

Article

Does Carbon Trading Policy Enhance the Autonomy and Controllability of Green Enterprises in Supply Chains? A Study of the Chain-Mediating Effects of Green Ambidextrous Innovation

Wenjie Chen  and Yisong Yang *

Business College, Central South University of Forestry and Technology, Changsha 410004, China; t20142193@csuft.edu.cn

* Correspondence: 20241200920@csuft.edu.cn or yys67120908@outlook.com

Abstract: Enhancing the Autonomy and Controllability of green enterprises is crucial for promoting the sustainable development of a green, low-carbon economy. Carbon trading policy has garnered widespread attention across China, offering a novel approach to enhancing the capabilities of Chinese green enterprises. This study aims to explore the impact of carbon trading policies on the Autonomy and Controllability of green enterprises. By introducing the mediating variable of Green ambidextrous innovation, the action mechanism between carbon trading policies and the Autonomy and Controllability of green enterprises is analyzed. In addition, the internal action mechanism of Green ambidextrous innovation is revealed, providing a reference for improving the Autonomy and Controllability of green enterprises and building a global safe and controllable green supply chain. Drawing on data from 126 publicly-listed green companies in China, this study constructs a chain mediation framework based on the logic of “Carbon Trading Policy—Green ambidextrous innovation—Autonomy and Controllability of Green Enterprises.” Utilizing the DID methodology, the analysis explores the impact and mechanisms of the carbon trading policy on green enterprises’ Autonomy and Controllability. The findings indicate that the carbon trading policy significantly enhances the Autonomy and Controllability of green enterprises. Mechanistic analysis reveals that the policy boosts the controllability of green enterprise customers through Green ambidextrous innovation, although its effect is not significant. Additionally, the study identifies internal mechanisms within Green ambidextrous innovation that influence these capabilities. Heterogeneity analysis shows that the carbon trading policy has a particularly pronounced effect on the Autonomy and Controllability of green enterprises in western China and is more impactful for green factories compared to green supply chain enterprises.

Keywords: carbon emission trading policy; autonomy and controllability of green enterprises; green exploratory innovation; green exploitative innovation; chain-mediating effects



Academic Editor: Grigorios L. Kyriakopoulos

Received: 9 January 2025

Revised: 31 January 2025

Accepted: 9 February 2025

Published: 12 February 2025

Citation: Chen, W.; Yang, Y. Does Carbon Trading Policy Enhance the Autonomy and Controllability of Green Enterprises in Supply Chains? A Study of the Chain-Mediating Effects of Green Ambidextrous Innovation. *Sustainability* **2025**, *17*, 1534. <https://doi.org/10.3390/su17041534>

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Faced with escalating carbon emissions concerns, developing a green economy has become a crucial priority for governments globally. As key micro-entities supporting the sustainable and environmentally friendly development of the real economy, green enterprises play a vital strategic role in refining economic structures and advancing green economic growth. Specifically, scholars such as Wang Weiguang proposed that the Autonomy and Controllability of the green enterprise supply chain greatly affects the extension

of the entire industrial chain and the optimization and upgrading of the industrial structure [1]. Therefore, this study believes that the Autonomy and Controllability of green enterprises should be based on the two aspects of Autonomy and Controllability; that is, green enterprises should improve their advantageous bargaining position (Controllability) in the supply chain by reducing their dependence on external technologies and products (Autonomy). This means that green enterprises should properly handle the contradiction between excessive external dependence and lack of internal development, improve their overall bargaining power in the supply chain, and enhance their Autonomy and Controllability in the supply chain. Currently, with frequent international economic, trade, and social events, the green industry faces severe challenges from external uncertainties. These factors challenge the enhancement of the autonomy level and controllable efficiency of green enterprise supply chains, underscoring the urgent need to bolster the resilience and recovery capabilities of supply and industrial chains. As a significant global power in a critical phase of cross-cycle economic adjustment, the Chinese government has consistently focused on building and upgrading industrial chains' Autonomy and Controllability systems. A Chinese government report highlighted "enhancing the Autonomy and Controllability of industrial chains and supply chains" as a key task [2]. Meanwhile, the government emphasized the utmost importance of ensuring the security of critical supply chains [3]. Although the Chinese government prioritizes controllability over the supply chain, it still lacks comprehensive control over critical segments of the entire supply chain, leading to frequent disruptions, with bottlenecks and breakpoints increasingly manifesting spill-over effects. Thus, enhancing the Autonomy and Controllability of green enterprises within the supply chain has become an essential strategy for the Chinese government to maintain economic stability while seeking progress and fostering stability through new developments.

The large quantities of greenhouse gases, such as carbon dioxide, brought about by excessive consumption of traditional energy have directly had a serious adverse impact on the global climate, requiring countries around the world to take into account the need for green and low-carbon development while ensuring economic benefits. Based on such problems, countries have begun to pay attention to carbon emissions and continue to explore low-carbon paths. The European Union set carbon emission quotas for industries such as power manufacturing through the 2005 carbon emissions trading system. The United States launched the Regional Greenhouse Gas Initiative in 2009. China issued the "Notice on the Pilot Work of Low-Carbon Provinces and Cities" in 2010. Despite this, the traditional carbon emission reduction policies of China, America, and European countries generally directly increase the operating costs of enterprises through administrative orders such as taxes and administrative penalties, thereby controlling the carbon emissions of enterprises. This mandatory carbon emission penalty often accelerates enterprises to replace the penalty costs by pursuing the economic benefits of carbon emissions. Therefore, this kind of environmental regulation of carbon emission reduction passively carried out by enterprises at the expense of product output is not sustainable. In the long run, it is not conducive to the transformation and development of enterprises to green and low carbon. The Pilot Policy for Carbon Emission Rights Trading (hereafter referred to as the carbon trading policy) promoted by the Chinese government provides a market-based solution to break this dilemma. On the one hand, carbon trading policies can encourage enterprises to carry out green technology innovation [4,5], improve energy efficiency, and thus obtain excess emission reduction benefits; on the other hand, carbon emission rights trading policies enable the carbon emission rights trading system to internalize external environmental costs mainly through price mechanisms, thereby constraining the carbon emissions of enterprises [6]. In summary, the emergence and use of market-based carbon emission measures not only promote the improvement of the overall benefits of enterprises

but also promote the green transformation of enterprises and enhance the competitiveness of green enterprises in the supply chain.

Carbon trading policies provide a new solution for improving the Autonomy and Controllability of green enterprises. On the one hand, it incentivizes enterprises to engage in green technological innovation, diversify their sourcing options, achieve multiple supply chain options, reduce reliance on single suppliers, and enhance their controllability over suppliers; on the other hand, the policy encourages companies to adjust their product structures through green technological innovation, diversify sales channels, reduce dependence on a single customer group, and improve their bargaining position within the supply chain. It can be seen that the impact of carbon trading policies on the Autonomy and Controllability of green enterprises is achieved through two steps. The first step of carbon trading policies is to encourage green enterprises to continuously explore green “bottle-neck” technologies. The second step is for green enterprises to promote the transformation of their own green patents into application results, which constitutes the specific concept of Green ambidextrous innovation. Therefore, a question worth studying arises: can carbon trading policies be used to stimulate green enterprises to conduct exploratory innovation of green technologies [7,8] thereby accelerating the application of innovative patents; that is, to achieve the “two-step” approach of Green ambidextrous innovation, thereby enhancing the Autonomy and Controllability of green technologies in the supply chain?

To date, academic research has extensively explored the relationship between carbon trading policies and green innovation, particularly focusing on the nexus between carbon trading policies and Green ambidextrous innovation. Regarding the relationship between carbon trading policies and green innovation, the scholarly opinion is broadly categorized into three groups. Some studies suggest that carbon trading policies can negatively affect corporate green innovation, as the unreasonable allocation of carbon emission rights may inhibit innovation activities [9]. Others argue that no correlation exists between carbon trading policies and corporate green innovation [10]. Scholars like Calel, R [5], by analyzing patent data from companies participating in the EU Emissions Trading System, have observed a notable increase in patents for green, low-carbon technologies in the later stages of the EU carbon market. Regarding promoting carbon green technology innovation through carbon trading policies, existing studies not only establish the relationship between carbon trading policies and corporate green innovation [11] but also explore the specific pathways of influence. Carbon trading policies can drive green technological innovation through two primary channels: internal environmental investment and external environmental regulations [7]. On the one hand, carbon trading policies primarily encourage internal green innovation within resource-based industries through four pathways: increasing the income benefits of resource-based industrial enterprises, reducing capital constraints, providing subsidies, and enhancing corporate research and development incentives [12]. On the other hand, the effectiveness of carbon trading policies varies under different circumstances: compared to enterprises with lower carbon emissions, those with higher emissions levels are more significantly motivated to innovate by carbon trading policies [13]. Additionally, market-driven environmental regulations like carbon emission trading policies play a crucial role in promoting overall green technological innovation in enterprises, with a stronger effect on technological innovation at the production end [14].

According to theories of technological innovation, Green ambidextrous innovation is divided into green exploratory innovation and green exploitative innovation. The current academic focus lies on three aspects: the relationship between green exploratory and exploitative innovation, the antecedents of Green ambidextrous innovation, and the outcome variables of Green ambidextrous innovation. Scholars such as [15,16] identify both a balance dimension and a combination dimension, where competition and complemen-

tarity coexist. Regarding the antecedents of ambidextrous innovation, scholars generally identify structural factors, leadership factors, and strategic factors as influencing Green ambidextrous innovation. Centralized organizational structures are not conducive to green exploratory innovation [17]. Scholars such as [18] have shown that a shared leadership style positively influences organizational Green ambidextrous innovation. Wang, Y.D et al. [19] have suggested that strategic orientation and market orientation influence corporate Green ambidextrous innovation by balancing organizational dual capabilities. In terms of outcome variables for ambidextrous innovation, existing studies demonstrate that both the balance and combination within Green ambidextrous innovation significantly enhance corporate performance [15,17,20].

Regarding the Autonomy and Controllability of green enterprises, current research is sparse and primarily focuses on industrial Autonomy and Controllability. Scholars such as [1] suggest that reducing dependence on external technology and products is one of the criteria for strong industrial Autonomy and Controllability. However, more research is needed in the academic field on the relationship between Green ambidextrous innovation and corporate Autonomy and Controllability or organizational resilience. Specifically, both green exploratory and exploitative innovations can reduce a company's reliance on customers [21], suggesting that ambidextrous innovation positively influences the Autonomy and Controllability of green enterprises by effectively mitigating external dependencies. In terms of the relationship between ambidextrous innovation and organizational resilience, existing research indicates that green exploratory innovation can increase the number of patents, allowing companies to sell these patents to generate immediate cash flow. This cash flow can be used to mitigate the negative impacts of shocks, thereby enhancing the company's resistance to external disruptions and improving crisis management capabilities. Additionally, a robust Green ambidextrous innovation environment also contributes to product diversification, enhancing organizational resilience [22,23]. Moreover, a few scholars have noted the impact of Green ambidextrous innovation on corporate resilience under different circumstances, suggesting that a company's green exploratory innovation only affects resilience when the company's profitability is low [24].

