

# The impact of green credit policy on enterprise risk-taking: an empirical test based on DID

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**Abstract.** Green finance is a driving force for energy conservation and green development. Based on the "Green Credit Guidelines" policy issued by China Banking Regulatory Commission (CBRC) in 2012 as a quasi-natural experiment, combined with the financial data of Chinese listed companies from 2008 to 2016, we constructed a DID model to study the impact of green credit as a financial instrument on enterprise risk taking. The results show that green credit can significantly improve enterprise risk taking level. This effect is more effective for state-owned enterprises, enterprises with flexible strategies and enterprises with high information transparency. Furthermore, mechanism analysis indicates that green credit can increase enterprise risk taking level by restraining the inefficient investment behavior and stimulating the endogenous power of enterprises' innovation.

**Keywords:** Risk taking, Green credit policy, DID, Natural experiment.

## 1. Introduction

Since 2007, China has gradually introduced credit as the environmental governance tool, advocated banks to incorporate environmental risks into the credit approval system, making capital flow to environmental-friendly enterprises and projects. As a key node, Green Credit Guidelines issued by China Banking Regulatory Commission in 2012 is considered as China's first normative document targeting at green credit [36]. With the implementation of the policy, green credit will have a certain impact on enterprise operation capacity. It may be carried out by various stakeholders of enterprises. For creditors, banks need to adjust credit issuance to ensure their funds' safety. So, there is difference in the credit resources available to enterprises according to their environmental performance, affecting cash flow for operation activities [8]. For shareholders, striving for their own interests' guarantee, they will have a strong incentive to reduce risks such as financial punishment caused by enterprises' failure to reduce emissions, which will prompt enterprises to achieve green development transformation [18].

Operation ability plays great role in enterprise survival and thrive, among which risk is an important factor affecting business operation. Enterprises must have certain risk-taking capacity to obtain long-term development potential. The uncertainty from macro policy will affect enterprise entities [14]. Managers make business decisions based on judgment of unknown, which could change enterprises' risk taking level. Specifically, whether and what kind of impact green credit policy will have on enterprise risk taking is worth discussing and studying.

As a financial tool of ecological governance, the impact of green credit on risk taking may vary with enterprises' different reactive strategies. Some companies just passively reduce the scale of investment or financing, while others actively promote strategic behaviors to improve productivity through innovation and other initiatives [8]. On the one hand, green credit policy will change enterprise debt financing cost [20]. Particularly, high-polluting enterprises are faced with punitive administrative intervention such as pollution tax, production suspension. So they tend to passively reduce investment capital, which will curb their sustainable development in the long run [30]. On the other hand, the high cost of pollution will make enterprises convert to technological transformation and upgrading. Green innovation can not only significantly reduce the negative externalities of environmental pollution, but bring about core competitiveness of enterprises [5] [13]. Based on this, the analysis of how green credit policy affects enterprise risk taking can be carried out focusing on investment and financing behavior,

innovation and so on. This is of great significance to the survival and thrive of micro enterprises under the background of supply-side structural reform.

This study may have the following contributions : (1) from the perspective of risk control, this paper discusses the micro-impact of green credit on enterprise risk taking. This will be conducive to evaluating the policy from a more diversified perspective, and has certain guiding significance for enterprises to adjust operation mode reasonably. (2) As a quasi-natural experiment, we use DID model to effectively eliminate endogenous problems and identify the real effect of policy implementation. (3) Through mechanism analysis, we verify that efficiency of investment and innovation are two channels for green credit to improve enterprise risk taking. This finding may help to grasp the realization path between external financial environment changes and enterprises.

## 2. Literature review

### 2.1 Factors influencing enterprise risk taking

The driving factors of enterprise risk taking can be discussed from macro and micro aspects.

