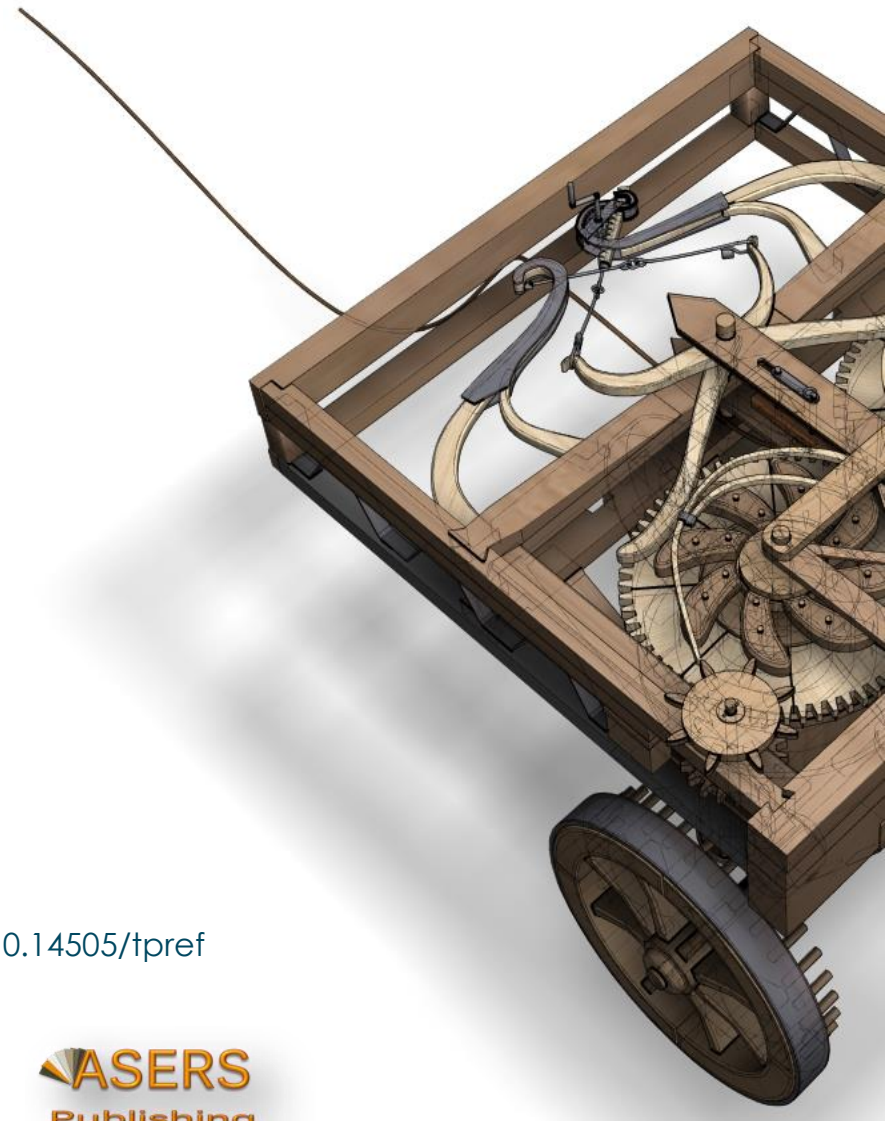
Theoretical and Practical Research in Economic Fields



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Theoretical and Practical Research in Economic Fields

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Green Credit Policy and Firms' Green Total Factor Productivity: The Mediating Role of Financial Constraints

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Abstract: In recent years, environmental pollution has emerged as a critical global challenge, prompting increasing attention toward the Green Credit Policy as a tool for environmental regulation. These policies aim to align financial systems with sustainability objectives, yet their impact on corporate development remains controversial. This study adopts the Propensity Score Matching-Difference-in-Differences (PSM-DID) method to analyze the effects of the Green Credit Policy on the green total factor productivity (GTFP) of Chinese listed companies over the period 2007–2022. The results reveal that while the Green Credit Policy is designed to enhance environmental performance, they have exacerbated financing constraints for enterprises, leading to a significant decline in GTFP. This negative impact is particularly pronounced in large enterprises and firms in eastern China, regions often subject to stricter environmental regulations. In contrast, the ownership type - whether state-owned or non-state-owned - does not significantly influence the outcomes, suggesting the pervasiveness of financing constraints across firms. The findings underscore the critical need for policymakers to design targeted green credit strategies that account for regional and enterprise-specific characteristics. For example, tailoring green finance mechanisms to address the challenges larger enterprises or firms face in economically developed regions could mitigate unintended consequences. Moreover, the study highlights the importance of integrating financial support mechanisms, such as tax incentives, subsidies, or green innovation funds, into the future Green Credit Policy. Such measures can promote investment in green technologies by alleviating financial pressures and fostering environmental and economic goals. Ultimately, this study advocates for a balanced, context-sensitive approach to green finance, ensuring sustainable development without compromising firms' productivity.

