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Effect of green credit policy on energy firms' growth: evidence from China

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ABSTRACT

The response of energy firms to green credit policy is of great significance, which is related to the emission reduction effect of green finance and transformation of energy firms. This paper analyzes the impact of green credit policy on the growth of energy firms based on the data of Chinese listed companies from 2009 to 2019. The empirical results show that green credit policy has significantly promoted the growth of energy firms. Further research shows that green credit policy promoted the growth of energy firms by reducing financing costs and promoting green innovation. Besides, the owned firms, big-scale firms and firms in central and eastern China are more susceptible to the impacts of the green credit policy. This study is relevant to the implementation of green credit policies and the promotion of the development and transformation of energy firms.

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1. Introduction

With the increase of greenhouse gases, a variety of environmental problems have been caused, causing a lot of harm to the natural environment and human life (Gregory, 2022). Excess greenhouse gases add heat to the Earth's climate system, which is eventually released in the form of extreme weather events (Zhang et al., 2021). China is one of the countries most affected by climate change, but it is also the world's largest energy producer and consumer, and its total carbon dioxide emission ranks first in the world (Zeng et al., 2021; Meng et al., 2022). Green development is an important factor in promoting sustainable development (Wang et al., 2022). Faced with the enormous pressure of climate and environment and emission reduction, China has formulated a series of carbon reduction plans. Among them, green credit, as an important means of ex ante governance, effectively overcomes the externalities of environmental problems and increases the conscientiousness of firms to protect the environment. In 2007, the former State Environmental Protection

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Administration (SEPA), the People's Bank of China (PBOC) and the China Banking Regulatory Commission (CBRC) jointly issued the Opinions on Implementing Environmental Protection Policies and Regulations to Prevent Credit Risks, requiring financial institutions to achieve social benefits of environmental protection by coordinating credit management and to prevent related risks in the process of implementing green credit. Subsequently, in February 2012, the China banking regulatory commission released the "green credit guidelines", which further defined the banking standards and principles of green credit, and emphasized compliance with environmental monitoring standards, pollution control effects and ecological protection as important prerequisites for credit approval in credit activities.

Under the influence of green credit policy, environmental protection can be guided by economic leverage, which can be used by firms to internalize the cost of pollution so as to achieve ex ante treatment, rather than the traditional expost pollution control means (Zhang et al., 2022). Commercial banks guide the capital flow through the way of differentiated pricing, which is conducive to environmental protection firms to make more effective use of funds and promote sustainable development of firms. By the end of 2020, the green credit balance of 21 major domestic banks reached 11.59 trillion yuan, ranking first in the world. The environmental benefits of green credit have gradually emerged, supporting the saving of 320 million tons of standard coal and reducing carbon dioxide by more than 730 million tons every year[1]. However, green credit policies are improving environmental governance and promoting the transformation of the energy mix while also causing shocks to the growth of energy companies. Traditional energy companies are a key target for carbon reduction because of the environmental pollution they inevitably bring. In particular, China's traditional energy firms are facing industrial transformation in recent years (Liu & He, 2021; Zhang et al., 2022). At the same time, new energy and renewable energy firms are in their infancy and need to invest capital to realize their growth (Wu & Huang, 2022; Xu et al., 2022; Yuan et al., 2022). But energy is the lifeblood of the economy, whether it is to maintain economic growth or ensure national security, energy companies are very important (Su et al., 2022). Therefore, clarifying the relationship between green governance and the growth of energy companies is a key concern for both the implementation of green credit policies and the development of energy companies.

Therefore, this paper analyzes the impact of green credit policy on the growth of energy firms. Based on the existing literature and relevant economic theories, we proposed three hypotheses. This paper uses listed company data and difference in difference method to verify the hypothesis. Further, this paper analyzes the ways of influence and the difference of influence. The empirical results show that green credit policy significantly promotes the growth of energy firms, and this effect is mainly achieved by alleviating the financing constraints of firms and encouraging firms to innovate. The promoting effect of green credit policy on the growth of energy firms is more obvious in state-owned firms, large firms and firms in the central and eastern region.

The innovation of this paper is as follows: Firstly, the existing research calls less direct attention to the impact of green credit policies on energy firms, and how green credit policies affect the growth of energy firms, as the special group most likely to

be affected by environmental policies, is the key issue that needs attention. This paper analyzes the micro effects of green credit policies on the growth of energy firms and further expands the study of environmental behavior on firm growth. Secondly, in the previous analysis of green credit policy, only the environmental effect of the policy was analyzed. This paper deeply explores the impact of green credit policy on energy companies, and studies its mechanism from the perspectives of green innovation and credit constraints, deepening the depth of relevant research. Finally, considering the various factors that affect the growth of firms, this paper extends the heterogeneity analysis of energy firms from firm scale and ownership attribute, enriching the research content. It provides empirical evidence for energy firms to choose a feasible growth path.

