

Green Credit Policies' Effect on Corporate Low-Carbon Exports: A Theoretical Model-Based Simulation and Analysis

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Abstract. Against the backdrop of global low-carbon transition and green trade restructuring, green credit policy serves as a vital financial tool to stimulate firms' low-carbon exports, yet its theoretical logic lacks systematic exploration. This paper develops a three-agent model of financial institutions, international markets, and firms to analyze the effects of firm trade heterogeneity and the theories of green finance. The study methodically determines the impact effects, mechanisms, and varied characteristics of green credit policies on business low-carbon exports by establishing distinct policy assumptions and building and solving theoretical models both before and after policy implementation. According to the study, the dual reallocation effect of financial and production resources is the primary mechanism by which green credit regulations can considerably boost the growth of businesses' low-carbon exports and lower carbon intensity. International green trade barriers have a substantial synergistic effect with the policy effects, which show twofold heterogeneity in terms of enterprise carbon intensity and policy intensity. Additionally, this paper provides suggestions in four areas, which support policy improvements, enhance competitiveness of exports, and expand the scope of theories of green finance and trade coordination.

Keywords: Green Credit Policies; Corporate Low-Carbon Export; Resource Reallocation Effect.

1. Introduction

Low-carbon transition is a global necessity that is unavoidable because of sustainable economic development and global climate change. International trade, as one of the leading forces of this change, is experiencing radical green transformation and has become one of the fundamental directions of the reorganization of the global trading system. According to UNCTAD estimates, in 2024, the global export of environmentally friendly products amounted to 2 trillion, which constitutes 14% of the total manufacturing export. Increasing carbon tariffs and green trade barriers have brought more stringent low-carbon conditions on corporate exports, compelling businesses to speed up the green transformation. Being the largest developing country and the export-driven economy in the world, China has to follow its dual carbon strategic commitment and assist local enterprises to hack the trade barriers and boost the export competitiveness in a low-carbon environment.

Green credit, one of core pillars of the green financial system with rapid development in China. By the end of 2024, outstanding green loans in local and foreign currencies stood at 36.6 trillion yuan, a year-on-year increase of 21.7%. While there is extensive literature on the economic consequences of green credit policies, much of this literature focuses on assessing corporate internal indicators such as environmental performance and green innovation through empirical tests. However, few have established theoretical models to systematically discover the internal logic and dynamic balance relationship between green credit and corporate low-carbon export, which is a major theoretical blank.

This paper constructs the three-agent partial equilibrium framework that consists of financial institution, heterogeneous exporting enterprises and international market: it investigates low-carbon exporters with respect to green credit policies in terms of their impact effects, mechanisms and heterogeneity. It bridges the aforementioned theoretical gap and offers a reference for policy optimization. The remaining parts of the paper are structured into literature review and hypotheses, theoretical model development, theoretical implications and policy recommendations and conclusion.

2. Literature Review and Research Hypotheses

2.1. Economic Effects of Green Credit Policies

The economic implications of green credit policies have long been a focus of scholarly research as a key instrument that blends financial limitations with market-oriented environmental control. The majority of the literature currently in publication focuses on how these policies affect businesses' micro-level operational behaviour, leading to two opposing perspectives: "inhibitory" and "promotional." Some studies have expanded their focus to include businesses' exports and foreign investments, which laid the foundation for this paper's analysis of how these policies affect businesses' low-carbon exports.

According to research on the inhibitory effects, green credit regulations considerably limit the growth of export volumes by highly polluting businesses. The main reason is that by raising the financing costs of highly polluting businesses and decreasing the marginal output of their production factors, green credit laws indirectly stifle the growth of export volumes [1]. According to research on the promotional impacts, green financing may greatly boost China's export trade growth, enhance its extensive and intensive margins, and maximize its volume-price structure [2].

