achieve sustainable development and growth (Liu and Jia, 2018). Technology SMEs is an important part of China's social innovation system and one of the important forces for the construction of China's "Innovative Country" (Lin et al., 2017). Superior technology is the foundation of technology SMEs' survival, which is the key for them to getting market competitive advantage. And the key to getting superior technologies lies in the improvement of technological innovation efficiency (Xu, 2020). There are many factors that promote the improvement of technological innovation efficiency of technology SMEs, and

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capital input is one of the most important factors. However, China's technology SMEs have always been plagued by inadequate financing, especially early-stage technology SMEs, more constrained by a financing dilemma (Huang and You, 2020). Therefore, solving the financing dilemma has become an important way to boost the technology SMEs to improve the technological innovation efficiency.

In March 2015, China selected some qualified financial institutions as pilot units to launch the "Investment-Loan linkage" financing mode. And in 2016, the "Investment-Loan linkage" was raised to the strategic height of promoting social technological progress and economic development. The "Investment-Loan linkage" is a financial mode that combines the investment of financial institutions and bank loans to meet the financial needs of enterprises (Qian and Wang, 2017; Jing et al., 2019). The proposal of this financing mode provides a good solution to the financing dilemma of technology SMEs; it meets the funding requirements of technological innovation.

Since the "Investment-Loan linkage" was proposed, some scholars have studied the relationship between the "Investment-Loan linkage" and the development of technology enterprises, and believe that the "Investment-Loan linkage" can effectively promote the development of technology enterprises (Li, 2019). Some scholars have also studied the effect of the "Investment-Loan linkage" on the financing efficiency of technology SMEs, and believe that the "Investment-Loan linkage" is a good attempt to solve the financing problems of technology SMEs (Xiao and Xu, 2017; Zhang, 2018). The relationship between the "Investment-Loan linkage" and the resource allocation of technology enterprises is also involved, it is believed that the "Investment-Loan linkage" financing mode is an important method to improve the efficiency of resource allocation of technology enterprises (Jing et al., 2019). However, there is very little research exploring the relationship between the "Investment-Loan linkage" and the technological innovation efficiency of technology enterprises, the very few existing studies mainly focused on the scale efficiency, but there is almost no research on the time efficiency. For example, Liu and Jia (2018) studied the relationship between "Investment-Loan linkage", capital institutions and R&D efficiency from the perspective of SMEs. They pointed out that "Investment-Loan linkage" can optimise the capital structure of SMEs, and help increase the amount of R&D funds and the scale of technological innovation for SMEs. Huang (2020) studied the relationship between "Investment-Loan linkage" and the development of science and technology innovation small-micro enterprises. The study pointed out that the impact of "Investment-Loan linkage" on the development of science and technology innovation small-micro enterprises is mainly reflected in serving technological innovation activities, but the impact mechanism of "Investment-Loan linkage" on the technology innovation efficiency of science and technology innovation small-micro enterprises is not involved. Cheng et al. (2021) used data from Chinese listed companies to study the impact of "Investment-Loan linkage" on the scale of enterprises' technological innovation, they believe that the implementation of China's "Investment-Loan linkage" mode can improve the scale efficiency of enterprises' technological innovation.

Research on the relationship between the "Investment-Loan linkage" and technology SMEs' time efficiency of technological innovation is still rarely, especially the research from the perspective of early-stage technology SMEs is almost in a blank state. In this study, from the perspective of early-stage technology SMEs, the participants and capital input are included in the analysis framework, we analyse the "Investment-Loan linkage" and other financing modes in theory by constructing the optimal model for balance interests first. Then, through numerical simulation, the impact of the "Investment-Loan linkage" and other financing modes on technology SMEs' time efficiency of technological innovation was compared.

2. Variables and assumptions

From the perspective of capital providers, before the "Investment-Loan linkage" mode was proposed, there are two main financing modes for technology SMEs: the "Only Investment without Loan" mode and the "Only Loan without Investment" mode (Liu, 2018). By constructing the optimal model for balance interests, this study analyses the difference of technology SMEs' time efficiency of technological innovation between the "Investment-Loan linkage" and other financing modes. According to the main participants of each mode and the differences in corporate right of control and residual claims (Zhou et al., 2019), we model the "Investment-Loan linkage" and the "Only Investment without Loan" from the perspective of private equity investment or risk investment (EI/RI), and model the "Only Loan without Investment" from the perspective of entrepreneurs.

The variables involved in the model are shown in Table 1.

