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Green Loan Interest Subsidy Policy, Green Technological Innovation, and High-Quality Enterprise Development

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Abstract: The question of how financial and fiscal policies can be coordinated to exert substantive incentive effects, thereby promoting enterprises' green and low-carbon transformation as well as high-quality development, stands as a crucial challenge currently confronting China's real economy. This paper zeros in on the synergistic perspective of financial and fiscal policies, leveraging data from A-share listed companies in China spanning the years 2008 to 2020. Employing a progressive difference-in-differences (DID) model, it empirically assesses the structural impact of Green Loan Interest Subsidy Policy on enterprises' total factor productivity (TFP). The research demonstrates that Green Loan Interest Subsidy Policy are effective in enhancing enterprises' TFP, thereby empowering their high-quality development. An analysis of the impact mechanism reveals that these policies stimulate incremental and qualitative improvements in enterprises' green technological innovation mechanisms, optimizing TFP and driving high-quality development. Heterogeneity analysis further indicates that the incentive effects of Green Loan Interest Subsidy Policy on TFP are more pronounced in eastern and central regions, , as well as among enterprises operating in green and low-carbon industries. These findings offer theoretical support for governments, banks, and enterprises in guiding enterprises towards green and low-carbon production and high-quality development through green credit and interest subsidy policies.

Keywords: Green Loan Interest Subsidy Policy; High-Quality Enterprise Development; Total Factor Productivity; Green Technological Innovation; Synergy between Financial and Fiscal Policies

JEL Classification Codes: D24, G38, H23.

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1. Introduction

The report of the 20th National Congress of the Communist Party of China highlights that promoting green and low-carbon economic and social development is a pivotal aspect of achieving high-quality growth. Following the announcement of China's "dual-carbon" goals—aiming to achieve carbon peaking and carbon neutrality—a series of economic policies have been

introduced to direct capital flows towards green and low-carbon sectors such as environmental protection. Gradually, a framework for green economic policies has emerged, integrating top-down design at the central level with pilot projects at the local level. This framework places particular emphasis on the coordination between financial and fiscal policies. In 2016, the concept of coordinating financial and fiscal green policies was first introduced in the *Guiding Opinions on Establishing a Green Financial System* jointly issued by the People's Bank of China, the Ministry of Finance, and other ministries and commissions (Hong et al., 2023). Subsequently, in 2022, the Ministry of Finance released the *Several Opinions on Fiscal Support for Achieving Carbon Peaking and Carbon Neutrality*, advocating for collaborative efforts across multiple departments to enhance the overall effectiveness of policies. Against this backdrop, green loan interest subsidy policies have emerged in recent years as one of the commonly used support measures by local governments, exemplifying the synergistic role of financial and fiscal policies in the green sector. The Green Loan Interest Subsidy Policy integrates green loans with fiscal subsidies, where local governments provide subsidies for part or all of the loan interest for enterprises that meet specific criteria when applying for green loans from financial institutions (Hong et al., 2023). Since 2017, various local governments in China have successively introduced Green Loan Interest Subsidy Policy. However, there has been limited research assessing the effectiveness of these policies, with most studies relying on macro-level theoretical models for analysis (Wang et al., 2017; Ma & Lv, 2022). This paper argues that a quantitative approach to studying Green Loan Interest Subsidy Policy can enhance the synergistic effect of financial and fiscal policies within the green sector, thereby more effectively promoting high-quality corporate development.

The report of the 20th National Congress of the Communist Party of China also emphasizes the need to "prioritize promoting high-quality development" and "focus on improving total factor productivity," highlighting the significance of enhancing total factor productivity in the current stage of high-quality development. Improving total factor productivity is not only a pathway to achieving economic high-quality development but also a core indicator for assessing its progress (Huang et al., 2023). Consequently, total factor productivity is often used as a metric to evaluate the level of high-quality development in enterprises. Against this backdrop, this study employs total factor productivity to measure the degree of high-quality development in enterprises and explores the mechanisms through which Green Loan Interest Subsidy Policy facilitate enterprises in achieving high-quality development.

Existing empirical evidence tends to suggest that green finance or fiscal policies can promote high-quality enterprise development (Ren & Lv, 2014; Guo & Fang, 2021). However, there are scarce studies that explore the synergistic mechanisms of these two policies at the enterprise level. What are the internal mechanisms through which Green Loan Interest Subsidy Policy facilitate high-quality enterprise development? This question is crucial for effectively advancing the coordination and synergistic enhancement of green finance and fiscal policy systems. Meanwhile, technological progress and innovation are the

primary driving forces for high-quality enterprise development, and one of the functions of financial and fiscal policies in supporting enterprise development is to assist them in continuously reducing costs, increasing efficiency, and fostering innovation. Therefore, does the Green Loan Interest Subsidy Policy contribute to enterprises' green technological innovation? Can the Green Loan Interest Subsidy Policy promote the quality of enterprise development by fostering green technological innovation? In light of this, this study selects local Green Loan Interest Subsidy Policy as the subject of analysis. By adopting a method that starts small and expands to the larger picture, we aim to explore the synergistic effects of green financial and fiscal policies in optimizing enterprises' total factor productivity. Our objective is to provide new perspectives and evidence for assessing green economic policies and determining whether they achieve a "1+1≥2" policy effect, thereby contributing to high-quality enterprise development.