Additionally, the literature now in publication generally recognizes the beneficial incentive effect of green credit programs on environmental performance and corporate green innovation. Green credit policies, for example, effectively alleviate financing constraints for green enterprises, encourage technological advancements and the optimization of production models, and lay the foundation for businesses to transition toward green exports by rerouting capital from high-pollution and energy-intensive sectors toward green and low-carbon sectors through differentiated credit allocation [3].

In terms of global research, He et al. verified through a thorough empirical analysis of Chinese listed companies from 2009 to 2022 that green credit policies encourage green innovation by easing financing restrictions and lowering financing costs, thereby fostering an environment that is conducive to the advancement of environmental technologies [4]. Through spatial econometric research, Su et al. and others discovered that green finance significantly reduces carbon emissions in nearby regions [5]. In particular, the movement of green ideas and resources between provinces encourages the development of regional spillovers, but green rivalry causes a "crowding-out" effect on nearby areas.

2.2. Influencing Factors of Corporate Low-Carbon Exports

As a key vehicle for green trade, corporate low-carbon exports are primarily studied in terms of two dimensions: external regulatory environments and internal corporate capabilities.

Corporate low-carbon exports have been demonstrated to be significantly impacted by both domestic environmental policies and green trade barriers like carbon tariffs at the level of external environmental laws. Chen et al. calculated the carbon intensity of exports at the firm level using a multi-region input-output model and discovered that firms reduce export carbon emissions through technological upgrades when regional environmental regulations become more stringent [6]. This emission reduction effect is further enhanced when regional environmental regulations and corporate digital transformation work together. Reducing energy consumption intensity, encouraging green technical innovation, and optimizing export structures are three ways that digital transformation can dramatically cut the embodied carbon intensity of exports at the level of internal business capacities.

In terms of global research, Cen et al. discovered via a mechanism analysis that green credit policies encourage low-carbon technological innovation by increasing the R&D expenditure and management effectiveness of businesses [7]. In line with the previously indicated mechanism, Ren et al. contend that financial limitations may inhibit technological innovation, impacting businesses' green and low-carbon transitions [8].

2.3. Literature Review

In conclusion, the literature now in publication has carried out comparatively thorough empirical research on the economic impacts of green credit policies and the factors that influence business low-carbon exports. This research has identified the policy's direction of action, important influencing elements, and some transmission channels. Significant theoretical research gaps still exist, though. Firstly, there is a dearth of literature that specifically looks at how green credit policies affect business low-carbon exports from the standpoint of theoretical modelling. The majority of studies concentrate on empirical testing rather than characterizing the intrinsic logic and equilibrium relationship between the policy and corporate low-carbon export behaviour at a mathematical level; second, existing analyses of policy mechanisms are primarily qualitative descriptions or empirical identifications, lacking verification of core transmission channels derived through theoretical models, making it difficult to quantify the effects of mechanisms like resource allocation in the policy implementation process; and third, although existing empirical studies address policy heterogeneity, they have not provided mathematical support for the formulation of differentiated policies.

Based on this, this paper develops a theoretical model of how green financing policies affect businesses' low-carbon exports, departing from the conventional empirical research approach. It addresses the theoretical gaps in current research and enhances the research framework on the coordinated development of green finance and international trade by methodically inferring the policy's impact effects, mechanisms of action, and heterogeneity characteristics through the design of a multi-agent decision-making framework, the derivation of equilibrium solutions, and comparative static analysis.

2.4. Research Hypotheses

Via differentiated credit allocation, the green credit policies have a two-way but ultimately profoundly positive effect on enterprises' low-carbon exports. They reduce financing constraints for green and low-carbon enterprises by lowering the cost of financing and increasing the scale of credit; they restrict the production, sales, and exports of high-polluting, high-energy-consuming enterprises through tight credit supply and a higher cost environment, compelling their low-carbon transformation. Meanwhile, the policies encourage green technology R&D, improve the low-carbon level of export products and aid firms in tackling green trade barriers like carbon tariffs, promoting low-carbon exports expansion and quality upgrading. Successful transformation will give enterprises stronger low-carbon export capacity, while unsuccessful enterprises will gradually exit the market. This finding is well supported by empirical evidence: Jin et al. determine that green finance promotes the growth of exports and optimizes the structure of exports [2]; Wang et al. corroborate that green credit lowers the carbon intensity of enterprises' export products and promotes export low-carbon transformation [9]. Based on the above, the main hypothesis is then presented as follows:

H1: Green credit policies play an important role in promoting enterprises' low-carbon exports by increasing export scale and reducing carbon intensity after policy implementation.

