Vilnius University Press

Content lists are available at VilniusUniversity Press

Transformations In Business & Economics
2025, Vol. 24 No 1 (64), pp.298-315.

E-ISSN 2538-872X
https://doi.org/10.15388/Tibe.2025.24.1.14

Chapter: Emergent Perspectives on Green Skills: Driving Change for a Sustainable Future

IMPACT OF BANK CREDIT ON GREEN TOTAL FACTOR PRODUCTIVITY OF PRIVATE ENTERPRISES: MICROANALYSIS FROM CHINA

Huanhuan Jin
E-mail: jhh@hdu.edu.cn
ORCID: https://orcid.org/0000-0002-1601-8331
Affiliation: School of Economics, Hangzhou Dianzi University, China
ROR: https://ror.org/05em1gq62

Huarong Deng
E-mail: denghuarong125@163.com
ORCID: https://orcid.org/0000-0003-2761-5913
Affiliation: College of Statistics and Mathematics, Zhejiang Gongshang University, China
ROR: https://ror.org/0569mkk41

Dongyu Xu
E-mail: xudongyu18@163.com
ORCID: https://orcid.org/0000-0002-1601-8331
Affiliation: College of Statistics and Mathematics, Zhejiang Gongshang University, China
ROR: https://ror.org/0569mkk41

Zhouyi Zhang
E-mail: zzy_shadow@163.com
ORCID: https://orcid.org/0000-0003-2761-5913
Affiliation: College of Statistics and Mathematics, Zhejiang Gongshang University, China
ROR: https://ror.org/0569mkk41

Annotation. The transformation and upgrading of private enterprises require significant financing. Overcoming this financing dilemma is key for private enterprises to achieve high-quality development. Green total factor productivity (GTFP) considers the quality of economic growth and environmental responsibility and is an important symbol of enterprises' high-quality development. From the credit perspective, this study reveals the mechanism by which bank credit influences the GTFP of private enterprises. The main conclusions are as follows: (1) The benchmark regression results show that bank credit can promote the improvement of the GTFP of private enterprises; (2) The mechanism test shows that hard technology acts as an intermediary, i.e., bank credit promotes the progress of hard technology, thereby improving the GTFP of private enterprises; (3) The moderating effect analysis shows that credit discrimination can weaken the promoting effect of bank credit on the GTFP of private enterprises. However, this effect is related to the size of enterprises. This study is conducive to further understanding the relationship between bank credit and private enterprises from a microperspective. Moreover, this study provides empirical evidence to promote high-quality economic development.

Keywords: bank credit, green total factor productivity, private enterprise, high-quality economic.

JEL classification: D00, E44, G30.

Introduction

The private economy is an integral part of the regional economy. The relationship among economic growth, energy conservation and emission reduction, government departments and the needs of the

Submitted on August 2024. **Accepted** on December 2025.

enterprise to be handled appropriately to achieve high-quality and sustainable development of private enterprises. In essence, coordination and unity of economic development and environmental performance of enterprises should be considered (Owen, 2023). Private enterprises constitute more than 90% of the total number of enterprises in China. The growth rate of the private economy has been maintained at approximately 30%, becoming the paramount driving force for national economic growth (Zhao, 2009). However, with economic development entering a new normal and the global inflation rate staying at a high level for a prolonged period, the internal and external environmental factors of the development of private economies have undergone profound changes owing to the influence of geopolitics and global security tensions (Yu *et al*., 2022). In particular, private enterprises face challenges such as shortages of funds, high financing costs, and financial risks (Liu *et al*., 2024). In other words, they require a significant amount of financing for high-quality development, which is one of the important factors restricting the development of the private economy (Hooli, 2024).

Since 2017, China has been successively introducing policies for the high-quality development of private enterprises in the areas of financial support and the business environment (Solodovnikov *et al*., 2023). On 14 February 2019, the Chinese government encouraged financial institutions to increase credit resources for private and small and micro enterprises. On 22 December, China issued the Opinions on Creating a Better Development Environment to Support the Reform and Development of Private Enterprises. The objective was to boost the confidence of private enterprises by optimising their business environment and addressing problems with costly and difficult financing (Beck, 2023). In July 2023, China issued the Opinions on Promoting the Development and Growth of the Private Economy. This policy proposed 31 specific measures in 8 aspects, including the development environment of the private economy, policy support, legal protection, and promotion of the healthy growth of private economic personnel. Overcoming the institutional barriers that restrict the development of private enterprises, setting up "traffic lights" for private capital, and promoting the healthy growth of private economic personnel are key factors in the high-quality development of China's economy in the new era (Nam, Tram, 2021).

This study mainly analyses the influence of bank credit on the green total factor productivity (GTFP) of Chinese private enterprises. First, this study analyses the relationship between bank credit and the GTFP of private enterprises based on the tracking survey data of Chinese industrial enterprises from 2017–2022. Then, it verifies the intermediary effect of technological progress by clarifying the mechanism through which bank credit affects the GTFP of private enterprises through technological progress and the decomposition of technological progress into hard and soft technology. Finally, it examines the nonlinear impact of credit discrimination on the GTFP of private enterprises as they suffer from credit discrimination in the financing process.