In summary, current research still has the following four shortcomings: First, the mechanisms by which carbon trading policies affect the Autonomy and Controllability of micro-green enterprises have not been elucidated. Second, previous studies have primarily focused on the antecedents and consequences of Green ambidextrous innovation, often using green exploratory and exploitative innovations as mediating variables, with scant attention given to the internal chain-like impact mechanisms of Green ambidextrous innovation. Third, current research primarily focuses on the Autonomy and Controllability of industries and the resilience and security of green enterprise supply chains. However, studies examining the controllability of upstream and downstream elements within the supply chain remain scarce. In light of these deficiencies, this paper constructs a theoretical analysis framework based on the Green ambidextrous innovation theory, following the "Carbon Trading Policy—Green ambidextrous innovation—Autonomy and Controllability of Green Enterprises" structure. This paper examines how carbon trading policies influence the Autonomy and Controllability of green enterprises, highlighting Green ambidextrous innovation as a key mediating variable that reveals the internal, chain-like mechanisms of such innovation. Specifically, carbon trading policies facilitate green technological innovation through Green ambidextrous innovation, transitioning from the exploratory stage to the application stage, developing replaceable energy-saving materials and a diverse range of green products. This enables enterprises to gain a competitive bargaining position in procuring raw materials and selling goods, thereby enhancing their Autonomy and Controllability. Thus, the marginal contributions of this paper are threefold: First, based

on the regression analysis of the impact of carbon trading policies on the Autonomy and Controllability of green enterprises, this paper empirically tests the mediating influence mechanism of Green ambidextrous innovation and provides new ideas for the sustainable development of green enterprises under the background of carbon peak and carbon neutrality goals. Second, unlike the existing research on Green ambidextrous innovation, this study fully explores the internal chain influence mechanism of Green ambidextrous innovation on the basis of examining the overall mechanism of Green ambidextrous innovation; that is, it examines the transmission effect from green exploratory innovation to green application innovation and provides more reliable quantitative evidence for the transition of green innovation results from theory to practice. Third, based on theories such as the five forces model, this paper fully measures the Autonomy and Controllability of green enterprises from three dimensions: customers, suppliers, and supply chains, refines the Autonomy and Controllability of green enterprises, and explores the impact mechanism of carbon trading policies on different stakeholders in the supply chain of green enterprises.

The remaining structure of this paper is organized as follows: Section 2 discusses the theoretical mechanisms and research hypotheses, Section 3 details the variables and model settings, Section 4 analyzes the impact and mechanisms of carbon trading policies on the Autonomy and Controllability of green enterprises and also explores the varying effects of these policies on green enterprises across different regions and businesses, and Section 5 discusses and summarizes the results.

2. Theoretical Hypotheses

A substantial body of research indicates that market-based trading mechanisms are among the most effective means of addressing the externalities associated with environmental pollution [25]. As previously mentioned, enterprises' Green ambidextrous innovation activities are mainly categorized into two types: green exploratory innovation, which primarily focuses on the pathway exploration of disruptive green technologies, and green exploitative innovation, which concentrates on the application and transformation of green innovation outcomes [17]. These two types of innovation work together to enhance the core capabilities of green enterprises at both the technological and market levels [26], thereby establishing a competitive bargaining position within the supply chain and strengthening the Autonomy and Controllability of green enterprises. As shown in Figure 1, The paper follows a chain-mediated impact pathway of "Carbon Trading Policy—Green Exploratory Innovation—Green Exploitative Innovation—Autonomy and Controllability of Green Enterprises" for analysis.

2.1. Carbon Trading Policy and the Autonomy and Controllability of Green Enterprises

Carbon trading policies enhance the bargaining power of green enterprises within the supply chain through customer preferences and pressure transmission, thereby impacting their Autonomy and Controllability. This influence is manifested in three main aspects: In the customer segment, the carbon trading policy and the trend towards economic green transformation have led to increased demand for environmentally friendly and low-carbon products. Customers are likely to favor products from green enterprises, thus increasing the stickiness between customers and green enterprises, enhancing customers' dependence on green products, and consequently boosting enterprises' control over their customers. On the other hand, green products emphasize resource conservation and recycling, which helps to reduce procurement costs and waste disposal expenses, thereby enhancing the cost-effectiveness of green products. From the perspective of purchasing costs, customers are more inclined to choose green products from green enterprises. Therefore, in negotiations and bargaining with customers, enterprises often hold an advantageous position [27],

strengthening green enterprises' Autonomy and Controllability. Regarding the supplier segment, carbon trading policies encourage green enterprises to procure substitutable energy-saving materials. This information is conveyed to suppliers through the supply chain feedback mechanism [28], reducing suppliers' opportunistic motives and the likelihood of contract breaches, thereby increasing the controllability green enterprises have over their suppliers. For the overall supply chain, carbon trading policies differentially impact enterprise procurement needs and customer preferences through the information transmission of the green enterprise supply chain, thereby enhancing the controllability of green enterprises over their supply chain. According to Porter's hypothesis, appropriate environmental regulations can stimulate enterprises to engage in green technological innovations, meaning that enterprises can choose more substitutable raw materials while also producing competitively marketable green products. Based on resource dependence theory, for survival, suppliers and customers depend on enterprises that control key green resources [29], thereby strengthening the enterprise's controllability over the supply chain. In summary, this study proposes hypothesis H1:

H1. *Carbon trading policies significantly enhance the level of Autonomy and Controllability of green enterprises.*

2.2. Carbon Trading Policy and Green Exploratory Innovation

Carbon trading policies enhance the innovative behaviors of green enterprises in scientific research and development through market-based carbon quota trading and accompanying fiscal measures such as tax relief and institutional subsidies, thereby obtaining innovation compensation through directional changes in green technology. Conceptually, the impact of carbon trading policies on green exploratory innovation is the first step in a chain impact mechanism; that is, carbon trading policies realize the marketization of carbon dioxide emission costs for green enterprises, forcing green enterprises to explore innovative green disruptive technologies and enhance their willingness for green exploratory innovation, thereby rationalizing and optimizing the internal costs of carbon emissions. Regarding internal influences, Porter's hypothesis suggests that appropriate environmental regulation can create an "innovation offset", which partially or fully compensates for the costs of implementing environmental management practices and enhances corporate competitiveness through innovation [27]. This competitive edge often manifests through "weak" and "strong" effects—the former indicating that well-designed environmental regulations can stimulate innovation, while the latter assesses the impact of environmental regulations on business performance metrics such as productivity. From an external environment perspective, on the one hand, carbon trading policies serve as a crucial mechanism for implementing environmental regulations, aiming to control total carbon emissions and promote inter-company carbon quota trading to optimize the allocation of carbon quota resources among enterprises. Under the pressure of carbon quotas, green enterprises consider that disruptive innovation can accelerate the transformation of their production and operational processes, enhance their core competitiveness in products and services, and increase their share in mainstream markets [30]. Meanwhile, the technological transformations from disruptive innovations directly reduce the marginal emission costs per unit of time. With increasing returns due to scale effects, the long-term value of green products will exceed the investment costs of developing disruptive technologies [31], prompting green enterprises to invest more in exploring disruptive innovation pathways. This investment strategy can sustain cash flow for green exploratory innovation [31,32]. On the other hand, for external green enterprises, carbon trading policies provide clear market price information and directions for technological innovation [33] and support disruptive green technologies and cutting-edge technological innovations with accompanying tax relief

measures and fiscal subsidies [34]. This creates an incentive mechanism for low-carbon technological innovation in enterprises, which can reduce various risks associated with low-carbon technological innovations to some extent and enhance the certainty of the value derived from investments in carbon emission reduction [35]. In conclusion, this study proposes Hypothesis H2:

H2. *Carbon trading pilot policies significantly enhance the level of green exploratory innovation in enterprises.*

2.3. Green Exploratory Innovation and Green Exploitative Innovation

The shift from demand-driven to application-oriented innovation signifies an internal mechanism within enterprises' Green ambidextrous innovation. This dual-mode innovation is primarily characterized by a transition from the incremental effects of green exploratory innovation to the breakthrough effects of green exploitative innovation. Technological innovation theory posits [36] that Green ambidextrous innovation comprises both green exploratory and exploitative innovations, suggesting that enterprises should be capable of learning and applying knowledge and continuously engage in innovative activities through ongoing breakthroughs and transformations [37]. Additionally, after accumulating innovation activities, enterprises excavate and reshape their existing knowledge systems to achieve a reintegration of resources and technological knowledge systems. This accelerates the practical application of green technological innovations in product design and production processes within the supply chain, subsequently benefiting consumers [38] and facilitating the widespread adoption of green innovations. Considering the intra-chain effects of ambidextrous innovation, which reflect the transition of green technology development from the trial-and-error phase to the application stage—achieving a breakthrough from zero to one—the associated experimentation and sunk costs can hinder the efficiency of realizing the Green ambidextrous innovation chain. To minimize these adverse effects as much as possible, it is advisable to utilize endogenous R&D and exogenous technology acquisition. This requires green enterprises to accumulate internal knowledge and technology while expanding external channels for acquiring new knowledge, staying abreast of cutting-edge technologies in relevant fields, and effectively integrating external heterogeneous knowledge with internal existing technologies to promote an efficient transition of green technology innovation from the exploratory to the application stage. In summary, we propose Hypothesis H3:

H3. *Green exploratory innovation significantly enhances the level of green exploitative innovation.*

2.4. Green Ambidextrous Innovation and the Autonomy and Controllability of Green Enterprises

Green ambidextrous innovation has a differentiated impact on the controllability of upstream suppliers, downstream customers, and the overall supply chain for enterprises. Autonomy and Controllability within enterprises is primarily reflected in the self-controllability of the industrial chain, with reducing dependence on external technology and products being one of the standards for measuring strong Autonomy and Controllability within existing industrial chains [1]. This implies enterprises can enhance their Autonomy and Controllability by reducing dependence on upstream and downstream segments. From this, it can be inferred that reducing reliance on upstream and downstream dependencies can improve an enterprise's Autonomy and Controllability to a certain extent. Specifically, the degree of dependence on different upstream and downstream segments can have multiple impacts on an enterprise's controllability, mainly focusing on the adverse effects on customers, suppliers, and the supply chain. In terms of customer interactions, a customer's bargaining power is often influenced by the concentration of the customer base.

In cases of high customer concentration, the strong bargaining power of major customers may increase opportunistic risks, forcing enterprises to accept more oppressive terms and thus reducing their profits [39,40]. Based on transaction cost theory, due to factors such as bounded rationality, transaction costs, and information asymmetry, enterprises' final contracts established with other segments typically only cover short-term production areas. After the execution of these contracts, renegotiations are required [41], causing fluctuations in the realization of long-term transactions. These two scenarios create compounded uncertainties in an enterprise's Autonomy and Controllability, ultimately reducing its controllability over customers. Regarding the supplier segment, the more dispersed the concentration of suppliers, the greater their bargaining power over enterprises [39]. Suppliers can use their clear bargaining advantage to exert adverse effects on enterprises in weaker positions, such as reducing product quality or increasing prices. Furthermore, high bargaining power among suppliers can lead to a "resource crowding" effect, where the bargaining advantage of suppliers in the supply chain impacts the business performance of enterprises [41], harming their interests and thereby reducing the enterprises' controllability over their suppliers. For the overall supply chain, the differences in bargaining power between enterprises and their upstream and downstream suppliers and customers create significant disparities in the degree and efficiency of resource exchanges across the supply chain. The former possess more substantial autonomous decision-making capabilities for actors within the supply chain with high bargaining power compared to those with low bargaining power who are in a weaker position. Within the framework of resource dependence theory, weaker entities often choose to accommodate the demands of more dominant parties to ensure access to critical resources necessary for their survival [42,43].