Table 1. Definition of variables

Variable	Symbol	Definition
innovation cycle	Z	The investment cycle of banks or EI/RI.
discount rate	γ	Average discount rate of market.
loan interest rate	γ^{ϖ}	The banks' regular business rate of return.
rate of return	γ^{p}	EI/RI's return rate of investment.
loan interest rate	γ_t^{ϖ}	The interest rate that banks provide loans to technology SMEs at the early stage.
product price	P_t	Exogenous variables.
wage level	ξ_t	Exogenous variables.
labour	Γ	Assume that entrepreneurs are the only labour of the enterprise during the investment cycle.
capital input	C_t	Assume that EI/RI and banks have reached a consensus on the amount of capital input at the beginning of the investment.
capital ratio of EI/RI	nC_t	Assume that EI/RI invest at a ratio of nC_t.
capital ratio of bank	$(1-n)C_t$	Assume that banks invest at a ratio of $(1-n)C_t$.
technical standard of exiting	A	The technical standard that the company must possess when the participant exits.

Variable	Symbol	Definition
technical level of investor	A_t	The current technological level of investors mainly depends on the current investment of technological innovation and existing technology accumulation.
technical standards for access	A_0	Technical standards for industry access of technology SMEs.
corporate value	χ	The market value of the enterprise when the EI/RI exits after the enterprise has matured.
EI/RI holdings	s	The ratio of equity held by EI/RI.
shareholding ratio of entrepreneurs	$1-s$	Percentage of corporate equity acquired by entrepreneurs by investing their intelligence and labour.

Source: Authors' processing.

In addition, this study also makes the following assumptions:

(1) When a bank acts as an investor of creditor's rights in a technology SME, its risk premium compensates for an interest rate of γ_t^{ϖ}, and it has the right to distribute corporate profits.

(2) The premise for entrepreneurs to participate in the "Investment-Loan linkage" mode is that their total present discounted value of weighted income is not less than the total present discounted value of their opportunity cost.

(3) Under the "Investment-Loan linkage" mode and the "Only Loan without Investment" mode, the precondition for banks to participate is that their loan-weighted principal and interest income is not less than their regular business income at the interest rate of γ^{ϖ}.

(4) The probability of maintaining business operations of technology SMEs obeys a certain survival function, and the probability of success continues to increase over time.

(5) All participants of technology SMEs can get a capital gain when the enterprise survives, and lose all input when it fails.

3. Models

Based on the above assumptions, by constructing an optimal model for balancing interests involving multiple stakeholders, we analyse the financing mechanisms of technology SMEs under different financing models, and then derive the time efficiency function of technological innovation for technology SMEs. It should be pointed out that the time efficiency of technological innovation in this study is defined from the periodicity of technological innovation, the shorter the technological innovation cycle, the higher the time efficiency. This is also the understanding of many scholars (Liu, 2018; Huang, 2020; Bai, 2020).

3.1 The "Investment-Loan linkage"

From the perspective of EI/RI, the profit maximisation function, technical state function and participation constraint function of technology SMEs are:

$$EQ_1^{\max}: \int_0^{Z_1} s(1-e^{-\beta t+\mu})(P_t A_t \Gamma^{\alpha} - (1-n)(1+\gamma_t^{\varpi} C_t)e^{-\gamma t} dt - \int_0^{Z_1} n(1+\gamma^{p})C_t e^{-\gamma t} dt$$
$$+ s(1-e^{-\beta Z_1+\mu})\chi * e^{-Z_1} \quad (1)$$

$$EQ_1^{\mathrm{A}}: dA_t / dt = aC_t^b - cA_t \quad (2)$$

$$EQ_1^{\text{E-con}st}: \int_0^{Z_1} (1-s)(1-e^{-\beta t+\mu})(P_t A_t \Gamma^{\alpha} - (1-n)(1+\gamma_t^{\varpi} C_t)e^{-\gamma t} dt - \int_0^{Z_1} \xi_t \Gamma * e^{-\gamma t} dt$$
$$+ (1-s)(1-e^{-\beta Z_1+\mu})\chi * e^{-\beta Z_1} \geq 0 \quad (3)$$

$$EQ_1^{\text{B-con}st}: (1-e^{-\beta t+\mu})(1+\gamma_t^{\varpi}) \geq 1+\gamma^{\varpi} \quad (4)$$

Formula (1) is the profit maximisation function of EI/RI, $\int_0^{Z_1} s(1-e^{-\beta t+\mu})(P_t A_t \Gamma^{\alpha} - (1-n)(1+\gamma_t^{\varpi} C_t)e^{-\gamma t} dt$ is the net present value of the weighted income gotten by EI/RI that minus the cost of debt in the technological innovation cycle, since capital input is mainly used for technological innovation, only endogenous technological variables are introduced in the production function. $\int_0^{Z_1} n(1+\gamma^{p})C_t e^{-\gamma t} dt$ is the net present value of the total cost paid for EI/RI. $s(1-e^{-\beta Z_1+\mu})\chi * e^{-\gamma Z_1}$ is the net present value of EI/RI's income based on the shareholding ratio when the technology SMEs are successfully listed or transferred. $1-e^{-\beta Z_1+\mu}$ is the survival probability of technology SMEs, technology SMEs will have different survival probabilities due to differences in market environment, technological level and type of enterprise.

