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# *The Impact of Green Credit on Firm Carbon Intensity*

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***Abstract.*** Green credit, a vital implement for advancing green finance, owns extreme importance to realize enterprises' low-carbon transformation. This paper chooses Mainland China's A-share listed companies during 2012 to 2023 as research samples, and adopts fixed-effects model to probe into the correlational relationship between green credit and firms' carbon emission intensity. Hence, empirical results prove that green credit policy implementation can cause a notable decline in enterprise-level carbon intensity. Moreover, mechanism tests indicate that green credit exerts its function via consolidating enterprises' green strategic orientation and alleviating financing constraints. Therefore, heterogeneity analysis shows that the carbon-reduction effect is more obvious in industries subject to green credit restrictions and in enterprises which issue internal control audit reports. This study not only expands the theoretical domain of green credit research, but also provides empirical proof and practical operation directions for policy-makers who intend to optimize green credit mechanisms and guide enterprises' green transformation.

***Keywords:*** green credit, carbon intensity, green strategic orientation, financing constraints

## 1. Introduction

Green credit, as a policy instrument to guide social capital into environment-friendly industries, has obtained increasing attention from policy makers and scholars. Therefore, to solve financing difficulties in green development, governments and financial regulatory organizations have established special green credit systems and required companies to make public their environmental information. As main carbon emitters, companies are of crucial importance to achieve national carbon emission reduction targets. The carbon intensity index can exactly reflect a firm's emission efficiency and its progress in green transition. However, thus it is still unsure whether these top-down policies can effectively drive corporate-level emission reductions. Despite policy's high expectations, the cause-effect link and inner transmission mechanisms need deep empirical research. Hence this study not only evaluates the effectiveness of green credit policies but also provides viewpoints for better credit distribution and the establishment of targeted encouragement measures to push companies to cut emissions.

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## 2. Literature review

### 2.1. Green credit related research

From a micro-level point of view, research on green credit can be approximately divided into two directions. First direction is about green credit management in commercial banks. Sun and colleagues [1] found that expanding green credit scale helps cut down non-performing loan ratios, at the same time increase net profits and non-interest income; therefore, bank efficiency is improved. Wang and Dong [2] reported that in large state-owned banks, green credit scale can elevate asset quality, specifically, bigger credit volumes are connected with lower non-performing loan ratios. Nevertheless, for small and medium-sized joint-stock commercial banks, this relationship presents an inverted U-shape, which means non-performing loan ratios first go up and then go down when green credit expands. Liao et al [3]. put forward that green credit has played an important positive role in boosting management efficiency; this effect will become gradually stronger in the short term and tend to be stable in the long run. Thus, this shows that banks' implementation of green credit not only completes social responsibilities but also raises their own operational efficiency. Second direction is the influence of green credit on enterprise operation and management. He et al. [4] pointed out that the promotion effect of green credit on technological innovation of environmental protection enterprises is more obvious in enterprises facing higher financing constraints. Moreover, the direct promotion effect of environmental protection enterprises on technological innovation has not been prominent yet. However, implementation of environmental protection industrial policies can significantly strengthen the incentive effect of green credit on technological innovation of environmental protection enterprises. Zhan [5] discovered that green credit affects corporate environmental information disclosure mainly through financing constraints and environmental performance channels.

### 2.2. Related research on green credit and corporate carbon emissions

To start with, when we think about the direct influence, most research studies show that green credit can effectively cut down enterprises' carbon emissions. Sun and colleagues [6] indicated that green credit has a function of carbon emission reduction. This is mainly shown through a big increase of total-factor carbon productivity and a drop of carbon emission intensity. Therefore, the government's strengthening of environmental rules will reduce the incentive effect of green credit on low-carbon economic transformation. Moreover, Wang and Huang [7] did an observation; by using the panel data set collected from 30 Chinese provinces and applying the PSTR model and SDM model, they thus also drew the conclusion that, on the whole, green credit helps to reduce carbon emissions.

Secondly, when we think about the indirect influence, Zhang and Li [8] made use of provincial panel data to do empirical verification that green credit mainly helps cut carbon emissions through four ways: industrial structure upgrading, green technological innovation, and the respective strengthening effects of these two factors on energy intensity. Hence, Hu and Liao [9] put forward that green credit promotes low-carbon transformation of the power generation industry via three mechanisms: releasing green power generation potential, pushing forward production technology progress, and making output structure green. Thus, Zhang et al. [10] pointed out that at the micro level, green credit can achieve energy saving and emission reduction through enterprise business performance and innovation.