The remainder of this paper is structured as follows: The second part is the literature review and research hypothesis, reviews the impact of green credit policy on the industry, and puts forward three research hypotheses; The third part is the empirical design, including data sources, model design and index selection; The fourth part is the analysis of empirical results; The fifth part is the further analysis, including the way that green credit affects firm growth and the heterogeneity analysis; The sixth part is the conclusion and relevant suggestions.

2. Literature review

2.1. The impact of green credit policy on firms

Since the promulgation of "Green Credit Guidelines", relevant studies have analyzed the implementation effect of the policy and its impact on firms. On the one hand, green credit policy requires banks and financial institutions to tighten credit exposure to industries with "high pollution and high energy consumption" and industries with excess capacity. The green credit reduces energy consumption by controlling external financing, and restrain the blind expansion of polluting firms (Wu et al., 2022). Therefore, some studies analyzed the impact of the policy from the perspective of credit allocation efficiency, and found that the policy restricted the financing of polluting firms (Liu et al., 2017; Chai et al., 2022; Zhang & Kong, 2022), and this hindering effect is more pronounced in SOEs and large firms (Yao et al., 2021). On the other hand, some studies explore the impact of green credit policy on firm performance and other aspects, and find that the policy improves the production efficiency of firms by stimulating technological innovation (Chen et al., 2022), promoting total factor productivity of listed companies (Cui et al., 2022). Green credit policy can guide capital flow to environmental protection industry and support green innovation and production activities of firms (Zhang & Kong, 2022). It can be seen that green credit plays an important role in promoting environmental protection and transforming the mode of economic development (Liu & He, 2021). Previous studies have shown that green credit can not only alleviate the financing constraints of firms and provide credit support for green industries, but also produce positive green spillover effects on the overall economy (Lei et al., 2021; Peng et al., 2022).In addition, research has also analyzed the impact of green credit policy on the competitiveness of banks,

believing that the policy has improved the core competitiveness of banks with high credit risk and credit risk (Luo et al., 2021).

2.2. Factors affecting firm growth

In the literature on firm growth, studies have verified numerous factors that influence firm growth, including firm size, firm age, and level of technology (Zhu et al., 2021; Zhang et al., 2022). Numerous studies have shown that the financing ability of firms in the capital market is also a key factor affecting the growth of firms (Didier et al., 2021). From the macro level, there is a significant positive correlation between the development of capital market and national economic growth, and it provides capital support for the development of firms (Bekaert et al., 2005). From the micro level, loose financing environment can relieve the financial pressure of firms, provide impetus for innovation, and help improve firm performance (Fernandez, 2022). Levine and Warusawitharana (2019) found that there is indeed a correlation between financial constraints and productivity growth based on the data of European firms. Some scholars have proved that capital constrains firm growth (Haschka et al., 2022). It can be seen that financial environment and financing conditions are important factors affecting the growth of firms.

3. Research hypotheses

First of all, for energy firms, achieving firm growth means balancing the win-win of green production and firm performance, where the key is technological change and upgrading through innovation (Kong et al., 2021). China's National Energy Administration pointed out that the establishment of a green and low-carbon industrial system needs to carry out scientific and technological empowerment, improve industrial technology and equipment and management level. Existing studies have found that green credit will increase capital input of energy firms, and then increase R&D input and innovation output (Chen et al., 2022). Therefore, this paper believes that the environmental effectiveness of green credit will promote the energy efficiency and sustainable growth ability of energy firms (Song et al., 2021). However, some of China's traditional energy firms are polluting firms, so the implementation of green credit policy may restrict the financing and development of energy firms. Green credit policies increase the financing constraints of firms in heavily polluting industries, and reduce the investment level and performance of firms (Yao et al., 2021). Based on this, Hypothesis 1 and the opposing hypothesis are proposed in this paper:

Hypothesis 1a: Green credit policies may boost the growth of energy companies.

Hypothesis 1b: Green credit policies may hinder the growth of energy companies.