At the macro level, economic policy, social system and cultural characteristics will exert influence on enterprise risk taking. First, economic policies such as monetary policies will affect the risk sensitivity of micro-market subjects, and ultimately change enterprise risk taking [22]. Another heterogeneity analysis shows that the effect of monetary policy on risk taking varies according to property rights nature, scale and industry type of enterprises [37]. Secondly, social system's protection of stakeholders will affect the risk-based decision-making of enterprises. John et al. [15] found that a better investor protection system, weakening the risk aversion tendency of managers, will make corporation prefer projects with greater risk and higher value. Contrarily, a better creditor protection system, focusing on security of control rights, will reduce enterprises' risk-taking [1]. Finally, for cultural characteristics, some studies have shown that cautious cultural traditions and harmonism index are negatively correlated with enterprise risk taking [11][17].

At the micro level, external governance, internal governance and managers' characteristics are important factors that affect enterprise risk taking. First, the external governance of the company is closely linked with investors, creditors and other stakeholders. Wright et al. [33] found that the shareholding ratio of investors was positively correlated with enterprise risk taking, and Guo Jin et al. [10] showed that there is a positive relation between bank's loan scale and enterprise's risk taking. Secondly, corporate internal governance is mainly reflected in the board of directors. Cheng [7], Koerniadi et al. [16], Zheng Xiaoqian et al. [39] and other scholars mainly believe that the larger the board of directors is, the lower the enterprise risk taking will be, due to the impact of compromise of group decision-making and the complementary effect among directors. Finally, as per managers, many scholars have discussed the influence of managers' age, gender, overconfidence and other traits on corporate risk taking [29][34], to supplement the research on the impact of managers on enterprise risk taking.

The above literatures have established a rich theoretical framework of the influencing factors of enterprise risk taking. However, few studies have focused on the important macro field of green credit policy. Therefore, this paper choose enterprise risk taking as a decision-making index to measure enterprises' ability to understand risk taking and carry out risk control in the context of green credit.

### 2.2 Economic consequences of green credit policy

Scholars mainly take enterprises as the entry point, obtain policy evaluation and suggestions from multiple perspectives. It can be grasped from the aspects such as financing, investment and innovation.

First, green credit will affect the financing behavior of enterprises. Bank credit is a core source of debt funds for enterprises, so banks' credit approval standard will directly affect enterprises' debt financing cost. Lian Lili [20] found that since China started green credit in 2007, the debt financing cost of environment-friendly enterprises decreased significantly. But some scholars disagree. Zhang Ying and Wu Tong [38] believe that the profit-driven nature of banks matches the characteristics of

heavy assets and stable profits of heavy polluting enterprises, so the impact of green credit on the debt financing costs of polluting enterprises is limited. Additionally, problems such as supervision system and talent construction, will also lead to the lack of financing constraint of green credit on heavy polluting enterprises.

Secondly, green credit policy will affect the investment behavior of enterprises, mainly referring to investment expenditure. Michanel Greenstone[9] believes that green credit will lead to insufficient investment expenditure of heavy polluting enterprises, because this policy aggravates their information disadvantage. Based on the financial data of Chinese listed companies from 2008 to 2016, Su Dongwei and Lian Lili [30] found that after the implementation of green credit, the new investment expenditure of heavily polluting enterprises decreased rapidly, and the inhibition was more obvious for state-owned and large-scale enterprises.

Finally, green credit will affect the innovation behavior of enterprises, specifically through environmental protection input, managers' innovation preference and other mechanisms. As for environmental protection investment, Cao Chao and Chen Qiulu [3] believe that green credit will force polluting enterprises to abandon the traditional operation mode and make capital investment tilt towards environmental-friendly technology. Such input will promote enterprise innovation in the long run[23]. As for managers, Ambec & Barla [2] concluded that environmental regulation can stimulate managers' innovation preference, and they will make innovation decisions in advance to reduce the punishment risk of pollution.

The above studies have systematically assessed the effect and mechanism of green credit on enterprise, but few studies have focused on risk control, which is an important field related to enterprise development. The positive impact and mechanism of green credit on enterprise risk taking revealed in this paper will provide new ideas for deep understanding of the significance of green credit on micro subjects, and help enterprise management make reasonable adjustment facing green credit policies.