The main contributions of this study are as follows: (1) Unlike previous research that explored the total factor productivity (TFP) of enterprises from the macroperspective of industry, it provides micro evidence for improving the GTFP of private enterprises and promoting the high-quality development of private enterprises from the perspective of enterprises; (2) It conducted a tracking survey on private enterprises and collected panel data of 4,044 private enterprises from 2017–2022, which is more timely than existing databases. It revealed the potential path to improve the GTFP of private enterprises from the perspective of bank credit; (3) It further demonstrates the contribution of hard technology to improving the GTFP of private enterprises by analysing the mechanism of technological progress affecting the GTFP of private enterprises, providing empirical evidence for accelerating the high-quality development of private enterprises.

This study is further organised as follows: Section 1 reviews the literature and presents the influence mechanism. Section 2 details the construction of the benchmark regression model. Section 3 focuses on the empirical analysis. Section 4 examines the mechanism test and adjustment effect analysis. Section 5 concludes the study and provides suggestions.

1. Literature Review and Influencing Mechanism

1.1 Green Total Factor Production and Bank Credit

GTFP can be mainly measured using two types of methods: the stochastic frontier method based on parameter estimation and the data envelopment method based on non-parameter estimation (Zhang *et al*., 2024). The stochastic frontier method is based on a priori production or cost function. This method needs to set the function form in advance and consider a random error. Based on linear programming, data envelopment analysis (DEA) solves the minimum convex envelope of each producer according to input and output data, thereby determining the production technology frontier and technical efficiency of each production (Zhang *et al*., 2024a; Xu, Deng 2022). In the specific calculation process, the basic idea of measuring the GTFP is to introduce environmental factors based on the TFP and consider the effective use of resources and environmental responsibility (Chen *et al*., 2022). For instance, energy consumption and environmental impact factors are introduced into the measurement framework of the TFP to measure the GTFP (Cui *et al*., 2022).

Existing studies on the impact of bank credit on the GTFP of enterprises can be summarised into the following two aspects: (1) The impact of financial development and credit scale on the GTFP of enterprises is examined from the perspective of financial institutions (Ruan, Liu, 2021). For instance, existing studies found that financial development can alleviate financing constraints caused by financial aggregation and information misalignment, thereby stimulating the green production vitality of enterprises and promoting the improvement of the enterprises' GTFP (Kong *et al*., 2022). Some studies also noted that an increase in credit scale owing to financial development will further strengthen the flow of financial resources to enterprises with high pollution and emissions, which is not conducive to improving the enterprises' GTFP (Huang, 2022). (2) Considering the green credit policies promulgated by government departments as the starting point, the mechanism of action and implementation effect of credit policies are studied through policy evaluation (Wu *et al*., 2020). For instance, green finance policies will exacerbate financing constraints of polluting enterprises and restrain their research and development investments, which are not conducive to the improvement of the production efficiency of polluting enterprises (Pan *et al*., 2023).

1.2 Mechanism of Influence

1.2.1 Intermediary effects of technological progress

The capital market can improve the GTFP by maintaining the effective allocation of capital, promoting the efficient circulation of information and eliminating information asymmetry. In other words, the capital market can alleviate financing constraints faced by private enterprises through efficient information flow and financial support. Moreover, it can guide enterprises to use funds for green production technologies, thereby comprehensively improving green production efficiency (Jiang, 2022). However, considering the security and return of credit funds, banks tend to prefer enterprises with stable earnings or low risks. This case can not only provide financial support for the technological upgradation of enterprises but also force enterprises with backward production technology to transform, upgrade, and promote the improvement of the GTFP (Ye *et al*., 2023).

Overall, the intermediary effects of technological progress on the GTFP of private enterprises can be understood from the following two perspectives: (1) Providing bank credit to private enterprises can improve their financing environment, promote the transformation and upgradation of production technology of enterprises, and guide the transfer of funds to human resources departments, thereby promoting the improvement of the TFP (Chen *et al*., 2023). (2) Private enterprises require substantial financial support in phasing out old production technologies and adopting new energy-saving and environmental protection technologies, which makes it difficult to rely on internal financing. Meanwhile, credit resources from financial institutions can be directed to meet the financing needs of enterprises and promote the improvement of the GTFP (Zhao, 2023).

Hypothesis 1: Bank loans enhance the GTFP of private enterprises through technological progress.

1.2.2 Intermediary effects of hard technological progress

Technological progress is an essential factor in improving the GTFP, which can generally be divided into two categories: hard and soft technological progress. Hard technological progress refers to progress in the use of tools and procedures, i.e., the scientific and technological innovation brought about by new technologies and inventions. Soft technological progress mainly refers to institutional innovation, policy optimisation and resource optimisation allocation in production (Fang *et al*., 2021). The GTFP of enterprises mainly depends on the contribution of technological progress; however, the extensive management of state-owned enterprises reduces resource allocation efficiency (Zhang *et al*., 2024b). Additionally, the government's policy bias toward state-owned enterprises creates moral hazard in state-owned enterprises, which is not conducive to the improvement of the GTFP (Anser *et al*., 2020). Compared with state-owned enterprises, the operation and management of private enterprises are more flexible; moreover, there is additional room for adjustment of resource allocation, which can stimulate the independent innovation of enterprises to the maximum extent and subsequently improve the GTFP (Roper *et al*., 2013).

The progress of hard technology in private enterprises affects the GTFP in the following two aspects: (1) Under the pressure of market competition, private enterprises will be motivated to adopt energy-saving and emission-reduction actions. They will also resort to advanced technology to improve the efficiency of machines, thereby reducing energy consumption in production (Du, Li, 2019); (2) Private enterprises are usually profit maximisation-oriented, and their demand for reducing production costs is stronger than that of state-owned enterprises; hence, they will actively develop and adopt new technologies in the production process (Kroll, Kou, 2019). However, private enterprises cannot obtain a "backstop" from the government and need to pay special attention to reducing environmental costs by implementing energy-saving and environmentally friendly technologies (Debbarma *et al*., 2022). In particular, under the "dual carbon" goal, private enterprises are increasingly inclined to improve the GTFP through new technologies, further highlighting the importance of hard technological progress (Bruno *et al*., 2023).