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## 3. Research framework

### 3.1. Data description

The research's sample is made up of A-share listed enterprises that cover the time range from 2012 to 2023. Firm-level data are obtained from the CSMAR database, and macroeconomic data are collected from the Wind database. Therefore, in order to make sure data reliability, we carry out the following screening standards: first, we eliminate enterprises that have been delisted; second, we take away companies that are insolvent; third, we throw away observations which have missing key variables.

### 3.2. Variable definition

#### 3.2.1. Target variable: Enterprise carbon intensity (CI)

Using the research method that was set up by Shang and Li [11] , we carry out measurement of corporate carbon intensity via the way that is written in detail in Equations (1) and (2). Therefore, according to the carbon dioxide calculation standard from Xiamen Energy Conservation Center, the carbon dioxide conversion coefficient for 1 ton of standard coal is 2.493.

$$\begin{aligned} Corporate\ carbon\ dioxide\ emissions = & \frac{Corporate\ operating\ costs}{Industry\ operating\ costs} \\ & \times Total\ energy\ consumption \quad \times Carbon\ dioxide\ conversion\ factor \end{aligned} \tag{1}$$

$$Enterprisecarbonintensity = \frac{Enterprisecarbondioxideemissions}{Enterprisemainbusinessincome} \times 10^9 \tag{2}$$

#### 3.2.2. Explanatory variable: green credit (GF)

Following research method by Xie and Liu [12] , green credit is measured through an inverse indicator: at the provincial level, the ratio that the interest costs of six energy-intensive industries occupy in the entire industrial interest costs.

#### 3.2.3. Control variable

A set of control variables is added to make consideration of firm-specific and regional characteristics. At the firm level, the control variables include firm scale, asset return ratio, debt-to-equity ratio, net cash inflow, board size, executive salary proportion, firm operation years, price-earnings ratio, and ownership concentration degree. At the regional level, the tertiary industry proportion in Gross Domestic Product and economic growth rate are contained in the control variables. Therefore, please look at Table 1 for detailed variable descriptions.

#### 3.2.4. Mediating variable

(1)Green Strategic Orientation (GSO): According to Yang [13] , measurement of the green strategic orientation is realized through combination of seven binary metrics which are gained from companies' annual reports and social responsibility reports. Therefore, these metrics judge whether a business first holds an environmental conservation ideology, second establishes environmental

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conservation goals, third puts into operation an environmental management framework, fourth gets ISO14000 accreditation, fifth develops environmental conservation education and training, sixth organizes environmental conservation initiatives, and seventh implements the "three simultaneous" mechanism.

(2)Financial constraint indicator (SA_index). Therefore, we adopt the SA_index as a measure to judge financing constraints, in accordance with the methodology of H and P [14] . Hence, when we make a comparison with the KZ index, this method is considered to have higher exogeneity, and the reason is that it is constructed only by using firm size, firm size's squared term, and firm age. The calculation formula is as follows:

$$SA\_index_{it} = -0.747 \times Size_{it} + 0.043 \times Size_{it}^2 - 0.04 \times Age_{it} \tag{3}$$

In this situation, Size stands for the natural logarithm of a firm's total asset scale, which is usually calculated in millions of currency units. At the same time, Age refers to the count of years that the firm has carried out its business operations. Therefore, the SA_index generally takes on negative values, hence a larger value means that the firm faces more severe financial constraint problems.

### 3.3. Model building

To make research on the influence that green credit exerts upon an enterprise's carbon intensity, the following standard regression model is therefore constructed:

$$CI_{it} = c_0 + c_1 GF_{it} + c_2 controls_{it} + I_i + Y_t + \varepsilon_{it} \tag{4}$$

In this situation, $i$ stands for time, $t$ indicates a single enterprise. Carbon intensity of the enterprise is represented by $CI_{it}$ , green credit is denoted by $GF_{it}$ , $controls_{it}$ is a vector-form collection of control variables. Firm-specific fixed effect is expressed by $I_i$ , time-related fixed effect is referred to by $Y_t$ , and random error term is signified by $\varepsilon_{it}$ .

To assess the mediating mechanisms, the following equations are estimated:

$$M_{it} = \alpha_0 + \alpha_1 GF_{it} + \alpha_2 controls_{it} + I_i + Y_t + \varepsilon_{it} \tag{5}$$

$$CI_{it} = \beta_0 + \beta_1 GF_{it} + \beta_2 M_{it} + \beta_3 controls_{it} + I_i + Y_t + \varepsilon_{it} \tag{6}$$

Here, $M_{it}$ acts as the intermediate variable, which is corresponding to the GSO and the SA_index. The definitional contents of the other variables keep consistent with those shown in Equation (4).

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## 4. Empirical study

### 4.1. Descriptive statistics

The specific information is presented in the following table.