By incorporating the mechanism of Green ambidextrous innovation, green enterprises can offset some negative impacts from dominant bargaining actors in the supply chain by strengthening endogenous R&D and integrating exogenous technologies. Firstly, investment in exploratory research and development enhances the strength of enterprises in green design knowledge and technology. Green enterprises can design new environmentally friendly products and improve energy efficiency, producing differentiated, diversified goods that meet market demands. This provides customers with various product choices, enhancing the enterprise's bargaining power over customers, resulting in a win-win situation of reduced customer concentration and controllable customer demand. Secondly, green enterprises can achieve greener usage of energy and production materials. It means that green enterprises can use more renewable energy and substitutable energy-saving materials, leading to a relative decline in supplier bargaining power. By diversifying suppliers, green enterprises enhance their controllability over suppliers. Furthermore, green enterprises use the information transmission mechanism within the supply chain to convey the concept of Green ambidextrous innovation to downstream consumers, who in turn transmit new demand signals to upstream suppliers. This stimulates suppliers to engage in Green ambidextrous innovation, creating a linear impact mechanism across upstream, midstream, and downstream segments of the supply chain. Through a process in which 'downstream feedback flows upstream', the supply chain creates a circular linkage, forming a closed-loop, full-cycle Green ambidextrous innovation ecosystem. This enhances the leading role of green enterprises within the Green ambidextrous innovation ecosystem and promotes their controllability over the supply chain. Lastly, green enterprises accelerate cooperative advantages through Green ambidextrous innovation, achieving win-win cooperation with customers and suppliers, mitigating opportunistic motives, and reducing the likelihood of breaching implicit contractual obligations. In summary, Green ambidextrous innovation enhances enterprise Autonomy and Controllability by meeting customer needs,

greening supply chain segments, and leading Green ambidextrous innovation across the supply chain. Based on this, we propose Hypothesis H4:

H4. *Green ambidextrous innovation significantly enhances the Autonomy and Controllability of green enterprises.*

H4a. *Green ambidextrous innovation enhances enterprise controllability over customers.*

H4b. *Green ambidextrous innovation enhances enterprise controllability over suppliers.*

H4c. *Green ambidextrous innovation enhances enterprise controllability over the supply chain.*

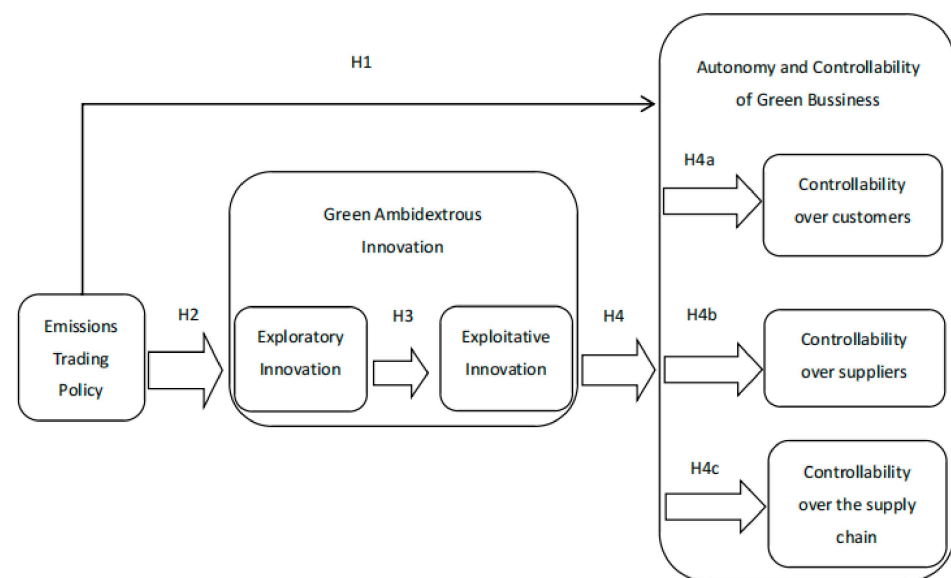


Figure 1. Hypothesis model.

3. Materials and Methods

3.1. Data Sources and Processing

This study focuses on green enterprises listed on the Shanghai and Shenzhen stock markets during 2008–2022, empirically testing the impact of carbon trading policies on the Autonomy and Controllability of green enterprises. Data sources are as follows: (1) The list of pilot cities for the carbon trading policy is derived from the carbon emission trading pilot work document approved by the National Development and Reform Commission of the People’s Republic of China in 2012 [44]; (2) Data related to Green ambidextrous innovation, precisely the number of green patent inventions independently applied for by listed companies annually, is sourced from the China Research Data Services Platform (CNRDS) database; (3) Following the approach of [45] on “Financial Research”, green enterprises are identified by matching their principal business activities with the “Green Industries Guidance Catalogue” and a list of green enterprises is compiled; (4) The list of enterprises recognized as green factories, green design products, and green supply chain enterprises from 2017 to 2023, published on the website of the Ministry of Industry and Information Technology of the People’s Republic of China, which includes a total of 7346 enterprises; (5) Considering that the “Green Industries Guidance Catalogue” categorizes green industries into seven categories—energy saving, environmental protection, clean production, clean energy, environmental services, infrastructure green upgrading, and green services—the study categorizes green enterprises into green factories and green supply chain enterprises. The list of green enterprises matches the lists of green factories,

green design products, green supply chain enterprises, and green parks, retaining the overlapping green factory and green supply chain enterprise stock names and codes. (6) Data related to customer concentration, supplier concentration, and supply chain concentration are sourced from the GTA (CSMAR) database and matched with the list of green factories and green supply chain enterprises. Data processing was as follows: (1) Exclusion of ST, ST* samples, and delisted samples; (2) removal of samples with severe missing variables; (3) exclusion of samples from the real estate industry; (4) to mitigate the impact of outliers, all continuous data were winsorized at the 1% and 99% percentiles. The final dataset includes 126 green enterprises, yielding 1856 observations.

3.2. Variable Definitions

1. **Dependent variable: Autonomy and Controllability of Green Enterprises (CAP).** Building on the theoretical analysis and following the methods used by Wu Qiang and other scholars [42], this study attempts to measure the Autonomy and Controllability of green enterprises using customer concentration (Cen_con), supplier concentration (Cen_sup), and supply chain concentration (Cen_chain). The concentration of the supply chain is measured by the sum of customer and supplier concentrations, where customer concentration is measured by the revenue percentage generated by the top five customers, and supplier concentration is measured by the procurement expenditure from the top five suppliers. It is noteworthy that, according to the study [42], in conjunction with the theoretical analysis mentioned earlier, all three categories of supply chain concentration are negatively correlated with the Autonomy and Controllability of green enterprises.
2. **Explanatory Variable: Carbon Trading Policy (DID).** This study investigates the impact of carbon emission policies on the Autonomy and Controllability of green enterprises. Therefore, the core explanatory variable is the interaction term (DID) between the policy group dummy variable (Treat) and the time dummy variable (Time). If a green enterprise participates in the carbon trading policy, it is part of the treatment group, and the Treat value is set to 1; otherwise, it is part of the control group, and the Treat value is set to 0. If the year is 2013 or later, which marks the post-policy implementation phase, Time is set to 1; otherwise, it is set to 0.
3. **Mediating Variable: Green ambidextrous innovation.** In this paper, Green ambidextrous innovation is defined as green exploratory innovation (inno_ex) and green exploitative innovation (inno_ap). One of the primary green innovation activities of enterprises is the application of green technology patents, which can be further divided into joint and independent applications. Therefore, following the method used by [7], the number of green patent applications by green enterprises is used as a proxy for ambidextrous innovation. Exploratory innovation is represented by the sum of the number of green invention patents applied independently and jointly in a given year; exploitative innovation is represented by the sum of the number of green utility model patents applied independently and jointly in a given year.
4. **Control Variables:** This study selects the following control variables: Leverage (Lev)— $\text{Leverage} = \frac{\text{Total liabilities at the end of the period}}{\text{Total assets}} \times 100\%$; Return on Assets (ROA)— $\text{Return on Assets} = \frac{\text{Net profit}}{\text{Total assets}} \times 100\%$; Accounts Receivable Ratio (REC)— $\text{Accounts Receivable Ratio} = \frac{\text{Net accounts receivable}}{\text{Total assets}} \times 100\%$; Current Ratio (CR)— $\text{Current Ratio} = \frac{\text{Current assets}}{\text{Current liabilities}} \times 100\%$; Quick Ratio (Quick)— $\text{Quick Ratio} = \frac{\text{Current assets} - \text{Inventories}}{\text{Current liabilities}} \times 100\%$; Book-to-Market Ratio (BM)— $\text{Book-to-Market Ratio} = \frac{\text{Book value}}{\text{Market value}} \times 100\%$; Firm Age (Firmage); Board Size (Board)—Number of board members; and the Shareholding Ratio of the Top Three Shareholders (Top3).

3.3. Model Setup

To test the impact of carbon trading policies on the Autonomy and Controllability of upstream and downstream supply chains of green enterprises following the approaches of [7,42], this paper establishes the following benchmark model to prove H1: “ α_1 ” represents the treatment effect of carbon trading policy on the controllability of the supply chain. The explained variable “CAP” is the Autonomy and Controllability of green enterprises on the supply chain, including the controllability of green enterprises over customers “CC” and the controllability of green enterprises over suppliers “SC”, “CONTROLS” is the control variable, “ ε ” is the random disturbance term, “i” represents green listed companies, “t” represents different years, “DID” is the cross product of Time and Treat, and for the robustness of the model, this paper controls the enterprise fixed effect “Ind_t” and the year fixed effect “Year_i”.

$$CAP_{it} = \alpha_0 + \alpha_1 DID_{it} + \sum_{k=1}^n CONTROLS_{it} + Year_i + Ind_t + \varepsilon_{it} \quad (1)$$

Additionally, the Difference-in-Differences (DID) method is used to estimate the causal effect of carbon trading policies on exploratory innovation, proving Hypothesis H2, where β_1 represents the treatment effect of carbon policy on green exploratory innovation. Among them, “GreenExplor” stands for green exploratory innovation.

$$GreenExplor_{it} = \alpha_0 + \beta_1 DID_{it} + \sum_{k=1}^n CONTROLS_{it} + Year_i + Ind_t + \varepsilon_{it} \quad (2)$$

To test the impact of green exploratory innovation on green exploitative innovation, this paper establishes the following baseline model to prove Hypothesis H3, where χ_1 represents the treatment effect of green exploratory innovation on green exploitative innovation. Among them, “GreenExploi” stands for green utilization innovation.

$$GreenExploi_{it} = \alpha_0 + \chi_1 GreenExplor_{it} + \sum_{k=1}^n CONTROLS_{it} + Year_i + Ind_t + \varepsilon_{it} \quad (3)$$

To examine the impact of Green ambidextrous innovation on the Autonomy and Controllability of green enterprises following the approaches of [46] and other scholars, this paper constructs regression models to prove H4a, H4b, and H4c. Here, γ_1 represents the treatment effect of Green ambidextrous innovation on customer controllability, δ_1 on supplier controllability, and ϕ_1 on supply chain controllability.

$$CC_{it} = \alpha_0 + \delta_1 GreenExplor_{it} \setminus GreenExploi_{it} + \sum_{k=1}^n CONTROLS_{it} + Year_i + Ind_t + \varepsilon_{it} \quad (4)$$

$$SUC_{it} = \alpha_0 + \gamma_1 GreenExplor_{it} \setminus GreenExploi_{it} + \sum_{k=1}^n CONTROLS_{it} + Year_i + Ind_t + \varepsilon_{it} \quad (5)$$

$$CAP_{it} = \alpha_0 + \phi_1 GreenExplor_{it} \setminus GreenExploi_{it} + \sum_{k=1}^n CONTROLS_{it} + Year_i + Ind_t + \varepsilon_{it} \quad (6)$$

4. Results

4.1. Descriptive Statistics

According to the descriptive statistics in Table 1, the Autonomy and Controllability of green enterprises primarily includes dimensions of customers, suppliers, and the supply chain. Regarding the controllability of green enterprises’ supply chains, the mean value

is 25.507, with a minimum of 1.48, indicating that the overall controllability of green enterprises' supply chains is at a mid-to-lower level. The variance in the controllability of the supply chain is 13.526, which is relatively high, suggesting significant volatility in the controllability of green enterprises' supply chains. For the controllability over customers of green enterprises, the mean value is 28.336, with a minimum of 0.31, showing that the overall controllability over customers is also at a mid-to-lower level. The variance in customer controllability is 18.204, which is relatively high, indicating significant volatility in the controllability of customers. Regarding the controllability over suppliers for green enterprises, the average is 27.384, with a minimum of 0.33, suggesting that the controllability over suppliers is generally at a mid-to-lower level. The variance in supplier controllability is 18.204, which is relatively high, highlighting noticeable fluctuations in the Autonomy and Controllability of suppliers. In summary, green enterprises in China exhibit significant variation in their levels of Autonomy and Controllability, typically positioned at a mid-to-lower level.