Formula (2) is the technical state function, *a*, *b*, and *c* are the investment effect parameters and depreciation rate, and the capital input of technological innovation described in formula (2) is mainly used for technology accumulation and technology depreciation.

Formula (3) is the technology SMEs' participation constraint function. $\int_0^{Z_1} (1-s)(1-e^{-\beta t+\mu})(P_t A_t \Gamma^{\alpha} - (1-n)(1+\gamma_t^{\varpi} C_t)e^{-\gamma t} dt$ is the net present value of weighted income that minus the cost of debt which obtained by entrepreneurs in the technological innovation cycle. $\int_0^{Z_1} \xi_t \Gamma * e^{-\gamma t} dt$ is the net present value of the opportunity cost. $(1-s)(1-e^{-\beta Z_1+\mu})\chi * e^{-\gamma Z_1}$ is the net present value of the income obtained by entrepreneurs based on the proportion of the shareholding after technology SMEs listing or transfer.

Formula (4) is the participation constraint function of banks, and the loan risk premium compensation of banks at *t* time is not less than the income of their general loan business at the interest rate of γ^{ϖ}.

Set up state variable that meet the endpoint conditions and state function as：

$$\Phi_t = \int_0^t ((1-s)(1-e^{-\beta t+\mu})(P_t A_t \Gamma^{\alpha} - (1-n)(1+\gamma_t^{\varpi})C_t) - \xi_t \Gamma)e^{-\gamma t} dt \quad (5)$$

The *Hamiltonian* function under the assumptions and conditions is:

$$H_1 = s(1-e^{-\beta t+\mu})(P_t A_t \Gamma^{\alpha} - (1-n)(1+\gamma_{\mathrm{t}}^{\varpi})C_t)e^{-\gamma t} - n(1+\gamma^{p})C_t e^{-\gamma t} +$$

$$+\lambda(aC_t^b - cA_t) + \pi((1-s)(1-e^{-\beta t+\mu})(P_t A_t \Gamma^\beta - (1-n)(1+\gamma_t^{\varpi})C_t)e^{-\gamma t} - \xi_t \Gamma * e - \gamma t + \sigma - e - \beta t + \mu + \gamma t \varpi - 1 + \gamma \varpi \quad (6)$$

$$C^*_t = \left(\frac{abce^{(\gamma+c)t+m} + ab(s+\pi^* - \pi^* s)(1-e^{-\beta t+\mu})P_t \Gamma^\beta}{c(s+\pi^* - \pi^* s)(1-n)(1+\gamma^{\varpi}) + cn(1+\gamma^p)}\right)^{\frac{1}{1-b}} \quad (7)$$

According to the transverse conditions of the state variables Φ_t and A_t, we can derive:

$$\lambda^*(aC^*_{Z_1}{}^b - cA^*_{Z_1}) - n(1+\gamma^p)C^*_{Z_1}e^{-\gamma Z_1} - \pi^* * \xi_{Z_1}\Gamma * e^{-\gamma Z_1} + \frac{s+\pi^* - \pi^* s}{1-s}\xi_{T_1}\Gamma * e^{-\gamma Z_1} = -\pi^* * \gamma(1-s)(1-e^{-\beta Z_1+\mu})\chi * e^{-\gamma Z_1} \quad (8)$$

Assuming that in the first technological innovation cycle, the marginal growth rate of technology is 0, which is $dA^*_{Z_1}/dZ_1 = aC^*_{Z_1}{}^b - cA = 0$, at this time, the time efficiency of technological innovation (technical innovation cycle) of technology SMEs under the "Investment-Loan linkage" mode is:

$$Z_1 = \frac{1}{\beta}\ln\left(1 - \frac{n(1-s)(1+\gamma^p)C^*_{Z_1} - s * \xi_{Z_1}\Gamma}{\pi^* * \gamma * \chi(1-s)^2}\right) - \frac{\mu}{\beta} \quad (9)$$

