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THE IMPACT OF TECHNOLOGY FINANCE ON CORPORATE ESG: A QUASI-NATURAL EXPERIMENT BASED ON THE "PILOT POLICY FOR PROMOTING THE INTEGRATION OF TECHNOLOGY AND FINANCE

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Abstract: As one of the five major key fields of financial development, technology finance is of great significance to China's supply-side structural reform and the development of new quality productive forces. Based on the pilot policy for promoting the integration of science, technology and finance, this paper adopts the DID method to explore the impact of technology finance on improving corporate ESG performance. The research results show that technology finance policies can significantly promote the improvement of corporate ESG performance. Heterogeneity analysis indicates that such promotional effect is more pronounced in state-owned enterprises, about 20% higher than that in non-state-owned enterprises, and it is mainly reflected in the secondary and tertiary industries. The conclusion supports government departments to further expand the scale of technology finance and deepen financial reform, which has important practical implications for industrial transformation and the development of new quality productive forces.
Keywords: Technology finance; ESG; Progressive DID; Reform

1 INTRODUCTION

In the government work tasks outlined in the 2025 Government Work Report, it is emphasized that we should develop new quality productive forces in light of local conditions, promote the transformation and upgrading of traditional industries, and accelerate the development of a modern industrial system. Corporate ESG (Environmental, Social, and Governance) can be understood as a set of requirements for enterprises from three dimensions. It represents the effective implementation of China’s development philosophy of "innovation, coordination, green development, opening up, and sharing" and serves as a crucial guarantee for achieving the "dual carbon" goals. In 2018, the China Securities Regulatory Commission (CSRC) revised the Code of Corporate Governance for Listed Companies, adding provisions on environmental protection and social responsibility. This revision established the basic framework for corporate ESG information disclosure, thereby legally solidifying the important status of ESG practices among enterprises. In 2020, the Shenzhen Stock Exchange (SZSE) amended the Measures for the Assessment of Information Disclosure by Listed Companies on the Shenzhen Stock Exchange, mandating that listed companies take the initiative to disclose ESG information and conducting assessments on such disclosures. These regulations imposed stricter requirements on corporate ESG accountability. Against this backdrop, corporate attention to ESG has increased significantly. Research by Liu et al. (2025) demonstrates that strong ESG performance exerts a robust and significant positive effect on attracting foreign capital inflows. Similarly [1], Feng et al. (2025) find that favorable ESG performance helps reduce earnings volatility, primarily by promoting green innovation and alleviating financing constraints [2].

Technology Finance is the integration of science and technology with finance. The term first emerged in the last century, and after years of development, it has taken on multiple meanings. Zhao et al. (2009) provided a clear and widely recognized definition of this term in their book Technology Finance: " Technology Finance refers to a systematic and innovative arrangement of a series of financial instruments, financial systems, financial policies and financial services that promote scientific and technological development, achievement transformation and the development of high-tech industries. It is a system composed of various subjects such as the government, enterprises, markets and social intermediary organizations that provide financing resources for scientific and technological innovation activities, as well as their behavioral activities in the process of scientific and technological innovation financing. It is an important part of the national scientific and technological innovation system and financial system" [3]. From this definition, it can be concluded that Technology Finance is closely linked to scientific and technological innovation. Technology Finance is a powerful tool to promote the formation of new quality productive forces. Research by Zou et al. (2024) shows that Sci-Tech Finance can significantly accelerate the formation of new quality productive forces [4]. At the Central Financial Work Conference held in October 2023, it was pointed out that efforts should be made to accelerate the building of a financial power and do a good job in the "five major priorities in finance" Technology Finance, Green Finance, Inclusive Finance, Pension Finance, and Digital Finance. As one of these five priorities, the importance of Technology Finance is self-evident.In the current unstable global situation, global trade is highly vulnerable to interference. As the world's second largest economy, China's foreign trade accounts for a large proportion of its GDP, so adequate response measures should be taken. This is especially true for domestic start-up and technology-based small enterprises, which are characterized by

long product cycles, lack of collateral, and vulnerable capital chains. Technology Finance helps alleviate enterprises' financing constraints, reduce their financing costs [5], accurately identify such enterprises, enhance their risk resistance capacity, and enable them to grow healthily in the volatile economic environment. In addition, the five major priorities in finance represent China's positioning for the future direction of financial development and even a guide for industrial structure planning. The previous development models of various regions in China are no longer sustainable. Attracting private capital and enterprises through preferential policies for investment promotion has driven employment and accelerated the urbanization process, but it has also led to a series of consequences. For example, the surge in housing prices caused by population concentration, the unfair distribution of wealth, and the fiscal austerity of local governments. More importantly, if the enterprises that initially drove the economy continue to develop in the old mode, they may not be in line with China's future planning. The direction of capital inflow represents China's positioning for the development direction, and the five major priorities in finance are the specific embodiment of this planning.

Science and technology are the primary productive forces, a great proposition put forward by China in the last century. Attaching importance to science and technology has been a consistent practice since the founding of the People's Republic of China. Studies show that fiscal investment in technology can promote technological reform [6]. Nowadays, China's demographic dividend is gradually fading, and the development of labor-intensive industries is increasingly constrained. Human resources are becoming more expensive and scarcer, while the emergence of artificial intelligence and robotic technologies offers potential solutions to such problems. There are many such examples. At present, China's small and medium-sized technology-based enterprises face problems such as difficult and expensive financing and lagging regulation. Technology finance uses financial strategies to support technological breakthroughs, greatly advancing the development of China's science and innovation-oriented enterprises.