The marginal contributions of this paper are primarily manifested in two aspects. Firstly, it examines the impact of local Green Loan Interest Subsidy Policy on the development quality of micro-enterprises from the dual perspectives of green finance and fiscal policies, focusing the macro policy effects of the synergy between green credit and fiscal interest subsidy policies on the specific target of enterprises' total factor productivity (TFP), and empirically tests the micro-level consequences of the synergy between financial and fiscal policies. Existing literature predominantly examines the impact of single policies on the development of macro and microeconomic entities (Ren & Lv, 2014; Marino et al, 2016; Guo & Fang, 2021; Zhou et al., 2023) There is limited literature exploring the effects of non-single policies on resource reallocation, strategic governance, and adjustments in enterprise development, particularly systematic research on their relationship with high-quality enterprise development. Secondly, this paper elucidates whether Green Loan Interest Subsidy Policy have a quality-enhancing effect on enterprises from the perspective of green technological innovation. From an internal enterprise perspective, compared to existing literature that explores the impact of green credit policies or green subsidies on enterprise technological innovation (Li & Xiao, 2020; Zhou et al., 2023), this study further investigates the influence of Green Loan Interest Subsidy Policy on enterprises' green technological innovation from the combined perspective of green finance and fiscal policies. Compared to traditional innovation measured by patent counts, green technological innovation exhibits stronger environmental friendliness, which is of great significance for China to achieve high-quality economic development. Therefore, this paper provides empirical evidence for understanding the relationship between Green Loan Interest Subsidy Policy and enterprises' green technological innovation.

2. Theoretical Analysis and Research Hypothesis

2.1 Green Loan Interest Subsidy Policy and High-Quality Enterprise Development

The combination of green financial and fiscal policies can guide enterprises to actively engage in green and low-carbon

transformation and clean production activities, contributing to their sustainable and high-quality development over the long term. The Green Loan Interest Subsidy Policy provides support for enterprises' funding needs and alleviates financing obstacles encountered in their pursuit of innovative development and productivity enhancement. According to the resource dependence theory, green finance can help enterprises mitigate financing difficulties by leveraging the financial resources of stakeholders such as banks and investors (Hong et al., 2023). Meanwhile, fiscal subsidies exert both an "income effect" and a "certification effect" on enterprises' investment activities (Feldman and Kelly, 2006). By offering implicit government credit guarantees, fiscal subsidies increase enterprises' attractiveness to external market funds and facilitate their access to more bank financing and social capital (Wu et al., 2020). Specifically, to facilitate the implementation of the Green Loan Interest Subsidy Policy, government departments need to bear corresponding interest subsidy responsibilities, thereby guiding capital to continue investing in green and low-carbon sectors. This leverages fiscal funds and government credit to attract banks to invest more credit funds, thereby influencing the incentive effect of green credit on enterprises' green, clean, and low-carbon production and operation, and ultimately promoting high-quality enterprise development. On this basis, this paper argues that the Green Loan Interest Subsidy Policy can effectively alleviate financing constraints for enterprises in funding technological innovation and productivity enhancement in their production and operation activities. It also effectively incentivizes enterprises to establish a positive virtuous cycle between continuously improving total factor productivity (TFP) and obtaining external financial resources, which contributes to promoting high-quality enterprise development. Based on the above analysis, this paper proposes Hypothesis 1:

H1: The Green Loan Interest Subsidy Policy contributes to promoting high-quality enterprise development.

2.2 Mechanism of Impact of the Green Loan Interest Subsidy Policy on High-Quality Enterprise Development

Drawing on Schumpeter's theory of innovation and endogenous growth, technological progress, as an internal driver of economic growth, often originates from research and development (R&D) activities in innovation (Aghion & Howitt, 1992). Green innovation is regarded as a crucial pathway for enterprises to achieve green and low-carbon transformations. It serves as an intrinsic driving force for the current green and high-quality development of enterprises and has profound and long-term positive benefits for the sustainable development of various socio-economic activities. Furthermore, the synergistic incentives of green credit and interest subsidy policies gradually steer enterprises' production factors and production relations towards green and low-carbon development through green innovation and efficiency enhancement (Bai et al., 2019; Wang, X & Wang, Y, 2021; Zhou et al., 2023). This can reduce environmental governance costs, financing costs, and potential environmental penalty costs in production and operation activities, effectively guiding enterprises towards cleaner production. At the enterprise

level, the Green Loan Interest Subsidy Policy supports high-quality development by promoting green technological innovation: on the one hand, the policy incentivizes enterprises to actively engage in green innovation. Through the continuous accumulation of green innovation, it improves production efficiency and forms competitive advantages, thereby enhancing the quantity of green innovation in the production and operation process and promoting high-quality development. On the other hand, while incentivizing green innovation, the Green Loan Interest Subsidy Policy also fosters a positive virtuous cycle with green innovation, facilitating sustained investment in green technological innovation R&D and increasing the intensity of resource allocation. This is conducive to enterprises achieving qualitative improvements in green innovation through quantitative accumulation. The positive benefits brought about by this will continue to expand, continuously optimizing enterprises' total factor productivity and promoting high-quality development. Based on the above analysis, this paper proposes the following hypotheses:

H2: The Green Loan Interest Subsidy Policy promotes high-quality enterprise development by incentivizing green technological innovation.

H2a: The Green Loan Interest Subsidy Policy promotes high-quality enterprise development through the quantity effect of incentivizing green innovation.

H2b: The Green Loan Interest Subsidy Policy promotes high-quality enterprise development through the quality effect of incentivizing green innovation.