Hypothesis 2: Private enterprises mainly improve the GTFP through "hard" technological progress.

2.2.3 Moderating effects of credit discrimination

Two mainstream views exist on whether credit discrimination influences the promoting effect of bank loans (BLs) on the GTFP: the "promotion theory" and the "inhibition theory" (Peng *et al*., 2022).

According to the "promotion theory," credit discrimination intensifies the market competition environment of private enterprises, which motivates them to strive and maintain competitive advantages

through technological upgradation and innovation. Moreover, they will actively invest loan funds in the R&D of new technologies to improve efficiency (Kang, Park, 2012). Additionally, they will focus on implementing environmentally friendly technologies, actively engage in energy conservation and emission reduction efforts, and reduce the cost of energy factor input and pollutant emissions, thereby improving the GTFP (Wellalage, Thrikawala, 2021).

According to the "inhibition theory," private enterprises with financing difficulties tend to be cautious about R&D investment with long cycles and high uncertainty. The main funds are used for simple expanded reproduction (Fraser, 2009); however, the expansion of production is often accompanied by high energy consumption and pollutant emissions, inhibiting the improvement of green productivity. Additionally, considering that obtaining sufficient loans from banks is difficult for private enterprises, they will choose private loans and other channels with significantly high financing costs to sustain and develop (Galli *et al.*, 2020). Enterprises tend to engage in high-yield production to pay high interest costs, which inhibits R&D and innovation activities and is not conducive to green productivity improvement (Cowling *et al*., 2016).

Hypothesis 3: Credit discrimination will hinder the promoting effect of bank credit on the GTFP of private enterprises.

2. Benchmark Regression Model

2.1 Model Setting

This study constructs the following benchmark regression model:

$$GTFP_{it} = a_0 + a_1 BL_{it} + \varphi C + \lambda_t + a_j + \theta_p + \varepsilon_{it}, \quad (1)$$

where GTFP is the green total factor productivity, *BL* is the bank credit, *i* is the enterprise, *t* is the year, *j* is the industry, and *p* is the region. *C* represents various control variables of the enterprise and ε_{it} is the disturbance term. Additionally, the fixed effects of the year (λ_t), industry (a_j) and region (θ_p) are also controlled.

Meanwhile, the interaction term $BL_{it} \times PA_{it}$ between credit ratio and *BL*, which represents the proxy variable of credit discrimination, is further introduced in Eq. (2) to test the nonlinear influence of credit discrimination on the GTFP. The model is set as follows:

$$GTFP_{it} = \beta_0 + \beta_1 BL_{it} \times PA_{it} + \beta_2 BL_{it} + \beta_3 PA_{it} + \varphi_1 C + \lambda_t + a_j + \theta_p + \varepsilon_{it}. \quad (2)$$

The estimated coefficients a_1 of the bank credit and β_1 of the interaction term $BL_{it} \times PA_{it}$ should be examined to test Hypotheses 1 and 2. Specifically, a_1 suggests that when other factors remain unchanged, the GTFP of private enterprises changes by a_1 units on average for every 1 unit increase in leverage ratio. The β_1 coefficient symbol indicates the direction of the adjustment action and the coefficient value indicates the adjustment intensity. Therefore, if Hypothesis 1 is true, then the estimated

coefficient of a_1 should be significantly positive. If Hypothesis 2 is true, then the estimated coefficient of β_1 should be significantly negative.

2.2 Description of Variables

2.2.1 Explained variables

In this study, the GTFP of private enterprises is measured using the stochastic frontier analysis method based on the form of production function over logarithm. It is assumed that the input factors of the enterprise are the following: capital (*K*), labour (*L*) and energy (*E*), while the expected output (Y) is the total industrial output value of the enterprise, and the unexpected output is the CO_2 emission (*C*). The production technology set can be described as follows:

$$T = \{(K,L,E,Y,C) : (K,L,E)\ produce(Y,C)\} \quad . (3)$$

Shepard direction distance function:

$$D_E(K,L,E,Y,C) = \sup\{a : (K,L,E/a,Y,C)\} \quad . (4)$$

The ratio of potential energy input to real energy input is defined as the GTFP, namely:

$$GTFP = \frac{E/\alpha}{E} = \frac{1}{\alpha} = \frac{1}{D_E(K,L,E,Y,C)} \quad . (5)$$

Notably, the trans-log function contains several parameters, is highly flexible, and has a high accuracy of approximation. Hence, the practice adopted in this study is to solve the GTFP using the trans-log function. Additionally, the time change trend is incorporated into the function to capture the dynamic change process of the model.

2.2.2 Core explanatory variables

The loan balance (BL) of each enterprise in the bank is an absolute indicator, and the difference in amount is large. The logarithm of the BL is processed here to narrow the differences among samples. However, considering that the loan amount of many enterprises is 0, the study chooses to add 1 and then takes the logarithm.

2.2.3 Control variables

The control variables selected include enterprise size (Size), debt-to-production ratio (Lev), operating profit margin (Roa), enterprise age (Age), and energy consumption structure (Enstr).