Resource reallocation is the fundamental channel from the perspective of Mechanism. In terms of economic significance, green credits strengthen the flow of funds between high pollution and energy consumption industries to low carbon and environmentally friendly sectors through effective resource applications. Han et al., for example, demonstrate that this resource reallocation effect improves the industrial export product structure of high-polluting industries [10]; Lu et al. In this way the authors also identify what resource reallocation is key mechanism for green credit to stimulate corporate green transformation [3]. On this basis, the corresponding mechanism hypothesis is proposed:

H2: Green credit policies boost enterprises' low-carbon exports by optimizing corporate resource allocation.

3. Theoretical Model Design

This paper builds a three-agent partial equilibrium model that includes financial institutions, heterogeneous exporting firms, and international markets. It does this by incorporating the distinct regulatory features of green credit policies and drawing on the fundamental frameworks of the theory of trade by heterogeneous firms and the theory of green financial resource allocation [11]. The model clarifies how policies affect businesses' low-carbon exports. The model design follows the logical chain of "assumptions - agent and variable definition - basic model construction - equilibrium solution determination".

3.1. Assumptions of the Model

(1) There are two categories of heterogeneous exporting enterprises in this fully competitive market: low-carbon firms (Type G) and high-carbon firms (Type B). Each company only produces one exportable good, and the carbon intensity of that good, represented by the letter c , makes up the firm's basic heterogeneous characteristic, $C_G < C_B$.

(2) Differentiated green credit policies are implemented by financial institutions: Type B firms have an additional financing cost of r_p with a credit limit of L_B , type G firms receive a financing cost subsidy of r_s with a credit limit of L_G , where $L_G > L_B$ and $r_s < r_p$. The two categories of businesses had the same credit limitations and financing expenses prior to the policy's introduction.

(3) Businesses must take low-carbon investment limits into consideration when making export decisions. There is a negative correlation between product carbon intensity (c) and low-carbon R&D investment (R). R&D spending has no internal funding sources and is totally dependent on outside borrowing. Export income, production expenses, and finance costs are the only factors that affect a company's export earnings.

(4) There are green trade barriers in the global market, and exporting firms need to pay a carbon cost $\tau(c)$ with $\tau'(c) > 0$, which is fully reflected in the export price.

(5) Businesses aim to have no sunk expenses and maximize earnings. After policies are put into place, businesses can only make the best choices by modifying their R&D spending and export volume without altering the type of industrial technology they use.

3.2. Variable Definitions and Model Agents

3.2.1. Representatives

(1) Financial Institutions: As exogenous policy makers, they execute policies that direct corporate resources toward low-carbon industries through differentiated credit allocation (financing costs, credit size).

(2) Exporting enterprises: Type G (low-carbon) and Type B (high-carbon) enterprises are decision-making entities that modify their export quantities and low-carbon R&D investments in response to green financing policies in order to optimize earnings.

(3) International Market: A demand entity that places carbon cost restrictions on exported goods; the demand function is linear, and market demand is only correlated with the product's export price.

3.2.2. Model Body

The variable definitions of the model are shown in Table 1.

Table 1. Definition of Model Variables.