Secondly, as a new way of environmental governance, green credit may affect the growth of firms mainly through the following two ways. On the one hand, based on Porter hypothesis, green credit may promote the innovation transformation of firms. Since firm R&D is characterized by high investment, green credit policy provides firms with more R&D investment and reduces the threshold and risk of firm

innovation (Xing et al., 2021). Further, previous studies have proved the incentive effect of technological innovation on the environmental performance of energy firms (Liang et al., 2022). It can be seen that firms that realize innovation transformation through green credit obtain larger market shares and operating profits with their clean competitiveness, and finally realize technological progress and scale growth. From the perspective of the financial resources allocation, on the other hand, green credit might prefer to capital in cleaning industry (Liu et al., 2017), improve the level of the cleaning industry investment and to its borrowing levels, thus to eliminated polluting firms market selection mechanism, so as to make the incumbent firms obtain more profits, to reach the company growth. However, considering that traditional energy firms in China are characterized by high pollution and high consumption, they have limited access to green credit subsidies, and the funds used for cleaner production may squeeze out the innovation investment of firms (Jiang et al., 2022). Therefore, green credit policy may restrict the financing of energy firms and reduce their R&D investment, which is detrimental to the scale expansion and growth of energy firms. Based on the above analysis, Hypothesis 2 and the opposing hypothesis are proposed:

Hypothesis 2a: Green credit can contribute to energy firm growth by promoting innovation in energy companies and reducing financing constraints.

Hypothesis 2a: Green credit can discourage energy firm growth by discouraging innovation and increasing financing constraints.

4. Data and methodology

4.1. Sample and data collection

The original sample used in this article is all A-share listed companies from 2009 to 2019. Taking into account the impact of the 2008 financial crisis, the sample interval of this article starts from 2009, and all financial firm samples are excluded. According to the "Guidelines" and the research purpose of this article, we set energy companies affected by the policy as the experimental group, and other companies as the control group. In order to improve the accuracy of the experiment, this article further processed the sample data: (1) Exclude ST and *ST companies to ensure the stability of the sample; (2) Delete newly listed companies after 2005 and companies that were delisted during the sample period; (3) Exclude companies with incomplete data or missing important variables.

In addition, in order to test the influence channels of green credit on the growth of energy companies, this article sorted out the number of green invention patents of listed companies from 2009 to 2019. Taking into account the regional heterogeneity of listed companies, this paper matches the above-mentioned data with the "China City Statistical Yearbook" to obtain the city-level characteristics of listed companies. Among them, the green innovation data of listed companies comes from the State Patent and Property Office (SIPO); the financial data and social responsibility data of listed companies come from the CSMAR database; the data of the China City Statistical Yearbook comes from the website of the National Bureau of Statistics.

4.2. Baseline regression model

In order to effectively identify the impact of green credit policies on the growth of energy companies, this article uses the "Green Credit Guidelines" ("Guidelines") formulated and implemented by the CBRC in 2012 as a quasi-natural experiment and uses the double difference method for empirical estimation. Among them, energy companies are the experimental group, and the policy implementation year is 2012. The cross-terms of the experimental group's dummy variables and time dummy variables are incorporated into the model, and the coefficients describe the impact of green credit on the growth of firms. At the same time, this article is based on the fixed effects model of unbalanced panel data, and analyzes on the basis of controlling time and industry.

The regression model is as follows:

$$Growth_{it} = \beta_0 + \beta_1 treat \times year + \beta_2 control_{it} + \lambda t + \lambda h + \varepsilon_{it} \quad (1)$$

Where i denotes the firm and t denotes the time. $Growth_{it}$ is the explanatory variable and measured by the scale of firm. $Treat \times year$ is a dummy variable of the green credit policy and expressed by the interaction term between policy variable and time variable. $Control_{it}$ is the control variable selected in this article at the firm level. λt is the time fixed effect, λh is the industry fixed effect, and ε_{it} is the random error term.

4.3. Variable measurement

Firm growth. In this article, we select the scale of assets as measurable indicator. The scale of assets reflects the degree of firm capital accumulation and the level of economies of scale. We use the natural logarithm of the total assets of listed companies (Didier et al., 2021).

Green credit policy. This variable is a dummy characteristic variable that distinguishes the experimental group and the control group. *Treat* is used to distinguish energy companies from non-energy companies, and *year* is used to distinguish policy years. Among them, this article is based on the 2011 China Standard Industry Classification, and referring to previous literature practices (Li et al., 2021), the following six industries are classified as energy industries: (1) coal mining and washing industry; (2) oil and gas mining; (3) Petroleum processing, coking, and nuclear fuel processing industries; (4) Motor and equipment manufacturing; (5) Electricity and heat production and supply industries; (6) Natural gas production and supply industries. Therefore, energy companies are assigned a value of 1, and other industries are assigned a value of 0; the value before 2012 is assigned a value of 0, and the current year and subsequent years of 2012 are assigned a value of 1.