Keywords: green credit policy; firm's green total factor productivity; financial constraints.
JEL Classification: D00; D02; Q01.

Introduction

The escalating global environmental concerns have made sustainable development a critical objective for nations worldwide (Aghion *et al.* 2016). As the world's largest carbon emitter, China faces the dual challenge of balancing rapid economic growth with urgent pollution reduction and transitioning to sustainable development (Zhang, 2000;

Zhang, 2017; Zhang, 2021). China's commitment to peaking carbon emissions by 2030 and achieving carbon neutrality by 2060 underscores the complexity of fostering environmentally friendly, circular, and low-carbon development (Zhang *et al.* 2021b). Recognizing the importance of green finance for sustainable development, China has introduced vital regulations, including the Green Credit Policy issued by the China Banking Regulatory Commission in 2012.

Firms' GTFP integrates energy consumption and environmental pollution into the framework of economic growth, representing a significant advancement over traditional total factor productivity (Xia and Xu, 2020). Lv *et al.* (2021) noted that China has developed a comprehensive green finance policy framework, surpassing many other nations in this domain (Wang *et al.* 2021). These policies restrict investment in high-pollution industries (An *et al.* 2021). However, it remains uncertain whether the Green Credit Policy effectively enhances firms' GTFP (Yan *et al.* 2020; Yuan *et al.* 2020; Wu *et al.* 2020b; Gao *et al.* 2021), raising important questions about the mechanisms and outcomes of such policies.

1. Literature Review

1.1 Green Credit Policy and Firms' GTFP

Environmental regulations are policies enacted by governments to protect the environment, encouraging businesses to reduce pollution and adopt cleaner technologies. The impact of these regulations on firms' productivity has been widely debated, resulting in three primary theoretical perspectives. The first perspective, restraint theory, argues that stringent environmental regulations increase production costs, thereby reducing firm competitiveness, particularly for those requiring substantial compliance resources (Wagner, 2007; Colea, 2010; Korhonen, 2015). The second perspective, known as the win-win hypothesis, suggests that environmental regulations promote innovation, leading to technological advancements that help mitigate compliance costs and improve competitiveness (Porter, 1995; Lanoie, 2011; Asano, 2014; Chakraborty, 2017; Costa-Campi *et al.* 2017). This hypothesis suggests that environmental and economic objectives can be simultaneously achieved. The third perspective, uncertainty theory, emphasizes that the effect of environmental regulations depends on several factors, such as the regulations' effectiveness, the specific environmental challenges faced, industry characteristics, and levels of industrial development (Rassieral, 2015; Rubashkina, 2015; Feng, 2018). This theory highlights the complexity and variability in the outcomes of environmental regulations, suggesting that their impact on firms' GTFP must be contextually evaluated.

This study, grounded in restraint theory, proposes that the Green Credit Policy, functioning both as a financial instrument and a regulatory mechanism, may negatively affect firms' GTFP. Stringent environmental regulations often raise production costs, weakening firms' competitive positions when substantial resources are allocated to compliance (Wagner, 2007). Empirical evidence supports this view, showing that the Green Credit Policy, combined with stringent regulations, increases compliance costs and reduces financial flexibility (K. Li *et al.* 2023). These increased costs can offset the potential benefits of green credit on industrial productivity. Additionally, the dual role of the Green Credit Policy - as financing tools and regulatory measures - imposes further costs for securing credit and managing pollution control. These financial burdens limit resources available for green innovation and efficiency improvements (J. Li *et al.* 2023). Based on these insights, we propose the following hypothesis:

H1: There is a significant negative relationship between the Green Credit Policy and firms' GTFP.

1.2 The Mediation Effect of Financial Constraints

Restraint theory also suggests that stringent environmental regulations elevate production costs, thereby diminishing firm competitiveness, particularly for companies required to allocate significant financial resources for compliance (Korhonen, 2015). Empirical studies indicate that such policies may inadvertently impose financing constraints on firms, adversely affecting firms' GTFP. For instance, the Green Credit Policy often restricts debt financing for enterprises, particularly non-state-owned firms (Yin *et al.* 2023). These constraints hinder investments in green technologies, slowing progress in green innovation and resource efficiency (Fang *et al.* 2024). Moreover, the financial burden of increased pollution control costs can counteract the benefits of green credit, exacerbating challenges for firms attempting to sustain or enhance their GTFP (J. Li *et al.* 2023).