Table 1. Definition of the control variables

Symbol	Variable	Definition
Size	Enterprise size	Small and micro enterprises are 1, medium-sized enterprises are 2, and large enterprises are 3
Lev	Debt-to-production ration	Total liabilities at year-end/total assets at year-end
Roa	Operating profit margin	Total corporate profits/total assets at year-end
Age	Enterprise age	**The natural logarithm of the difference between the year observed and the year of incorporation plus 1**
Enstr	Energy consumption structure	Electricity energy consumption/combined energy consumption

Source: created by authors.

Table 1 presents the descriptive statistics.

2.2.4 Instrumental variable

Bank credit can have an impact on the GTFP and may also be affected by its reverse effect. We need to construct instrumental variables to alleviate the problem of reverse causality. The characteristics of comprehensive instrumental variables directly affect BLs but do not directly affect the GTFP. They are endogenous and highly correlated with explanatory variables. Finally, the SA index is chosen and calculated as follows:

$$SA = -0.737 \times Size + 0.043 \times Size^2 - 0.04 \times Age. \quad (6)$$

2.3 Data and Description

2.3.1 Data

The research object of this study is private enterprises, and the research period is 2017–2022. Considering that conducting a long-term follow-up survey on all private enterprises in China is not feasible, this study conducts a sample survey based on the 2017 industrial enterprise directory database. The methodology involves performing stratified sampling according to a proportion of 1‰ (to ensure a relatively reasonable distribution of industries) and obtaining a sample of 24,163 private enterprises. Data collection is carried out annually, excluding private enterprises that have withdrawn from the list database. By 2022, there are 10,846 sample private enterprises. Based on this, considering the rationality of subsequent analysis, this study makes the following treatment: (1) The enterprises with several missing values are deleted, i.e., if an enterprise misses three or more variable data in the same year; (2) For missing data, the mean value of corresponding projects in the same industry is used instead; (3) The samples of enterprises whose gross industrial output value and fixed assets are missing or less than or equal to 0, whose number of employees is less than 8, and that evidently do not meet accounting standards are excluded. After the above processing, the valid data in this study include 20,220 private enterprises (an average of 4,044 per year).

2.3.2 Variable selection and processing

In the process of measuring the GTFP of enterprises, the input indicators include capital input (*K*), which is calculated by fixed asset investment. Considering the missing data from 2017–2019, we assumed that the annual growth rate remains unchanged. Moreover, the original growth rate of fixed assets is calculated according to data from 2020–2022. Labour input (*L*) is measured by the average number of workers employed by each firm, whereas energy input (*E*) is expressed as the combined annual energy consumption of each enterprise. Then, output indicators include the expected output (*Y*), expressed as each enterprise's total industrial output. The 2017 price is deflated, and the deflator is calculated using the output price index of the sub-sectors of the national economy to eliminate the impact of price changes. Undesirable output (*C*) is expressed as carbon emissions. In the specific calculation process, the practice of Zhang *et al.* (2023) is used for the conversion estimation of enterprise carbon dioxide emissions.

2.3.3 Descriptive statistical analysis of main variables

Table 2 shows the descriptive statistical analysis results for each variable. The average value of the GTFP of enterprises is 0.620, the maximum value is 1, the standard deviation is 0.261, and the minimum value

is 0.001. These results indicate a significant gap in green production efficiency among enterprises. However, few enterprises have low productivity, while most are in the upper middle level. After logarithmic processing, the minimum value of the BL balance is 0, the maximum value is 10.514, and the average value is 2.183. These results indicate that there is a big difference in the bank credit obtained by different enterprises. Moreover, most private enterprises have relatively small bank credit scales and face potential financing difficulties.

Table 2. Descriptive statistical analysis of main variables

Variables	N	Mean	Standard deviation	Minimum	Maximum
GFTP	20,220	0.620	0.261	0.001	1
BL	20,220	2.183	1.760	0	10.514
Size	20,220	2.224	0. 489	1	4
Lev	20,220	0.569	0.301	0	6.162
Roa	20,220	0.052	0.111	-4.625	2.519
Age	20,220	2.709	0.443	1.098	4.219
Enstr	20,220	0.810	0.296	0.003	1.343

Source: created by authors.

3. Empirical Analysis

3.1 Benchmark Regression Result

In *Table 3*, column (1) shows the regression results without adding any control variables, (2) shows the results with control variables and (3)–(5) shows the results with gradual control time, industry, and region fixed effects, respectively. From the regression results, the coefficients of the core explanatory variable BL are all significantly positive, indicating that bank credit has a significant promoting effect on the GTFP of private enterprises. Taking the regression results in column (5) as an example, a 1% increase in credit will increase the GTFP of private enterprises by 1.05%.

Table 3. Regression results of BLs on the GTFP benchmark

Variables	(1) GTFP	(2) GTFP	(3) GTFP	(4) GTFP	(5) GTFP
BL	0.0102***	0.0159***	0.0114***	0.0105***	0.0105***
	(6.03)	(11.76)	(9.03)	(8.67)	(8.73)
Size		0.0222***	0.0177***	0.0208***	0.0198***
		(5.98)	(5.47)	(6.88)	(6.60)
Roa		-0.0254**	-0.00238	0.00722	0.00217
		(-2.08)	(-0.21)	(0.07)	(0.21)
Lev		-0.0234***	-0.0195***	-0.00259	-0.00645
		(-4.82)	(-4.26)	(-0.62)	(-1.49)
Age		0.0331***	0.0127***	0.0662***	0.00622***
		(12.59)	(5.11)	(2.78)	(2.61)
Enstr		0.498***	0.559***	0.493***	0.499***
		(134.45)	(182.47)	(131.88)	(132.00)
Control year	No	No	Yes	Yes	Yes
Control industry	No	No	No	Yes	Yes
Control region	No	No	No	No	Yes
Constant term	0.613***	0.111***	0.0863***	0.148***	0.156***
	(51.79)	(11.72)	(9.85)	(6.14)	(3.34)
N	20220	20220	20220	20220	20220
R^2	0.276	0.481	0.582	0.624	0.628

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

Source: created by authors.