3 Research Design

3.1 Sample Selection and Data Sources

To investigate the implementation effects of the Green Loan Interest Subsidy Policy on the high-quality development of enterprises, this study treats the implementation of the Green Loan Interest Subsidy Policy in the region where an enterprise is registered as a quasi-natural experiment. Chinese A-share listed enterprises from 2008 to 2020 are selected as samples for empirical analysis. The Opinions on Implementing Environmental Protection Policies and Regulations to Prevent Credit Risks, issued in 2007, marks the comprehensive implementation of China's green credit policy (Hong et al., 2023). However, considering the possible lagged effects of the green credit policy and the time required from initiating R&D innovation to patent application, this paper selects 2008 as the starting year for the policy to have practical effects and 2020 as the end year for studying corporate social responsibility. Following Wang, X & Wang, Y(2021)、Hong et al.(2023)、Huang et al.(2023), this paper processes the listed enterprise data as follows: excluding ST, PT, and *ST enterprises during the sample period; excluding financial enterprise data; excluding data for enterprises with a debt-to-asset ratio greater than 1; and excluding data with severe missing financial or other indicators, ultimately obtaining a total of 29,298 sample observations. The enterprise total factor

productivity and financial data in this paper are sourced from the CSMAR database, the Green Loan Interest Subsidy Policy document data are sourced from the websites of provincial and municipal people's governments and Hong et al.(2023), and the green innovation-related data are sourced from the CNRDS China Research Data Service Platform. Additionally, to reduce the impact of extreme values, all continuous variables have undergone a 1% winsorization process.

3.2 Model Construction and Variable Definition

To assess the impact of the Green Loan Interest Subsidy Policy on firm-level total factor productivity, this study employs a progressive difference-in-differences (DID) model for quantitative analysis, as detailed below:

$$TFP\_(OP,LP)_{it} = \beta_0 + \beta_1 GLISP_{it} + \beta_2 Controls_{it} + \gamma_i + \eta_t + \varepsilon_{it} \quad (1)$$

Where, $TFP_{i,t}$ denotes the total factor productivity of the ith listed firm in year t. $GLISP_{it}$ is a dummy variable indicating whether the city where the ith listed firm is registered has implemented the Green Loan Interest Subsidy Policy in year t; the variable takes a value of 1 if the policy is implemented in that city, and 0 otherwise. $Controls_{i,t}$ represents a set of time-varying firm-level control variables. γ_i denotes industry-fixed effects, η_t represents time-varying variables for year-fixed effects, and $\varepsilon_{i,t}$ is the random disturbance term.

Based on the theoretical analysis presented earlier, the Green Loan Interest Subsidy Policy can influence firm-level total factor productivity through the green technological innovation mechanism and its quantity and quality effects. To conduct a mechanism test, this paper builds a mechanism testing model based on the benchmark regression model, adopting a two-step approach inspired by Jiang(2022) as follows:

$$M_{i,t,j} = \alpha_0 + \alpha_1 GLISP_{i,t} + \alpha_2 Controls_{i,t} + \gamma_i + \eta_t + \varepsilon_{i,t} \quad (2)$$

Where, M_j $(j = 1,2,3)$ denotes the mechanism variable for the firm (green technological innovation, the quantity of green innovation, and the quality of green innovation), with other variables consistent with the benchmark model. By sequentially setting the dependent variable to these three mechanism variables and combining with the theoretical analysis presented earlier, we can test whether the selected mechanism pathways hold.

Additionally, detailed descriptions of all variables involved in models (1) and (2) are provided in Table 1.

Table 1. Definitions and Descriptions of Variables

Variable Type	Name	Symbol	Definition	Reference	Data Source
Dependent Variable	High-Quality Enterprise Development	*TFP_OP*	Firm-level total factor productivity calculated using the Olley-Pakes (OP) method	Lu & Lian(2012)、Huang et al.(2023)	China Stock Market & Accounting Research (CSMAR) Database

		TFP_LP	Firm-level total factor productivity calculated using the Levinsohn-Petrin (LP) method		
Core Explanatory Variable	Green Loan Interest Subsidy Policy	*GLISP*	Take the value of 1 if the city where the enterprise is registered has implemented the Green Loan Interest Subsidy Policy, otherwise take 0.	Hong et al.(2023)	Websites of provincial and municipal people's governments, as well as Hong et al.(2023)
		GLISPtreat	Take the value of 1 if the region where the enterprise is located falls within the designated scope of the Green Loan Interest Subsidy Policy at the prefecture-level city, otherwise take 0.		
		GLISPyear	Take the value of 1 for the initial and subsequent years if the region where the enterprise is located has implemented the Green Loan Interest Subsidy Policy, otherwise take 0.		
Mechanism Variable	Green Technological Innovation	*GI*	The logarithm of the sum of green invention patent applications and green utility model applications plus one.	Xu & Cui(2020)、Wang, X & Wang, Y(2021)	China National Research Data Service Platform (CNRDS)
	Number of Green Innovations	*GIN*	The natural logarithm of the number of green utility model applications plus one.		
	Quality of Green Innovations	*GIQ*	The natural logarithm of the number of green invention patent applications plus one.		
Control Variable	Enterprise Size	*Labor*	Natural logarithm of the number of enterprise employees	Si & Cao(2022)、Hong et al.(2023)、Huang et al.(2023)	China Stock Market & Accounting Research (CSMAR) Database
	Enterprise Age	*Age*	Natural logarithm of the difference between the current financial year and the year of establishment of the enterprise		
	Financial Leverage	*Lev*	Total liabilities at the end of the year divided by total assets at the end of the year		
	Profitability	*Return*	Net profit divided by operating revenue		
	Growth Rate	*Growth*	The ratio of current year's operating revenue to the previous year's operating revenue minus one		
	Cash Asset Ratio	*Cashflow*	Cash flow generated from operating activities divided by total assets		
	Current Ratio	*Liquid*	Current assets divided by total assets		
	Board Size	*Board*	Natural logarithm of the number of board members		
	Nature of Property Rights	*Soe*	Value of 1 for state-owned enterprises and 0 otherwise		
	Per Capita Regional GDP	*pGDP*	Regional GDP divided by total population		
	Credit Environment	*UCE*	The proportion of total urban credit to regional GDP		