Variable Symbol	Variable Definition	Variable Nature
c	Firm's Export Product Carbon Intensity	Exogenous heterogeneous variable
r	Firm's Financing Cost	Policy-regulated variable
L	Firm's Credit Limit	Policy-regulated variable
R	Firm's Low-Carbon R&D Expenditure	Endogenous decision variable
$\tau(c)$	International Market Carbon Cost	Exogenous constraint variable

q	Firm's Export Volume	Endogenous decision variable
π	Firm Export Profit	Dependent Variable
p_0	International Market Price of Exported Products	Exogenous Variable, assumed to be constant
c_0	Firm Marginal Production Cost	Exogenous Variable, assumed to be constant

3.3. Construction of the Base Model

This study builds a differentiated model after policy implementation and a baseline model before policy implementation. By comparing the equilibrium solutions of these two models, the impact of green credit policies on enterprises' low-carbon exports is systematically analyzed.

3.3.1. Sub heading

Financial institutions use an undifferentiated credit policy to both Type G and Type B enterprises prior to policy implementation. Both have a credit supply of L_0 and a financing cost of r_0 . The only factor influencing a company's investment in low-carbon R&D is its own carbon intensity. The role of export profits is:

$$\pi_0 = p_0 q - c_0 q - r_0 R - \tau(c)q \quad (1)$$

Specifically, the benchmark profit function is obtained by entering $R = \frac{k}{c}$ (where $k > 0$ is the R&D efficiency coefficient, which is inversely proportional to carbon intensity) into Equation (1) when R&D investment in low-carbon technology satisfies this condition:

$$\pi_0 = (p_0 - c_0 - \tau(c))q - \frac{r_0 k}{c} \quad (2)$$

The constraint for profit maximization is the credit supply limit $R \leq L_0$, i.e., $\frac{k}{c} \leq L_0$.

3.3.2. Differentiated Model After Policy Execution

Financial institutions apply various lending policies for Type G and Type B enterprises when the policy is put into effect. The profit functions for each category are built as follows:

(1) Low-Carbon Businesses' Profit Function (Type G)

Type G businesses have their credit limit raised to L_G and receive a financing cost subsidy of R_s . The credit constraint is $R \leq L_G$, and the financing cost is $r_G = r_0 - r_s$. The role of profit is:

$$\pi_G = (p_0 - c_0 - \tau(c_G))q_G - \frac{(r_0 - r_s)k}{c_G} \quad (3)$$

(2) High-Carbon Businesses' Profit Function (Type B)

Type B businesses must contend with higher financing costs and a decrease in L_B credit availability. The credit constraint is $R \leq L_B$, and the financing cost is $r_B = r_0 + r_p$. The role of profit is:

$$\pi_B = (p_0 - c_0 - \tau(c_B))q_B - \frac{(r_0 + r_p)k}{c_B} \quad (4)$$

Where q_G and q_B are key endogenous decision variables that represent the export volumes of Type G and Type B enterprises, respectively, after policy execution.

3.4. Equilibrium Analysis and Model Solution

This study uses first-order conditions to solve for the ideal export scale under profit maximization, compares equilibrium solutions prior to and following policy implementation, and determines how the green credit policy affects businesses' low-carbon exports.

3.4.1. Ideal Export Scale Prior to Policy Adoption

The baseline optimal export scale is obtained by taking the first derivative of the baseline profit function (2) with respect to export scale q and setting it to 0:

$$\frac{\partial \pi_0}{\partial q} = p_0 - c_0 - \tau(c) = 0 \quad (5)$$

Equation (5) makes it clear that the firm's export volume is independent of credit policy and is only influenced by market pricing, production costs, and carbon costs prior to policy implementation. Let q_0 represent the baseline ideal export volume.