Table 1. Statistical summary

| VarName | Obs | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| CI | 19502 | 2.885 | 2.441 | 0.006 | 205.967 |
| GF | 19502 | 0.061 | 0.017 | 0.012 | 0.122 |
| GSO | 19502 | 1.835 | 1.836 | 0.000 | 7.000 |
| SA_index | 19502 | -3.833 | 0.285 | -5.397 | -2.085 |
| Size | 19502 | 3.111 | 0.061 | 2.877 | 3.357 |
| ROA | 19502 | 0.053 | 0.040 | 0.000 | 0.171 |
| Leverage | 19502 | 1.297 | 0.725 | 0.630 | 4.947 |
| Liquidity | 19502 | 0.777 | 1.731 | -5.723 | 8.204 |
| Board | 19502 | 8.460 | 1.655 | 0.000 | 18.000 |
| Salary | 19502 | 0.245 | 0.293 | 0.005 | 1.689 |
| Age | 19502 | 10.037 | 7.781 | 0.000 | 27.000 |
| PE | 19502 | 65.548 | 93.146 | 6.843 | 550.452 |
| Top5 | 19502 | 0.495 | 0.185 | 0.200 | 0.989 |
| Industry | 19502 | 54.344 | 10.528 | 34.500 | 84.800 |
| GDP | 19502 | 10.748 | 0.733 | 6.565 | 11.818 |

### 4.2. Benchmark regression results

Based on the Hausman inquiry which refutes the random-effects specification, we make utilization of a fixed-effects model. As Table 2 has shown, the estimated coefficient value of green credit reaches -14.8854 and holds significance at the 1% threshold. Therefore, this result thus indicates that the implementation of green credit can bring about a significant reduction to the carbon intensity at the level of individual firms.

Table 2. Baseline results

| Variables | FE | RE |
|---|---|---|
| GF | -14.8854*** | -11.5577*** |
| | (-5.20) | (-8.61) |
| Control variables | Yes | Yes |
| Observations | 19,502 | 19,502 |
| Number of enterprises | 2,428 | 2,428 |

Please take note: 1. Significance levels: *** means p-value smaller than 0.01, ** means p-value smaller than 0.05, * means p-value smaller than 0.1; 2. The values inside round brackets stand for t-statistics.

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## 4.3. Verification for endogeneity

Selecting the regional financial development level, measured by the ratio of financial institutions' outstanding loans to regional gross domestic product, as instrumental variable. Therefore, a higher regional financial development degree means a more powerful credit supply capacity and a larger scope of financial market liberalization. This can improve firms' green credit access accordingly, thus satisfying the relevance criterion. As a macro-level factor, regional financial development cannot directly affect corporate carbon intensity through micro-level channels except green credit; hence, it meets the exogeneity condition. To solve the endogeneity problem, we adopt the two-stage least squares approach. The first-stage F-statistic is 878.572 (p = 0.0000), which exceeds the critical value of 10, therefore confirming this instrumental variable is not weak. The two-stage least squares results show that the green credit parameter still keeps strong inverse relation, hence further validating the conclusion that green credit lowers corporate carbon intensity.

Table 3. Endogeneity inspections

| Variables | IV |
|---|---|
| GF | -110.0436*** |
| | (-20.37) |
| Control variables | Yes |
| Observations | 19,502 |

Note: The same as above.

## 4.4. Robustness verification

A group of robustness examinations are implemented. Specifically: firstly, the inspected variable is replaced with the logarithm value of environmental protection investment plus one; secondly, the explanatory variable is moved backward by one time period; thirdly, data is winsorized at the 1st and 99th percentiles. Therefore, no matter which model is utilized, the coefficients of green credit remain notably negative, hence indicating that the outcomes are robust.

Table 4. Robustness checks

| Variables | Replace the core explanatory variables | Use lagged terms of the explanatory variables | Winsorize the data |
|---|---|---|---|
| EP1 | 0.0354 *** | | |
| | (-7.76) | | |
| lag_GF | | 6.9846*** | |
| | | (-3.96) | |
| GF | | | 11.5577 *** |
| | | | (-8.61) |
| Control variables | Yes | Yes | Yes |
| Observations | 11,485 | 17,125 | 19,502 |
| Number of enterprises | 2244 | 2408 | 2428 |

Note: The same as above.