### **3. Theoretical rationale and Mechanism**

#### **3.1 The relationship between enterprise investment efficiency and risk taking level**

Investment efficiency is an effective index to measure the allocation of resources and development of enterprises. The choice of investment projects are great reasons for the change of investment efficiency. Capital and innovative expenditures are generally considered as high-risk investment projects due to long cycle and high uncertainty of results. Enterprises choosing such investment often means high risk taking level. For another, investment reflects managers' risk tendency and attitude. In ideal capital market, managers will take projects' marginal value as the only factor of investment decision. However, the information asymmetry between external stakeholders and internal managers will lead moral hazard and adverse selection, causing investment decisions deviate from the optimal level, thus affecting the risk taking capacity [35]. The reduction of information asymmetry can improve the risk taking by alleviating agency problem.

#### **3.2 The relationship between enterprise innovation efficiency and risk taking level**

Innovation efficiency can reflect the level of an enterprise's innovation ability. The R&D expenditure is a high risk investment, which will make enterprise cash flow and profitability strongly volatility, causing higher risk taking level. In addition, innovation requires managers to have higher willingness to take risks. Studies have shown that R&D will increase enterprise earnings in the long run [12]. For one thing, when managers feel material incentives, they are inclined to be more proactive in taking risks [6]. For another, the great feedback on enterprise value from R&D will promote the continuity of innovation activities, which is conducive to the risk taking level.

### 3.3 The relationship between green credit and enterprise investment efficiency

Green credit changes the financial market environment, thus affecting enterprise investment activities. First, green credit requires banks to strictly control the issuance of credit to highly polluting sectors, which will reduce the long-term interest-bearing debt scale of heavily polluting enterprises [30]. Therefore, limited by funds, managers need to choose projects or enter certain fields more prudently, grasping the balance between investment benefits and efficiency. Particularly, aiming to adapt uncertainty brought by green credit, enterprises will be more motivated to choose R&D projects. Additionally, when environmental uncertainty increases, managers will bear more private costs in investment, which will also weaken the blind investment in expansion [28]. For another, in order to alleviate the financing constraints, enterprises will actively seek alternative financing channels to meet the necessary investment needs. Among them, commercial credit financing, with low cost and few restrictions, is considered as great informal financing methods [27]. Enterprises can avoid missing high-quality projects due to lack of cash flow by making use of their credit level for financing. In addition, commercial credit financing method can alleviate information asymmetry between banks and enterprises [4], bringing in better external supervision on enterprises and rationalizing their investment. Under the combined of limited financing and alternative financing, green credit may improve the investment efficiency by restraining the tendency of over-investment and under-investment.

### 3.4 The relationship between green credit and enterprise innovation efficiency

Green credit may increase enterprises' innovation efficiency by jointly improving R&D input and innovation output. As for R&D input, green credit can guide profit-seeking capital flow to R&D production or investment, enhancing the allocation of innovative capital [32]. Other ways in which green credit influences R&D input include managers and stakeholders. Based on behavioral theory, managers will be more motivated to make innovation decisions when facing the uncertainty brought by green credit [2]. The stakeholders, take shareholders as example, will stimulate the innovation of enterprises in the process of participating in decision-making [24]. As for innovation output, Su Xin and Zhou Shengshi [31] argues that environmental regulation and innovation output show a U-shaped relationship with the intensity of regulation. Therefore, with the continuous implementation of green credit policies, enterprises will have better innovation yield, and the compensation effect gradually appears. In addition, the accumulation of innovation behavior in the early stage may transform to actual achievements, which will also promote innovation output level.

## 4. Research method

### 4.1 Measure of risk-taking

Referring to John et al. [15] this paper adopts the volatility of ROA (net profit/total asset balance) in a certain period to measure risk taking. First, in order to eliminate the influence of economic cycle and industry heterogeneity, the average ROA of the same industry in the same year is subtracted from the annual sub-industry of each company. Secondly, model (1) is used to calculate the risk taking of each company:

$$\sigma(\text{ROA})_{i,t} = \sqrt{\frac{1}{T-1} \sum_{i=1}^T \left( \text{ROA}_{i,t} - \frac{1}{T} \sum_{i=1}^T \text{ROA}_{i,t} \right)^2} \quad |T=3 \quad (1)$$

Where, *i* represents company and *t* represents time. Taking every three years as an observation period, the standard deviation of ROA is calculated by rolling calculation respectively. The higher the Risk value is, the higher the enterprise's risk taking level is.