In December 2010, the Ministry of Science and Technology, together with the "One Bank and Three Commissions" (now "One Bank, One Commission and One Administration"), jointly issued the "*Notice on Issuing the Pilot Implementation Plan for Promoting the Integration of Science, Technology and Finance*". The first batch of pilot regions was confirmed in October 2011, followed by the second batch in 2016, bringing a total of 50 cities into the policy implementation. The specific pilot cities are shown in Table 1. This pilot policy aligns with the core concept of technology finance and serves as an appropriate proxy for technology finance among the five major financial priorities. Drawing on the research of Beck et al. [7], this paper takes the pilot policy for integrating science, technology and finance as the policy shock of a quasi-natural experiment to examine the impact of technology finance on corporate ESG performance.

Corporate ESG is a comprehensive indicator covering Environment, Social, and Governance dimensions, whose name is derived from the initials of these three aspects. ESG ratings for enterprises originate from market demand. China's past development model is increasingly constrained and inconsistent with future directions, making supply-side structural reform and industrial upgrading imperative. Therefore, corporate ESG performance has received growing attention, and ESG ratings for enterprises are adopted by countries worldwide. Corporate ESG performance acts as a "value bridge" connecting enterprises with the market, regulators, and society, affecting not only short-term resource acquisition but also long-term sustainable development potential. At present, many domestic institutions rate corporate ESG performance, with evaluation criteria covering the E, S, and G dimensions and numerous sub-indicators. Institutions with high recognition for ESG ratings include Huazheng and SynTao Green Finance.

Technology finance functions as a policy tool for government departments and a financing tool for enterprises. Governments invest resources in technology-based and innovative enterprises through conditional screening, while enterprises need to reform and innovate to meet the policy requirements of technology finance and obtain resources. This development path injects sustained impetus into industrial transformation and upgrading, in line with supply-side reform. Meanwhile, it promotes the implementation of the "dual carbon" goals, enabling more accurate carbon emission monitoring and more efficient energy conservation for enterprises. It drives breakthroughs in ESG governance optimization and green transformation through innovation, providing technical support and institutional backing for fostering new quality productive forces and consolidating a solid foundation for high-quality development. Therefore, studying the relationship between technology finance and corporate ESG performance is of great significance for the wider popularization of technology finance.

Table 1 Information on Pilot Cities

First Batch Provinces and Pilot Cities						
Municipalities	Jiangsu		Anhui	Gansu	Shaanxi	Zhejiang
Beijing	Nanjing	Lianyungang	Hefei	Tianshui	Xi'an	Hangzhou
Tianjin	Wuxi	Huainan	Bengbu	Qingyang	Baoji	Wenzhou
Shanghai	Xuzhou	Yangzhou	Wuhu	Pingliang	Weinan	Huzhou
Chongqing	Changzhou	Zhenjiang		Longnan	Tongchuan	
	Suzhou	Taizhou			Shangluo	
	Nantong	Suqian				
Guangdong	Liaoning	Shandong	Hubei	Hunan	Sichuan	
Guangzhou	Dalian	Qingdao	Wuhan	Changsha	Chengdu	
Foshan					Mianyang	
Dongguan						
Shenzhen						
Second Batch Provinces and Pilot Cities						
Henan	Fujian	Zhejiang	Shandong	Jiangxi	Guizhou	Ningxia

Zhengzhou	Xiamen	Ningbo	Jinan	Nanchang	Guiyang	Yinchuan
Inner Mongolia	Liaoning					
Baotou	Shenyang					

2 LITERATURE REVIEW

Some scholars have studied the impact of technology finance policies on corporate ESG performance or its three sub-dimensions. Research by Zou et al. (2024) shows that technology finance fosters new quality productive forces by enhancing technological innovation and driving the in-depth transformation and upgrading of traditional industries [4]. New quality productive forces are industrial productive forces guided by green and low-carbon development, emphasizing the integration of economic growth and environmental protection. Zhang et al. (2023) find that technology finance promotes green technological innovation through the employment effect and digital-intelligence driving effect of intelligent manufacturing [8]. This study is based on provincial panel data and does not focus on the enterprise level. Yu et al. (2025) prove that the "Pilot Policy for Promoting the Integration of Science, Technology and Finance" significantly boosts green innovation among Chinese enterprises [9], focusing on the enterprise level. Corporate green innovation is conducive to the "E" (Environmental) dimension of corporate ESG performance. The above studies provide favorable evidence that technology finance improves one aspect of corporate ESG performance.

Research by Zhao et al. (2025) shows that the implementation of technology finance policies expands regional employment scale and optimizes regional employment structure [10]. Focusing on the city level, this study concludes that technology finance policies encourage enterprises to expand employment. Huazheng ESG ratings consider indicators such as employee turnover rate and employment status. This study also indirectly proves that technology finance enhances corporate social responsibility. Liu et al. (2025) find that good corporate ESG performance exerts a robust and significantly positive effect on attracting foreign capital inflows [1]. Although the dependent variable in this study is foreign capital inflow, similar studies show that domestic capital also prefers enterprises with good ESG performance and low performance volatility [2]. Technology finance has a significant and positive impact on industrial structure upgrading and enhances the resilience of urban industrial chains [11-12]. From the perspectives of expanding employment scale, improving investment attraction, and upgrading urban industrial structure and resilience, the above studies all reflect the positive role of technology finance in enhancing the "S" (Social) dimension of corporate ESG performance.