Green credit policies significantly affect capital investment, often reducing the availability of total and long-term bank loans for energy-intensive industries. This limitation restricts their capacity to invest in green technologies and improve resource use efficiency (Wang *et al.* 2020). In regions with underdeveloped digital economies, green credit integration has not substantially enhanced firms' GTFP, underscoring the critical role

financing constraints play in limiting policy effectiveness (Guo *et al.* 2022). Consequently, financial constraints emerge as a pivotal factor impeding Green Credit Policy from fully enhancing firms' GTFP across different regions and enterprise types. Based on the analysis above, while the Green Credit Policy aims to promote green innovation and sustainability, it also imposes financial constraints that undermine its effectiveness. The dual function of these policies - as both regulatory mechanisms and financial instruments - creates challenges for firms balancing compliance and innovation. Thus, we propose the following hypothesis:

H2: Financial constraints significantly mediate the relationship between Green Credit Policy and firms' GTFP.

2. Method

Data Source

This study investigates the impact of the Green Credit Policy on firms' GTFP using data from Chinese listed companies from 2007 to 2022. The dataset is derived from the China Stock Market & Accounting Research (CSMAR) database, encompassing 31,152 firm-year observations during the sample period. The following preprocessing steps were undertaken to ensure data quality: (1) records with missing values were excluded; (2) observations from the financial sector were removed; and (3) companies with abnormal listing statuses were omitted.

Variable

Dependent Variable

This study employs the SBM directional distance function and the Global Malmquist-Luenberger (GML) index model to measure firms' GTFP (Xia and Xu, 2020; Färe *et al.* 2007; Yu *et al.* 2022). The GTFP of companies from 2007 to 2022 was computed by multiplying each year's GML index by the GML index of the preceding year, using 2012 as the base year. The measurement framework incorporates three types of indicators: input indicators, desired outputs, and undesired outputs (Li *et al.* 2023; Tone, 2001).

Independent Variable

Policy Dummy Variable (Time): This study leverages the 2012 implementation of the Green Credit Policy by the China Banking Regulatory Commission as the pivotal event for constructing a PSM-DID model. The policy dummy variable is assigned a value of 0 for 2007–2011 and 1 for 2012–2022.
Group Dummy Variable (Treated): Following the implementation of the Green Credit Policy, financial institutions were expected to account for the environmental and social impacts of businesses they finance and their associated entities. This shift is anticipated to significantly constrain highly polluting firms' funding and operational expansion while exerting a relatively minor influence on non-polluting businesses. Using the classification method developed by Yang and Zhang (2022), this study categorizes heavily polluting firms as the treatment group (Treated=1) and low-polluting firms as the control group (Treated=0).
Difference-in-Differences Variable (PSM-DID - TimeTreat): This study primarily investigates the joint effect of the Green Credit Policy and the treatment group on firms' GTFP. This combined impact is evaluated through the interaction term between the policy dummy variable and the treatment group dummy variable.

Mediating Variable

Financing Constraint (Cost): The Green Credit Policy primarily influences how banks and financial institutions restrict firms' access to financing. Following the method used by Wang *et al.* (2020), this study evaluates financing constraints by measuring the ratio of total financial expenses—including interest payments, fees, and other related charges—to the total liabilities recorded at year-end.

Control Variables

Based on existing research, this study incorporates several control variables that may influence the primary variable. These include the firm's debt level (leverage ratio), liquidity (current ratio), board size, ownership concentration (percentage held by the largest shareholder), asset efficiency (total asset turnover), and growth performance (revenue growth rate). Detailed definitions and descriptions of these variables are provided in Table 1.

Table 1. Variable definition

	Variable Name	Variable Meaning	Measurement	Author source
Dependent variable	GTFP	Green total factor productivity	SBM-GML index	Li *et al.*(2023), Lee & Lee (2022)
Independent variable	PSM-DID	Difference-in-Differences Variable	TimeTreat	Yang & Zhang (2022)
Mediating variable	Cost	Financing constraint	(Interest expenses + Fees + Other financial expenses) / Total liabilities at year-end	Wang *et al.* (2020)
Control variable	Lev	Leverage Ratio	Total assets / Total liabilities	Li *et al.*(2023), Lee & Lee (2022) Yang & Zhang (2022) Wang *et al.* (2020)
	Liquid	Liquidity Ratio	Current assets / Current liabilities	
	Board	Board size	Natural logarithm of the number of board members	
	Top1	Shareholding Ratio of the Largest Shareholder (Top1)	Number of shares held by the largest shareholder / Total number of company shares	
	ATO	Total Asset Turnover Ratio	Operating income / Average total assets	
	Growth	Revenue Growth Rate	Current year's operating income / Previous year's operating income	

Source: Compiled by the author

Model Specification

This study employs a PSM-DID model to examine the effect of the Green Credit Policy on firms' GTFP. By categorizing the sample into an experimental group and a control group, the PSM-DID model addresses potential endogeneity concerns and facilitates a comparative analysis of changes in crucial variables between policy-affected and unaffected scenarios.