3.2 The "Only Investment without Loan"

From the perspective of EI/RI, the profit maximisation functional, state function of technology and participation constraint function of technology SMEs are:

$$EQ_2^{\max}: \int_0^{Z_2} s(1-e^{-\beta t+\mu})P_t A_t \Gamma^\alpha e^{-\gamma t}dt - \int_0^{Z_2}(1+\gamma^p)C_t e^{-\gamma t}dt + s(1-e^{-\beta Z_2+\mu})\chi * e^{-\gamma Z_2} \quad (10)$$

$$EQ_2^{\mathrm{A}}: dA_t/dt = aC_t^b - cA_t \quad (11)$$

$$EQ_2^{\text{E-const}}: \int_0^{Z_2}(1-s)(1-e^{-\beta t+\mu})P_t A_t \Gamma^\alpha e^{-\gamma t}dt - \int_0^{Z_2}\xi_t \Gamma * e^{-\gamma t}dt + (1-s)(1-e^{-\beta Z_2+\mu})\chi * e^{-\gamma Z_2} \geq 0 \quad (12)$$

The *Hamiltonian* function based on the same conditions above is:

$$H_2 = s(1-e^{-\beta t+\mu})(P_t A_t \Gamma^\alpha - (1+\gamma_t^{\varpi})C_t)e^{-\gamma t} + \lambda(aC_t^b - cA_t) + \pi(1-s)(1-e^{-\beta t+\mu})(P_t A_t \Gamma^\alpha - \xi_t \Gamma)e^{-\gamma t} \quad (13)$$

The optimal control capital input under optimal control conditions is:

$$C^*_t = \left(\frac{abce^{(\gamma+c)t+m} + ab(s+\pi^* - \pi^* s)(1-e^{-\beta t+\mu})P_t \Gamma^\alpha}{c(1+\gamma^p)}\right)^{\frac{1}{1-b}} \quad (14)$$

Then the time efficiency of technological innovation (technical innovation cycle) of technology SMEs under the "Only Investment without Loan" mode is:

$$Z_2 = -\frac{1}{\beta}\ln\left(1 - \frac{(1-s)(1+\gamma^p)C^*_{Z_2} - \mathrm{s} * \xi_{Z_2}\Gamma}{\pi^* * \gamma * \chi(1-s)^2}\right) - \frac{\mu}{\beta} \quad (15)$$

3.3 The "Only Loan without Investment"

Entrepreneurs have full ownership of the equity and remaining assets of technology SMEs under the "Only Loan without Investment" mode, and have absolute power to invest in technological innovation. Therefore, under this mode, the profit maximisation functional, state function of technology, and participation constraint function of technology SMEs are:

$$EQ_3^{\max}: \int_0^{Z_3}(1-e^{-\beta t+\mu})(P_t A_t \Gamma^{\alpha}-(1+\gamma_t^{\varpi} C_t)e^{-\gamma t}dt-\int_0^{Z_3}\xi_t \Gamma e^{-\gamma t}dt+(1-e^{-\beta Z_3+\mu})\chi * e^{-\beta Z_3} \quad (16)$$

$$EQ_3^{\mathrm{A}}: dA_t/dt = aC_t^b - cA_t \quad (17)$$

$$EQ_3^{\text{E-const}}: (1-e^{-\beta t+\mu})(1+\gamma_t^{\varpi}) \geq 1+\gamma^{\varpi} \quad (18)$$

The *Hamiltonian* function based on the same conditions above is:

$$H_3 = (1-e^{-\beta t+\mu})(P_t A_t \Gamma^{\alpha}-(1+\gamma_t^{\varpi})C_t)e^{-\gamma t}-\xi_t \Gamma * e^{-\gamma t}+\lambda(aC_t^{\,b}-cA_t)$$
$$+\sigma((1-e^{-\beta t+\mu})(1+\gamma_t^{\varpi})-(1+\gamma^{\varpi})) \quad (19)$$

The optimal control of capital input is:

$$C^*_t = \left(\frac{abce^{(\gamma+c)t+m}+ab(1-e^{-\beta t+\mu})P_t\Gamma^{\beta}}{c(1+\gamma^{\varpi})}\right)^{\frac{1}{1-b}} \quad (20)$$

The time efficiency of technological innovation (technical innovation cycle) of technology SMEs under the "Only Loan without Investment" mode is:

$$Z_3 = -\frac{1}{\beta}\ln\left(1-\frac{\xi_{Z_3}\Gamma}{P_{Z_3}A*\Gamma^{\beta}-(1+\gamma_{Z_3}^{\varpi})C^*_{Z_3}-\gamma\chi}\right)-\frac{\mu}{\beta} \quad (21)$$

Comparing the above functional formulas, it can be found that there are some differences in the technological innovation efficiency of technology SMEs under the three financing modes.

Comparing formula (9) and formula (15), it can be found that the technological innovation cycle under the "Only Investment without Loan" mode is the state when *n=1* under the "Investment-Loan linkage" mode, because the shareholding ratio of EI/RI mainly depending on its investment ratio, it is hard to directly judge the difference in technological innovation efficiency of technology SMEs between the two modes.