3.2 Robustness Test

A robustness test is performed in this section. The specific process is as follows:

(1) Replace variables. Only carbon emissions were considered in the calculation of the GTFP. Therefore, based on the existing data and robustness of the model, sulfur dioxide (SO_2) emissions were considered in the calculation as the non-expected output. Moreover, GTFP1 was obtained for regression. Column (1) of *Table 4* shows the results.

(2) Change the measurement method of GTFP. The DEA-Slack-based model in the non-parametric method is used to calculate the GTFP, and column (2) of *Table 4* shows the regression results.

(3) Replace the estimation model. The value of total factor energy GTFP is limited to 0–1, and the characteristics of this variable satisfy the conditions for using the Tobit model. Considering the robustness of the test results obtained using this model, column (3) of *Table 4* shows the results.

(4) Change the date range. Considering the "dual carbon" policy proposed in September 2020, only data before 2020 are used for regression to avoid the impact of this policy on the results. Column (4) of Table 4 shows the results.

(5) Increase control variables. The asset status and tax payment of enterprises will also affect the micro efficiency of enterprises, thereby affecting their GTFP. Therefore, Asize and the proportion of value-added tax to industrial output value (Vatpv) are added as control variables for a robustness test. Column (5) of Table 4 shows the results.

Table 4. Robustness test results

Variables	(1) GTFP1	(2) GTFP	(3) GTFP	(4) GTFP	(5) GTFP
BL	0.00835***	0.00936***	0.0105***	0.00606***	0.00784***
	(6.58)	(4.65)	(8.91)	(10.71)	(6.02)
Size	0.0191***	-0.116***	0.0185***	0.0181***	0.0324***
	(6.01)	(-22.35)	(6.35)	(6.23)	(8.68)
Roa	-0.0112	0.246***	0.00246	0.00217	-0.00131
	(-1.04)	(8.29)	(0.28)	(0.21)	(-0.12)
Lev	-0.00353	0.0795***	-0.00314	-0.00645	0.00761
	(-0.86)	(8.53)	(-0.96)	(-1.49)	(0.18)
Age	0.00783***	-0.0683***	0.00767***	0.00622***	0.00522**
	(3.27)	(-18.29)	(3.54)	(2.61)	(2.18)
Enstr	0.566***	0.0684***	0.522***	0.499***	0.501***
	(141.71)	(11.15)	(142.66)	(132.00)	(131.07)
Asset	-	-	-	-	0.00612***
					(5.43)
Vatpv	-	-	-	-	0.000236
					(0.84)
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes
Regional fixed effect	Yes	Yes	Yes	Yes	Yes
Constant term	0.255***	0.578***	0.148**	0.156***	0.0820*
	(4.91)	(23.37)	(2.48)	(3.34)	(1.68)
N	20220	16176	20220	20220	20217
R^2	0.650	0.182	-	0.629	0.629

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

Source: created by authors.

3.3 Endogenous Processing

Endogeneity tests are performed in this section as follows:

(1) Change the explained variable. The GTFP at the firm level used in this study alleviates the problem of reverse causality to some extent. However, the major drawback of benchmark regression is sample loss, which causes sample selection bias to a certain extent. Specifically, the situation of banks lending to private enterprises may be non-random, including two decision-making stages of whether to lend and how much to lend. It ignores the possibility that two-stage decision-making is affected by varying factors or the same factors to different degrees, which may lead to evident sample selection bias. Therefore, this study applies the Heckman two-step method to re-estimate the benchmark regression method. Moreover, this study examines whether banks lend to enterprises as the explained variable of the selection model. *Table 5* presents the specific test results. According to the regression results of the Heckman model in column (1) of *Table 5*, the imr coefficient of the inverse Mills ratio is significantly positive. This result indicates the existence of a sample selection effect but does not affect the robustness of the benchmark conclusions obtained in this study.

Table 5. Endogeneity test results

Variables	(1) Heckman	(2) IV stage 1	(3) IV stage 2
BL	0.0119***		0.0180***
	(4.86)		(0.0056)
imr	0.0577***		
	(3.38)		
SA		1.0516***	
		(0.0531)	
Size	0.0354***	0.0875*	0.0344***
	(7.83)	(0.0490)	(0.0058)
Roa	-0.0127	-0.6622***	0.0061
	(-0.57)	(0.1026)	(0.0141)
Lev	0.00414	0.4946***	-0.0053
	(0.57)	(0.0385)	(0.0064)
Age	0.01000***	0.0924***	0.0037
	(3.26)	(0.0215)	(0.0044)
Enstr	0.618***	-0.0013	0.5318***
	(98.54)	(0.0279)	(0.0066)
Year fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
Regional fixed effect	Yes	Yes	Yes
KP-LM			204.545
KP-F			391.975
N	12002	20220	20220
R^2	0.565		0.5058

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

Source: created by authors.