Table 1. Descriptive statistics.

Variable	N	Mean	Std. Dev.	Median	Max	Min
Cen con	1856	28.336	18.204	23.24	95.02	0.31
Cen sup	1856	27.384	14.815	23.265	97.33	0.33
Cen chain	1856	25.507	13.526	22.95	79.91	1.48
Treated	1856	0.277	0.448	0	1	0
time	1443	53.314	124.132	1	526	0
DID	1856	0.199	0.400	0	1	0
Lev	1856	0.435	0.167	0.441	0.864	0.043
ROA	1856	0.047	0.050	0.045	0.219	−0.427
REC	1856	0.15	0.091	0.132	0.507	0
RC	1856	2.158	1.910	1.607	24.226	0.455
Quick	1856	1.698	1.730	1.222	21.888	0.312
BM	1856	0.354	0.141	0.337	0.846	0.049
Firmage	1856	2.878	0.374	2.944	3.689	1.099
Board	1856	2.158	0.187	2.197	2.708	1.609
Top3	1856	0.449	0.142	0.436	0.885	0.149

4.2. Baseline Regression Results

This study aims to examine the impact of carbon trading policies on the Autonomy and Controllability of green enterprises. As shown in Table 2, columns (1) through (3) control for individual and time effects and include results with control variables. The estimated coefficients of the policy effect DID in columns (1) and (3) are negative and significant at the 1% confidence interval, whereas the estimated coefficient of DID in column (2) is positive but not significant at the 10% confidence interval. In summary, the carbon trading policy significantly enhances the controllability of green enterprises over customers and the supply chain, although the impact on the controllability over suppliers is not significant. This suggests that carbon trading policies have improved the Autonomy and Controllability of green enterprises, thus validating Hypothesis H1. This is consistent with the research of Zhang, S et al. [47], but this study takes green enterprises as the research subject and expands the impact of carbon trading policies on the autonomous and controllable supply chain capabilities of green enterprises under microeconomic entities. The reasons may be as follows: Compared to government-enforced measures, carbon trading policies effectively address the balance between environmental benefits and economic gains. Under punitive environmental regulations, considering that the economic benefits often gained at the expense of the environment far outweigh the costs of mandatory tax penalties, most enterprises focus more on improving efficiency and lack intrinsic motivation for green

transformation. Additionally, government-enforced measures typically exhibit a one-time characteristic, where compulsory penalties by the government occur only once in the short term, potentially leading to a vicious cycle. With the implementation of a market-based carbon trading mechanism, the transient shortcomings of administrative measures are offset by an open and transparent market pricing system. This transformation enables enterprises to consider the long-term costs associated with carbon emissions more comprehensively, enhancing their intrinsic motivation for green transformation. Consequently, businesses are spurred to innovate in green technologies, strengthening the green preferences of downstream customers.

Table 2. Estimation results of the basic model.

Variable	(1) Cen_con	(2) Cen_sup	(3) Cen_chain
DID	−2.989 *** (0.986)	0.702 (1.190)	−1.637 * (0.877)
Lev	−12.29 *** (3.544)	−5.208 (4.075)	−8.678 *** (2.512)
Roa	−22.04 *** (6.497)	−6.194 (6.920)	
REC	17.43 *** (5.359)	−4.433 (6.118)	
CR	−3.670 *** (1.348)	−0.475 (1.612)	
Quick	4.851 *** (1.414)	1.590 (1.706)	
BM	−8.008 *** (2.737)	−4.858 (2.993)	−5.213 ** (2.328)
Firmage	−8.387 *** (2.981)	4.056 (3.796)	
Board	−5.715 ** (2.232)	5.182 ** (2.470)	−4.218 ** (1.984)
Top3	6.304 * (3.793)	−2.858 (4.453)	
Constant	63.23 *** (9.730)	18.63 (11.57)	41.56 *** (4.787)
Year&Ind	Yes	Yes	Yes
Observations	1773	1471	1775
R-squared	0.668	0.677	0.767
Number of scode	125	125	125

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.3. Robustness Tests

4.3.1. Parallel Trends Test

Meeting the parallel trends assumption is a prerequisite for using the Difference-in-Differences (DID) model, meaning that the Autonomy and Controllability of green enterprises in both the treatment and control groups should follow the same trends before implementing the carbon trading pilot. This paper, based on the baseline regression model, uses the first period as the baseline group for the parallel trends test. It examines the controllability over customers and the supply chain of green enterprises in the two periods before and the three periods after policy implementation, as well as the controllability

over suppliers in the three periods before and after the policy enactment. As shown in Figures 2–4, there is no significant difference in the controllability level between the treatment group and the control group before the implementation of the carbon trading policy, which meets the parallel trend hypothesis. After the implementation of the carbon trading policy, the controllability of green enterprise customers has been significantly improved, and the autonomous controllability of green enterprise supply chains has been slightly improved, but the controllability of suppliers has not been significantly improved. This is consistent with the research of Li Wan et al. [48]. The reason is that the non-significant impact of the carbon trading policy on the controllability of green enterprise suppliers may have weakened the impact of the carbon trading policy on the autonomous controllability of green enterprise supply chains to a certain extent.

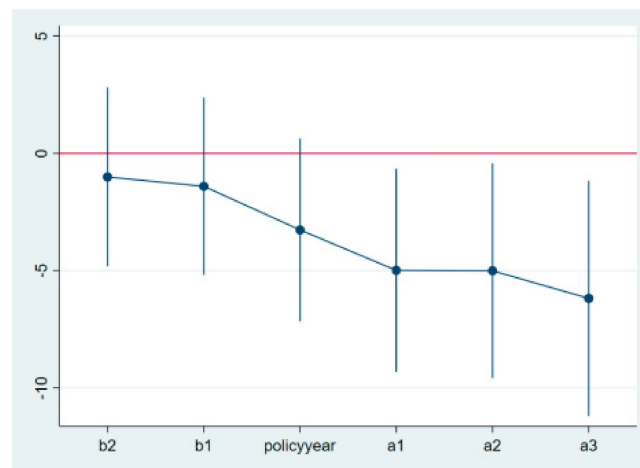


Figure 2. Parallel trends test results for customers.

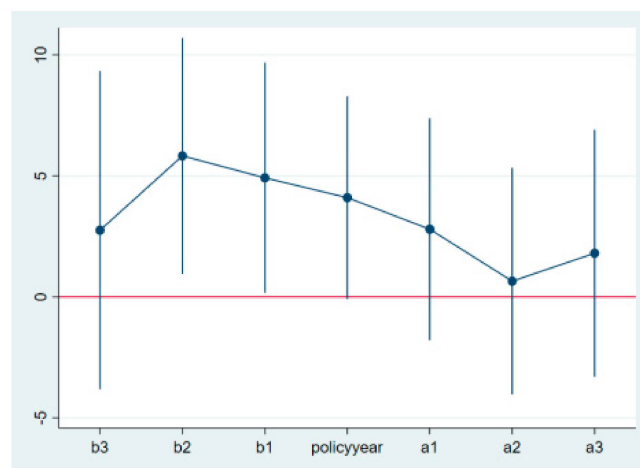


Figure 3. Parallel trends test results for suppliers.

4.3.2. Placebo Test

Considering that the impact of the carbon trading pilot policy on the Autonomy and Controllability of green enterprises might be influenced by random factors, this study conducts a placebo test using random event sampling to eliminate the effects of these random factors. The rationale for the placebo test assumes that the effects of the carbon trading policy would still be significant if the policy were hypothetically not implemented in the current pilot cities. By randomly selecting non-pilot cities as the experimental group and conducting 500 random samplings, Figures 5–7 show the distribution graphs of the regression coefficients for customers, suppliers, and the supply chain, respectively.

As illustrated, the distributions are nearly normal, with a mean close to zero. The high goodness-of-fit across these three aspects suggests that random factors do not cause the baseline regression results, and the placebo test is passed.

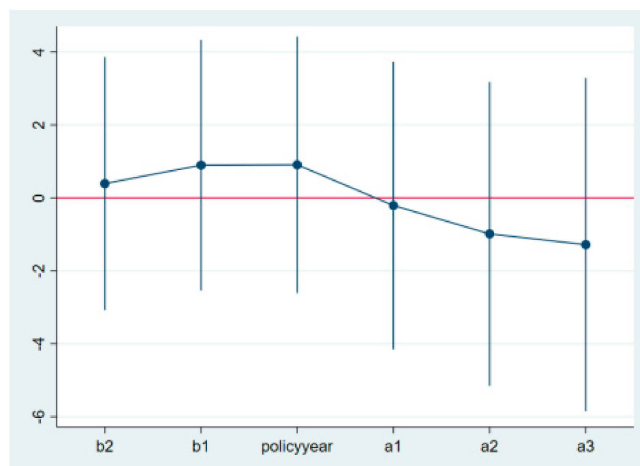


Figure 4. Parallel trends test results for the supply chain.

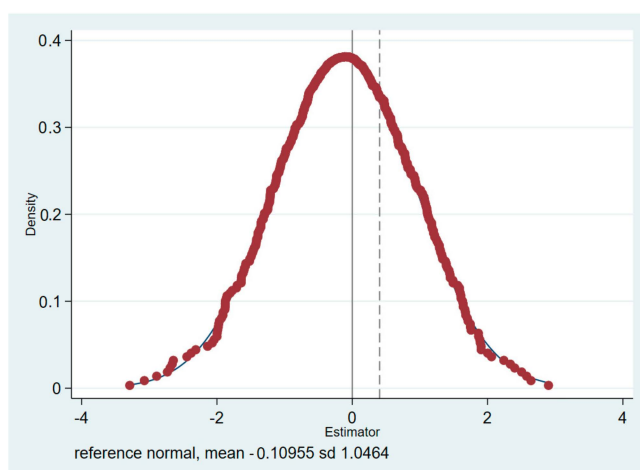


Figure 5. Placebo test results for customers.