## 4.2 Empirical model and variable definition

Based on the green credit guidelines of China Banking Regulatory Commission (CBRC) in 2012 as a quasi-natural experiment, this paper uses DID model to test the correlation between this policy and the level of enterprise risk taking. Thus, the model is constructed as follows:

$$Risk = \beta_0 + \beta_1(treat) + \beta_2(post) + \beta_3(treat \times post) + \lambda X_i + Firm + Year + \varepsilon \quad (2)$$

Where, Risk represents the enterprise risk taking level and Treat represents the group dummy variable. The heavy pollution enterprise is set as experimental group and the value is 1; otherwise is the control group and the value is 0. Post is the event dummy variable. The value is 1 in the current and after the policy year; otherwise is 0. TreatPost is a DID variable, and we mainly observe the DID coefficient, which measures effect of the policy on enterprise risk taking in 2012. And we select company size, asset-liability ratio, etc as control variables. represents the error term. In addition, the firm's individual and year fixed effects were added to eliminate the interference of company characteristics and time trends. The main variables are defined in Table 1.

**Table 1.** Variable description of the DUAL difference model

	The variable name	Variable symbol	Variable definitions
Explained variable	Level of risk-taking	Risk	Standard deviation of ROA adjusted by year and industry
Explanatory variables	The experimental variable	Treat	For heavily polluting enterprises, the value is 1; otherwise, the value is 0
	The time variable	Post	The value for 2008 and later is 1; otherwise, it is 0
Control variables	The company size	Size	The natural log of total assets at the end
	Asset-liability ratio	Lev	Total liabilities/total assets at year-end
	Cash flow ratio	Cashflow	Net operating cash flow/Total assets
	Growth rate of operating income	Growth	Current year operating Income/previous year operating income -1
	Fixed number of year of the listed	Listage	Ln (Current year - listing year +1)
	directors	Board	Take the natural log of the number of board members
Proportion of independent directors	Indep	Number of independent directors/directors	

## 4.3 Data and sample selection

First, A-share listed companies from 2008 to 2016 are taken as the initial sample, and it is further processed according to the following standards: (1) ST companies are excluded; (2) Companies in financial industry are excluded; (3) The continuous variables in the model are tail-tailed at 1% and 99% levels to eliminate the influence of outliers.

As for selection of sample, according to "classification of industry of listed companies guidelines" (ring it [2008] no. 373) revised by China Securities Supervision Commission, sixteen industries such as thermal power and cement are classified as heavy polluting industries. Based on above, the final sample contains 2672 listed companies, including 789 heavy pollution enterprises as the experimental group and 1883 companies in other industries as the control group, with a total observation value of 14,088.

## 5. Empirical results and analysis

### 5.1 Summary statistics

Table 2 lists the descriptive statistical results for the main variables. The maximum value of Risk is 0.342, and the minimum value is 0, indicating that there are significant differences in risk taking

level among companies in China. The mean value of Treat was 0.297, indicating that the samples of heavily polluted enterprises accounted for 29.7% of the total samples. The mean of Post was 0.798, indicating that 79.8% of the sample was taken after the green Credit Guidelines were issued. The standard deviation of Size is large, which is consistent with reality. The values of other variables are statistically consistent with the existing research results, with no exception values.

**Table 2.** Summary statistical results of each variable

The variable name	Number of observations	The mean	The standard deviation	The minimum value	The maximum
Risk	14088	0.024	0.026	0	0.342
Treat	14088	0.297	0.457	0	1
Post	14088	0.798	0.402	0	1
Lev	14088	0.451	0.211	0.027	0.925
Cashflow	14088	0.042	0.073	0.224	0.257
Size	14088	22.115	1.263	19.525	26.063
Growth	14088	0.197	0.517	0.595	4.806
ListAge	14088	2.256	0.653	0.693	3.219
Board	14088	2.153	0.199	1.609	2.708
Indep	14088	0.373	0.053	0.3	0.6