In previous studies, in order to examine the environmental effects of green credit policies, heavy-polluting firms were usually set as the experimental group, and other firms as the control group. In fact, there are a large number of overlapping samples between heavily polluting companies and energy companies. However, in order to reduce the possible errors caused by the impact of green credit policies on heavily

polluting companies, this paper deletes the heavily polluting companies in the control group.

Control variables. This paper draws on existing research and selects the following control variables (Chowdhury & Endres, 2021; Yao et al., 2021; Kweh et al., 2022): business scale (*salerate*), expressed in the logarithm of the business income of the current year; firm age (*lnage*), used in the current year of the firm minus the year of establishment plus one year after the logarithm; asset-liability ratio (*debt*), the ratio of the company's total liabilities to total assets; management level (*manage*), measured by the proportion of listed company management expenses to total assets; corporate market value (*marvalue*), measured by the logarithm of the listed company's market value; property rights (*prisg*), private companies are assigned a value of 1, otherwise it is 0; the salary incentive (*pay*), that is, the sum of the annual salaries of the three highest-paid executives in the company takes the natural logarithm.

5. Empirical result

5.1. The result of benchmark regression

Based on the measurement model and related data, this article analyzes the impact of green credit policies on the growth of energy companies. Table 1 show that in the case of time fixed effects, industry fixed effects, and regional fixed effects, the impact of green credit policies on the growth of energy firms presents a significant promotion effect. This article believes that there are three points: First, green credit, as a credit subsidy policy for special industries, directly promotes capital inflows in the energy industry and provides a starting force for the initial growth of firms. Secondly, green credit can solve financing problems and realize scale effect in the stage of firm scale expansion and transformation. From the regression results, it can be seen that

Table 1. The effect of guidelines on growth.

	(1)	(2)	(3)
treat × year	0.0927***	0.0804**	0.0525*
	(4.36)	(3.01)	(1.84)
lnage	0.188***	0.141***	0.144***
	(26.40)	(11.99)	(12.36)
debt	0.00778	−0.0110	−0.0128
	(0.21)	(−0.33)	(−0.39)
manage	−2.664***	−2.310**	−2.265**
	(−3.40)	(−3.10)	(−3.03)
marvalue	0.879***	0.748***	0.756***
	(58.56)	(39.94)	(39.34)
Prisg	−0.152***	−0.0292	−0.0307
	(−6.74)	(−0.68)	(−0.70)
pay	0.104***	0.113***	0.118***
	(8.71)	(8.02)	(8.16)
Constant	0.0380	2.883***	2.584***
	(0.12)	(6.57)	(5.75)
Year FE	Yes	Yes	Yes
Industry FE	No	Yes	Yes
City FE	No	No	Yes
N	23588	23588	23588
R-squared	0.871	0.779	0.785

Notes: t-statistics are reported in parentheses. *, **, and***indicate significance at the 10%, 5%, and 1% level.
Source: Authors.

the green credit policy promotes the scale expansion of energy firms. Finally, as a policy support for special industries, green credit brings greater competitiveness to the energy industry and provides financial and policy support for the growth of energy firms (Le, 2022). The benchmark regression results prove hypothesis 1a.

In terms of control variables, the coefficient of firm age is significantly positive, indicating that the longer an energy firm has been established, the larger its size will be. The level of management is negatively correlated with the growth of energy companies, and the corporate market value is positively correlated with the growth of energy companies. The coefficient of salary incentive is significantly positive, indicating that high salary incentives can better promote the supervision and management of energy companies by executives, thereby promoting corporate growth.

5.2. Parallel trend test and dynamic effect test

The prerequisite for obtaining unbiased estimates using the method of difference is the establishment of the common trend hypothesis, which requires that the experimental group (samples affected by the policy) and the control group (samples not affected by the policy) have similar development trends before the implementation of the policy, before the implementation of the green credit policy, the growth trends of the control group and the experimental group were basically the same. Based on this, this article assumes that the experimental group and the control group have different development trends before the policy is implemented. In order to test whether the hypothesis is true, this article constructs the following model:

$$Growth_{it} = \sum_{\tau=-3}^{6} \alpha_\tau Treat_{i\tau} + \gamma X_{it} + \delta_j + \delta_p + \delta_t + \mu_{ijt} \tag{2}$$

Table 2 show that the coefficients of *pre3, pre2, and pre1* are not significant. This indicates that before the implementation of the green credit policy, there was no significant difference between the growth of the experimental group and the control group, which means that the growth indicators of the sample had the same development trend before the release of the "Green Credit Guidelines", and there was no other interference with the empirical results. This also means that the result of double difference is valid.