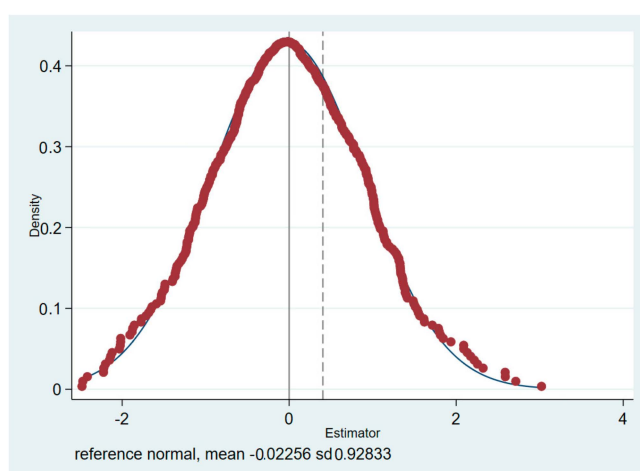


Figure 6. Placebo test results for suppliers.

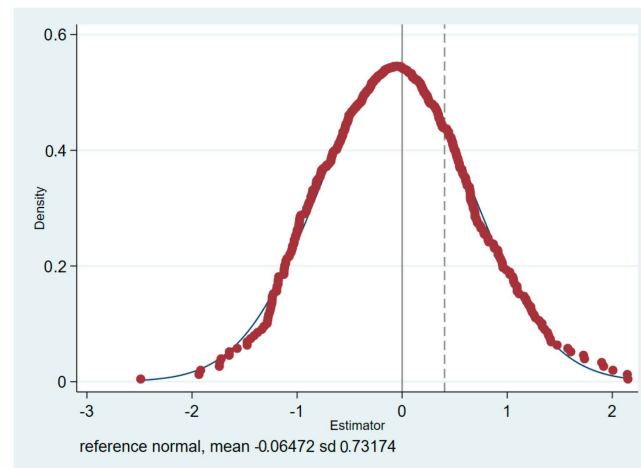


Figure 7. Placebo test results for the supply chain.

4.3.3. PSM-DID Test

The Propensity Score Matching Difference-in-Differences (PSM-DID) method effectively addresses endogeneity bias arising from omitted variables. The specific idea is, first, select the debt-to-asset ratio (Lev), net profit margin of total assets (ROA), accounts receivable ratio (REC), current ratio (CR), quick ratio (Quick), book-to-market ratio (BM), years of establishment (Firmage), shareholding ratio of the top three shareholders (top3), and other variables as corresponding matching variables, construct the Logit model, and perform sample matching according to the kernel matching principle and then perform the PSM-DID applicability test to determine whether there are significant differences in the covariates between the experimental group and the control group. The specific operation is as follows: on the one hand, first estimate the propensity score, then use the kernel function to find matching individuals in the control group for each individual in the treatment group, the matching weight is determined by the kernel function, and then calculate the average treatment effect after matching. Finally, draw the kernel density map of the propensity score to intuitively determine whether the common support hypothesis is established, and compare whether the mean difference in the covariates between the treatment group and the control group before and after matching is significantly reduced. As shown in Figures 8–13, the absolute values of the standard deviations of other variables have dropped significantly after matching, and there are no significant differences in the covariates between the experimental group and the control group, indicating that the one-to-one matching is effective and successfully passed the PSM test. On the other hand, the data balance test is used to eliminate the unmatched variables, and then a benchmark regression is performed. The results are shown in columns (1) and (3) of the Table 3. The positive impact of carbon trading policies on the controllability of green enterprises' customers and the controllability of green enterprises' supply chains is more significant, which is consistent with the benchmark regression results. The benchmark regression results are reliable.

Table 3. Propensity score matching (PSM) regression results.

Variables	(1) Cen_con	(2) Cen_sup	(3) Cen_chain
DID	−3.754 ***	0.426	−1.856 **
Constant	26.90 *** (1.129)	34.30 *** (1.229)	26.37 *** (0.991)

Table 3. Cont.

Variables	(1) Cen_con	(2) Cen_sup	(3) Cen_chain
Controls	Control	Control	Control
Year&Ind	Yes	Yes	Yes
Observations	1795	1490	1797
R-squared	0.016	0.055	0.159
Number of scode	125	125	125

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$.

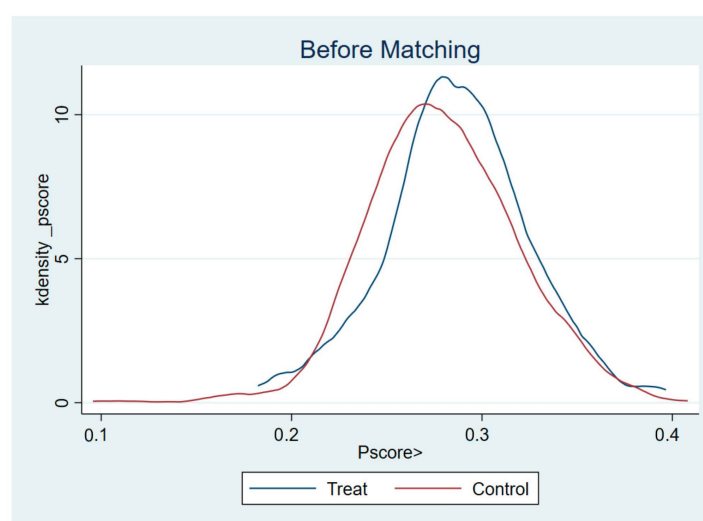


Figure 8. Kernel density function diagram before customer propensity score matching.

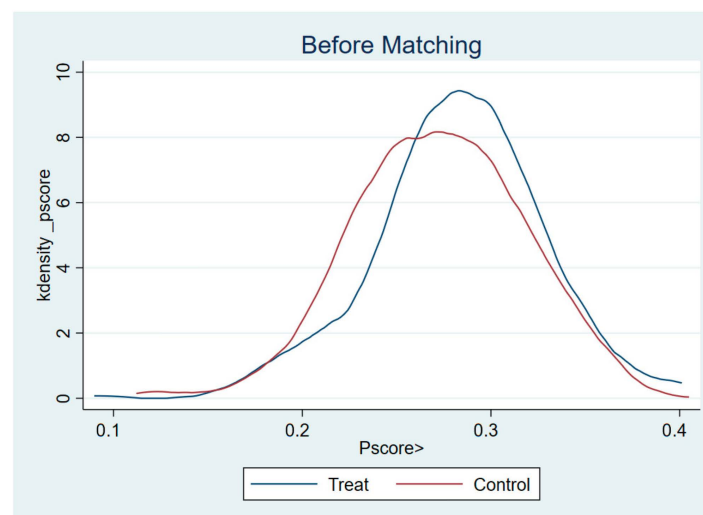


Figure 9. Kernel density function diagram before supplier propensity score matching.

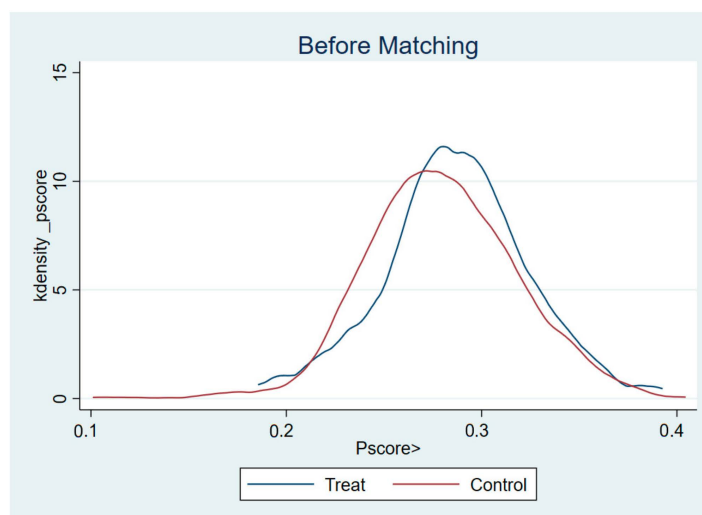


Figure 10. Kernel density function diagram before supply chain propensity score matching.

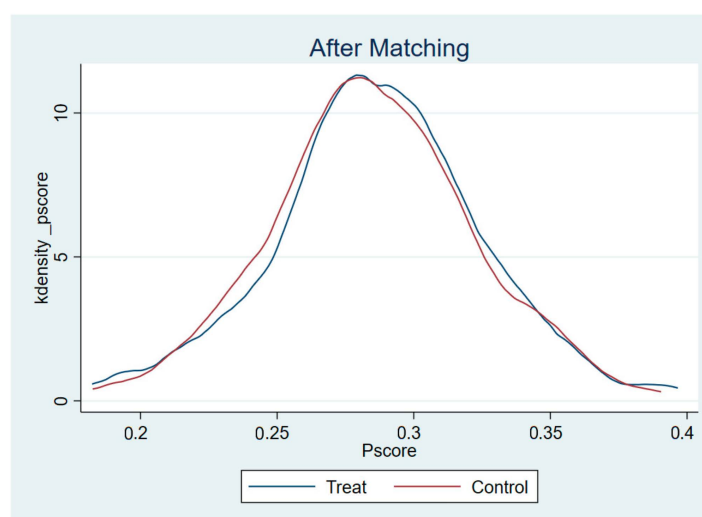


Figure 11. Kernel density function after customer propensity score matching.

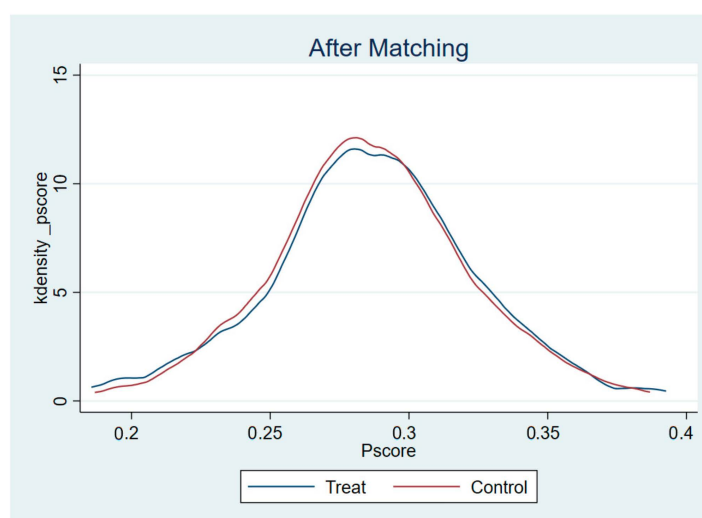


Figure 12. Kernel density function after supplier propensity score matching.

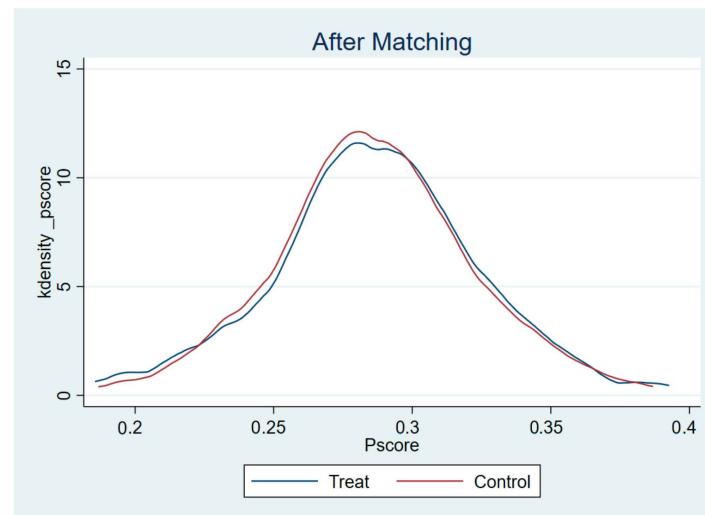


Figure 13. Kernel density function after supply chain propensity score matching.