## 5.2 Correlation analysis

**Table 3.** Pearson's table of phase relationships among variables.

	treat	post	Risk	Lev	Cashflow	Size	Growth	ListAge	Board	Indep
treat	1									
post	0.022 ***	1								
Risk	0.076 ***	0.063 ***	1							
Lev	0.056 ***	0.097 ***	0.00600	1						
Cashflow	0.097 ***	0.022 **	0.081 ***	0.169 ***	1					
Size	0.078 ***	0.044 ***	0.207 ***	0.485 ***	0.042 ***	1				
Growth	0.066 ***	0.080 ***	0.054 ***	0.027 ***	0.00300	0.044 ***	1			
ListAge	0.052 ***	0.016 *	0.091 ***	0.383 ***	0.021 **	0.279 ***	0.036 ***	1		
Board	0.090 ***	0.096 ***	0.064 ***	0.165 ***	0.047 ***	0.275 ***	0.021 **	0.115 ***	1	
Indep	0.045 ***	0.046 ***	0.00300	0.014 *	0.024 ***	0.017 **	0.0130	0.041 ***	0.482 ***	1

\*\*\* P <0.01, \*\* P <0.05, \* P <0.1

Through Pearson Correlation Analysis, we can preliminarily judge whether there is collinearity among variables. The results showed that the biggest value of correlation coefficient between variables is 0.485, significantly lower than 0.75. It indicates that there is no multicollinearity problem in this model, and regression analysis can be carried out on this basis.

## 5.3 Baseline regression results

The experimental and control group were tested by DID method to study the impact of green credit policy on the risk taking level of heavy pollution enterprises. Model (1) and (2) are used for regression. Table 4 reports the basic regression results.

It shows that Treat  $\times$  Post's coefficient is positive and significant at the 1% level. We can conclude that the risk taking level of heavy polluting enterprises has increased since the due to green credit policy. Specifically, the coefficient value of Treat  $\times$  Post is 0.004, which means that compared with those not affected by green credit policy, the risk taking level of enterprises affected by policy increased by 16.7%. Among the control variables, asset-liability ratio, growth rate of operating income, and listed years are positively correlated with the level of risk taking, while the cash flow ratio, company size, number of directors, and proportion of independent directors are negatively correlated with the level of risk taking.

**Table 4.** Baseline regression results

The variable name	Risk
Treat by Post	0.004 * * * (3.59)
Lev	0.011 * * * (2.92)
Cashflow	0.016 * * * (3.29)
Size	0.009 * * * (7.55)
Growth	0.003 * * * (5.20)
ListAge	0.002 (0.96)
Board	0.007 * * (2.33)
Indep	0.006 (0.76)
Constant	0.226 * * * (8.76)
Firm	Yes
Year	Yes
Observations	14088
Number of id	2534
R-squared	0.039

\*\*\* P <0.01, \*\* P <0.05, \* P <0.1

## 5.4 Heterogeneity analysis

### 5.4.1. Nature of equity

**Table 5.** Heterogeneity analysis of property rights

The variable name	State-owned enterprises	Non-state-owned enterprise
Treat by Post	0.006 * * * (3.97)	0.001 (0.62)
Lev	0.018 * * * (2.95)	0.007 (1.50)
Cashflow	0.011 * (1.67)	0.021 * * * (2.85)
Size	0.010 * * * (5.95)	0.008 * * * (5.16)
Growth	0.003 * * (2.55)	0.003 * * * (4.16)
ListAge	0.005 (1.50)	0.002 (0.87)
Board	0.006 (1.48)	0.010 * * (2.10)
Indep	0.005 (0.50)	0.011 (0.91)
Constant	0.241 * * * (6.37)	0.223 * * * (6.16)
Firm	Yes	Yes
Year	Yes	Yes
Observations	6093	7995
Number of id	1013	1637
R-squared	0.052	0.035

\*\*\* P <0.01, \*\* P <0.05, \* P <0.1

According to the nature of equity, sample enterprises are divided into two groups. As can be seen from the regression results in Table 5, compared with non-state-owned enterprises, green credit policy has a significant positive impact on the risk taking level of state-owned enterprises.