(2) Instrumental variable method. This study alleviates the endogeneity problem caused by the missing variable bias by constructing an instrumental variable method. Columns (2) and (3) of Table 5 report the results of the instrumental variable estimates. Column (2) reports the regression of the first stage, and the results indicate that the instrumental variables have a significant positive effect on the GTFP. This result suggests that the instrumental variables meet the correlation conditions. Column (3)

reports the second stage of regression. The results show that BLs have a significant positive impact on the GTFP of enterprises, which is consistent with the baseline regression results. In addition, the statistical values of KP-LM and KP-F are greater than 10. This finding demonstrates that there are no drawbacks associated with the insufficient identification of instrumental variables and weak instrumental variables, i.e., the baseline regression results are robust.

3.4 Heterogeneity Test

The heterogeneity test is carried out in this section. The specific process is as follows:

(1) Enterprise scale. Considering that significant differences may exist in different types of enterprises, this study divides the size of enterprises according to the Measures for the Division of Large, Small, and Micro Enterprises in Statistics (2017) issued by the National Bureau of Statistics. The enterprise type will produce multicollinearity with the enterprise Size in the control variable. Hence, the variable Size is removed here. Columns (1)–(3) of *Table 6* present the regression results for small and micro, medium-sized, and large enterprises, respectively.

The results show that BLs significantly improve the GTFP of small, medium, and large enterprises. The degree of effect on small and medium-sized enterprises is better than that of large enterprises. The main reason is that in recent years, the Chinese government has increased its support for small and medium enterprises. The government provided them with additional efficient and high-quality services in terms of cultivation and development, resource allocation, policy environment, and public services, which has significantly improved the GTFP.

Table 6. Heterogeneity analysis results

Variables	(1) GTFP	(2) GTFP	(3) GTFP	(4) GTFP	(5) GTFP	(6) GTFP	(7) GTFP
BL	0.00709***	0.00410**	0.00451*	0.00877***	0.00184*	0.00544***	0.00812***
	-6	-2.51	-1.84	-6.51	-1.81	-5.68	-3.06
Size				0.0390***	0.00365	0.00734	0.0661***
				-5.44	-0.69	-1.49	-5.42
Roa	-0.0043	0.00299	0.0382	0.01	-0.00691	0.00949	-0.0229
	(-0.61)	-0.1	-0.58	-0.52	(-0.49)	-0.65	(-0.55)
Lev	0.00169	-0.0315**	-0.06	-0.00334	-0.0113	-0.00409	-0.00543
	-0.1	(-2.31)	(-1.63)	(-0.04)	(-1.36)	(-0.65)	(-0.28)
Age	0.00868*	0.00202	-0.0157	-0.00259	0.0167***	0.00525	0.00636
	-1.75	-0.24	(-0.96)	(-0.45)	-3.1	-1.11	-0.51
Enstr	0.490***	0.605***	0.435***	0.478***	0.507***	0.485***	0.532***
	-69.53	-66.81	-12.13	-58.57	-61.68	-69.59	-38.27
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant term	0.188***	0.116***	0.358***	0.176***	0.179***	0.211***	0.0292
	-11.71	-4.06	-5.88	-9.12	-9.45	-12.85	-0.77
N	16207	3423	589	12672	7548	17495	2725
R^2	0.603	0.661	0.8	0.608	0.683	0.589	0.63

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

Source: created by authors.

(2) Mode of trade. Considering the different trade modes of enterprises, enterprises with and without export businesses have different requirements for their green production efficiency. Therefore, this study analyses export (column (4) shows the results) and non-export (column (5) shows the results) enterprises. According to the regression, BLs significantly improve the GTFP of export and non-export enterprises, and the impact of non-export enterprises is considerably more substantial than that of export.

(3) Industry category. According to the above analysis, the GTFP level of different industries where enterprises are located will also differ. According to the Statistical Report on National Economic and Social Development, industries with high pollution and energy consumption are divided into petroleum processing, coking, and nuclear fuel processing industries; chemical raw materials and chemical products manufacturing industry; non-metallic mineral products industry; ferrous and non-ferrous metal smelting and rolling processing industry; and electric power and heat production and supply industry. Columns (6) and (7) of *Table 6* show the results considering the differences brought by the heterogeneity of industries among enterprises. From the regression results, the promoting effect of bank credit on the GTFP is slightly higher for high-polluting and energy-consuming enterprises than for non-high-polluting enterprises.

4. Mechanism Test and Regulatory Effect

4.1 Mechanism Test

According to the influence mechanism analysis, BLs can improve the GTFP of private enterprises through technological progress in which hard technology plays an intermediary role. Therefore, this study constructs the following model for testing:

$$TC_{it} = a_0 + a_1 BL_{it} + \varphi C + \lambda_t + \alpha_j + \theta_p + \varepsilon_{it}, \quad (7)$$

$$TECH_{it} = a_0 + a_1 BL_{it} + \varphi C + \lambda_t + \alpha_j + \theta_p + \varepsilon_{it}, \quad (8)$$

$$EFF_{it} = a_0 + a_1 BL_{it} + \varphi C + \lambda_t + \alpha_j + \theta_p + \varepsilon_{it}, \quad (9)$$

where TC_{it} is the technical progress, $TECH_{it}$ and EFF_{it} represent hard and soft technology levels, respectively, and other variables are the same as in Eq. (1).