4.3.4. Elimination of Outliers and Changes to the Sample Interval

On the one hand, considering that extreme outliers can significantly impact the estimation of regression coefficients, it is necessary to winsorize continuous variables. This study applies a [1%, 99%] winsorizing to the sample data. As shown in Table 4, the baseline regression results remain robust. On the other hand, considering that policy changes may adversely affect the outcomes, following the approach of [49], the analysis period was shortened to 2011–2015. The results, as displayed in Table 4, confirm that the conclusions from the previous sections remain robust.

Table 4. Estimation results of robustness test.

Variables	(1) Winsor_cus	(2) Winsor_sup	(3) Winsor_chain	(1) 2011–2015_cus	(2) 2011–2015_sup	(3) 2011–2015_chain
DID	−3.604 *** (0.983)	0.231 (1.131)	−1.908 ** (0.851)	−3.754 *** (0.994)	0.426 (1.186)	−1.856 ** (0.872)
Constant	26.94 *** (1.116)	33.54 *** (1.172)	25.95 *** (0.967)	26.90 *** (1.129)	34.30 *** (1.229)	26.37 *** (0.991)
Controls	Control	Control	Control	Control	Control	Control
Year&Ind	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1795	1490	1797	1795	1490	1797
R-squared	0.615	0.656	0.667	0.016	0.055	0.159
Number of scode	125	125	125	125	125	125

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$.

4.4. Endogeneity Test

Given the potential bidirectional causality between the Autonomy and Controllability of green enterprises and carbon trading policies, to address possible endogeneity issues, this paper employs the following DID-lagged one-period method: Considering that the effect of carbon trading policies on the Autonomy and Controllability of green enterprises might have a lag, a lagged one-period explanatory variable is used as an instrumental variable in the baseline regression model. The results, as presented in Table 5, show significant changes in the impact of the carbon trading policy on the controllability of suppliers after introducing the instrumental variable, changing from insignificant to significant. This suggests a lag in the influence of the carbon trading policy on the controllability of suppliers; meanwhile, the significance of the carbon trading policy's impact on the controllability

over customers and the supply chain remains unchanged, mainly confirming the reliability of the baseline regression results.

Table 5. Intermediation effect test.

Variables	(1) IV_cus	(2) IV_sup	(3) IV_chain
L.DID	−5.622 *** (0.994)	−3.213 ** (1.278)	−4.329 *** (0.863)
Constant	26.60 *** (1.081)	28.52 *** (2.242)	16.78 *** (0.938)
Controls	Control	Control	Control
Year&Ind	Yes	Yes	Yes
Observations	1669	1415	1671
R-squared	0.032	0.031	0.197
Number of scode	125	125	125

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$.

4.5. Mechanism Analysis

The above research demonstrates that carbon trading policies significantly promote the Autonomy and Controllability of green enterprises. To further explore the mechanisms through which carbon trading policies impact the Autonomy and Controllability of green enterprises, based on the theoretical analysis provided earlier, this study will discuss two pathways: “Carbon Trading Policy → Green ambidextrous innovation → Autonomy and Controllability of Green Enterprises” and “Green Exploratory Innovation → Green Exploitative Innovation”. Considering that the evaluation criteria for green supply chain enterprises and green factories were introduced in 2017 and 2018, respectively, and the sample period spans from 2008 to 2022, uncertainty arises concerning the year fixed effects. Therefore, adjustments have been made to employ a fixed individual and random year model to test the mediating effects. The regression results are presented in Table 6.

Table 6. Estimated results of mechanism test.

Variables	(1) inno_ex	(2) inno_ap	(3) cen_con	(4) cen_sup	(5) cen_chain
inno_ap			−0.0795 *** (0.0170)	0.0140 (0.0181)	−0.0115 (0.0162)
inno_ex		0.273 *** (0.00740)	0.0450 *** (0.00700)	−0.0132 * (0.00758)	0.0236 *** (0.00666)
DID	15.19 *** (3.787)	6.366 *** (1.171)	−2.030 ** (0.828)	−1.897 * (1.019)	3.290 *** (0.788)
Controls	Control	Control	Control	Control	Control
Constant	11.01 *** (1.230)	2.307 *** (0.387)	28.71 *** (0.277)	27.93 *** (0.343)	24.59 *** (0.264)
Year&Ind	Yes	Yes	Yes	Yes	Yes
Observations	1856	1856	1795	1490	1797
R-squared	0.409	0.456	0.429	0.405	0.422
Number of scode	125	125	125	125	125

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

1. To test the “Carbon Trading Policy → Green Exploratory Innovation” mechanism, as shown in Column (1) of Table 6, the results indicate that the regression coefficient is 15.19, and it is significant at the 1% confidence interval, suggesting that the carbon trading policy is significantly positively correlated with the level of green exploratory innovation within enterprises. The results confirm the “Carbon Trading Policy → Green Exploratory Innovation” mechanism and support Hypothesis H2. This conclusion is consistent with the research of Borghesi, S et al. [4,5], but this paper expands the detailed research on the effect of carbon trading policy on green innovation; that is, in influencing the innovation process of green enterprises, carbon trading policy will first have a significant positive effect on green exploratory innovation, which lays the foundation for the mechanism analysis in the following text.
2. To test the “Green Exploratory Innovation → Green Exploitative Innovation” mechanism, as shown in Column (2) of Table 7, the results indicate that the regression coefficient is 0.273, and it is significant at the 1% confidence interval, demonstrating that green exploratory innovation is significantly positively correlated with green exploitative innovation. The results confirm the “Green Exploratory Innovation → Green Exploitative Innovation” mechanism and support Hypothesis H3. This conclusion is consistent with the research of Cao, Q et al. [15,16], but this paper finds that green exploratory innovation and green application innovation in Green ambidextrous innovation not only have a combination and competition relationship, but also a sequential mechanism between the two; that is, green exploratory innovation can effectively improve the level of green application innovation.

Table 7. Estimation results of robustness test.

Variables	(1) East	(2) West	(3) Mid	(4) East	(5) West	(6) Mid	(7) East	(8) West	(9) Mid
DID	−2.878 *** (1.750)	−7.636 ** (4.066)	−2.555 (3.019)	−0.0253 (1.813)	2.196 (3.550)	1.891 (3.122)	−0.950 (1.506)	−6.112 ** (3.518)	−2.498 (2.671)
Controls	Control	Control	Control	Control	Control	Control	Control	Control	Control
Constant	27.78 *** (1.404)	27.93 *** (3.145)	24.15 *** (2.309)	34.47 *** (1.505)	32.95 *** (2.840)	31.63 *** (2.494)	26.99 *** (1.209)	24.48 *** (2.722)	23.43 *** (2.043)
Year&Ind	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1221	187	387	1031	146	313	1223	187	387
R-squared	0.712	0.792	0.756	0.763	0.741	0.766	0.871	0.740	0.793
Number of scode	86	13	28	86	13	28	86	13	28

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$.

3. To test the “Green ambidextrous innovation → Autonomy and Controllability of Green Enterprises Over Customers” mechanism, as shown in Column (3) of Table 7, the results indicate that the regression coefficient is −0.0795, and it is significant at the 1% confidence interval, indicating that Green ambidextrous innovation is significantly positively correlated with the controllability of green enterprises over customers. The results confirm the “Green ambidextrous innovation → Autonomy and Controllability of Green Enterprises Over Customers” mechanism and support Hypothesis H4a. This conclusion is consistent with the research of Hua Zhibing et al. [21], but this paper not only finds the impact of Green ambidextrous innovation on customer concentration, but also proves the impact of Green ambidextrous innovation on the controllability of green enterprise customers, broadening the impact path of Green ambidextrous innovation.
4. To test the “Green ambidextrous innovation → Autonomy and Controllability of Green Enterprises Over Suppliers” mechanism, as shown in Column (4) of Table 7,

the results indicate that the regression coefficient is 0.012, and it is not significant at the 10% confidence interval, suggesting that the influence of Green ambidextrous innovation on the controllability of green enterprises over suppliers is not significant. The results indicate that the “Green ambidextrous innovation → Autonomy and Controllability of Green Enterprises Over Suppliers” mechanism does not hold. This conclusion is consistent with the research of Yuan Zeming et al. [49]; that is, the results of this paper once again verify that the impact of Green ambidextrous innovation on the controllability of green enterprise suppliers is not obvious. The reason may lie in the current disconnection within the green enterprises during the Ambidextrous Innovation process, where endogenous innovation is generally confined to enhancing the Autonomy and Controllability within the green enterprise itself, with the external spillover effects on other segments of the green supply chain remaining unclear, resulting in poor overall supply chain linkage effects.

5. To test the “Green ambidextrous innovation → Autonomy and Controllability of Green Enterprises Over the Supply Chain” mechanism, as shown in Column (5) of Table 7, the results indicate that the regression coefficient is -0.0115 , and it is not significant at the 10% confidence interval, suggesting that the impact of Green ambidextrous innovation on the controllability of the supply chain for green enterprises is not significant. The results confirm that the “Green ambidextrous innovation → Autonomy and Controllability of Green Enterprises Over the Supply Chain” mechanism does not hold. The reason could be attributed to the lag in the cycle of research and development of applied technologies by green enterprises. Therefore, the enhancement of overall supply chain controllability appears to be inconsequential, akin to the influence of Green ambidextrous innovation on suppliers’ controllability. Green enterprises’ Green ambidextrous innovation may predominantly depend on exogenous technological inputs rather than on indigenous research and development initiatives.

4.6. Further Analysis: Heterogeneity Test

Considering the significant differences in industrial structure development across eastern, central, and western China, the impact of carbon trading policies on the Autonomy and Controllability of green enterprises may vary regionally. Additionally, given the distinct operational models of green enterprises, carbon trading policies could have varying effects on their Autonomy and Controllability. On this basis, this study conducts further analysis from two perspectives: regional heterogeneity and firm heterogeneity.

4.6.1. Regional Heterogeneity

Due to the disparities in industrial structures and the varying degrees of energy dependence among enterprises in different regions of China, the impact of carbon trading policies on the Autonomy and Controllability of green enterprises is more pronounced in the western region. Therefore, this study divides the sample into eastern, central, and western regions for heterogeneity testing. The results of the regional heterogeneity regression are presented in Table 7.

For the eastern region of China, the regression results presented in columns (1), (4), and (7) of Table 7 reveal that the impact coefficients of carbon trading policies on the controllability of customers, suppliers, and the supply chain for green enterprises are -2.878 , -0.0253 , and -0.950 , respectively. The impact coefficient on the controllability of customers is statistically significant at the 1% confidence level, whereas the coefficients about suppliers and the supply chain do not reach significance at the 10% confidence level. This suggests that in the eastern region, the carbon trading policy significantly enhances the controllability of green enterprises over customers, but it does not have a

notable effect on improving the controllability of suppliers and the supply chain. This may be due to the diversified industrial structure of green enterprises in the eastern region, where the overall supply chain presents a loose network structure. Upstream suppliers, midstream green enterprises, and downstream consumers all have multiple options, resulting in relatively lower bargaining power for green enterprises that link the upstream and downstream sectors.

For the central region of China, the regression results shown in columns (3), (6), and (9) of Table 7 indicate that the coefficients of the impact of carbon trading policies on the controllability over customers, suppliers, and the supply chain of green enterprises are -2.555 , 1.891 , and -2.498 , respectively, and are not significant at the 10% confidence interval. This suggests that in the central region, the impact of carbon trading policies on the Autonomy and Controllability of green enterprises is not significant. This may be attributed to the fact that green enterprises in the central region are primarily engaged in communications, agricultural spare parts, and other basic processing sectors, where the overall industrial structure is relatively underdeveloped and characterized by labor-intensive features. Labor-intensive enterprises have a lower dependency on energy and utilize it less intensively compared to other types of enterprises. Furthermore, primary processing enterprises have a relatively concentrated consumer base, lacking significant diversification. A high concentration of customers is unfavorable for enhancing green enterprises' controllability over customers. Therefore, the correlation between carbon trading policies and the Autonomy and Controllability of green enterprises is not prominent in this region.