The shift of enterprises from real to virtual economy has long been a serious problem. When the real economy is sluggish, some professional managers tend to reinvest corporate liquid funds for profits. Technology finance can mitigate this problem to some extent through its identification function, restrain the financialization of high-tech enterprises, and this pathway shows a dynamically evolving trend of continuous enhancement [13]. Expanding the scale of the real economy can promote its high-quality development [14]. Moreover, the development of technology finance significantly inhibits the debt default risk of high-tech enterprises [15]. Technological R&D is usually characterized by long cycles, uncertain outcomes, and high capital consumption [16]. Although new products or technological innovations can bring considerable returns, both individuals and corporate shareholders are risk-averse and often unwilling to invest in uncertain projects. Technology finance policies are, in a sense, special funds established to encourage R&D and innovation, with dedicated usage. Studies show that the pilot policy for integrating science, technology and finance can significantly enhance the R&D investment intensity of enterprises, and this policy effect is sustainable [17]. A series of studies indicate that technology finance policies can influence corporate governance decisions.

The above literature demonstrates that technology finance policies affect certain aspects of corporate ESG to some extent. However, the research perspectives are inconsistent—some focus on the city level and others on the enterprise level—and there is limited research on how technology finance improves corporate ESG performance.

The marginal contributions of this paper are as follows. First, based on the pilot policy for promoting the integration of finance and technology, this paper uses the DID method to examine the impact of technology finance policies on corporate ESG performance, supplementing relevant research. Second, different from traditional DID models, this paper controls for fixed effects of firm, year, city, and industry to eliminate their influences. Third, this paper uses SynTao Green Finance ESG ratings as the dependent variable in robustness tests and divides enterprises into primary, secondary, and tertiary industries in heterogeneity analysis to explore the heterogeneous effects of technology finance on corporate ESG performance.

3 THEORETICAL ANALYSIS AND HYPOTHESES

China's past development model is unsustainable, and it is urgent to transform the growth model to break the environmental constraints on economic growth. As the world's largest carbon emitter, China accounts for about 30% of global carbon emissions (2023). To fulfill the Paris Agreement, China has proposed the "dual carbon" goals, and the State Council issued the "*Action Plan for Carbon Peaking Before 2030*". The ESG concept focuses on environmental governance, social responsibility, and corporate governance while balancing economic and social benefits and green and low-carbon goals [18]. Technology finance policies can effectively identify high-tech and green environmental protection enterprises, support new production capacities, eliminate outdated ones to achieve supply-side reform, and foster new quality productive forces. This paper theoretically analyzes the impact of technology finance on corporate ESG from the three dimensions of ESG and demonstrates the improvement effect of technology finance policies on corporate ESG performance through theory and literature citations.

Impact on Improving Corporate Environmental Protection Responsibility. The role of technology finance in promoting corporate green and environmental protection lies in its identification function. Through technology finance policies, the government selectively allocates resources to green innovation-oriented and environment-friendly enterprises. This identification function drives more financial capital into high-quality R&D projects, thereby improving the efficiency of corporate green innovation [19]. On the other hand, the follow-up supervision of technology finance ensures the dedicated use of funds; if the fund usage is inconsistent with the loan description, banks will immediately terminate cooperation with the enterprise [13]. Studies show that technology finance promotes both the quality and quantity of green technological innovation through the employment effect and digital-intelligence driving effect [8]. Technology finance policies significantly boost green innovation among Chinese enterprises [9]. By enhancing corporate green innovation and transforming into environment-friendly enterprises, multiple studies confirm that technology finance policies strengthen corporate environmental protection responsibility.

Impact on Improving Corporate Social Responsibility. The role of technology finance in promoting social responsibility is mainly reflected in driving corporate innovation and increasing employment. The biggest challenge for technology-based enterprises is often capital shortage, and technology finance can provide support for such enterprises. Alleviating financing difficulties and high costs enhances enterprises' bargaining power in the labor market [20], helps reduce employment costs, incentivizes enterprises to hire more workers, and ultimately expands production scale and improves profitability [21], especially increasing demand for high-tech talents. When innovative achievements are transformed into products, enterprise employment expands further, boosting production capacity, promoting economic benefits at the enterprise and city levels, and increasing residents' income [10]. Technology finance has a significant and positive policy effect on industrial structure upgrading and significantly enhances the resilience of urban industrial chains [11-12]. Yu et al. (2025) prove that technology finance policies influence corporate behavior through financing constraints and media attention [9]. Enterprises are subject to supervision by the CSRC and other authorities as well as social media attention. When technology finance accurately matches technology and innovation-oriented enterprises, enterprises face public pressure and social supervision, making corporate image management more important. Huazheng ESG ratings consider multiple social indicators such as employee turnover rate, gender ratio, and employee training frequency. With sufficient capital, enterprises are more willing to fulfill social responsibilities to improve their ratings in this dimension.