Before introducing the Green Credit Policy, companies applied for loans through traditional credit evaluation methods. However, following the policy's implementation, financial institutions began incorporating environmental factors into their loan assessment criteria. Firms with high resource consumption, pollution, and emissions faced stricter credit restrictions due to their environmental impact.

In this study, heavily polluting firms constitute the experimental group, while low-polluting enterprises are the control group. The analysis employs a PSM-DID model to evaluate the effect of the 2012 Green Credit Policy on the firms' GTFP. The specific model equation is presented as follows:

$$Y_{it}=\beta_0+\beta_1*TimeTreat_{it}+\beta_2*Time_{it}+\beta_3*Treat_{it}+\beta_4*Cons_{it}+\varepsilon_{it} \quad (1)$$

$$Cost_{it}=\beta_0+\beta_1*TimeTreat_{it}+\beta_2*Time_{it}+\beta_3*Treat_{it}+\beta_4*Cons_{it}+\varepsilon_{it} \quad (2)$$

$$Y_{it}=\beta_0+\beta_1*TimeTreat_{it}+\beta_2*Time_{it}+\beta_3*Treat_{it}+\beta_4*Cons_{it}+\beta_5*Cost_{it}+\varepsilon_{it} \quad (3)$$

The equation shown above includes several vital variables, where $TimeTreat_{it}$ is the independent variable, Y_{it} is the dependent variable, an β_0 is the intercept term. A notably positive coefficient of determination β_1 suggests that adopting the Green Credit Policy may improve the firm's GTFP. Conversely, a considerably negative coefficient of determination$\beta_1$show the opposite impact. The symbol $Cons_{it}$ identifies the control variables, $Cons_{it}$ represents the mediating variable, $i$represents the person, and t specifies time.

3. Research Results

Descriptive Statistics

This paper presents a statistical overview of the sample, including the variables' number, mean, standard deviation, minimum, and maximum values. The firms' GTFP has a mean of 0.9976, a standard deviation of 0.1178, and minimum and maximum values of 0.7345 and 1.1712, respectively. Most variables, except for TimeTreat and the operating income growth rate, exhibit a standard deviation close to or less than the mean, indicating relatively stable data with minimal variation. Detailed descriptive statistics for all variables are provided in Table 2.

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
GTFP	31,152	0.9976	0.1178	0.7345	1.1712
TimeTreat	31,152	0.0356	0.1852	0.0000	1.0000
Time	31,152	0.8411	0.3656	0.0000	1.0000
Treat	31,152	0.0469	0.2114	0.0000	1.0000
Lev	31,152	0.4160	0.1947	0.0558	0.8442
Liquid	31,152	2.4382	2.3705	0.3405	15.2672
Board	31,152	2.1328	0.1996	1.6094	2.7081
Top1	31,152	34.3673	14.8403	8.4804	74.2950
ATO	31,152	0.6706	0.4538	0.0927	2.7144
Growth	31,152	0.1653	0.3359	-0.4965	1.8333

PSM-DID Results

The regression results presented in Table 3, obtained using the Propensity Score Matching-Difference-in-Differences (PSM-DID) method, indicate a significant negative correlation between the Green Credit Policy and firms' GTFP at the 5% significance level (coefficient = -0.012, t-value = -2.432). After PSM matching, the coefficient of the TimeTreat variable is -0.033 with a t-value of -2.395, further confirming a significant negative correlation at the 5% significance level. The findings suggest that the Green Credit Policy significantly reduces firms' GTFP in both the baseline and PSM-DID regression models. Additionally, the time variable in the control group demonstrates a significant positive correlation in both models. Other variables, such as Liquid and Board, exhibit varying degrees of significance across the models. Using the PSM-DID approach enhances the robustness of the analysis, reinforcing the conclusion that the Green Credit Policy has an adverse effect on firms' GTFP.

Table 3. Baseline results: the Green Credit Policy and firms' GTFP

Variables	Baseline Regression	PSM-DID Regression
	GTFP	GTFP
TimeTreat	-0.012** (-2.432)	-0.033** (-2.395)
Time	0.229*** (174.838)	0.201*** (32.057)
Treat	0.003 (0.721)	0.019 (1.396)
Lev	0.007** (2.083)	0.070** (2.341)
Liquid	-0.001*** (-4.596)	-0.003 (-1.128)
Board	-0.048*** (-20.465)	-0.068*** (-3.586)
Top1	-0.000*** (-15.842)	-0.000* (-1.835)
ATO	-0.008*** (-7.991)	0.004 (0.318)
Growth	-0.003** (-2.148)	0.010 (0.909)
_cons	0.930*** (164.184)	0.947*** (21.733)
N	31152.000	1570.000
r2	0.545	0.082
F	4136.481	188.571

Note: t statistics in parentheses

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

Parallel Trend Test

This study performed a parallel trend test to examine the relationship between the Green Credit Policy and firms' GTFP before and after the policy's implementation. The analysis utilized data from three periods before the policy and five periods after, with the pre-implementation period serving as the baseline. Detailed results of the parallel trend test are provided in Table 4.