Furthermore, this article assesses the dynamic impact of green credit policies on corporate growth on this basis. The results of column (2) in Table 2 show that the coefficients of the current period of the green credit policy implementation and the following six periods all indicate the policy's promotion of the growth of energy companies. This means that the reform policy not only produced effects in the year, but also continued to play a role in promoting the growth of the company.

In addition, in order to ensure the exogeneity of the policy, this paper constructs an econometric model to evaluate the expected effect of the policy. The specific model is as follows:

$$Growth_{it} = \alpha_0 ztreat_{i(t-\tau)} + \gamma X_{it} + \delta_j + \delta_p + \delta_t + \mu_{ijt} \tag{3}$$

Table 2. Prerequisites of the DID method.

	(1)	(2)	(3)	(4)
pre3	0.0240	0.0064		
	(0.68)	(0.25)		
pre2	−0.0053	0.0011	−0.0096	
	(−0.23)	(0.05)	(−1.31)	−0.0059
Pre1	0.0137			(−0.82)
	(0.73)			
current	0.0791**	0.0635***		
	(3.29)	(4.01)		
post1		0.104***		
		(5.36)		
post2		0.0964***		
		(4.44)		
post3		0.165***		
		(5.32)		
post4		0.102***		
		(3.45)		
post5		0.0793**		
		(3.12)		
post6		0.0593**		
		(2.56)		
Constant	0.0443	0.0302	−1.004***	−1.005***
	(0.13)	(0.09)	(−24.65)	(−24.66)
Control variables	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
N	23588	23588	23588	23588
R-squared	0.881	0.906	0.2965	0.1703

Notes: t-statistics are reported in parentheses. *, **, and***indicate significance at the 10%, 5%, and 1% level.
Source: Authors.

Where $ztreat_{i(t-\tau)}$ represents that before the policy is implemented, other variables are consistent with those in the baseline regression. The original hypothesis of the expected effect is that the policy has been pre-judged before the policy is implemented. However, the results of columns (3) and (4) in Table 2 indicate that before the policy is implemented, the companies in the sample have not formed expectations for the reform of the policy and impact firm growth. The expected effect test further proves the reliability of this paper's benchmark regression.

5.3. The result of robustness test

The previous empirical results show that green credit has significantly promoted the growth of energy companies. In order to test the robustness of the benchmark regression results, this paper conducts the robustness test by replacing the explained variables and using the PSM-DID method. First of all, we change the measure of firm growth. Many literatures use operating income growth rate and profit growth rate to measure the growth rate of firms. This article draws on the practice of existing research, using Tobin's Q value, net asset growth rate (*roa*) and rate of profit growth(*prorate*) as substitute indicators for corporate growth. We measured the impact of green credit on the growth of energy firms by new growth indicators.

Besides, previous papers on green credit policies used heavily polluting companies as experimental groups. In order to improve the reliability of the results of the double

Table 3. Robustness test results.

	(1) Tobin	(2) roa	(3) prorate	(4) Growth
treat	4.978***	0.0171**	0.170**	0.0918***
	(3.75)	(2.10)	(2.44)	(4.27)
lnage	−0.647	−0.0196***	−0.191***	0.200***
	(−0.83)	(−27.13)	(−9.82)	(30.81)
debt	−9.443	−0.0119**	−0.176*	0.00971
	(−1.32)	(−2.06)	(−1.84)	(0.45)
manage	1096.3***	0.0287*	−0.203	−2.813***
	(39.01)	(1.72)	(−0.25)	(−3.71)
marvalue	12.71***	0.0121***	0.0318	0.888***
	(11.88)	(12.52)	(1.31)	(59.87)
Prisg	−0.915	0.0102***	0.105	−0.0410**
	(−0.43)	(5.03)	(1.56)	(−2.05)
pay	−6.856***	0.0138***	0.286***	0.105***
	4.978***	(12.73)	(8.75)	(8.94)
Constant	−236.6***	−0.394***	−4.762***	−0.230
	(−11.79)	(−19.90)	(−9.16)	(−0.73)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
N	23588	23588	23535	23588
R-squared	0.9801	0.1395	0.0221	0.8649

Notes: t-statistics are reported in parentheses. *, **, and***indicate significance at the 10%, 5%, and 1% level.
Source: Authors.