#### 5.4.2. Degree of strategic adjustment

Green credit policy causes changes in enterprises' external environment, requiring them to make corresponding strategic adjustments. Based on the measurement method by Lian Yanling et al[21], we reflect strategic adjustment by calculating the fluctuation of strategic resource allocation in annual interval. The strategic resources include financial leverage, fixed asset renewal, inventory level, R&D investment, period cost input, advertising and publicity input. The larger the fluctuation is, the larger the degree of strategic adjustment is. According to median of strategic adjustment degree, enterprises are divided into two groups. We can see from the regression results in Table 6 that, compared with enterprises with low strategic adjustment degree, green credit policy has a significant positive impact on the risk taking of those with high strategic adjustment degree.

**Table 6.** Heterogeneity analysis of strategic adjustment degree

The variable name	High degree of strategic adjustment	Low degree of strategic adjustment
Treat by Post	0.008 * * * (3.87)	0.002 (1.10)
Lev	0.010 * * (2.15)	0.012 * * (2.16)
Cashflow	0.021 * * * (2.85)	0.012 * * (2.12)
Size	0.009 * * * (5.83)	0.004 * * (2.56)
Growth	0.002 * * * (3.45)	0.002 (1.55)
ListAge	0.000 (0.08)	0.001 (0.27)
Board	0.007 (1.35)	0.004 (1.12)
Indep	0.003 (0.19)	0.002 (0.19)
Constant	0.236 * * * (6.89)	0.126 * * * (3.34)
Firm	Yes	Yes
Year	Yes	Yes
Observations	6792	6789
Number of id	1828	1810
R-squared	0.039	0.045

\*\*\* P < 0.01, \*\* P < 0.05, \* P < 0.1

#### 5.4.3 Analyst attention

According to the median of analysts' attention, enterprises are divided into two groups. As the regression results shown in Table 7, the coefficients of interaction items in column (1) and column (2) are significantly 0.003 and 0.006 respectively, indicating that the risk taking level of enterprises with high analyst attention and low analyst attention has both increased, but more significantly on enterprises with low analyst attention.

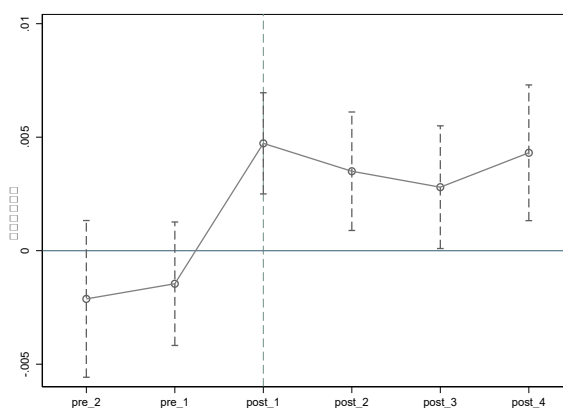
**Table 7.** Heterogeneity analysis of analyst attention

The variable name	High analyst profile	Low analyst attention
Treat by Post	0.003 * * (2.04)	0.006 * * * (3.27)
Lev	0.002 (0.48)	0.013 * * (2.31)
Cashflow	0.024 * * * (4.20)	0.015 * (1.90)
Size	0.004 * * * (2.84)	0.012 * * * (6.75)
Growth	0.002 * * * (2.68)	0.004 * * * (4.58)
ListAge	0.002 (0.71)	0.001 (0.26)
Board	0.009 * * * (2.82)	0.007 (1.25)
Indep	0.009 (1.00)	0.000 (0.03)
Constant	0.131 * * * (4.49)	0.290 * * * (7.04)
Firm	Yes	Yes
Year	Yes	Yes
Observations	7417	6671
Number of id	1974	1800
R-squared	0.042	0.048

\*\*\* P < 0.01, \*\* P < 0.05, \* P < 0.1

## 6. Robustness checks

### 6.1 Parallel trend test



**Figure 1.** Parallel trend test results

We use Parallel Trend Test to estimate the change of enterprise risk taking in the years before and after the green credit policy. As is shown in Figure 1, before the implementation of the policy, enterprise risk taking level in the experimental and the control group has basically same trend, with no significant difference. However, after the implementation of the policy, the gap expanded, which indicate that enterprise risk taking level in the experimental group has significantly increased. Therefore, DID method adopted in this paper satisfies the parallel trend hypothesis.