For technological progress, we refer to Abad *et al*.'s (2023) method of measuring Malmquist, which is divided into hard technology (TECH) and soft technology (EFF). Hard technology refers to the technology directly related to production technology; thus, the improvement of production efficiency generally depends on the progress of production technology (TECH). Conversely, soft technology refers to efficiency improvement (EFF) caused by upgrading the industrial structure, optimal allocation of resources, and institutional innovation; therefore, the technological progress from t to t + 1 can be expressed as follows:

$$TC_i(x_t, y_t; x_{t+1}, y_{t+1}) = \left[\frac{D_i^t(x_{t+1}, y_{t+1})}{D_i^{t+1}(x_{t+1}, y_{t+1})} \times \frac{D_i^t(x_t, y_t)}{D_i^{t+1}(x_t, y_t)}\right]^{\frac{1}{2}}, \quad (10)$$

where (x_t, y_t) represent the input and output of phase t, respectively. Considering data availability, R&D costs and the monthly average number of workers are selected as input indicators, and the output value of new products is selected as output indicators. $D_0^j(x_i, y_i)$ represents the input-output direction distance function of phase I concerning phase j. By further decomposing TC, the following is obtained:

$$TC_i(x_t, y_t; x_{t+1}, y_{t+1}) = \frac{D_i^t(x_{t+1}, y_{t+1})}{D_i^t(x_t, y_t)} \times [\frac{D_i^t(x_{t+1}, y_{t+1})}{D_i^{t+1}(x_{t+1}, y_{t+1})} \times \frac{D_i^t(x_t, y_t)}{D_i^{t+1}(x_t, y_t)}]^{\frac{1}{2}} = EFF \times TECH \quad . \quad (11)$$

Table 7 shows the results of the mechanism test. As shown in column (1), BL has a positive promoting effect on the technological progress of private enterprises. This result indicates that bank credit has significantly improved the level of technological progress of private enterprises. Combined with the benchmark regression results, we can conclude that BLs improve the GTFP of private enterprises by promoting their technological progress. Hence, Hypothesis 1 is established.

To further discuss the role of technological progress, the decomposed hard technology (TECH) and soft technology (*EEF*) are regressions as mediating variables, respectively. As presented in columns (2) and (3), improvement of the GTFP of private enterprises is highly dependent on scientific and technological progress, i.e., the contribution of hard technology. Therefore, Hypothesis 2 is established as well.

Table 7. Mechanism test

Variables	(1) *TC*	(2) *TECH*	(3) *EEF*
BL	0.00658***	0.0106***	-0.00534***
	(2.66)	(4.67)	(-9.23)
Size	-0.00614**	-0.0750***	0.0221***
	(-2.17)	(-16.81)	(17.23)
Roa	0.0933***	0.131***	-0.0219***
	(4.38)	(4.89)	(-4.26)
Lev	0.0178	0.0235*	-0.00320**
	(1.18)	(1.66)	(-2.19)
Age	0.00968***	0.0134***	-0.000938
	(3.28)	(3.76)	(-1.04)
Enstr	-0.00319	-0.00499	-0.00982***
	(-0.52)	(-0.80)	(-6.12)
Constant term	0.958***	1.172***	0.895***
	(64.81)	(69.90)	(262.62)
Year fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
Regional fixed effect	Yes	Yes	Yes
N	20220	20220	20220
R^2	0.769	0.481	0.849

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

Source: created by authors.

4.2 Moderating Effect of Credit Discrimination

This study introduces an interactive term for credit ratio construction to test the nonlinear influence of credit discrimination on the GTFP of private enterprises. Specifically, it adopts the method Shi *et al*.

(2020) used to measure the loan amount ratio between state-owned and private enterprises. Additionally, enterprise scale is crucial for financial institutions to assess loan risks (Kadam *et al*., 2024). Therefore, private and state-owned enterprises are also divided into three categories according to their scales. The average loan amount eliminates the differences caused by different sample sizes. In summary, the formula for calculating credit discrimination is as follows:

$$PA_i = \frac{\overline{DL}}{\overline{PL}}(i = 1,2,3), \tag{12}$$

where DL is the loan amount of state-owned enterprises, PL is the loan amount of private enterprises, and 1, 2, and 3 represent the small and micro, medium, and large enterprises, respectively.

The nonlinear influence of credit discrimination on the GTFP is tested by introducing the enterprise credit ratio of different sizes into the model as an interaction term. *Table 8* shows the results. As shown in column (1), the coefficient of BL is significantly positive, whereas that of the interaction term between BL and credit discrimination is significantly negative. This result indicates that the enhancement effect of bank credit on the GTFP is negatively moderated by credit discrimination. In other words, the greater the credit discrimination of private enterprises, the more detrimental it is to the promotion of the GTFP.

Table 8. Moderating effect of credit discrimination

	(1) GTFP	(2) GTFP	(3) GTFP	(4) GTFP
BL	0.00810***	0.00905***	0.00390**	0.000424
	(4.43)	(4.35)	(2.09)	(0.33)
PA×BL	-0.00897***	-0.0163***	-0.00805**	-0.00118
	(-4.80)	(-7.29)	(-2.15)	(-0.65)
PA	0.00280*	0.00676**	-0.00320	-0.00304
	(1.79)	(2.12)	(-0.43)	(-0.82)
Size	0.0213***	-	-	-
	(4.38)			
Roa	0.537***	0.0104	-0.0164	-0.0327
	(83.18)	(0.69)	(-0.31)	(-1.50)
Lev	-0.0185	-0.00178	-0.0816***	-0.0696***
	(-8.15)	(-0.30)	(-3.08)	(-2.63)
Age	0.0256***	0.0129***	-0.00828	0.00365
	(12.92)	(2.98)	(-0.66)	(0.49)
Enstr	0.531***	0.560***	0.589***	0.588***
	(81.14)	(77.99)	(19.52)	(42.67)
Year fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
Regional fixed effect	Yes	Yes	Yes	Yes
Constant term	0.195***	0.189***	0.325***	0.230***
	(12.33)	(10.49)	(6.84)	(8.19)
N	20220	12938	2762	474
R^2	0.648	0.745	0.842	0.915
p		0.017***		

Note: *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. The "empirical p-value" was used to test the significance of differences in the PA×BL coefficient among small, micro, and medium-sized enterprises, which was obtained through 1000 times of self-sampling (bootstrap).