Table 4. Parallel Trend results

GTFP	Coefficient	Std. err.	t	P>t	[95% conf.	interval]
pre_3	0.0051	0.0107	0.4700	0.6350	-0.0159	0.0260
pre_2	0.0316	0.0106	2.9700	0.0030	0.0108	0.0525
current	-0.1440	0.0101	-14.1900	0.0000	-0.1639	-0.1241
post_1	-0.1208	0.0100	-12.0500	0.0000	-0.1405	-0.1012
post_2	-0.0913	0.0099	-9.1800	0.0000	-0.1108	-0.0718
post_3	-0.0703	0.0098	-7.1400	0.0000	-0.0896	-0.0510
post_4	-0.0412	0.0096	-4.2800	0.0000	-0.0601	-0.0223
post_5	0.0559	0.0064	8.8000	0.0000	0.0435	0.0684
time	0.2290	0.0013	177.8900	0.0000	0.2265	0.2316
Treat	-0.0045	0.0056	-0.8100	0.4170	-0.0154	0.0064
Lev	0.0066	0.0031	2.1300	0.0340	0.0005	0.0126
Liquid	-0.0011	0.0003	-4.3500	0.0000	-0.0016	-0.0006
Board	-0.0460	0.0023	-20.0000	0.0000	-0.0505	-0.0415
Top1	-0.0005	0.0000	-15.7900	0.0000	-0.0005	-0.0004
ATO	-0.0079	0.0010	-7.6800	0.0000	-0.0099	-0.0059
Growth	-0.0041	0.0013	-3.0200	0.0030	-0.0067	-0.0014
_cons	0.9256	0.0056	166.0100	0.0000	0.9147	0.9366

As presented in Table 4, the parallel trend test shows no significant correlation in the pre_3 period before the policy's implementation (P-value=0.6350), while a significant positive correlation is observed in the pre_2 period (P-value=0.0030). This indicates that the parallel trend assumption before the policy implementation is satisfied. Upon the policy's implementation (current), firms' GTFP decreases significantly (P-value=0.0000), with a coefficient of -0.1440, demonstrating a significant negative impact of the Green Credit Policy on firms' GTFP. In the post-implementation periods (post_1 to post_4), firms' GTFP continues to decline significantly (P-values=0.0000 for all periods), with coefficients of -0.1208, -0.0913, -0.0703, and -0.0412, respectively. These findings highlight that the policy consistently negatively influences firms' GTFP during these periods. However, in the post_5 period, firms' GTFP increases significantly (P-value=0.0000), with a coefficient of 0.0559. This suggests that, over time, companies gradually adapt to the policy, leading to a recovery and improvement in GTFP. These results validate the PSM-DID model and illustrate that while the Green Credit Policy negatively affects firms' GTFP in the early stages of implementation, firms adapt over time, resulting in improved GTFP in the later stages.

Mechanism Test

This study employs a mediation effect model to examine how the Green Credit Policy impacts the firm's GTFP. The findings indicate that TimeTreat significantly increases corporate debt financing costs at the 1% significance level (coefficient = 0.004) and substantially reduces firms' GTFP at the 10% significance level (coefficient = -0.008). Additionally, corporate debt financing costs significantly decrease firms' GTFP (coefficient = -0.945) at the 1% significance level. These results support the hypothesis that the Green Credit Policy reduces firms' GTFP by increasing financing constraints. Detailed results are presented in Table 5.

Table 5. Mediation effect estimation results: financial constraints as a mediator

Variables	(1)	(2)	(3)
	GTFP	Cost2	GTFP
TimeTreat	-0.012** (-2.432)	0.004*** (4.793)	-0.008* (-1.672)
Time	0.229*** (174.838)	-0.002*** (-8.011)	0.227*** (175.701)
Treat	0.003 (0.721)	0.004*** (5.420)	0.007 (1.625)
Lev	0.007** (2.083)	0.018*** (33.105)	0.023*** (7.450)
Liquid	-0.001*** (-4.596)	-0.001*** (-20.666)	-0.002*** (-8.017)
Board	-0.048*** (-20.465)	0.000 (0.635)	-0.048*** (-20.637)
Top1	-0.000*** (-15.842)	-0.000*** (-16.938)	-0.001*** (-18.768)
ATO	-0.008*** (-7.991)	-0.001*** (-8.190)	-0.010*** (-9.442)
Growth	-0.003** (-2.148)	-0.003*** (-13.760)	-0.006*** (-4.437)
Cost2			-0.945*** (-29.155)
_cons	0.930*** (164.184)	0.018*** (18.896)	0.948*** (168.565)
Observations	31152.000	31152.000	31152.000
R — squared	0.545	0.149	0.557
F	4136.481	604.879	3909.323

Note：t statistics in parentheses

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

Heterogeneity

Regional Heterogeneity

The regression results presented in Table 6 illustrate the varying relationships between the Green Credit Policy and firms' GTFP across different regions.