Impact on Strengthening Corporate Governance. The role of technology finance in promoting corporate governance lies mainly in the dedicated use of funds and follow-up supervision. Driven by interests, enterprises always pursue expansion but lack motivation to improve corporate governance. Although enterprises are subject to public supervision and legal constraints, such forces are insufficient in practice. Restrictions on capital inflows are necessary to attract sufficient corporate attention. The capital inflow restrictions imposed by technology finance effectively constrain enterprises, supplementing legal constraints. Improving technology finance helps alleviate information asymmetry among listed companies. As external supervision, media reports affect corporate reputation and thus investors' decisions [22]. Huang et al. (2024) prove that technology finance promotes the level of corporate professional division of labor by alleviating financing constraints and reducing external transaction costs [23]. Dugger (2016) also shows that corporate division of labor is determined by the trade-off between external transaction costs and internal management costs [24]. More refined professional division of labor improves corporate governance. Rating agencies such as Huazheng and SynTao Green Finance pay attention to negative events such as corporate governance accidents. Once governance problems occur, corporate credit ratings will be affected, impacting credit standards.

Accordingly, this paper proposes the following hypothesis:

H1: Technology finance policies significantly improve corporate ESG performance.

4 RESEARCH DESIGN

4.1 Data Sources and Processing

Huazheng ESG data are obtained from the Wind Database. SynTao Green Finance ESG data are sourced from the CSMAR Database. Control variables (listed company-level information) are collected from CSMAR and CNRDS. In the analysis, data of ST, PT, and delisted enterprises are excluded, as well as observations without Huazheng ratings or incomplete corporate information. Winsorization at the 1% level is applied to control variables including revenue growth rate (Growth), firm size (Size), leverage ratio (Lev), independent director ratio (indep), and return on assets (ROA) to eliminate the impact of extreme values.

4.1.1 Dependent variable

Following Hao et al. [18], this paper adopts Huazheng ESG rating data. Huazheng assigns nine ratings (AAA to C) to listed companies, which are coded from 1 to 9 in this paper; a higher value indicates a better ESG rating and higher ESG score. Huazheng ESG business has obtained an independent assurance report issued by PWC in compliance with the International Organization of Securities Commissions (IOSCO) principles, and its ratings are objective and impartial, widely used in academic research. SynTao Green Finance ESG rating data are also collected but suffer from high incompleteness. After deleting unrated year observations, the sample size is small, so these data are only used in robustness tests.

4.1.2 Independent variable

$policy_{it} = treat_D \times post_t$, $treat_D$ is an individual-level dummy variable equal to 1 if the enterprise's city is included

in the pilot policy for promoting the integration of science, technology and finance, and 0 otherwise. $post_t$ is a time-level dummy variable equal to 1 for years after the city joined the pilot policy, and 0 otherwise. Beijing was confirmed as a pilot city in October 2011; thus, for enterprises in Beijing, $treat_D = 1$ and $post_t = 1$ for 2011 and later years, while $treat_D = 1$ and $post_t = 1$ for years before 2011. $policy_{it} = 1$ only when both $treat_D$ and $post_t$ equal 1.The sample includes cities never included in the pilot policy and cities joining the second batch in 2016 (e.g., Zhengzhou, Yinchuan). The data span 2009–2024, ensuring that enterprises joining the first batch have observations with $policy_{it} = 0$, providing a sufficient control group.

4.1.3 Control variables

Following Hu et al. (2023) and Wang et al. (2024) [25-26], this paper selects firm size (Size), firm age (FirmAge), revenue growth rate (Growth), leverage ratio (Lev), independent director ratio (indep), duality (Dual), board size (board), and return on assets (ROA) as control variables, as shown in Table 2.

Table 2 Variable Types and Indicators

Variable Type	Variable Name	Variable Symbol	Definition
Dependent Variable	Corporate ESG	ESG	Huazheng ESG rating, coded 1–9 from AAA to C
Independent Variable	Technology Finance	$Policy_{it}$	$policy_{it} = treat_D \times post_t$, $treat_D$ (individual), $post_t$ (time)
Control Variable	Firm Size	Size	Natural logarithm of total assets
	Firm Age	FirmAge	Natural logarithm of years since establishment
	Revenue Growth Rate	Growth	Quarter-on-quarter growth rate of operating revenue
	Leverage Ratio	Lev	Total liabilities / total assets
	Independent Director Ratio	indep	Proportion of independent directors on the board
	Duality	Dual	1 if chairman and CEO are the same person, 0 otherwise
	Board Size	board	Natural logarithm of the number of directors
	Return on Assets	ROA	Net profit ratio of total assets

4.2 Model Construction

Model:

$$ESG_{itsp} = \beta_0 + \beta_1 \mathrm{T} + \beta_2 D + \beta_3 T * D + \beta_K \sum Z_K + \mu_i + \lambda_t + \gamma_s + \eta_p + \varepsilon_{itsp} \quad (1)$$

In Equation (1), i denotes the enterprise, t denotes the year, s denotes the industry, and p denotes the province. μ_i, λ_t, γ_s and η_p represent firm, year, industry, and province fixed effects, ε_{itsp} is the error term.

Model Principle:

Treatment group, as shown in Equation (2):

$$E(t=1 \mid D=1) - E(t=0 \mid D=1) = (\beta_0 + \beta_1 + \beta_2 + \beta_3) - (\beta_0 + \beta_2) = \beta_1 + \beta_3 \quad (2)$$

The treatment group refers to the change in the expected value of corporate ESG caused by policy factors and other factors (including those not considered in the model) before and after the policy implementation.