### 6.2 Placebo test

We form Placebo by 500 times random sampling and the remaining is the control group, on this basis for regression. We observe whether the kernel density map of the observed values is concentrated around 0, and whether the randomized coefficient of DID variable deviates from the real value. As shown in Figure 2, the coefficient presented a normal distribution between -0.02 and 0.02, and significantly deviated from the true value of 0.004, thus passing the placebo test.

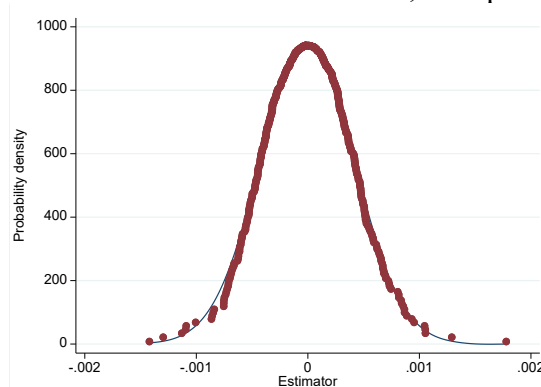


Figure 2. Placebo test results

### 6.3 Propensity-Score-Match (PSM) analysis

To alleviate the problem of non-randomness in sample selection, we use Propensity-Score - Matching (PSM) method to form control group that is similar to treatment group. Specifically, we chose asset-liability ratio, cash flow ratio, company size, operating income growth as match standards. Table 9 shows the coefficient of Treat×Post is still positive at 1% significance level, which is same as previous baseline results. This indicates that our results are robust.

Table 9. PSM propensity score matching

The variable name	Risk
New_Treat × Post	0.004 * * *
	(3.60)
Lev	0.007
	(1.64)
Cashflow	0.021 * * *
	(3.56)
Size	0.008 * * *
	(6.40)
Growth	0.003 * * *
	(4.36)
ListAge	0.004
	(1.18)
Board	0.008 * *
	(2.22)
Indep	0.008
	(0.86)
Firm	Yes
Year	Yes
Observations	10230
Number of id	1514
R-squared	0.044

\*\*\* P < 0.01, \*\* P < 0.05, \* P < 0.1

## 6.4 Mechanism analysis

### 6.4.1. Investment efficiency

To calculate enterprise investment efficiency, we use investment model(3) constructed by Richardson [26] with GMM method, which can eliminate biased results caused by endogenous problems. The absolute residual value calculated by model(3) is used to measure the investment efficiency of each enterprise. The closer the value of residual is to 0, the higher investment efficiency will be; the larger the value is, the lower the investment efficiency will be. Then we construct the regression model(4) to find the relationship between green credit and invest efficiency, where variable definitions and control variables are same as baseline model (2).

$$\text{Invest}_{i,t} = \beta_0 + \beta_1 \text{Invest}_{i,t-1} + \beta_2 \text{rowth}_{i,t-1} + \beta_3 \text{Lev}_{i,t-1} + \beta_4 \text{Cash}_{i,t-1} + \beta_5 \text{Age}_{i,t-1} + \beta_6 \text{Size}_{t-1} + \beta_7 \text{Return}_{i,t-1} + \text{Industry} + \text{Year} + \varepsilon \quad (3)$$

$$\text{Invest\_Efficiency} = \alpha_0 + \alpha_1(\text{treat}) + \alpha_2(\text{post}) + \alpha_3(\text{treat} \times \text{post}) + \lambda X_i + \varepsilon \quad (4)$$

The results in Table 10 shows that Treat × Post coefficient is positive significantly at the level of 5%. We can conclude that enterprise investment efficiency has increased due to green credit policy. Therefore, investment efficiency has passed the mechanism test, that is, green credit policy can promote the investment efficiency of enterprises and then improve the level of risk taking.