Table 6. Regional heterogeneity

Variables	East Region	Midwest Region
	GTFP	GTFP
TimeTreat	-0.012* (-1.742)	-0.010 (-1.383)
time	0.229*** (144.801)	0.228*** (97.392)
treat	0.002 (0.408)	0.004 (0.589)
Lev	0.008** (2.280)	0.004 (0.677)
Liquid	-0.001*** (-4.804)	-0.001 (-0.921)
Board	-0.049*** (-17.645)	-0.041*** (-9.252)
Top1	-0.001*** (-15.158)	-0.000*** (-5.896)
ATO	-0.008*** (-6.840)	-0.009*** (-4.443)

Variables	East Region	Midwest Region
	GTFP	GTFP
Growth	-0.006*** (-3.894)	0.005** (2.056)
_cons	0.936*** (139.155)	0.906*** (85.203)
Observations	22637.000	8509.000
R — squared	0.529	0.578
F	2821.441	1291.747

Note: t statistics in parentheses
* p < 0.1, ** p < 0.05, *** p < 0.01

Table 6 demonstrates that the Green Credit Policy significantly negatively impacts firms' GTFP in the eastern region, with a coefficient of -0.012, statistically significant at the 10% level. However, the policy's impact in the Midwest region is not statistically significant, with a coefficient of -0.010. The time variable shows a significant positive effect on firms' GTFP in both regions, with coefficients of 0.229 in the eastern region and 0.228 in the Midwest regions, both significant at the 1% level. Among the control variables, leverage (Lev) positively influences GTFP in the eastern region, while board size (Board), the shareholding ratio of the largest shareholder (Top1), and total asset turnover (ATO) negatively affect GTFP across both regions. Liquidity (Liquid) significantly negatively affects GTFP in the eastern region. Still, it is not significant in the Midwest regions, whereas the growth rate (Growth) negatively impacts GTFP in the eastern region but positively influences it in the Midwest regions. These findings highlight the heterogeneous effects of the Green Credit Policy on firms across different regions while also reflecting regional variations in the direction and significance of the control variables.

Ownership Type Heterogeneity

The regression results presented in Table 7 illustrate the varying impact of the Green Credit Policy on firms' GTFP across different ownership types.

Table 7. Ownership type heterogeneity

Variable	State-Owned Enterprises	Non-State Owned Enterprises
	GTFP	GTFP
TimeTreat	-0.006 (-1.119)	-0.009 (-0.545)
time	0.224*** (125.083)	0.229*** (116.250)
treat	0.003 (0.666)	-0.004 (-0.230)
Lev	0.001 (0.247)	0.026*** (6.038)
Liquid	0.001* (1.660)	-0.001*** (-3.921)
Board	-0.030*** (-7.821)	-0.049*** (-15.523)
Top1	-0.000*** (-4.738)	-0.001*** (-12.054)
ATO	-0.011*** (-7.478)	-0.005*** (-3.554)
Growth	0.004* (1.828)	-0.009*** (-5.301)
_cons	0.878*** (91.691)	0.928*** (121.576)
Observations	11360.000	19194.000
R — squared	0.623	0.444
F	2087.514	1702.461

Note：t statistics in parentheses
* p < 0.1, ** p < 0.05, *** p < 0.01

As shown in Table 7, the Green Credit Policy does not have a statistically significant impact on firms' GTFP for state-owned enterprises (SOEs) or non-SOEs, with coefficients of -0.006 and -0.009, respectively, which are not significant. However, the time variable has a significant positive effect on firms' GTFP for both ownership types, with coefficients of 0.224 for SOEs and 0.229 for non-SOEs, both significant at the 1% level. Among the control variables, leverage (Lev) is not significant for SOEs but significantly impacts GTFP for non-SOEs. Liquidity (Liquid) positively affects GTFP for SOEs but negatively impacts GTFP for non-SOEs. Board size (Board) negatively influences GTFP in both SOEs and non-SOEs, as do the shareholding ratio of the largest shareholder (Top1) and total asset turnover (ATO). The growth rate (Growth) impacts GTFP for SOEs but negatively affects GTFP for non-SOEs.These findings highlight that the effects of the Green Credit Policy and the control variables on firms' GTFP vary significantly depending on ownership type, reflecting the differing dynamics and characteristics of SOEs and non-SOEs.

Corporate Size Heterogeneity

The results presented in Table 8 illustrate the varying impact of the Green Credit Policy on firms' GTFP across different corporate sizes.