Control group, as shown in Equation (3):

$$E(t=1 \mid D=0) - E(t=0 \mid D=0) = (\beta_0 + \beta_1) - \beta_0 = \beta_1 \quad (3)$$

The control group refers to the change in the expected value of corporate ESG caused by non-policy factors (including those not considered in the model) before and after the policy implementation.

After excluding external factors, the marginal change in ESG caused by the pilot policy for promoting the integration of science, technology and finance is given by the DID estimate, which equals the treatment group minus the control group. The final test model is shown as Equation (4):

$$ESG_{itsp} = \beta_0 + \beta_3 policy_{it} + \beta_K \sum Z_K + \mu_i + \lambda_t + \gamma_s + \eta_p + \varepsilon_{itsp} \quad (4)$$

$policy_{it} = treat_D * post_t$, The definitions of other symbols are the same as those in (1).

5 EMPIRICAL ANALYSIS

5.1 Descriptive Statistical Analysis

The descriptive statistics show that although SynTao Green Finance ESG and Huazheng ESG have similar value ranges, their means and standard deviations differ significantly due to extensive missing values in SynTao data, which are therefore only used in robustness tests. $Policy_{it}$ is the product of Treat and Post. Ratio-related control variables are winsorized at 1% to reduce extreme value impacts, and continuous control variables are logarithmically transformed, making them dimensionless. After processing, a statistically significant coefficient indicates the impact of a 1% change

in the variable on corporate ESG, as shown in Table 3.

Table 3 Descriptive Statistical Results

Variable	Observations	Mean	Std. Dev.	Min	Max
Huazheng ESG	48704	4.141	0.938	1.000	8.500
SynTao ESG	38883	1.036	1.901	0.000	8.000
$Policy_{it}$	48704	0.605	0.489	0.000	1.000
FirmAge	48704	2.942	0.363	0.000	4.205
Growth	48704	0.142	0.372	-0.560	2.200
Dual	48704	0.285	0.451	0.000	1.000
top1	48704	0.338	0.152	0.000	0.900
board	48704	2.089	0.344	0.000	3.040
Size	48704	22.281	1.453	19.746	27.398
Lev	48704	0.427	0.217	0.050	0.940
indep	48704	36.987	7.233	0.000	57.140
ROA	48704	0.038	0.066	-0.230	0.220

5.2 Baseline Regression Results

The baseline regression (Table 4) uses Huazheng ESG ratings as the dependent variable. The impact of technology finance policies on corporate ESG is positive and significant at the 1% level. The coefficient changes little after adding control variables, indicating robust results and few omitted variables. H1 is preliminarily verified.

There is no endogeneity concern in this analysis. First, ESG ratings do not reverse-cause the government's selection of pilot cities, ruling out reverse causality. Second, pilot cities are clearly defined after policy announcement, avoiding measurement error of the independent variable. Third, the control variables are widely adopted in corporate research, and the core coefficient is stable after adding controls, suggesting negligible omitted variable bias.

Table 4 Baseline Regression Results

	No Controls	Fixed Effects	Full Controls
	(1)	(2)	(3)
$Policy_{it}$	0.207***	0.072***	0.079***
	(0.009)	(0.021)	(0.020)
Size			0.313***
			(0.008)
FirmAge			-0.068
			(0.044)
Growth			-0.104***
			(0.009)
Lev			-0.957***
			(0.033)
indep			0.006***
			(0.001)
Dual			-0.011
			(0.011)
top1			0.309***
			(0.052)
board			-0.022
			(0.015)
ROA			0.269***
			(0.070)
_cons	4.016***	4.097***	-2.552***
	(0.007)	(0.013)	(0.207)
year, firm fe	NO	YES	YES
industry, province fe	NO	YES	YES
Obs	48704	48704	48704
R^2	0.012	0.453	0.483

Notes: Robust standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

5.3 Robustness Tests

5.3.1 Residual normality test

Using Huazheng ESG scores as the dependent variable and including all control variables, the residuals show a bell-shaped symmetric distribution around zero (Figure 1). Shapiro-Wilk and Kolmogorov-Smirnov tests confirm no significant non-normality, supporting the robustness of Column (3) in Table 3.