The difference in structure between formula (9) and formula (21) is quite obvious. The state shown in formula (21) is basically the same as the state of formula (9) when *n=0*. Therefore, it can be inferred that the technological innovation cycle under the "Only Loan without Investment" mode is shorter than that of the "Investment-Loan linkage" mode and the "Only Investment without Loan" mode.

Comparing the optimal capital input function (7), (14) and (20), it can be found that the main difference between the three modes depends on the denominator, which is the difference in the cost ratio of capital under different modes, while the "Only Investment without Loan" mode is 0 and the "Only Loan without Investment" mode

is positive infinity, this ratio is $(s+\pi^*-\pi^* s)(1-n)/n$ under the "Investment-Loan linkage" mode.

From the perspective of fundamental characteristics, the difference in the cost ratio of capital of the three modes is mainly due to the differences in their capital structures. If measured by the debt-equity ratio, while the ratio under the "Investment-Loan linkage" mode is *(1-n)/ n*, the other two modes have not changed.

4. Parameter setting

At present, most of technology SMEs in China have not yet been listed, it is difficult to obtain sufficient and accurate data, especially for those technology SMEs in the early stage, part of the available data is also incomplete and could not meet the basic requirements of model estimation. Then using simulation method can not only solve the problem of missing data, but also give more consideration to related non-linear influencing factors, which can also understand the mechanism of interaction between variables more intuitively. Therefore, this study uses the simulation method to empirically test the difference between the time efficiency of technological innovation of technology SMEs under the "Investment-Loan linkage" mode and the other two modes. All simulation and calculation processes are implemented by MATLAB.

The three financing modes are composed of multiple parameters and variables, based on the functional analysis of the three financing modes above, simulating the main parameters in the production function, survival probability function and constraint function of each financing mode. Depends on the assumptions above, refer to existing research to set some parameters, and for the parameters without literature basis, reasonable calibration according to relevant conditions under the analysis framework of this study. The parameter settings are shown in Table 2.

Table 2. The table of parameter setting

Parameter	Value	Setting basis
a	0.451	It is set based on the research results of Liu and Jia(2018) on technical capital elasticity.
b	0.50	Lack of authoritative literature for reference, and 0<b<1, so the median value is used.
c	0.15	Take the median value of the research results of Ma(2019).
μ	-0.163	It is calibrated and set according to the survival function and the 15% survival probability boundary value at the initial stage of investment.
β	0.315	It is calibrated and set based on the survival function and the 80% survival probability boundary value within the investment period.
π^*	1.00	Constant, it is set to 1 for the convenience of simulation analysis.
A	0.90	The enterprise's listing shows that it is relatively mature in technology, set the technical level at the time of listing to 0.90.
γ	2.65%	The yield rate of government bonds is usually used as a reference standard, which is set as the average value of the interest rate on the 1-year government bonds in the last three years.
γ^p	21.5%	Make a small reduction according to research result of Qian and Zhang (2007), and set to 21.5%.

Parameter	Value	Setting basis
γ^{ϖ}	5.00%	Set as the average value of the 1-year loan interest rate of banks in the last three years.
γ_Z^{ϖ}	10.49%	The setting is calibrated by combining formula (6), γ^{ϖ} and the boundary value of the concept of investment cycle survival.
χ	4.28	Calculated according to formula (9), the average shareholding ratio of RI institutions is 30.8% (Shen et al,2013; Li and Xu,2016), the average investment cycle of technology SMEs is 2.3 years (Qian and Zhang,2007; Liu et al,2013), and the proportions of labour and capital are 48% and 36% respectively (Lv and Guo,2012;Tan and Chao,2016), the average P/E ratio of IPO of technology SMEs is 145 times (Fu and Zhou,2017; Song et al,2019).
$\xi_Z\Gamma$	0.04	

Source: Authors' processing.

5. Results

5.1 Model fitting and analysis

Based on the parameter setting, it is assumed that the relationship between the shareholding ratio and investment ratio of EI/RI of technology SMEs in the early stage is $s=0.7n$, and the financing leverage is $(1-n)/n$. The set value and assumptions are brought into the formula of time efficiency of technological innovation under the "Investment-Loan linkage" mode and the "Only Investment without Loan" mode, calculating the technological innovation cycle and drawing the relation figure between the debt-equity ratio and the technological innovation cycle (Figure 1) of technology SMEs, and drawing the relation figure between EI/RI shareholding ratio and technological innovation cycle (Figure 2).