Source: created by authors.

Columns (2)–(4) show the regression results of small, medium, and large enterprises, respectively. The results show that credit discrimination has no significant impact on the GTFP of large and medium-sized enterprises. Conversely, the negative regulatory effect on small and micro enterprises is substantial. The user-Scheer combination test was conducted to verify the differences in interaction term coefficients between small and micro enterprises and medium-sized enterprises. The results show that the coefficients are different at the 1% significance level, suggesting that credit discrimination affects the GTFP of private enterprises differently based on their size.

Conclusions

The private economy is an essential part of the regional and national economy and is important in promoting high-quality development. GTFP is the core symbol of high-quality development; however, the development of private enterprises requires a significant amount of financing. Effectively solving the financing problems of private enterprises is essential. Taking private enterprises as the object, this study analyses the relationship between bank credit and the GTFP using tracking survey data on Chinese private enterprises from 2017–2022. First, the benchmark regression model is used to verify whether bank credit can significantly and positively affect the GTFP of private enterprises. Then, technological progress is divided into hard and soft technology. The intermediary effect analysis shows that bank credit can effectively improve the hard technology of private enterprises and then affect the GTFP, i.e., hard technological progress acts as an intermediary. Finally, credit discrimination will weaken the promoting effect of bank credit on the GTFP of private enterprises, but the effect depends on the size of the enterprises.

Based on the research conclusions, the following suggestions are proposed:

First, government departments should reform and improve the regulatory assessments and incentive and restraint mechanisms of financial institutions. They should also link performance assessments with support for the private economy and optimise due diligence exemption, fault tolerance, and error correction mechanisms. Additionally, government departments should adopt multiple measures to broaden the financing channels of private enterprises, comprehensively use direct and indirect financing channels and fully mobilise various financial resources, such as credit, bonds, equity, wealth management, trust, and insurance.

Second, banks should improve the bank credit risk assessment mechanisms. Based on the characteristics of private enterprises and industries, banks should set effective risk assessments and monitoring indicators, reduce the dependence on collateral, and increase the issuance of credit loans. Additionally, the internal assessments of banks should implement a due diligence exemption mechanism to solve the problem of “dare not lend.” Government financing guarantees that institutions should further increase their support for private enterprises’ credit financing, including increasing the amount of guarantee, optimising the guarantee process, and improving guarantee efficiency.

Third, private enterprises should maximise financing to achieve leapfrog improvements at the technical level. Competitive enterprises are the microfoundation of high-quality development. Private enterprises should take the initiative to promote innovation in the industry–university–research cooperation, improve the intensity of R&D, and stimulate the creativity of technology and knowledge. Moreover, private enterprises should focus on high-end and sophisticated technology in the subdivision field, develop in the direction of “specialisation and special new,” and evolve into “intelligent” modelling enterprises rich in intellectual property rights.

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Acknowledgements

This work was supported by the project of Economic Forecasting and Policy Simulation Laboratory, Zhejiang Gongshang University（No.2024SYS032.

BANKŲ KREDITŲ POVEIKIS PRIVAČIŲ ĮMONIŲ ŽALIAJAM BENDRAJAM GAMYBOS VEIKSNIŲ NAŠUMUI: KINIJOS MIKROANALIZĖ

Huanhuan Jin, Hualong Deng, Dongyu Xu, Zhouyi Zhang

Santrauka. Privačioms įmonėms pertvarkyti ir modernizuoti reikia didelio finansavimo. Kokybiškai privačių įmonių plėtrai šios finansavimo problemos sprendimas yra labai svarbus. Žaliasis bendras gamybos veiksnių produktyvumas (ŽBVP) atspindi ekonominio augimo kokybę ir atsakomybę už aplinką ir yra svarbus įmonių kokybiškos plėtros simbolis. Šiame tyrime iš kreditavimo perspektyvos atskleidžiamas mechanizmas, kuriuo bankų kreditai veikia privačių įmonių ŽBVP. Lyginamosios regresijos rezultatai atskleidė, kad banko kreditas gali skatinti privačių įmonių ŽBVP gerėjimą. Mechanizmo testas atskleidė, kad sunkiosios technologijos veikia kaip tarpininkas, t. y. banko kreditas skatina sunkiųjų technologijų pažangą taip gerindamas privačių įmonių ŽBVP. Moderuojančio poveikio analizė atskleidė, kad kredito diskriminacija gali susilpninti banko kredito skatinamąjį poveikį privačių įmonių ŽBVP. Tačiau šis poveikis susijęs su įmonių dydžiu. Šis tyrimas padeda geriau suprasti bankų kreditų ir privačių įmonių ryšį iš mikroperspektyvos. Be to, šiame tyrime pateikiama empirinių įrodymų, skatinančių kokybišką ekonomikos plėtrą.

Reikšminiai žodžiai: privati įmonė; kokybiškas vystymasis; žaliasis bendrasis gamybos veiksnių našumas; banko kreditas.