Table 4. The result of Propensity score matching.

		Mean				
Variable	Sample	Treated	Control	%bias	%reduct	t-test
lnage	Unmatched	2.140	2.007	14.8	46.5	6.41
	Matched	2.140	2.069	7.9		1.33
debt	Unmatched	0.476	0.453	2.7	−9.9	0.90
	Matched	0.476	0.528	2.9		137
manage	Unmatched	0.044	0.528	−3.9	66.6	−1.30
	Matched	0.044	0.470	−1.3		−1.65
marvalue	Unmatched	23.069	22.802	23.4	30.9	11.13
	Matched	23.069	22.884	16.2		−1.16
prisg	Unmatched	0.903	0.901	0.9	44.3	0.39
	Matched	0.903	0.901	0.5		−0.15
pay	Unmatched	14.316	14.289	4.0	12.0	1.64
	Matched	14.316	14.292	3.5		−0.10

Source: Authors.

difference method, this paper optimizes the experimental group and the control group by setting the feature variables for kernel matching, so that the two are closer in all aspects. Table 3 shows the results of the robustness test. The results of columns (1), (2) and (3) show that after replacing the measurement indicators of the explained variables, green credit still has a significant role in promoting the growth of energy companies. The results in column (4) show that the results of PSM-DID are consistent with the benchmark results. The results of robustness test prove hypothesis 1a.

Among them, in the propensity score matching part, this paper selects the control variables in the benchmark regression as the matching variables to screen the samples. Table 4 shows the results of propensity score matching and the changes of the covariates of the experimental group and the control group. The smaller the *t*-value after matching and the larger the *p*-value, it indicates that the sample mean difference

between the experimental group and the control group is not significant. Most of the matching results in this paper passed the *t* test.

6. Further discussion

In the part of benchmark regression, this paper empirically tests the role of green credit policy in promoting the growth of energy firms. In order to explore the mechanism of the green credit policy influencing the growth of energy firms, this article analyzes from the perspective of green innovation and financing costs. In addition, considering the heterogeneity of green credit policies affecting corporate growth, this paper analyzes in detail the differential policy effects of green credit policies from both internal factors and external environment.

6.1. Potential mechanisms

In order to test the influence channels of green credit policy on the growth of energy firms in the hypothesis of this article, this article adopts the sequential test method to analyze the intermediary effect. The intermediary effect model constructed in this article is as follows:

$$metavar_{it} = \beta 0 + \beta 1 Treat_{jt} + \beta 2 X_{it} + Dt + Di + Dp + \varepsilon_{ijt} \tag{4}$$

$$Growth_{it} = \varphi 0 + \varphi 1 Treat_{jt} + \varphi 2 metavar_{it} + \varphi 3 X_{it} + Dt + Di + Dp + \varepsilon_{ijt} \tag{5}$$

In the above formula, the main explanatory variable and the explained variable are consistent with the previous article. The intermediary variables in this article are innovation level and financing constraints. Among them, the level of innovation is measured by the number of green patents of listed companies. In our paper, financing constraints are measured using the SA index (Li et al., 2020).The results of columns (1) and (2) in Table 5 show that the green credit policy has significantly

Table 5. The result of mechanism analysis.

	(1) greenpatent	(2) Growth	(3) cost	(4) Growth
treat × year	1.860**	0.0882***	−0.0663*	0.0712***
	(3.11)	(4.14)	(−1.73)	(3.69)
greenpatent		0.00225*		
		(1.85)		
cost				−0.00165**
				(−2.42)
Control variables	Yes	Yes	Yes	Yes
Constant	−10.15***	0.0822	−0.455	0.742**
	(−3.65)	(0.25)	(−0.69)	(2.32)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
N	23474	23474	23588	23588
R-squared	0.057	0.870	0.385	0.860

Notes: t-statistics are reported in parentheses. *, **, and***indicate significance at the 10%, 5%, and 1% level.
Source: Authors.

promoted the level of green innovation of firms, and after adding the green innovation of firms to the regression model, the role of green credit in promoting the growth of energy firms still for promotion. This shows that green credit policies may promote the growth of energy companies through innovation effects.

In addition, when green credit conducts environmental governance through financial means, the impact on firms is mainly realized as financing constraints. Green credit has increased the focus on environmental risks and imposed financing constraints on heavily polluting companies. Faced with the pressure of public opinion on the environment, energy companies have gradually turned to green projects out of cautious consideration to ease financing constraints. Furthermore, heavy pollution companies among energy companies face greater financing constraints, while clean energy companies have credit advantages and achieve faster growth. The results of columns (3) and (4) in Table 5 show that green credit policies can help reduce the financing constraints of energy firms and promote their growth. The mediating mechanism test results prove hypothesis 2a.