From Figure 1, when the debt-equity ratio of technology SMEs reaches a certain level, the time efficiency of technological innovation under the "Investment-Loan linkage" mode is higher than that of the "Only Investment without Loan" mode.

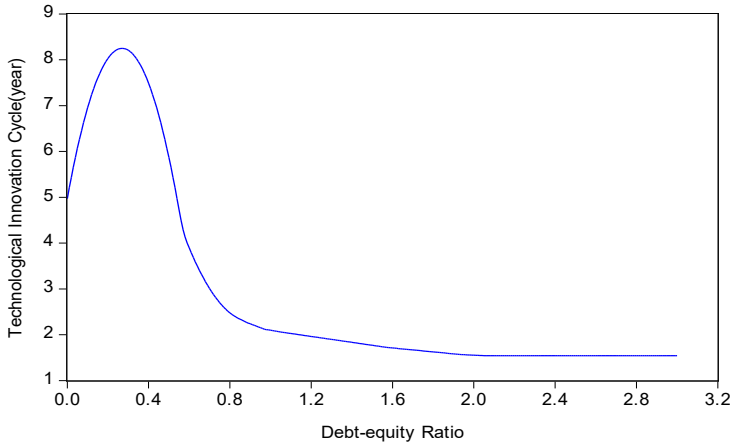

Figure 1. The relation figure between debt-equity ratio and technological innovation cycle

Source: Authors' construct.

In Figure 2, when the EI/RI's shareholding ratio is less than 0.65, the curve is the technological innovation cycle under the "Investment-Loan linkage" mode. When the shareholding ratio is between 0.65 and 1, the curve is the technological innovation cycle under the "Only Investment without Loan" mode. It can be found that the time efficiency of technological innovation under the "Only Loan without Investment" mode is the highest, and under the condition that the entrepreneur has the controlling rights, the time efficiency of technological innovation under the "Investment-Loan linkage" mode will increase with the decreasing of EI/RI's shareholding ratio and the rising of capital leverage ratio.

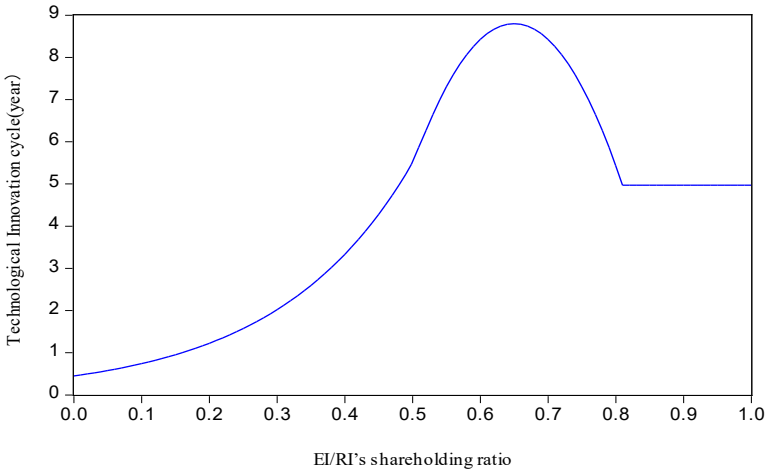

Figure 2. The relation figure between EI/RI's shareholding ratio and technological innovation cycle
Source: Authors' construct.

The above results are analysed from the dimension of the time efficiency of technological innovation. The following is based on formula (7), formula (14) and formula (20), which incorporates technological innovation capital input and risk factors into the analysis framework to further analyse its internal mechanism.

Figure 3 shows the investment curve of the technological innovation capital of EI/RI under the "Investment-Loan linkage" mode and the "Only Investment without Loan" mode. Technology SMEs are enterprises with high risks, high investment, and high returns. From the perspective of EI/RI, under the condition of a reasonable shareholding ratio, technology SMEs' time efficiency of technological innovation under the "Investment-Loan linkage" mode is significantly higher than that of the "Only Investment without Loan" mode, and its risk diversification function is more obvious.

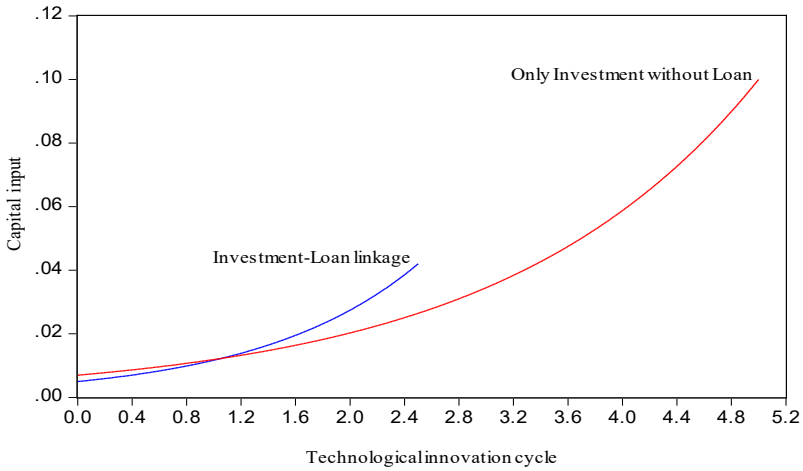

Figure 3. EI/RI's capital input of technological innovationunder different modes
Source: Authors'construct.