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## 4.5. Mechanism test

### 4.5.1. Financial constraints

Table 5 researches the mediating action of financing constraints. In the second column, calculation results about green credit's influence on the SA index are negative and statistically obvious. Therefore, this means green credit expansion reduces corporate financing difficulties and gives favorable treatment to environment-centered enterprises. The third column shows that, although financial constraint index itself has positive relation with carbon intensity, restricted financing thus worsens emissions, yet green credit's coefficient still stays clearly negative. This situation indicates green credit reduces carbon intensity partly via easing firms' financing constraints. Hence, all above findings verify that financing constraint easing serves as a key transmission route through which green credit advances corporations' low-carbon transition.

### 4.5.2. Green strategic orientation

The coefficient takes positive value and passes statistical significance test, thus it demonstrates that green credit drives enterprises to carry out explicit green development strategies. When we put GSO into the regression analysis, the coefficient of green credit still keeps significantly negative level, meanwhile, GSO itself also has a remarkable negative influence on carbon intensity. Therefore, this finding indicates that the improvement of green strategic orientation is not only one outcome brought by green credit policy, hence it is also an effective method to realize carbon emission reduction.

Table 5. Mechanism assessments

| Variables | SA_index | CI | GSO | CI |
|---|---|---|---|---|
| GF | -0.5501*** | -10.3520*** | 14.5531*** | -11.2595*** |
| | (-9.32) | (-7.71) | (15.18) | (-8.40) |
| SA_index | | 0.7940*** | | |
| | | (10.61) | | |
| GSO | | | | -0.0900*** |
| | | | | (-8.59) |
| Control variables | Yes | Yes | Yes | Yes |
| Observations | 25,476 | 19,502 | 25,476 | 19,502 |
| Number of enterprises | 3,396 | 2,428 | 3,396 | 2,428 |

Note: The same as above.

## 4.6. Heterogeneity analysis

In this study, sectors of publicly traded companies are divided into industries facing green credit limitations and industries not facing such limitations. For non-limited industries, the influence on carbon intensity presents a large reverse relationship. For industries under green credit limitations, the coefficient value is negative yet does not reach statistical significance. Therefore, from a statistical angle, the policy's emission-reduction function on these key controlled industries is not obviously visible. This situation can be attributed to the lock-in effects existing in production

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technologies and carbon emission structures of industries restricted by green credit. Industries with features of "high pollution, high energy consumption, and overcapacity" are typical cases. Low-carbon transformation of these industries needs transformative technological innovations and large capital inputs, which cannot bring immediate effects. At the same time, these industries may already be under strong environmental supervision. Hence, the marginal restrictive effect of green credit is relatively small. In fact, due to their failure to meet standards in the short term, they may even be partially excluded from credit support scope, causing policy implementation to be ineffective.

Futher, the sample is grouped according to whether or not to disclose the internal control audit report (ICAR), to measure the quality of information disclosure and compliance. From the last two columns reveal that the carbon-reducing effect of green credit is notably unfavorable at the 1% level for firms that disclose ICAR, while for the enterprises that did not disclose ICAR, the coefficient of green credit is negative but insignificant, which means that the policy fails to produce emission reduction effect on the enterprises with low transparency. The possible reason is that enterprises that disclose ICAR tend to have higher information transparency, stronger compliance willingness and better internal supervision. This enables financial institutions to more accurately evaluate their environmental performance and transformation potential, so that the reward and punishment signals of green credit can be clearly transmitted, and effectively guide enterprises to reduce emissions.

Table 6. Heterogeneity scrutinys

| Variables | Green credit Restricted industry | Non-green credit Restricted industries | Disclosure of internal controls | Failure to disclose internal controls audit report |
|---|---|---|---|---|
| GF | -8.1899 | 11.4402*** | 13.5314*** | -5.3734 |
| | (-1.59) | (-7.72) | (-7.54) | (-1.32) |
| Control variables | Yes | Yes | Yes | Yes |
| Observations | 738 | 17,450 | 10,913 | 313 |
| Number of enterprises | 79 | 2,234 | 2,229 | 234 |

Note: The same as above.

## 5. Conclusion

This paper takes 2,428 A-share listed enterprises during 2012 to 2023 as the sample, and uses the fixed effect structure to investigate the influence of green credit on businesses' carbon emission intensity and the mechanism of its effect. First, green credit has a significant promotion effect on corporate carbon emission intensity, and this conclusion is still valid after the instrumental variable method and robustness check. Secondly, the development of green credit can promote the reduction of carbon emission intensity through financing constraints and green strategic orientation. Third, heterogeneity analyses reveal that the carbon-reducing effect of green credit varies across industry types and corporate disclosure practices. Specifically, the inhibitory effect is more pronounced in non-restricted industries compared to green credit-restricted sectors. Regarding information disclosure, firms that publish internal control audit reports exhibit a significantly stronger carbon reduction effect from green credit than those that do not, highlighting the importance of corporate transparency in policy transmission.

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