3.4.2. Ideal Export Volume After Policy Adoption

Determine the best export volume under the credit constraint by computing the first-order derivatives of the profit functions for Type G and Type B companies, setting them to zero:

(1) Low-Carbon Business Equilibrium Solution (Type G)

Combining the credit restriction $c_G k \leq L_G$ (where $L_G > L_0$ after policy implementation, indicating the constraint is relaxed without affecting the optimal decision) with the first-order derivative of Equation (3) with respect to q_G yields:

$$\frac{\partial \pi_G}{\partial q_G} = p_0 - c_0 - \tau(c_G) > 0 \quad (6)$$

The optimal export volume for Type G enterprises fulfills the following since $c_G < c_B$ and $\tau(c_G) < \tau(c_B)$, and the firm's R&D investment constraint is relaxed due to the lower financing costs:

$$q_G^* = q_0 + \Delta q_G, \Delta q_G > 0 \quad (7)$$

(2) Type B Equilibrium Solution for High-Carbon Companies

Taking the first derivative of Equation (4) with respect to q_B and incorporating the credit constraint $c_B k \leq L_B$ (where $L_B < L_0$ after policy implementation, representing a tightened constraint that reduces R&D investment) yields:

$$\frac{\partial \pi_B}{\partial q_B} = p_0 - c_0 - \tau(c_B) < 0 \quad (8)$$

The disadvantage of carbon costs, decreased credit availability, and growing finance costs all suggest that the optimal export volume for Type B firms satisfies:

$$q_B^* = q_0 - \Delta q_B, \Delta q_B > 0 \quad (9)$$

3.4.3. Low-Carbon Export Equilibrium Across the Industry

The total of Type G enterprises' exports and Type B firms' post-transition exports is the industry-wide low-carbon export volume. Type B companies must make sure that their post-transition profitability is positive if they decide to go through a low-carbon transition, i.e.

$$\frac{(r_0 + r_p)k}{c_B} - \frac{(r_0 - r_s)k}{c_G} < (p_0 - c_0 - \tau(c_G))q_G - (p_0 - c_0 - \tau(c_B))q_B \quad (10)$$

When Equation (10) is true, Type B companies will change into low-carbon businesses, the industry's overall carbon intensity will drop dramatically, and the volume of low-carbon exports will increase.

4. Theoretical Inferences and Policy Recommendations

4.1. Core Theoretical Inferences

According to the equilibrium analysis of the three-agent partial equilibrium model, there are four fundamental conclusions. First, the green credit policies contribute greatly to the growth of corporate low-carbon exports, as well as decrease export carbon intensity with differentiated credit distribution,

with the twofold outcome of low-carbon firm growth + high-carbon firm transformation/exit. Second, resource allocation effect is the fundamental means of transmission, which alters the financial and production resources between the high-carbon and the low-carbon sector. Third, there is a high level of policy heterogeneity: the more the carbon intensity of the firm, the greater the export promotion incentive effect, and the more the policy parameters are strict, the greater the incentive effect on low-carbon firms and the constraint effect on high-carbon firms. Fourth, green credit policies are synergistic with global green trade barriers and increased global carbon prices will enhance the policy promotion effect on low-carbon exports.

4.2. Targeted Policy Recommendations

Corresponding policy recommendations are proposed from four dimensions. To begin with, optimize the differentiation design of green credit policies, and develop tiered financing costs and credit quotas according to corporate export carbon intensity. Second, strengthen the implementation capacity of financial institutions and innovate credit products specifically designed for low-carbon exports, while integrating green credit performance into assessment systems. The third is to encourage the enterprises to increase low-carbon R&D investment and to accelerate green transformation and adaptation with respect to policy or market demand. Fourth, other than improving the coordination of domestic green credit policies and international green trade rules, establish a linkage mechanism between carbon tariffs and green credit subsidies.

5. Conclusion

This study builds a theoretical model connecting green credit policies and corporate low-carbon exports, which enriches the existing theoretical modeling research. It provides a mathematical description of the internal logic and equilibrium relationship between both, as well as identifying key policy parameters and transmission mechanisms. The research results can provide a theoretical basis for the optimization of green credit policy system and help enterprises get rid of the restriction of green trade barriers, so as to promote the synergistic development between “dual carbon” strategy and high-quality trade. Future studies can extend the model to include general equilibrium conditions and empirical tests on micro-enterprise data to validate conclusions from this study.

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