Figure 4 shows the relationship betweenthe technological innovation capital input and technological innovation cycle of banks under the "Investment-Loan linkage" mode and the "Only Loan without Investment" mode. It can be found that the highrisk tolerance of banks is the prerequisite for the "Only Loan without Investment" mode having a high time efficiency of technological innovation, but in reality, banks generally have a low risk tolerance, the advantage of risk diversification of the "Investment-Loan linkage" mode is more obvious.

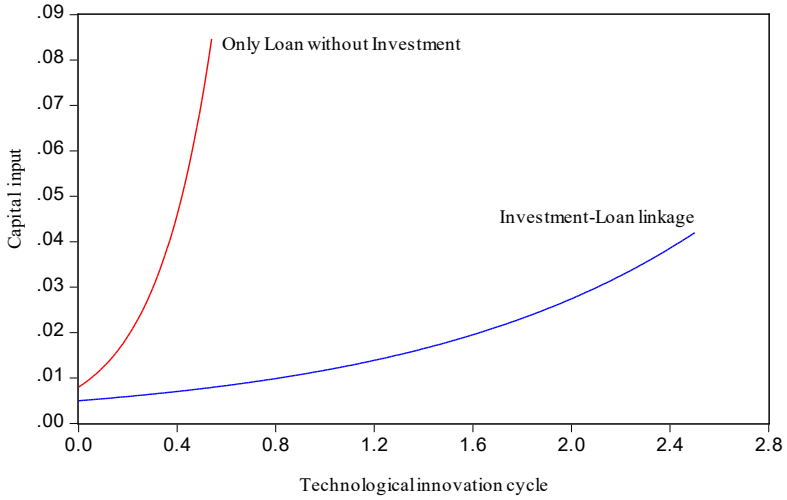

Figure 4. Bank's capital input of technological innovationunder different modes
Source: Authors'construct.

Analyse the above simulation results from the perspective of entrepreneurs and practice:

(1) From the perspective of entrepreneurs, the effect of "equity incentives-debt pressure" is the most important factor of the time efficiency of technological innovation of technology SMEs in the early stage. Under the "Investment-Loan linkage" mode, when entrepreneur's shareholding ratio is greater than 50%, the equity incentive for entrepreneurs is obvious, and they can also bear huge pressure of debt. Under the dual forces, the time efficiency of technological innovation of technology SMEs will be very high. When the entrepreneur's shareholding ratio is between 30% and 50%, the effect of equity incentive is relatively weak and the pressure of debt is still high, at this time the technology SMEs' time efficiency of technological innovation is relatively low. When the shareholding ratio is less than 30%, the incentive of equity and the pressure of debt to entrepreneurs are all very small. Although there are technological innovations in technology SMEs, the time efficiency is very low. Therefore, it can be considered that the time efficiency of technological innovation of technology SMEs at the early stage and the capital leverage ratio have a proportional relationship. The higher the capital leverage, the higher the time efficiency of technological innovation. The capital structure of technology SMEs is mainly determined by the entrepreneurs' financing capacity of debt and the risk acceptance.

(2) From a realistic perspective, banks only use one of the modes of "Only Investment without Loan" and "Only Loan without Investment" to support technology SMEs is extremely rare, especially the "Only Loan without investment" mode. Since banks generally have a low risk tolerance, and the credit supply of the capital market is almost unchanged in short term, it is extremely unlikely that entrepreneurs can raise a large amount of funds for technology research and development in short term, so the high financing efficiency of the "Only Loan without Investment" mode is almost impossible in reality. Therefore, many entrepreneurs optimise the financing structure by combining "investment" and "loan" in reality, the "Investment-Loan linkage" has become the favoured financing mode for entrepreneurs.

5.2 Sensitivity analysis

The distribution characteristics of the data play a decisive role in the stability and precision of the model-fitting results. The setting value of each parameter has a great influence on the simulation result in this study, and its stability needs to be tested. The correlation between the parameters selected in this study is weak; therefore, based on the functions above, the local sensitivity analysis method is used to perform a sensitivity analysis of the time efficiency of technological innovation of each financing mode (Table 3), and the stability of the simulation results is tested by the value of elasticity.