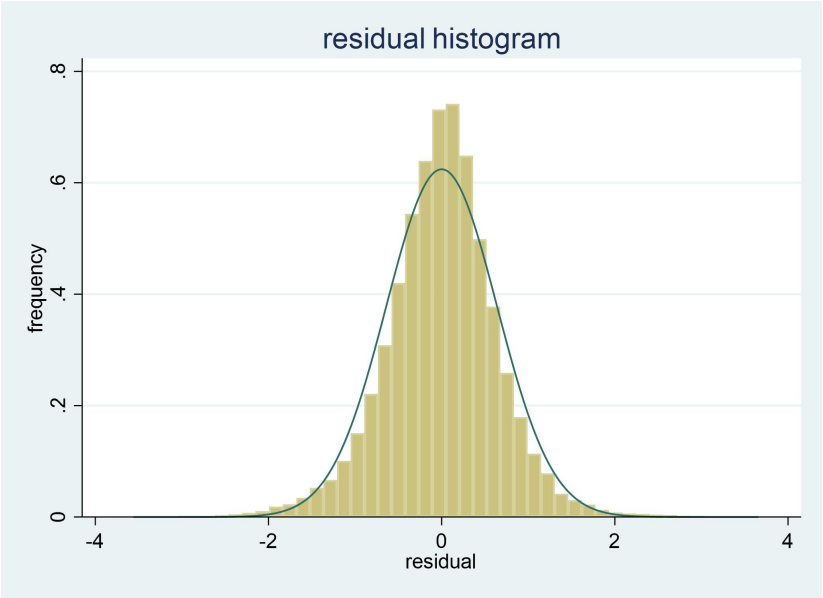

Figure 1 Residual Histogram

5.3.2 Parallel trend test

This paper adopts a progressive DID design due to the two-stage implementation of the pilot policy, including enterprises in non-pilot cities as the control group. The parallel trend test verifies whether the treatment and control groups follow similar trends before the policy. Results (Figure 2) show parallel pre-policy trends with insignificant policy effects, validating the quasi-natural experiment. Post-policy effects are positive, mostly significant, and strengthen over time, confirming that technology finance policies significantly improve corporate ESG performance and supporting H1.

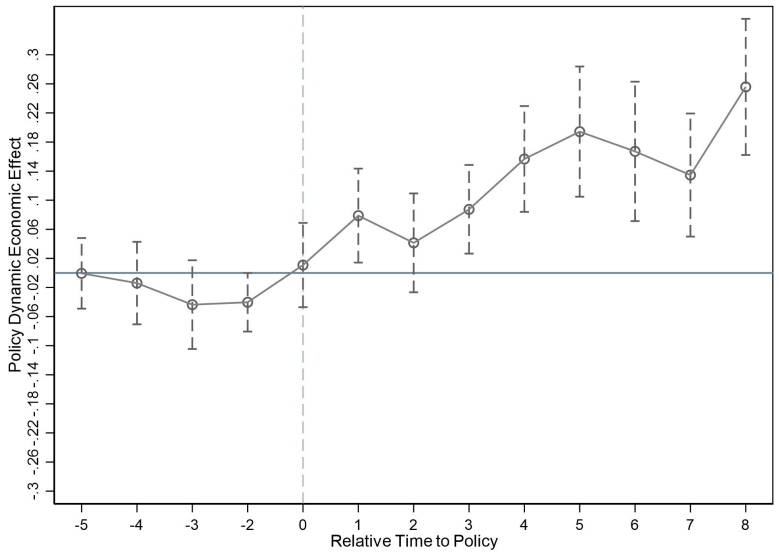

Figure 2 Parallel Trend Test

5.3.3 Placebo test

The placebo test (Figure 3) randomly assigns treatment status and repeats the regression 500 times. The estimated coefficients of the interaction term are symmetrically distributed around zero, ruling out random factors as drivers of the policy effect. Combined with baseline results, this reversely verifies H1 that technology finance policies effectively improve corporate ESG performance.

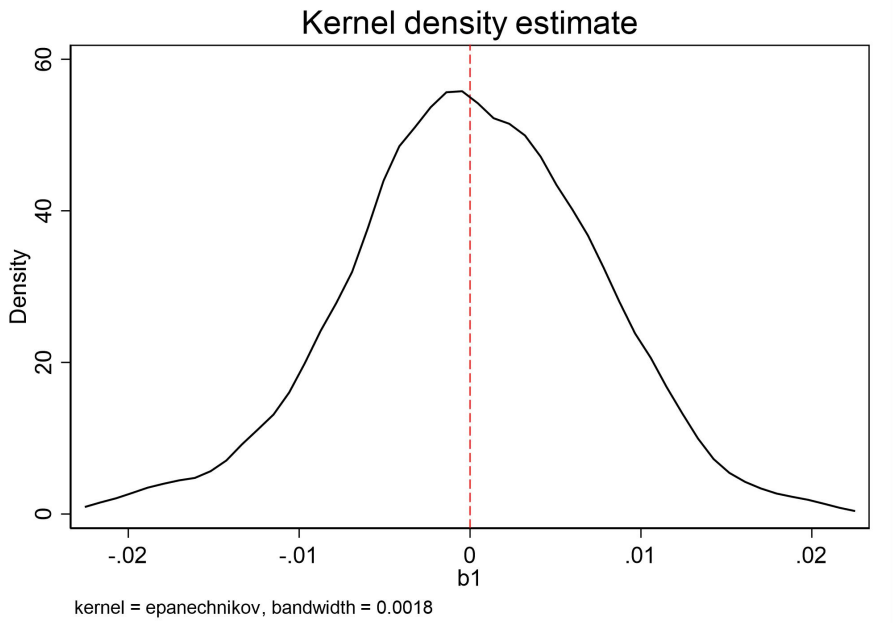

Figure 3 Placebo Test Results

5.3.4 Propensity Score Matching (PSM-DID)

PSM-DID is used to mitigate endogeneity from potential reverse causality, with all control variables as covariates. Nearest neighbor matching (1:1, 1:4), caliper matching (1:4, caliper 0–0.01), and kernel matching are adopted; kernel matching results are reported. Figure 4 shows that covariate balance is achieved after matching, with deviations concentrated around zero. Figure 5 confirms the common support condition. All matching methods yield significantly positive $Policy_{it}$ coefficients, further supporting H1.