Table 8. Corporate Size heterogeneity

Variables	Small enterprises	Large enterprises
	GTFP	GTFP
TimeTreat	-0.014 (-1.269)	-0.012** (-2.056)
Time	0.229*** (125.517)	0.227*** (120.160)
Treat	-0.010 (-1.111)	0.005 (1.050)
Lev	0.028*** (5.331)	-0.014*** (-3.199)
Liquid	-0.000 (-1.443)	-0.001 (-1.574)
Board	-0.055*** (-15.953)	-0.045*** (-13.846)
Top1	-0.001*** (-10.857)	-0.001*** (-12.574)
ATO	-0.009*** (-5.132)	-0.008*** (-6.464)
Growth	-0.003* (-1.780)	-0.003 (-1.305)
_cons	0.936*** (110.460)	0.938*** (113.943)
Observations	15571.000	15581.000
R — squared	0.547	0.545
F	2089.533	2070.144

Note：t statistics in parentheses

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

As shown in Table 8, the Green Credit Policy negatively impacts firms' GTFP in small and large enterprises. However, this impact is statistically significant only for large enterprises, with a coefficient of -0.012 at the 5% significance level, while the impact on small enterprises is not statistically significant. The time variable has a significant positive effect on firms' GTFP in both small and large enterprises, with coefficients of 0.229 and 0.227, respectively, both significant at the 1% level. Among the control variables, leverage (Lev) positively influences GTFP in small enterprises but negatively affects GTFP in large enterprises. Liquidity (Liquid) does not significantly impact GTFP for either firm size. Board size (Board) negatively influences GTFP in both small and large enterprises, as do the shareholding ratio of the largest shareholder (Top1) and total asset turnover (ATO). The growth rate (Growth) negatively affects GTFP in small enterprises but does not significantly impact large enterprises. These findings indicate that the effects of the Green Credit Policy and control variables on firms'

GTFP vary significantly depending on the size of the enterprise, reflecting different dynamics between small and large firms.

4. Discussions

This study provides valuable insights into the relationship between the Green Credit Policy and firms' GTFP in China. The findings reveal a significant tradeoff: while the Green Credit Policy aims to promote environmental sustainability, it also imposes considerable financing constraints that negatively affect firms' GTFP. This challenges the prevailing assumption that the Green Credit Policy universally enhances productivity through sustainable practices. Instead, the results uncover a more nuanced reality: the financial burden associated with compliance can hinder the very firms' GTFP these policies are intended to improve.

Our analysis demonstrates that the negative impact of the Green Credit Policy on firms' GTFP is particularly pronounced in large enterprises and firms located in the eastern region of China. These firms, facing stricter environmental regulations, encounter heightened financial pressures that constrain their ability to invest in green technologies. This finding aligns with existing literature on the financial constraints posed by regulatory compliance but extends current understanding by highlighting the differential impacts across firm sizes and regional contexts. The observation that larger firms and those in more economically developed regions bear a disproportionate burden emphasizes the necessity for a tailored approach to implementing the Green Credit Policy. Interestingly, the ownership structure of firms - whether state-owned or non-state-owned - does not significantly alter the impact of the Green Credit Policy on firms' GTFP. This finding suggests that financing constraints introduced by the Green Credit Policy are pervasive and affect firms across ownership types. This challenges the conventional wisdom that state-owned enterprises might have more resources or preferential access to credit to mitigate the financial impacts of such policies.

In the broader context of sustainable development, this study highlights the complexities of designing and implementing an effective Green Credit Policy. While well-intentioned, the effectiveness of these policies can be compromised if they are not adapted to the unique needs and characteristics of various industries, regions, and firm sizes. The unintended negative consequences observed in this study underscore the importance of adopting a more nuanced and context-sensitive approach to policy design. Policymakers must carefully balance the environmental objectives of the Green Credit Policy with the economic realities targeted firms face to ensure the policies achieve their intended goals without stifling firms' GTFP.

Conclusions and Further Research

This study sheds light on the intricate relationship between the Green Credit Policy and firms' GTFP in China. While these policies promote environmental sustainability, they impose significant financing constraints that can hinder firms' GTFP. This challenges the assumption that the Green Credit Policy universally enhances productivity through sustainable practices and underscores the complexity of balancing environmental objectives with economic realities. The findings highlight the need for policymakers to adopt a more tailored approach, recognizing the diverse impacts across firm sizes, regions, and industries.

The results also have broader implications for policymakers and financial institutions. Policymakers must integrate complementary financial mechanisms, such as tax incentives, subsidies, and green innovation funds, to reduce the financial burden on firms while encouraging green investments. Additionally, financial institutions should develop more flexible green credit products and adjust loan terms better to accommodate smaller enterprises or those in disadvantaged regions. These strategies can mitigate the adverse effects of the Green Credit Policy and promote sustainable development while safeguarding firms' GTFP.