4. Analysis of Empirical Results

4.1 Descriptive Statistical Analysis

The descriptive statistical results for the main variables in this paper are presented in Table 2. The mean values of *TFP_OP* and *TFP_LP* are 6.6272 and 8.2420, respectively, with standard deviations of 0.8860 and 1.0454. These results indicate that the overall variation in total factor productivity among the sampled enterprises is relatively small and is comparable to the findings

of Huang et al. (2023).

Table 2. Descriptive Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Median	Maximum
TFP_OP	29298	6.6272	0.8860	4.1063	6.5275	9.2452
TFP_LP	29298	8.2420	1.0454	5.5007	8.1454	11.2713
Labor	29298	7.6992	1.2458	3.5553	7.6280	11.2480
Age	29298	2.8425	0.3485	1.0986	2.8904	3.5835
Lev	29298	0.4354	0.2044	0.0353	0.4307	0.9085
Return	29298	0.0653	0.1748	-1.5435	0.0646	0.6168
Growth	29298	0.1692	0.4286	-0.6597	0.1036	4.4291
Cashflow	29298	0.0479	0.0697	-0.1989	0.0464	0.2913
Liquid	29298	0.5611	0.2019	0.0777	0.5746	0.9651
Board	29298	2.1377	0.2003	1.6094	2.1972	2.7081
Soe	29298	0.3972	0.4893	0.0000	0.0000	1.0000
pGDP	29298	11.3017	1.2076	5.8390	11.2420	21.0353
UCE	29298	1.5478	0.6475	0.2948	1.5657	5.3047

4.2 Analysis of Empirical Results

4.2.1 Main Results

Table 3 presents the regression results of the Green Loan Interest Subsidy Policy (GLISP) on firms' total factor productivity (TFP_OP and TFP_LP). According to the results in columns (2) and (4), the impact coefficient of the GLISP on firms' TFP calculated using the OP method is 0.0606, and that for the TFP calculated using the LP method is 0.0715. Both coefficients are significant at the 1% level. These basic regression analysis results indicate that the GLISP has a positive and significant impact on firms' total factor productivity, contributing to the promotion of high-quality firm development. Hence, Hypothesis H1 is supported.

Table 3. Effect of Green Loan Interest Subsidy Policy on firms' TFP

Variable	(1)	(2)	(3)	(4)
	TFP_OP	*TFP_OP*	*TFP_LP*	*TFP_LP*
GLISP	0.1042***	0.0606***	0.1531***	0.0715***
	(0.0158)	(0.0126)	(0.0200)	(0.0126)
Labor		0.1890***		0.4665***
		(0.0045)		(0.0043)
Age		0.0359***		0.0518***
		(0.0123)		(0.0120)
Lev		1.1489***		1.0639***

		(0.0271)		(0.0267)
Return		0.4882***		0.4501***
		(0.0292)		(0.0293)
Growth		0.2088***		0.2142***
		(0.0121)		(0.0119)
Cashflow		1.0651***		1.0062***
		(0.0655)		(0.0651)
Liquid		1.2354***		1.4976***
		(0.0257)		(0.0255)
Board		0.1307***		0.0927***
		(0.0200)		(0.0196)
Soe		0.1669***		0.1457***
		(0.0093)		(0.0092)
pGDP		0.0343***		0.0322***
		(0.0035)		(0.0035)
UCE		0.0430***		0.0394***
		(0.0065)		(0.0064)
_cons	6.6157***	2.9514***	8.2251***	2.3963***
	(0.0048)	(0.0715)	(0.0058)	(0.0699)
adj. R^2	0.2607	0.5082	0.2145	0.6615
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
N	29298	29298	29298	29298

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The values in parentheses are standard errors. Robust standard errors are used in calculations for (1) to (4) in this table. The same applies to the following tables.

4.2.2 Testing the Parallel Trends Assumption

Drawing on the methodology of Wang & Ge (2022), this study employs the event study approach to test the parallel trends assumption. Taking into account the data distribution characteristics of the five years preceding policy implementation, the study aggregates data from those years into a single period labeled as "-5". Additionally, the year immediately prior to the introduction of the Green Loan Interest Subsidy Policy (2016) is selected as the base period. The results of the parallel trends test depicted in Figure 1 indicate that, for both measures of firm total factor productivity (TFP_OP and TFP_LP), the coefficient estimates for all periods prior to the implementation of the policy are insignificant, whereas they become positively significant subsequent to policy implementation. This suggests that, prior to policy enforcement, there were no discernible differences in total factor productivity between firms located in pilot cities and those in non-pilot cities. However, following policy

implementation, firms in pilot cities exhibited significantly higher total factor productivity compared to those in non-pilot cities. These findings demonstrate that the research sample meets the requirements for testing the parallel trends assumption.