For the western region of China, the regression results shown in columns (2), (5), and (8) of Table 8 indicate that the coefficients of the impact of carbon trading policies on the controllability over customers, suppliers, and the supply chain of green enterprises are -7.636 , 2.196 , and -6.112 , respectively. Notably, the effects of the carbon trading policy on the controllability over customers and the supply chain are significant within the 1% to 5% confidence intervals, whereas the impact on the controllability over suppliers is not significant at the 10% confidence interval. This suggests that the carbon trading policy significantly enhances the controllability over customers and the supply chain for green enterprises in the Western region, but its impact on supplier controllability is not significant. This could be because green enterprises in the western region primarily consist of firms involved in automobile manufacturing or supplying automotive parts. Such green enterprises belong to industries with high energy consumption and carbon emissions. The carbon trading policy increases the cost of carbon emissions for green enterprises, thereby compelling them to engage in green innovations to improve energy efficiency and adjust product structures. This reduces reliance on a single consumer group and enhances the bargaining power of green enterprises within the supply chain. Thus, the carbon trading policy significantly improves the controllability over customers and the supply chain for green enterprises. On the other hand, green enterprises involved in producing automobiles or automotive parts typically have relatively stable demands for raw materials. Increases in raw material prices have little impact on the decisions of green enterprises regarding upstream supplier selection. The cooperation between green enterprises in the western region and their suppliers is relatively stable, and changes in energy policies do not affect the existing supply systems of these western green enterprises. Therefore, the effect of the carbon trading policy on enhancing the controllability over suppliers for green enterprises is not significant.

Table 8. Estimation results of robustness test.

Variables	(1) green	(2) green_chain	(3) green	(4) green_chain	(5) green	(6) green_chain
DID	−7.366 *** (2.748)	−2.185 (4.467)	−13.11 *** (2.970)	4.027 (4.910)	−10.24 *** (2.150)	0.923 (3.683)
Controls	Control	Control	Control	Control	Control	Control
Year&Ind	Yes	Yes	Yes	Yes	Yes	Yes
Constant	29.21 *** (2.388)	39.76 *** (3.766)	36.02 *** (2.580)	29.39 *** (4.139)	32.62 *** (1.868)	34.57 *** (3.104)
Observations	267	79	267	79	267	79
R-squared	0.199	0.284	0.254	0.126	0.270	0.191
Number of scode	24	7	24	7	24	7

Standard errors in parentheses. *** $p < 0.01$.

4.6.2. Firm Heterogeneity Test

Considering that green supply chain enterprises and green factory enterprises face different requirements for supply chain development due to differences in target consumer groups and market positioning, the impact of carbon trading policies is more significant on the controllability of green factories. Therefore, this study further divides the sample into green supply chain enterprises and green factories for subgroup regression, with results presented in Table 8.

For green supply chain enterprises, the regression results shown in columns (1), (3), and (5) of Table 8 indicate that the coefficients of the impact of carbon trading policies on the controllability of customers, suppliers, and the supply chain are −2.185, 4.027, and 0.923, respectively, and are not significant at the 10% confidence interval. This suggests that the carbon trading policy does not significantly enhance the Autonomy and Controllability of green supply chain enterprises. The reason may primarily lie in the overall orientation and interconnectivity of the market for green supply chain enterprises. These enterprises focus on green business activities centered around logistics distribution and product integration, promoting coordinated development of the economy, society, and environment through pollution reduction and emission control measures. Generally adopting a flexible management approach with light-asset operations, green enterprises are characterized by flexibility, speed, and timeliness. Therefore, the impact of carbon trading policies on the Autonomy and Controllability of such enterprises is not substantial, making green supply chain enterprises less sensitive to changes in energy policies such as carbon trading.

For green factories, the regression results shown in columns (2), (4), and (6) of Table 8 indicate that the coefficients of the impact of carbon trading policies on the controllability of customers, suppliers, and the supply chain are −7.366, −13.11, and −10.24, respectively, and are significant at the 10% confidence interval. This indicates that carbon trading policies significantly enhance the Autonomy and Controllability of green factories. The reason may be that green factories focus on product-oriented operations, playing a primary role in resource conservation, environmental protection, and efficient energy use. The implementation of carbon trading policies curtails the freedom of carbon emissions from the productive activities of green factories. These factories make swift decisions by comparing the costs of carbon trading with the expenses of switching energy sources. Compared to other types of factories, these decisions are more flexible and less dependent on traditional energy sources. Additionally, these enterprises can continually adjust their energy structures to optimize product configurations, diversify product offerings, expand sales channels, and

enhance service efficiency, thereby increasing the green factory's controllability over its supply chain.

5. Conclusions and Discussion

The carbon trading policy is an essential tool for enhancing green enterprises and bolstering the sustainable development capacity of the global green industry. This study, based on data from green enterprises listed on the Shanghai and Shenzhen stock exchanges during 2008–2022, investigated the overall effect of China's carbon trading policy on the Autonomy and Controllability of green enterprises, and its heterogeneous effects, and explored the internal mechanisms at play. The main conclusions are as follows: First, the carbon trading policy significantly enhances the Autonomy and Controllability of green enterprises. This finding remains valid after a series of robustness checks, including tests for endogeneity, removing outliers, and changing sample periods. However, the impact of the carbon trading policy on the controllability of suppliers is not evident. Second, the carbon trading policy significantly improves green exploratory innovation in green enterprises. Furthermore, there is a transmission effect within Green ambidextrous innovation; an enhancement in green exploratory innovation capabilities significantly boosts green exploitative innovation abilities. Third, Green ambidextrous innovation enhances the controllability of green enterprises over their customers. However, its effects on the controllability of suppliers and the supply chain are not significant and exhibit a certain degree of lag. Fourth, the impact of carbon trading policies on improving the Autonomy and Controllability of green enterprises demonstrates apparent heterogeneity. Regional heterogeneity results indicate that the carbon trading policy does not significantly enhance the Autonomy and Controllability of green enterprises in Eastern and Central China but has a significant effect in western China. Firm heterogeneity analysis indicates that the carbon trading policy significantly enhances the Autonomy and Controllability of green factories, while its impact on green supply chain enterprises remains negligible.

Based on these conclusions, this study offers the following four recommendations:

1. To advance carbon trading policies, it is essential to enhance both policy frameworks and market mechanisms. From a governmental standpoint, incentives such as tax breaks, fiscal subsidies, or reductions in loan interest rates should be allocated to enterprises that achieve significant emission reductions. This approach alleviates the economic burden associated with green transformation and propels the external shift towards sustainable business practices. In refining the carbon trading market mechanism, a gradual transition from free allocation to paid allocation of carbon quotas is recommended. This shift ensures that carbon price signals accurately mirror the market's supply and demand dynamics, thereby facilitating a fair distribution of carbon emission rights, fostering green technological innovation within enterprises, and reinforcing the Autonomy and Controllability of green businesses.
2. The ambidextrous innovation capabilities of green enterprises must be fortified alongside the enhancement of their Autonomy and Controllability. Comprehensive innovation systems should be established, professional talent teams cultivated, and cross-departmental collaboration mechanisms developed to achieve seamless integration of resources, technology, and outcomes. Concurrently, governments are encouraged to establish innovation funds aimed at promoting collaborative innovation throughout the green supply chain. Such funds reduce trial-and-error costs for green enterprises, expand the application scenarios for green technologies, and facilitate the conversion of green technologies from tacit knowledge into explicit performance. These measures collectively support the dual objectives of innovation and controllability within green enterprises.

3. A clear pathway must be established to translate Green ambidextrous innovation into Autonomy and Controllability for green enterprises. Optimization and upgrading of innovation systems, tailored to specific enterprise needs, should accelerate the efficient integration of government, industry, academia, and research sectors. Emphasis should be placed on the role of Green ambidextrous innovation within supply chains, enhancing information exchange and sharing across various upstream and downstream segments. Focus areas include the learning, absorption, and application of innovative resources and outcomes within the supply chain. By fostering a closed-loop Green ambidextrous innovation ecosystem across the entire supply chain, green enterprises can reinforce their leadership roles within this ecosystem.
4. To promote a fair distribution of carbon emission rights and stimulate green technological innovation, the carbon trading market mechanism should undergo continuous improvement. Governments should increase green financial support and social investment in enterprises in western China, leveraging the region's rich energy resources and dense energy industries. Priority should be given to green innovation and transformation in clean and sustainable energy, aiming to create an integrated "production–transportation–storage–usage" energy supply chain system. In terms of green enterprise types, policymakers should consider prioritizing the development of upstream green energy production enterprises, such as green factories and hydro or wind power plants, to achieve Autonomy and Controllability on the green energy supply side.

This article has mainly expanded from three aspects. Firstly, based on theories such as the five forces model, we endeavor to construct a quantitative index of green enterprises' Autonomy and Controllability. Secondly, the double difference model was used to quantitatively evaluate the impact of carbon trading policy on green enterprises' Autonomy and Controllability and its mechanism analysis. Thirdly, robustness tests were conducted using methods such as placebo test, PSM-DID, elimination of outliers, and replacement of the sample interval, which increases the reliability of the results. Compared with the existing literature, the theoretical contributions, innovation, and application nature of this article are as follows: Firstly, from the supply chain perspective, we found that the Autonomy and Controllability of green enterprises can be enhanced through two pathways, improving their advantageous bargaining position (controllability) in the supply chain and reducing their dependence on external technologies and products (Autonomy). Simultaneously, the Autonomy and Controllability of green enterprises are quantified from the perspectives of customers, suppliers, and the supply chain, thereby enriching the research on the Autonomy and Controllability of micro-economic entities. Secondly, this study fully explores the internal chain influence mechanism of Green ambidextrous innovation; that is, green exploratory innovation can enhance the level of green exploitative innovation, which provides a theoretical basis for achieving the "two-step" approach of green ambidextrous innovation. Thirdly, this article enriches the research on the impact of carbon emission trading policies on the Autonomy and Controllability of green enterprises and expands the path to enhance the Autonomy and Controllability of microeconomic entities. At the same time, it also provides case references and guidance for achieving sustainable development of global green industries and promoting carbon trading policies on a global scale. Nevertheless, this research has its limitations, primarily due to the restricted availability of data from listed companies, which did not allow for detailed segmentation of green enterprises, such as those engaged in green design products or green industrial parks. Therefore, Future studies should further subdivide green enterprises and explore the heterogeneous effects of carbon trading policies on the Autonomy and Controllability of green enterprises, thus enriching and completing the existing results.

Author Contributions: Conceptualization, W.C.; methodology, W.C.; software, Y.Y.; validation, Y.Y.; formal analysis, Y.Y.; investigation, Y.Y.; resources, Y.Y.; data curation, Y.Y.; writing—original draft preparation, Y.Y.; writing—review and editing, W.C.; visualization, Y.Y.; supervision, W.C.; project administration, W.C.; funding acquisition, W.C. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by the Changsha Natural Science Foundation, specifically the Smart Transportation Governance Innovation under the Goal of “Dual Carbon” (Grant No. kq2402264); the Scientific Research Project of the Hunan Provincial Department of Education, titled “Research on Innovation-Driven Green High-Quality Development Path from the Perspective of New Quality Productivity” (Grant No. 24C0105); and the National Social Science Foundation of China for the project “Low-Carbon Transition Path and Policy Mix Innovation Based on Green Governance” (Grant No. 19CGL043).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: All data and materials are available upon request.