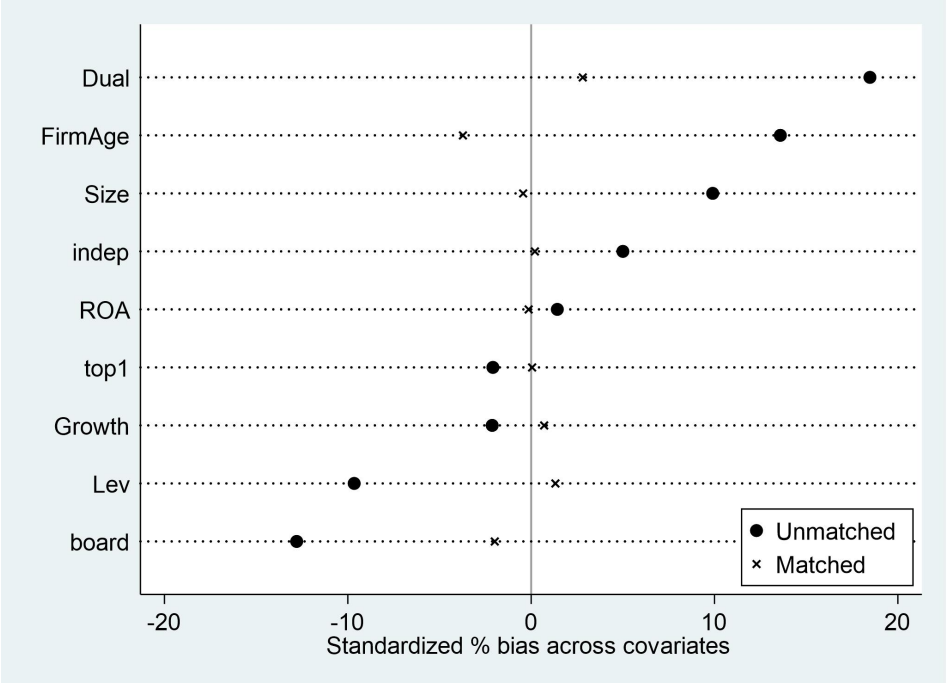

Figure 4 Covariate Balance Test

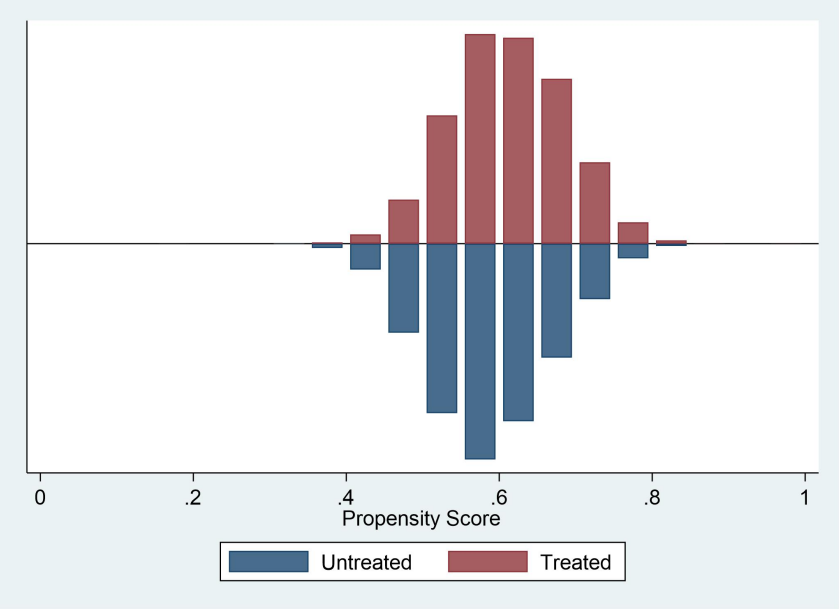

Figure 5 Common Support Test

5.3.5 Alternative dependent variable

SynTao Green Finance ESG ratings are used to test robustness. Results (Table 5) show significantly positive Policyit coefficients, confirming the robustness of H1. The significance is lower for SynTao data due to smaller sample size: SynTao has scarce data before 2015, failing to capture changes around the 2011 first batch, while Huazheng data cover both 2011 and 2016 policy shocks.

Table 5 Robustness Test

	Huazheng ESG		SynTao ESG	
	(1)	(2)	(3)	(4)
$Policy_{it}$	0.072***	0.079***	0.319	0.391*
	(0.021)	(0.020)	(0.205)	(0.202)
Size		0.313***		0.490***
		(0.008)		(0.042)
FirmAge		-0.068		0.928***
		(0.044)		(0.299)
growth		-0.104***		-0.048
		(0.009)		(0.031)
Lev		-0.957***		-0.690***
		(0.033)		(0.158)
indep		0.006***		0.004
		(0.001)		(0.003)
Dual		-0.011		-0.072*
		(0.011)		(0.039)
top1		0.309***		0.421*
		(0.052)		(0.237)
board		-0.022		0.012
		(0.015)		(0.108)
ROA		0.269***		-0.542**
		(0.070)		(0.235)
_cons	4.097***	-2.552***	4.144***	-10.507***
	(0.013)	(0.207)	(0.139)	(1.345)
year, firm fe	YES	YES	YES	YES
industry, province fe	YES	YES	YES	YES
Obs	48704	48704	5772	5772
R^2	0.453	0.483	0.627	0.639

*Notes: Robust standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.*

6 HETEROGENEITY ANALYSIS

The sample is divided by ownership (state-owned vs. non-state-owned enterprises). Results (Table 6) show that $Policy_{it}$ significantly improves ESG performance in both groups, with the effect about 20% stronger in SOEs ((0.085–0.017)/0.085). This indicates SOEs are more willing to improve ESG performance after receiving technology finance funding, reflecting stronger social responsibility.