4.2.3 Endogeneity Test

(1) Placebo Test. Building upon the validation of the parallel trends assumption, the placebo test is conducted to further assess the extent to which the Main Results of the basic regression are influenced by random factors and omitted variable issues. Specifically, this paper adopts the methodology employed by previous scholars (Wang, L et al., 2021; Cui et al., 2023) by randomly assigning the Green Loan Interest Subsidy Policy (*GLISP*) to sample enterprises to reconstruct policy dummy variables for the placebo test. These reconstructed variables are then included in the basic regression model for re-estimation, and the process is repeated 1000 times to ultimately produce a distribution plot of the regression coefficients for the false (*GLISP*). Given that the *GLISP* in this context is obtained through random sampling, the randomly simulated false experimental group should theoretically have no substantial impact. If, under random construction conditions, the significant results of the false estimation coefficients are due to chance factors, the estimated coefficients of the core explanatory variables from the Main Results of the basic regression in this paper will be notably included in the density distribution of the 1000 randomly generated pseudo-variable coefficients. Conversely, this would indicate that the observed effects in the basic regression analysis indeed originate from the Green Loan Interest Subsidy Policy. As shown in Figure 2, the false regression coefficients are primarily concentrated near 0 and deviate significantly from the Main Results coefficients (0.0606 and 0.0715) obtained in this study. This suggests that the Main Results of the basic regression in this study are not caused by unobserved chance factors. In other words, the influence of unobservable factors on the basic regression results can be excluded, demonstrating the reliability and robustness of the conclusions of this study.

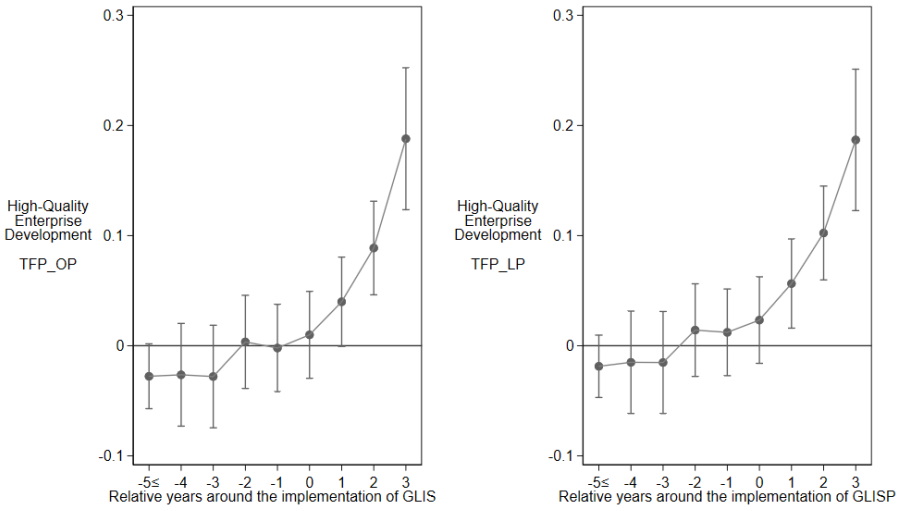

Figure 1. Results from Testing the Parallel Trends Assumption

(2) Propensity Score Matching and Difference-in-Differences Method (PSM-DID). Given that differences in the development levels of enterprises across regions may lead to sample selection bias, affecting the accuracy of the Main Results of the basic regression, this section employs the PSM-DID method to enhance the comparative rationality between enterprises in pilot cities and those in non-pilot cities. Drawing on the existing practices of Cui et al.(2023), this paper adopts both mixed matching and period-by-period matching in the sample matching process, utilizing nearest neighbor 1:1 and 1:2 matching strategies to pair treatment group samples with control group samples, respectively. The basic regression is then re-examined based on the matched samples. The regression results presented in Table 4 below indicate that the regression coefficient of GLISP remains significantly positive at the 1% level, and its magnitude is consistent with the coefficient in the basic regression. This suggests that, after considering potential issues of sample self-selection and sample selection bias, the positive effect of the Green Loan Interest Subsidy Policy on firm-level total factor productivity remains significant, reinforcing support for Hypothesis H1.