6.2. Heterogeneity analysis

Considering that the differences in the characteristics of enterprises may affect the relationship between green credit policy and the growth of energy enterprises, this paper conducts heterogeneity tests. First, the ownership attributes of firms may lead to differences in policy outcomes. The "political asylum" of state-owned firms can avoid the administrative punishment caused by the incomplete implementation of environmental regulations, which leads to the lack of motivation for state-owned firms to adopt green innovation in response to environmental regulations. On the contrary, the private firm can better match the good institutional environment. Because under the green credit system, private firms are more inclined to adapt themselves to environmental constraints through transformation in order to obtain long-term loans and capital input (Lee, 2009). Second, large-scale firms can quickly adapt to the tightening of financing brought by green credit, while small-scale firms may fail to produce normally due to the break of financing chain (Chen et al., 2022). Therefore, firms of different sizes have different capacities to bear green credit policies, which may bring different policy effects. This paper believes that the impact of green credit on the growth of energy firms will play different effects among firms of different sizes. Third, there is a gap in resource endowment, industrial structure and development level between the eastern and western regions (Li et al., 2020). Therefore, this paper conducts heterogeneity tests from three aspects: firm ownership, firm size, and firm location.

First, based on the classification of firm ownership in the CSMAR database, this article analyzes the difference between the green credit policy between state-owned firms and private firms. The results of columns (1) and (2) in Table 6 show that the effect of green credit policy on energy firms is significantly positive in both state-owned firms and private firms. Policy have promoted the growth of state-owned firms and private firms. However, there is a significant difference between the coefficients of state-owned firms and private firms, with the coefficients of state-owned

Table 6. Heterogeneity tests (firm ownership and size).

	(1) own	(2) Unown	(3) Small	(4) Big
treat × year	0.168***	0.131***	0.0871***	0.0397
	(10.28)	(8.00)	(3.30)	(1.60)
lnage	0.123***	0.168***	0.0505***	0.123***
	(18.52)	(32.88)	(5.50)	(8.67)
debt	0.385***	0.071***	−0.0300	0.613***
	(22.62)	(9.43)	(−1.35)	(11.52)
manage	−3.700***	−4.556***	−0.0170	−4.202***
	(−41.45)	(−42.66)	(−0.26)	(−10.74)
marvalue	1.062***	0.996***	0.365***	0.773***
	(226.42)	(195.48)	(17.17)	(52.41)
pay	0.073***	0.115***	0.0984***	0.0188*
	(10.25)	(16.17)	(6.38)	(1.79)
Prisg			0.0685*	−0.0392**
			(1.73)	(−2.35)
Constant	−3.441***	−2.512***	10.98***	3.883***
	(−31.44)	(−22.54)	(20.83)	(11.68)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
N	21379	2209	5638	6018
R-squared	0.893	0.843	0.2413	0.877

Notes: t-statistics are reported in parentheses. *, **, and***indicate significance at the 10%, 5%, and 1% level.
Source: Authors.

firms being significantly larger than those of private firms, which means that from the perspective of the coefficient, green credit promotes the growth of state-owned firms slightly more than private firms. The possible reason is firm background. Considering the particularity of energy industry, most of China's energy firms are state-owned (Wu et al., 2022). Therefore, the empirical analysis results show that green credit policy has a greater impact on state-owned energy firms. In addition, state-owned energy firms can get more financial support in green subsidies, which makes the growth stronger.

Secondly, this paper divides small-scale firms and large-scale firms based on the 25% quantile and 75% quantile of firm scale. The specific division method is to use the logarithm of the number of employees in the company to measure the size of the company. The samples below the 25% quantile of firm scale are classified as small-scale firms, and the samples above the 75% quantile of firm scale are classified as large-scale firms. The results of columns (3) and (4) in the Table 6 show that green credit has significantly promoted the growth of small-scale energy companies, but the impact on large-scale energy companies is not statistically significant. The reason is that this article believes that large-scale energy companies already have a certain market position and market competitiveness. Therefore, the growth of large-scale companies is often not restricted by financing and have sufficient strength to deal with market shocks. However, the growth of small-scale firms requires capital investment for market development, and this process requires continuous capital injection. Therefore, the green credit policy helps small-scale firms to break the financing barriers, and the funds obtained by the firms under the background of the green credit policy avoid the risk of social capital withdrawing at will. Therefore, the green credit policy has significantly promoted the growth of small-scale energy companies.