By industry (primary, secondary, tertiary), technology finance significantly improves ESG in the secondary

(manufacturing) and tertiary (services) industries, with the strongest effect in manufacturing. Manufacturing features rapid technological iteration and fierce competition; after receiving dedicated technology finance funds, manufacturing enterprises are more motivated to upgrade ESG and drive transformation. The $policy_{it}$ has a significantly negative effect on the primary industry (agriculture), possibly due to pesticide/fertilizer abuse and low-efficiency small-scale production.

Table 6 Heterogeneity Test Results

	SOEs	Non-SOEs	Agriculture	Manufacturing	Services
	(1)	(2)	(3)	(4)	(5)
$Policy_{it}$	0.085***	0.068**	-0.346*	0.120***	0.079***
	(0.030)	(0.029)	(0.195)	(0.026)	(0.020)
Size	0.295***	0.337***	0.341***	0.362***	0.313***
	(0.013)	(0.010)	(0.071)	(0.010)	(0.008)
FirmAge	0.086	-0.036	-2.211***	-0.329***	-0.068
	(0.075)	(0.055)	(0.638)	(0.058)	(0.044)
growth	-0.088***	-0.108***	-0.091	-0.134***	-0.104***
	(0.015)	(0.012)	(0.076)	(0.013)	(0.009)
Lev	-0.982***	-0.910***	-0.985***	-1.003***	-0.957***
	(0.057)	(0.040)	(0.263)	(0.042)	(0.033)
indep	0.009***	0.004***	-0.011*	0.005***	0.006***
	(0.001)	(0.001)	(0.006)	(0.001)	(0.001)
Dual	-0.028	-0.002	0.138	-0.014	-0.011
	(0.021)	(0.013)	(0.093)	(0.013)	(0.011)
top1	-0.068	0.488***	0.596	0.402***	0.309***
	(0.082)	(0.069)	(0.476)	(0.068)	(0.052)
board	-0.002	-0.024	-0.019	-0.026	-0.022
	(0.026)	(0.019)	(0.135)	(0.019)	(0.015)
ROA	0.095	0.260***	-0.125	0.271***	0.269***
	(0.133)	(0.082)	(0.481)	(0.090)	(0.070)
_cons	-2.678***	-3.110***	3.423	-2.833***	-2.552***
	(0.356)	(0.256)	(2.398)	(0.269)	(0.207)
year, firm fe	YES	YES	YES	YES	YES
indust, provin fe	YES	YES	YES	YES	YES
Obs	17736	30968	572	31083	48704
R^2	0.492	0.485	0.410	0.454	0.483

Notes: Robust standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

7 CONCLUSIONS AND IMPLICATIONS

This paper takes the pilot policy for promoting the integration of science, technology and finance as a quasi-natural experiment of technology finance, uses the DID method, and deduces the theoretical basis of the model to examine the improvement effect of technology finance on corporate ESG performance. Widely adopted enterprise-level control variables are introduced, and residual normality and other tests verify the rationality of the model. Multiple robustness tests confirm that technology finance policies improve corporate ESG performance, providing guidance for subsequent policy implementation. Local governments nationwide should cooperate with banks to implement technology finance policies, set enterprise eligibility criteria, and allocate resources to qualified enterprises. For enterprises, only through reform and transformation can they access more funding under financing constraints.

In addition, heterogeneity tests reveal several findings. First, the improvement effect of technology finance on corporate ESG performance is stronger in SOEs than in non-SOEs, indicating SOEs undertake more social responsibility. Second, technology finance policies significantly improve ESG performance in the secondary and tertiary industries but exert a negative effect on the primary industry. Accordingly, this paper draws the following implications.

First, as one of the five major financial priorities, technology finance policies help improve corporate ESG performance. Against the "dual carbon" background, China should accelerate industrial structure transformation toward green, coordinated, and sustainable development. Local governments should cooperate with banks to launch technology finance programs, establish clear eligibility standards, and support qualified enterprises. For enterprises, transformation and upgrading are prerequisites for obtaining financial support. Technology finance should become a mandatory policy in corporate lending. The past local government model of large-scale investment relying on land finance is unsustainable; technology finance and similar policies should channel targeted funds to enterprises to improve the supply side.

Second, compared with SOEs, private enterprises lack motivation to improve ESG performance. Given that private enterprises account for a much larger number and contribute about twice the GDP of SOEs, faster industrial transformation requires private enterprises to take more environmental, social, and governance responsibilities. In the future, private enterprises should proactively improve ESG performance to access more resources.

Third, technology finance policies should prioritize supporting secondary and tertiary industries, while credit extension to primary industry enterprises should be based on rational planning. The results show that technology finance hinders ESG improvement in agriculture, whose funding support may rely more on the other four of the five major financial priorities.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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