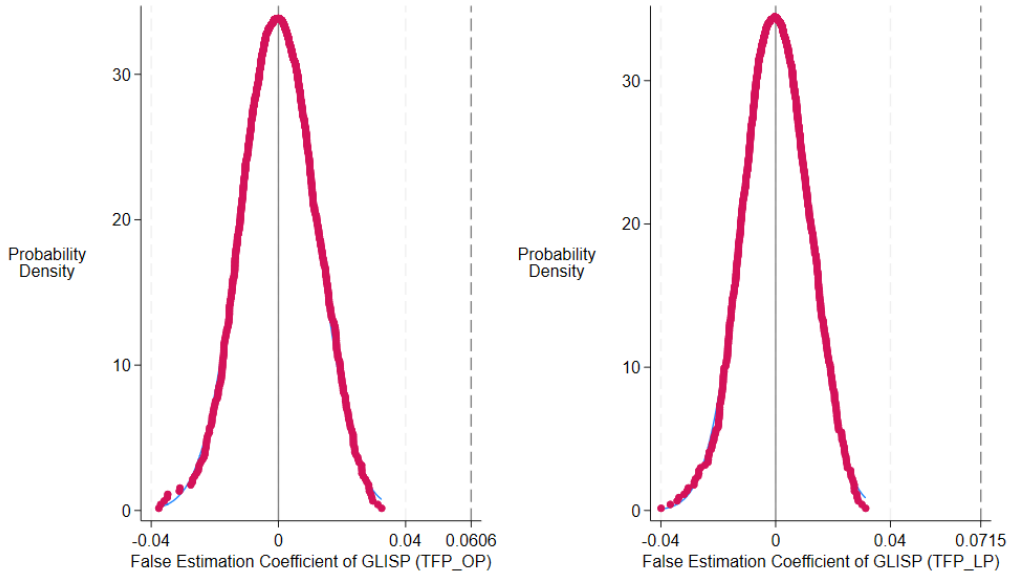

Figure 2. Presentation of Placebo Test Results

Table 4. Robustness Check: PSM-DID

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mixed Matching:				Year-by-Year Matching:			
Variable	Nearest Neighbor Matching		Nearest Neighbor Matching		Nearest Neighbor Matching		Nearest Neighbor Matching	
	1:1		1:2		1:1		1:2	
	TFP_OP	*TFP_LP*	*TFP_OP*	*TFP_LP*	*TFP_OP*	*TFP_LP*	*TFP_OP*	*TFP_LP*
GLISP	0.0530***	0.0552***	0.0532***	0.0566***	0.0775***	0.0861***	0.0674***	0.0781***
	(2.9947)	(3.1418)	(3.6028)	(3.8515)	(4.3805)	(4.9044)	(4.5207)	(5.2610)
adj. R^2	0.5373	0.6811	0.5296	0.6745	0.5208	0.6713	0.5178	0.6691
Control Variable	YES	YES	YES	YES	YES	YES	YES	YES

Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Industry Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
N	12,065	12,065	17,425	17,425	12,468	12,468	17,975	17,975

4.2.4 Robustness Checks

(1) Replacement of the Dependent Variable Measurement Method. To examine the sensitivity of our Main Results to the calculation method of firm-level total factor productivity (TFP) and to mitigate the impact of measurement errors, we follow the ideas of existing scholars (Lu & Lian, 2012; Huang et al., 2023) and recalculate TFP using the OLS method, FE method, and GMM. By replacing the dependent variable indicators and re-performing the basic regression, we aim to verify the robustness of our findings.

(2) Control for Non-parallel Trends. Drawing on insights from the literature, we control for non-parallel trends by including city-time interaction terms (Wang & Ge, 2022) and industry-time interaction terms (Si & Cao, 2022). ① Control for City-time Interaction Terms: If the Green Loan Interest Subsidy Policy is correlated with factors such as a city's economic development level, historical background, and geographical location, these factors may change over time and have different impacts on firm-level TFP, leading to estimation bias. To avoid the influence of non-random policy selection on the results, we include interaction terms between city-specific basic characteristics and time trends in the basic regression. ② Control for Industry Trends: Given that industry characteristics may evolve over time and have differential impacts, and industry trends may also shock firm-level TFP, we incorporate interaction terms between industry and time fixed effects into the control variables of the basic model to minimize coefficient estimation bias.

(3) Exclusion of Other Policy Effects. Following the literature, we exclude other policy factors primarily by excluding special years and special samples (Cui et al., 2023): ① Exclusion of Special Years: In 2015, China formally implemented the Environmental Protection Law of the People's Republic of China, which explicitly stipulates that enterprises need to transition towards green and low-carbon development. This may have a significant impact on firm-level TFP. We mitigate the influence of the Environmental Protection Law by excluding 2015 firm samples from the regression. ② Exclusion of Special Environmental Pilot Policies: In 2014, the Ministry of Environmental Protection issued the Interim Measures for Interviews on Environmental Protection, implementing mandatory environmental regulatory measures to promote high-quality, green, and low-carbon development among enterprises by interviewing local government officials who fail to fully fulfill their environmental protection responsibilities. To avoid the potential impact of environmental interviews on our research conclusions, we re-examine the basic regression after excluding firms located in cities that were interviewed.

The empirical results of the above robustness checks consistently show that[1] the impact of the Green Loan Interest Subsidy Policy on firm-level TFP is consistent with the Main Results, which once again verifies the reliability and robustness of the main conclusions of this paper.

4.3 Analysis of Impact Mechanisms

Previous sections have validated the incentive effect of the Green Loan Interest Subsidy Policy (GLISP) on promoting high-quality enterprise development. Next, we aim to empirically test the mechanisms proposed in the theoretical analysis hypothesis regarding how GLISP promotes high-quality enterprise development. The following analysis focuses on mechanism testing, as detailed below:

Research by Wang, X & Wang, Y(2021) indicates that green credit facilitates green innovation among enterprises. Therefore, does GLISP promote high-quality enterprise development by enhancing green technological innovation? This paper adopts the green technological innovation, green innovation quantity, and green innovation quality indicators constructed by Xu & Cui(2020), as well as 、Wang, X & Wang, Y(2021), and uses the method proposed by Jiang(2022) to test this mechanism. As shown in Table 5, columns (1), (4), and (7) reveal that the regression coefficients of *GLISP* have significant positive incentive effects at the 5% level, indicating that *GLISP* promotes green technological innovation(*GI*), its increment(*GIN*), and quality improvement(*GIQ*) among enterprises. This may be because green credit and interest subsidies are credit rationing and funding support based on environmental constraints and urging enterprises toward high-quality development. Therefore, under equal conditions, green credit and subsidy funds are more inclined to support green technological innovation enterprises, which have direct financing encouragement and investment support effects on enterprise technological innovation, providing external funding for green technological innovation. In other words, green credit and interest subsidies promote green technological innovation among enterprises through funding constraints and support (Wang, X & Wang, Y, 2021; Hong et al., 2023). Based on the green credit and interest subsidy funds obtained by enterprises for technological innovation, they increase R&D investment in potential green technology improvement directions in production, thereby increasing the quantity and improving the quality of green innovation. This is conducive to enhancing enterprise production efficiency and competitiveness, increasing profitability, and promoting their transition to green and low-carbon development. It facilitates a virtuous cycle between financial and social performance among enterprises, thereby promoting high-quality enterprise development.