**Table 10.** Regression results of investment efficiency

The variable name	Invest Efficiency
Treat by Post	0.006 * *
	(2.12)
Lev	0.018
	(1.29)
Cashflow	0.005
	(0.50)
Size	0.040 * * *
	(8.66)
Growth	0.027 * * *
	(7.63)
ListAge	0.009
	(1.40)
Board	0.018 * *
	(2.28)
Indep	0.001
	(0.04)
Constant	0.747 * * *
	(7.72)
Firm	Yes
Year	Yes
Observations	12645
Number of id	2438
R-squared	0.120

\*\*\* P < 0.01, \*\* P < 0.05, \* P < 0.1

### 6.4.2. Innovation efficiency

Referring to Quan Xiaofeng et al.[25] and Li Wenjing et al. [19] we use Patent/ ln(1+ R&D expenditure) as indicator to measure innovation efficiency. Where, Patent are total number of patent applications, including invention, utility model, and design , plus the natural logarithm of . They are given a weight of 3 : 2 : 1 respectively. Then we construct regression model (5), in which variable definition and control variables are same as baseline model (2).

$$\text{Inno\_Eff} = \alpha_0 + \alpha_1(\text{treat}) + \alpha_2(\text{post}) + \alpha_3(\text{treat} \times \text{post}) + \lambda X_i + \varepsilon \quad (5)$$

Table 10 shows that Treat × Post coefficient is positive significantly at the level of 5%, so enterprise innovation efficiency has improved affected by green credit policy. Therefore, it passes mechanism test, so green credit can enhance enterprise risk taking by promoting innovation efficiency .

**Table 11.** Regression results of innovation efficiency

The variable name	Inno Eff
Treat by Post	0.009 * *
	(2.21)
Inno_Eff	/
	/
Lev	0.002
	(0.23)
Cashflow	0.011
	(0.85)
Size	0.023 * * *
	(7.00)
Growth	0.002
	(1.21)
ListAge	0.020 * * *
	(3.37)
Board	0.009
	(1.05)
Indep	0.022
	(0.86)
Constant	0.402 * * *
	(5.58)
Firm	Yes
Year	Yes
Observations	10693
Number of id	2168
R-squared	0.081

\*\*\* P <0.01, \*\* P <0.05, \* P <0.1

## 7. Conclusion

Based on the Green Credit Guidelines issued by CBRC in 2012, this paper examine the impact of green credit on enterprise risk taking.As a quasi-natural experiment ,the baseline estimates show that green credit significantly improves enterprise risk taking level, which is still valid after the robustness test of parallel trend, placebo test and propensity-score-matching.Through heterogeneity analysis, we find this effect is more obvious in state-owned enterprises, enterprises with high degree of strategic adjustment and strong binding force of analyst supervision.

In addition, we have also obtained two mechanisms of green credit to improve enterprise risk taking level, namely investment efficiency and innovation efficiency.First, the policy can enhance enterprises to allocate their limited capital reasonably, guiding them to choose projects or enter certain fields carefully,which will increase investment funds' use efficiency.Second, the policy has made enterprises realize the urgency of transformation and upgrading, pushing them to strengthen innovation activities and high-tech achievements.These two aspects are important driving forces to increase enterprise risk taking, which is beneficial for their long-term sustainable development.

In the context of supply-side structural reform, our study could have a certain impact on the two-way promotion between enterprise advance and ecological protection.First,continuous and stable implementation of green credit policy by the government is not only advantageous to enterprises' risk control ability, but arouses their enthusiasm about optimum investment strategies and innovation initiates.Secondly,green credit policy's applicable scope and its intensity of rewards and punishments can be reasonably adjusted.Through differentiated credit standards for enterprises with different ownership nature, the asymmetry of policy's micro impact on enterprises can be alleviated.Finally, faced with uncertainties brought by green credit policy, enterprises make positive strategic adjustments such as optimizing capital structure and upgrading technology, which will have a favorable impact on their risk taking and improvement of core competitiveness.[32]

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