Table 7. Heterogeneity tests (location).

	(1) East	(2) Central	(3) West
treat × year	0.071**	0.109**	0.074
	(2.56)	(3.07)	(1.16)
lnage	0.200***	0.200***	0.168***
	(23.13)	(16.32)	(7.98)
debt	0.096**	−0.049**	−0.037***
	(3.28)	(−2.00)	(−4.30)
manage	−5.772***	−1.956*	−0.034
	(−8.97)	(−1.81)	(−1.35)
marvalue	0.838***	0.889***	0.965***
	(49.53)	(36.45)	(28.36)
pay	0.125***	0.112***	0.139***
	(8.54)	(5.27)	(3.32)
Prisg	−0.041	0.003	−0.120
	(−1.53)	(0.08)	(−1.36)
Constant	0.736*	−0.440	−2.488**
	(1.95)	(−0.81)	(−2.37)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
City FE	Yes	Yes	Yes
N	13126	7641	2821
R-squared	0.884	0.849	0.811

Notes: t-statistics are reported in parentheses. *, **, and***indicate significance at the 10%, 5%, and 1% level.
Source: Authors.

Finally, in addition to considering the heterogeneity of firms, this article also analyzes the impact of differences in the external environment on the effects of green credit policy. According to the division of China's economic regions, this article divides the sample into three parts, the eastern region, the central region, and the western region. The results in Table 7 show that the green credit policy has a significant promotion effect on the growth of energy companies in the eastern and central regions, but this promotion effect is not significant in the western region. This article believes that there are two main reasons. The samples selected in this article are listed companies, which are mainly geographically concentrated in the eastern and central regions. The sample size in the western region is too small to be representative. In addition, the eastern and central regions have geographic advantages, resource advantages, and historical advantages (Yang et al., 2022). Under the condition that the distribution of resources and the market environment are relatively fair, the energy that is easier to obtain financing can achieve better development. In the western region, financing is more difficult, so the green credit policy does not significantly promote the growth of energy companies.

7. Discussion

This paper uses the data of Chinese listed companies to analyze the impact of green credit policy on the growth of energy companies. The results show that the green credit policy significantly promotes the growth of energy companies, and the green credit policy promotes the development of energy companies by reducing financing costs and promoting green innovation. In addition, the sensitivity of energy companies with

different characteristics to the impact of green credit policies is also different. These conclusions are in line with expectations and fill the gaps in related research.

This study is of great significance to the implementation of green credit policies and the promotion of energy enterprise development and transformation. There are still some limitations in this study. This article uses the data of Chinese listed companies from 2009 to 2019, focusing on China's green credit policy, and there is room for further expansion in the data range. If other scholars can combine the green policies and data of other countries to conduct more in-depth research on the growth of energy companies, the research in this field will be more abundant.

8. Conclusion and policy implications

Firm growth is an important link in achieving high-quality economic development. Green finance, as an important intermediary for resource allocation, provides a guarantee for firm growth. This article uses the "Green Credit Guidelines" policy to study the impact of green credit policy on the growth of energy firms, and analyzes the internal mechanism and differential economic effects. The study found that "Green Credit Guidelines" policy has significantly promoted the growth of energy companies, and provided assistance to firms' growth through the channels of stimulating green innovation and reducing financing costs. Moreover, the promotion effect on the growth of energy firms is more obvious in state-owned firms, small-scale firms, and the eastern and central regions. It can be seen that the green credit policy not only improves investment efficiency, but also gives full play to the ecological effect in the energy firms.

Based on the above research conclusions, this article proposes the following policy enlightenment: On the one hand, it is necessary to improve the dual mechanism of green credit incentives and restraints to stimulate the internal driving force of corporate innovation and transformation. Give full play to the role of banking institutions in guiding the allocation of credit resources, and actively guide funds to enter the new energy industry. Encourage capital to enter energy firms and play the role of capital in promoting green transformation. On the other hand, banking institutions should put forward targeted green credit standards and risk management requirements based on the specific characteristics of industries and firms. For example, bank carry out environmental risk stress tests for different types of firms, and develop personalized green credit products and services. In addition, the government should play the function of overall planning and guidance, establish and improve supporting policies related to green credit. In particular, the relevant departments improve the efficient fiscal discount mechanism for green credit, and give banks a certain amount of risk compensation.

Note

1. Data source: The China Banking Regulatory Commission.

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