To complete the logical chain of impact mechanisms, this paper separately tests the impact of green technological innovation(*GI*), green innovation quantity(*GIN*), and green innovation quality(*GIQ*) on enterprise total factor productivity. As shown in columns (2), (3), (5), (6), (8), and (9) of Table 5, the regression coefficients of *GI*, *GIN*, and *GIQ* have significant

[1] Due to space limitations, the detailed content of this section is not enumerated here, and the results are available upon request.

positive mechanism effects at the 1% level, and the effect of green innovation quality on high-quality enterprise development is more pronounced. That is, enterprises can positively incentivize high-quality development by promoting green technological innovation (Wang, X & Wang, Y, 2021; Zhou et al., 2023), increasing the quantity of green innovation (Ren et al., 2019; Wang, X & Wang, Y, 2021), and improving the quality of green innovation (Wang, X & Wang, Y, 2021). This aligns with the conclusions drawn from existing academic research. Thus far, this paper has tested the impact mechanism of *GLISP* → promoting green technological innovation → increasing number and improving quality of green innovation → enhancing enterprise *TFP*.

Table 5. Analysis of Influence Mechanisms

Variable	(1) *GI*	(2) *TFP_OP*	(3) *TFP_LP*	(4) *GIN*	(5) *TFP_OP*	(6) *TFP_LP*	(7) *GIQ*	(8) *TFP_OP*	(9) *TFP_LP*
GLISP	0.0385**			0.0315***			0.0302**		
	(0.0170)			(0.0121)			(0.0144)		
GI		0.0882***	0.0807***						
		(0.0048)	(0.0046)						
GIN					0.0924***	0.0823***			
					(0.0064)	(0.0061)			
GIQ								0.1180***	0.1093***
								(0.0059)	(0.0056)
adj. R^2	0.1689	0.5124	0.6639	0.1457	0.5105	0.6627	0.1477	0.5133	0.6646
Control Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	29298	29298	29298	29298	29298	29298	29298	29298	29298

4.4 Heterogeneity Analysis

The previous empirical test results all indicate that the Green Loan Interest Subsidy Policy is conducive to promoting high-quality enterprise development. However, how does this policy exert asymmetric effects on heterogeneous enterprises? This paper analyzes the differential impacts from a heterogeneity perspective, as detailed below:

4.4.1 Heterogeneity Analysis Based on Regional Space

Considering that the varying degrees of development and approval standards for corresponding green credit products and interest subsidy services in the regions where enterprises are located may differently influence the relationship between the Green Loan Interest Subsidy Policy and enterprise total factor productivity. To explore whether the impact of the Green Loan

Interest Subsidy Policy on high-quality enterprise development exhibits heterogeneity across regions, this paper follows the approach of Li, J. J et al.(2020) and divides China's 31 provinces and municipalities into eastern, central, and western regions. The estimation results are presented in columns (1) to (4) of Table 6 below. For the subsample of enterprises in the western region, the impact of the Green Loan Interest Subsidy Policy on enterprise TFP is not significant. However, for the subsample of enterprises in the eastern and central regions, the regression coefficients of the Green Loan Interest Subsidy Policy on enterprise TFP are significantly positive at the 1% level. The reasons may be that compared to enterprises in the western region, those in the eastern and central regions have deeper promotion and education on green development and more extensive application of green products. They face a richer and more diverse range of green credit products and interest subsidy services. Furthermore, these enterprises have a stronger demand for green credit and interest subsidy funds and actively apply for and obtain these resources to support their green and low-carbon development. The Green Loan Interest Subsidy Policy plays a role in allocating resources for factor production in their green transformation and development, thereby contributing to optimizing TFP through the policy and promoting high-quality development of enterprises in the eastern and central regions.

Table 6. Heterogeneity Analysis - Regional Space

Variable	(1) Western Region	(2) Eastern and Central Regions	(3) Western Region	(4) Eastern and Central Regions
	TFP_OP	*TFP_OP*	*TFP_LP*	*TFP_LP*
GLISP	-0.0099	0.0521***	-0.0006	0.0629***
	(0.0532)	(0.0133)	(0.0510)	(0.0132)
adj. R^2	0.5679	0.5091	0.7122	0.6603
Control Variable	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
N	4923	24372	4923	24372

4.4.2 Heterogeneity Analysis Based on Green and Low-Carbon Industries

On the one hand, when allocating green credit resources, banks and other financial institutions may exhibit credit rationing due to "credit discrimination against non-green and low-carbon industries," prioritizing enterprises in non-energy-intensive, non-heavily polluting, and non-green credit-restricted industries. On the other hand, to incentivize banks to issue green credits, the government bears a certain amount of interest subsidies, leveraging and signaling to guide banks to invest more credit funds and promote enterprises' transition to green and low-carbon development. To explore whether the impact of the Green Loan Interest Subsidy Policy on enterprise total factor productivity exhibits heterogeneity among green and low-carbon industries,

this paper follows the classifications of Li, H et al.(2023) for six high-energy-consuming industries versus other non-energy-consuming industries, Pan et al.(2019) for 14 heavily polluting industries versus other non-heavily polluting industries, and Wang, X & Wang, Y(2021) for nine green credit-restricted industries versus other non-green credit-restricted industries. The estimation results are presented in columns (1) to (4), (5) to (8), and (9) to (12) of Table 7 below. For the subsample of enterprises in non-green and low-carbon industries, the impact of the Green Loan Interest Subsidy Policy on enterprise TFP is not significant. However, for the subsample of enterprises in green and low-carbon industries, the regression coefficients of the Green Loan Interest Subsidy Policy on enterprise TFP are significantly positive at the 1% level. The possible reasons are that enterprises in green and low-carbon industries are more favored by the Green Loan Interest Subsidy Policy, are more likely to meet the conditions for green credit and interest subsidies, and face relatively lower costs and shorter profit pain periods for green transformation. Consequently, they can obtain more green credit and interest subsidy funds to optimize the efficiency of factor allocation, thereby enhancing the incentive effect of the Green Loan Interest Subsidy Policy on high-quality enterprise development.