Table 3. The table of sensitivity coefficient

Parameter	Z_1	Z_2	Z_3
a	-3.09	-3.89	-0.01
b	3.68	6.39	0.02
c	3.30	4.28	0.01
μ	0.23	0.12	0.14
β	-0.91	-1.03	-0.19
π^*	-1.04	-2.01	0.00
A	3.19	5.41	0.02
γ	-0.96	-1.88	0.01
γ^p	0.26	1.60	0.00
χ	-1.12	-2.11	0.01
$\xi_Z\Gamma$	-0.49	-3.41	0.05

Source: Authors' processing.

The data in Table 3 shows that the differences in parameter settings have different impacts on the time efficiency of technological innovation of technology SMEs under each financing modes. Firstly, the difference in parameter types makes the simulation results more sensitive to production function parameters than return rate parameters and survival probability function parameters. Secondly, from the perspective of different financing modes, the "Only Investment without Loan" mode is the most sensitive to the change of parameters, followed by the "Investment-Loan linkage" mode, and the "Only Loan without Investment" mode is the weakest. Therefore, only a few of the parameters set are sensitive to the empirical results in this study, and the coefficient of elasticity is also normal. Most of the parameters set have a weak influence on the empirical results. Therefore, the simulation results of this study are both stable and reliable.

6. Viewpoints and discussion

6.1 Viewpoints

From the perspective of technology SMEs, this study compares the time efficiency of technological innovation under the "Investment-Loan linkage" mode with other financing modes through the optimal model to balance interests**,** and uses simulation to empirical tests. The conclusions of this study are the following:

(1) When the capital structure is fixed, the time efficiency of technological innovation of technology SMEs under the "Investment-Loan linkage" mode is higher than that of the "Only Investment without Loan" mode, and has a more obvious advantage of risk diversification also.

(2) The practical feasibility and risk aversion function of the "Investment-Loan linkage" mode is better than the "Only Loan without Investment" mode.

(3) Due to the limitations of the marketability of the participants and the balance between policies and regulations, the impact of the "Investment-Loan linkage" on the time efficiency of technological innovation of technology SMEs is limited.

6.2 Discussion

The number of entrepreneurs is a decisive factor for the number and scale of technology SMEs, and it also determines the R&D funds. At the beginning of the establishment of technology SMEs, the huge pressure of competition made the support to technology SMEs from government is particularly important. Therefore, the balance between entrepreneurial autonomy and support from policy determines the living space of technology SMEs. On one hand, EI/RI and banks are the suppliers of capital invested in technological innovation, getting the most profit is their goal, and they will try their best to seek unfair means to get super profit in a free market. At this time, the laws and regulations from government are indispensable. On the other hand, the adverse selection mechanism of EI/RI and banks will select the entrepreneurial projects. Therefore, the government's policy and the policy resilience of EI/RI and banks have become the important indirect factors of technology SMEs' survival and development that in the early-stage.

The "Investment-Loan linkage" mode involves the interests of multiple participants, in order to be better to promote the technological innovation efficiency of technology SMEs through the financing support effect, the mode can be optimised from the following three aspects: (1) Strengthening the ability of EI/RI and banks to negotiate and cooperate form an effective information sharing mechanism, weakening government's excessive participation and interference, and strengthen their trust in each other. (2) Emphasising the combination of market autonomy and policy guidance, particularly emphasis on market autonomy, compliance with EI/RI and banks' independent investment in early stage technology SMEs based on the pursuit of profit maximisation. At the same time, the government needs to provide reasonable guidance and supervision to guide EI/RI and banks to actively participate, avoid excessive and disorderly competition in the market. (3) The government's support policies and the market autonomy of EI/RI and banks maintain a certain tacit agreement, and the direction and intensity of financial subsidies are rationally planned. When providing policy support, the government can refer to the selection criteria of EI/RI and banks, use limited resources as much as possible on high-quality entrepreneurial projects, improve the overall resource utilisation efficiency, and try to control the cost of unit technological innovation.

In this study, we studied the effect that the "Investment-Loan linkage" financing mode on the technology SMEs' time efficiency of technological innovation in China from the perspective of early-stage technology SMEs. However, is there any difference in the effect of the "Investment-Loan linkage" on the time efficiency and scale efficiency of technology SMEs? And what is the effect of the "Investment-Loan linkage" on the technological innovation efficiency of other types of enterprises? This study does not give a clear answer. These are issues that Chinese scholars and government pay close attention to, which are directly related to the value of the "Investment-Loan linkage" financing mode, it is necessary to conduct an in-depth study, and it will be the focus of our future research.

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