Future research should investigate the long-term effects of the Green Credit Policy on firm-level innovation, competitiveness, and environmental performance. Comparative studies across countries and industries could offer deeper insights into how regulatory and financial frameworks influence outcomes. Furthermore, exploring alternative green financing mechanisms, such as green bonds and sustainability-linked loans, could reveal innovative ways to align environmental sustainability with economic growth. This study underscores the importance of context-sensitive policies and lays the groundwork for future research to advance the understanding and implementation of green credit systems.

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Credit Authorship Contribution Statement

Fan Jing: Conceptualization, Methodology, Data curation, Formal analysis, Writing original draft, Supervision, Project administration, Funding acquisition.
Haslinah Muhamad: Software, Validation, Writing, review and editing, Visualization.
Ridzwana Mohd Said: Methodology, Writing, review, and editing.
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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declare that no generative AI or AI-assisted technologies were used in the writing process before submission.

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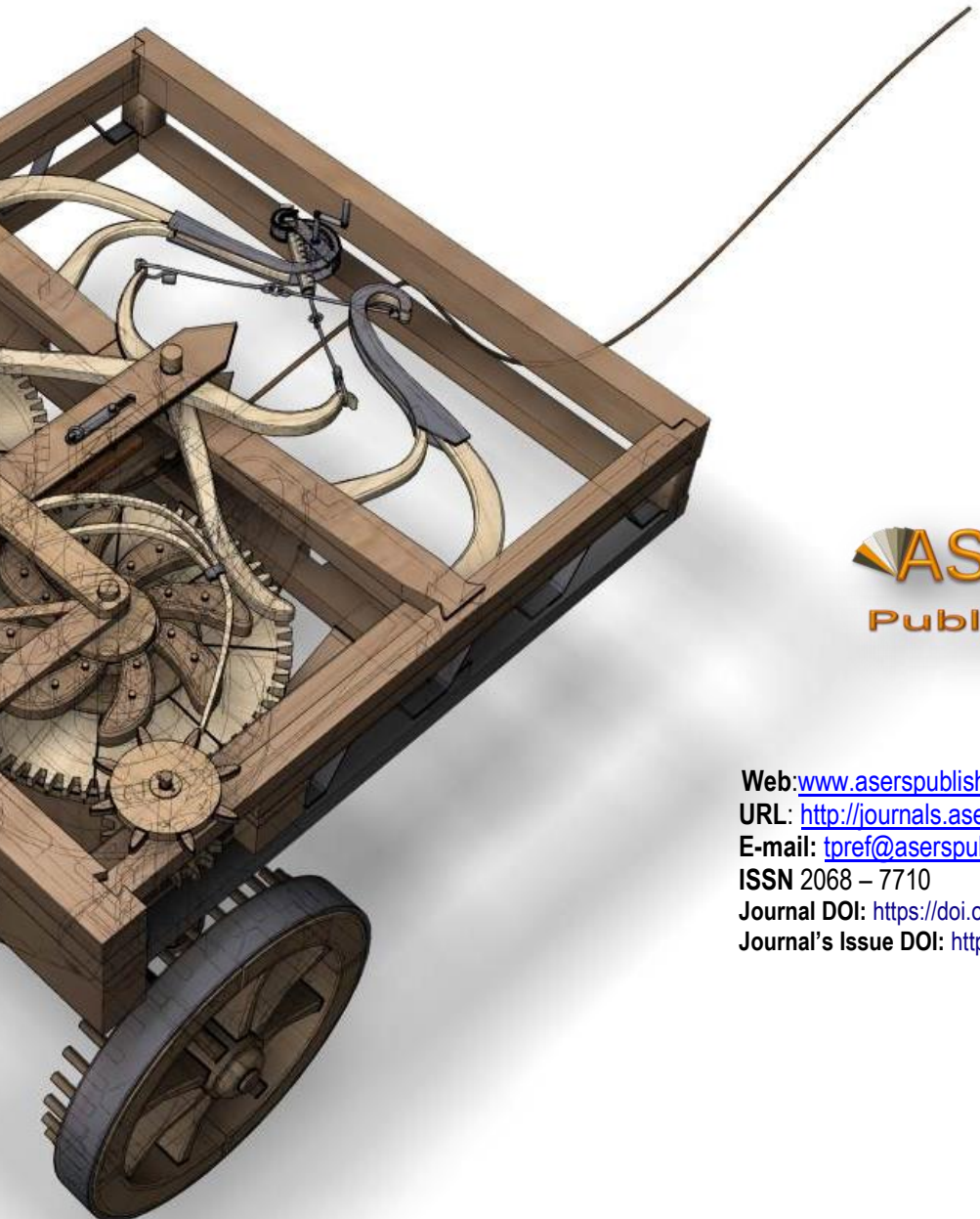

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