Table 7. Heterogeneity Analysis: High-Energy-Consuming, Heavy-Polluting, and Green Credit-Restricted Industries

Variable	(1) Energy consumption *TFP_OP*	(2) Non-energy consumption *TFP_OP*	(3) Energy consumption *TFP_LP*	(4) Non-energy consumption *TFP_LP*	(5) Pollution *TFP_OP*	(6) Non-pollution *TFP_OP*	(7) Pollution *TFP_LP*	(8) Non-pollution *TFP_LP*	(9) restrictions *TFP_OP*	(10) Non-restrictions *TFP_OP*	(11) restrictions *TFP_LP*	(12) Non-restrictions *TFP_LP*
GLISP	0.0204	0.0673***	0.0282	0.0780***	0.0287	0.0679***	0.0363	0.0785***	0.1053	0.0535***	0.0850	0.0664***
	(0.0365)	(0.0134)	(0.0348)	(0.0135)	(0.0324)	(0.0137)	(0.0311)	(0.0138)	(0.0711)	(0.0127)	(0.0685)	(0.0127)
adj. R^2	0.4703	0.5168	0.6623	0.6642	0.4544	0.5301	0.6496	0.6703	0.5036	0.5186	0.6990	0.6651
Control Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	4764	24534	4764	24534	7063	22235	7063	22235	1674	27621	1674	27621

5. Conclusions

5.1 Research Conclusions

This paper examines the impact of the Green Loan Interest Subsidy Policy on the high-quality development of enterprises using a gradual Difference-in-Differences (DID) model based on data from China's A-share listed companies from 2008 to 2020. The research conclusions are as follows: ① The Green Loan Interest Subsidy Policy is conducive to enhancing enterprises' total factor productivity and promoting their high-quality development. This basic conclusion remains stable and reliable after being tested through parallel trend tests, placebo tests, propensity score matching DID methods, alternative dependent variable measurement methods, controlling for non-parallel trends, and excluding other policy interferences. ② Examination of the impact mechanism reveals that the Green Loan Interest Subsidy Policy promotes high-quality enterprise development through the incremental and qualitative improvement effects of green technological innovation mechanisms. ③ Heterogeneity analysis shows that the incentive effect of the Green Loan Interest Subsidy Policy on high-quality enterprise development is more pronounced in eastern and central regions and among enterprises in green and low-carbon industries.

5.2 Research Implications

Based on the conclusions drawn from the analysis, the following policy implications are proposed: Firstly, starting from the relationship between the Green Loan Interest Subsidy Policy and high-quality enterprise development, it is necessary to improve green credit and interest subsidy support measures for high-quality enterprise development. ① The government should continuously refine green credit and interest subsidy support measures for high-quality enterprise development, promoting the establishment of interest subsidy regulations and measures for asset and credit assessments related to enterprises' green innovation outcomes. Meanwhile, it is essential to collaborate with multiple departments to establish a detailed and generalizable green technological innovation evaluation system tailored to industry characteristics, strengthen interdepartmental collaboration and coordinated governance, and leverage the resource allocation role of green funds. By guiding enterprises to actively pursue green and low-carbon development and clean production, adapting to the situation, using fiscal funds to incentivize market participants, and guiding the public to focus on environmental protection, the government can optimize and amplify the production of green and low-carbon development factors for enterprises, thereby promoting the high-quality development of the real economy. ② Banks and other financial institutions can consider the number of green technological innovations as an important criterion for green credit approval, introduce diversified green credit services backed by existing green innovation stock and patents under review, and establish a series of tiered and differentiated green lending standards. By implementing incentive policies, requiring enterprises to regularly disclose information on green and low-carbon production and operation, and evaluating and supervising enterprises' green development and technological innovation, banks can stimulate

listed companies' intrinsic motivation to optimize resource allocation and total factor productivity. ③ If enterprises want to obtain green credit and interest subsidy support measures from financial institutions and the government, they must meet these green development standards and certifications. This will guide enterprises to pay more attention to green, low-carbon, and clean production and operation, thereby promoting high-quality enterprise development.

Secondly, according to heterogeneity analysis, in the process of supporting high-quality enterprise development with green credit and interest subsidy funds, attention should be paid to the limited incentive effect and insufficient sensitivity of the Green Loan Interest Subsidy Policy on certain types of enterprises. Specific reasons should be thoroughly investigated and analyzed to optimize the allocation of credit and fiscal funds. For the western region, the government should strengthen publicity and education on the importance of green and low-carbon transformation and development among enterprises and, based on the industry situation of local enterprises, collaborate with financial institutions to promote green credit products and interest subsidy services based on the experience of advanced regions. For non-green and low-carbon industries, the government should encourage banks to provide differentiated credit service support to avoid a "one-size-fits-all" approach. Instead, financing incentives and financial support should also be provided to enterprises in high-energy-consuming, heavy-polluting, and green credit-restricted industries that engage in green technological innovation, further optimizing the support effect of the Green Loan Interest Subsidy Policy and advancing high-quality enterprise development.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data Availability

All data included in this study are available upon request by contact with the corresponding author.

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