Acknowledgments: We would like to thank the reviewers for their thoughtful comments that helped improve the quality of this work.

Conflicts of Interest: The authors declare no conflicts of interest.

References

- Wang, W.G.; Han, X. Strategic Technological Innovation of Enterprises and Industrial Autonomy and Controllability. *China Ind. Econ.* **2024**, *8*, 43–60.
- To Enhance the Resilience of China’s Economy, It Is Crucial to Achieve Autonomy in Industrial and Supply Chains. Available online: <http://theory.people.com.cn/n1/2020/1221/c40531-31973009.html> (accessed on 3 November 2024).
- Implementation of the Central Economic Work Conference’s Directives Is Crucial for Achieving Greater Success in Development and Reform Initiatives—National Development and Reform Work Conference Convened in Beijing. Available online: https://www.ndrc.gov.cn/xwdt/xwfb/202412/t20241213_1395024.html (accessed on 14 December 2024).
- Borghesi, S.; Cainelli, G.; Mazzanti, M. Linking emission trading to environmental innovation: Evidence from the Italian manufacturing industry. *Res. Policy* **2015**, *44*, 669–683. [CrossRef]
- Calel, R.; Dechezleprêtre, A. Environmental policy and directed technological change: Evidence from the European carbon market. *Rev. Econ. Stat.* **2016**, *98*, 173–191. [CrossRef]
- Dong, Y.; Wang, Y.; Sun, K.; Sun, X. Research on the governance effect and emission reduction mechanism of “carbon emission trading”. *Sci. Res. Manag.* **2024**, *45*, 160–171.
- Li, X.L.; Shi, W.; Tian, Y. Carbon Emission Trading and Corporate Green Technological Innovations. *Stat. Inf. Forum* **2024**, *11*, 89–99.
- Feng, X.; Zhao, Y.; Yan, R. Does carbon emission trading policy has have emission reduction effect?—An empirical study based on quasi-natural experiment method. *J. Environ. Manag.* **2024**, *351*, 119791. [CrossRef]
- Gagelmann, F.; Frondel, M. The impact of emission trading on innovation—science fiction or reality? *Eur. Environ.* **2005**, *15*, 203–211. [CrossRef]
- Requate, T. Dynamic incentives by environmental policy instruments—A survey. *Ecol. Econ.* **2005**, *54*, 175–195. [CrossRef]
- Lv, M.; Bai, M. Evaluation of China’s carbon emission trading policy from corporate innovation. *Financ. Res. Lett.* **2021**, *39*, 101565. [CrossRef]
- Zhao, X.; Shang, Y.; Ma, X.; Xia, P.; Shahzad, U. Does carbon trading lead to green technology innovation: Recent evidence from Chinese companies in resource-based industries. *IEEE Trans. Eng. Manag.* **2022**, *71*, 2506–2523. [CrossRef]
- Mu, Y.; Zhao, J. Production Strategy and Technology Innovation under Different Carbon Emission Polices. *Sustainability* **2023**, *15*, 9820. [CrossRef]
- Zhang, N.; Bi, Y.; Gao, W.; Deng, J.; Tang, E. Heterogeneous effects of environmental regulations on green technology innovation: Measurement by using patents and evidence from China’ prefecture-level cities. *Scientometrics* **2024**, *129*, 7667–7698. [CrossRef]
- Cao, Q.; Gedajlovic, E.; Zhang, H. Unpacking organizational ambidexterity: Dimensions, contingencies, and synergistic effects. *Organ. Sci.* **2009**, *20*, 781–796. [CrossRef]

16. Li, C.R.; Lin, C.J.; Huang, H.C. Top management team social capital, exploration-based innovation, and exploitation-based innovation in SMEs. *Technol. Anal. Strateg. Manag.* **2014**, *26*, 69–85. [\[CrossRef\]](#)
17. Jansen, J.J.P.; Bosch, F.A.J.V.D.; Volberda, H.W. Exploratory innovation, exploitative innovation, and performance: Effects of organizational antecedents and environmental moderators. *Manag. Sci.* **2006**, *52*, 1661–1674. [\[CrossRef\]](#)
18. Mihalache, O.R.; Jansen, J.J.; Van den Bosch, F.A.; Volberda, H.W. Top management team shared leadership and organizational ambidexterity: A moderated mediation framework. *Strategic Entrep. J.* **2014**, *8*, 128–148. [\[CrossRef\]](#)
19. Wang, Y.D.; Li, J.H. Constructing a “Four Forces, Five Dimensions” Model for Ambidextrous Organizational Innovation. *Sci. Sci. Manag. ST* **2012**, *33*, 173–180.
20. He, Z.L.; Wong, P.K. Exploration vs. exploitation: An empirical test of the ambidexterity hypothesis. *Organ. Sci.* **2004**, *15*, 481–494. [\[CrossRef\]](#)
21. Hua, Z.B.; Wu, Y. Ambidextrous Innovation and Its Impact on Customer Concentration: A Resource Dependence Perspective. *Res. Dev. Manag.* **2024**, 1–15. [\[CrossRef\]](#)
22. Mafabi, S.; Munene, J.C.; Ahiauzu, A. Creative climate and organisational resilience: The mediating role of innovation. *Int. J. Organ. Anal.* **2015**, *23*, 564–587. [\[CrossRef\]](#)
23. Arora, A.; Fosfuri, A.; Gambardella, A. Markets for technology and their implications for corporate strategy. *Ind. Corp. Change* **2001**, *10*, 419–451. [\[CrossRef\]](#)
24. Engelen, A.; Huesker, C.; Rieger, V.; Berg, V. Building a resilient organization through a pre-shock strategic emphasis on innovation. *J. Prod. Innov. Manag.* **2024**, *41*, 36–61. [\[CrossRef\]](#)
25. Coase, R.H. The problem of social cost. *J. Law Econ.* **2013**, *56*, 837–877. [\[CrossRef\]](#)
26. Sun, Y.N.; Jiang, L.Y. How Ambidextrous Innovation Enhances Organizational Resilience: A Multiple Case Study in the Chinese Context. *Nanjing Soc. Sci.* **2024**, *3*, 41–51.
27. Porter, M.E.; Linde, C.V.D. Toward a new conception of the environment-competitiveness relationship. *J. Econ. Perspect.* **1995**, *9*, 97–118. [\[CrossRef\]](#)
28. Cai, Q.F.; Yan, W.W.; Shu, S.W. Green Innovation Spillover in Supply Chains—From the Perspective of Core Enterprises and Suppliers’ Collaborative Development. *Econ. Manag.* **2024**, *46*, 43–59.
29. Xia, J. Mutual dependence, partner substitutability, and repeated partnership: The survival of cross-border alliances. *Strateg. Manag. J.* **2011**, *32*, 229–253. [\[CrossRef\]](#)
30. Tang, F.C.; Gu, S.L.; Huan, G. Digital Platform Capability and Disruptive Corporate Innovation: An Empirical Study Based on Platform Ecology and Dynamic Capabilities. *Syst. Eng. Theory Pract.* **2024**, 1–23.
31. Zhu, J.; Fan, Y.; Deng, X.; Xue, L. Low-carbon innovation induced by emissions trading in China. *Nat. Commun.* **2019**, *10*, 4088. [\[CrossRef\]](#)
32. Cui, J.; Dai, J.; Wang, Z.; Zhao, X. Does environmental regulation induce green innovation? A panel study of Chinese listed firms. *Technol. Forecast. Soc. Change* **2022**, *176*, 121492. [\[CrossRef\]](#)
33. Nong, D.; Nguyen, T.H.; Wang, C.; Van Khuc, Q. The environmental and economic impact of the emissions trading scheme (ETS) in Vietnam. *Energy Policy* **2020**, *140*, 111362. [\[CrossRef\]](#)
34. Opinions of the CPC Central Committee and the State Council on Fully Implementing the New Development Concept to Address Carbon Peak and Carbon Neutrality. Available online: https://www.ndrc.gov.cn/xxgk/jd/zctj/202110/t20211024_1300729.html (accessed on 3 November 2024).
35. Lu, J.; Wang, X.F. The Impact of Low-Carbon Pilot Policies on Urban Technological Innovation in China: A Quasi-Natural Experiment of Low-Carbon City Pilots. *J. China Univ. Geosci. (Soc. Sci. Ed.)* **2019**, *19*, 128–141.
36. Ngo, L.V.; Bucic, T.; Sinha, A.; Lu, V.N. Effective sense-and-respond strategies: Mediating roles of exploratory and exploitative innovation. *J. Bus. Res.* **2019**, *94*, 154–161. [\[CrossRef\]](#)
37. Sheng, M.Q.; Wu, S.M.; Zhang, Y.N. Exploratory Innovation and Corporate Total Factor Productivity. *Ind. Econ. Res.* **2020**, *1*, 28–41.
38. Yang, Z.; Li, J.Z.; Ling, H.C. Policy Uncertainty and Innovation Digitalization: The Perspective of Ambidextrous Innovation. *Sci. Res. Manag.* **2022**, *43*, 1–10.
39. Tang, Y.J. Bargaining Power of Suppliers and Distributors and Company Performance: Evidence from Chinese Manufacturing Listed Companies from 2005 to 2007. *China Ind. Econ.* **2009**, *10*, 67–76.
40. Porter, M.E. The five competitive forces that shape strategy. *Harv. Bus. Rev.* **2008**, *86*, 78–93.
41. Deng, F.; Yang, K.X.; Zheng, Y.Y. The Impact of Supply Chain Characteristics on Corporate Green Innovation: An Analysis from the Perspectives of Resource Synergy and Crowding Out. *Sci. Res. Manag.* **2024**, *45*, 1–11.
42. Wu, Q.; Yao, X.Y. Enterprise Digital Transformation and Supply Chain Configuration: Centralization or Diversification. *China Ind. Econ.* **2023**, *8*, 99–117.
43. Fink, R.C.; Edelman, L.F.; Hatten, K.J.; James, W.L. Transaction cost economics, resource dependence theory, and customer-supplier relationships. *Ind. Corp. Change* **2006**, *15*, 497–529. [\[CrossRef\]](#)

44. Beijing and Tianjin among 7 Provinces and Cities Authorized to Initiate Carbon Emission Trading Pilot Projects. Available online: http://www.gov.cn/jrzq/2012-01/13/content_2043687.htm (accessed on 3 November 2024).
45. Li, J.C.; Peng, Y.C.; Wang, W.W. Can Green Credit Policies Foster the Development of Green Enterprises?—A Risk-Taking Perspective. *Financ. Res.* **2023**, *3*, 112–130.
46. Li, S.; Li, D.; Tian, M.F.; Du, G.Y. Has Technological Innovation Reduced Enterprises' Dependence on Major Clients? *Nankai Manag. Rev.* **2021**, *24*, 26–39.
47. Zhang, S.; Ma, X.; Cui, Q.; Liu, J. Does the low carbon transition impact urban resilience? Evidence from China's pilot cities for carbon emission trading. *Environ. Sci. Pollut. Res.* **2024**, *31*, 11128–11149. [[CrossRef](#)]
48. Li, W.; Chen, L.; Chi, Y. Supplier/customer concentration and corporate green innovation. *Soft Sci.* **2023**, *37*, 97–102+126.
49. Yuan, Z.M.; Huang, C.; Liu, J. The Spillover Effects of Carbon Emission Trading on High-Quality Corporate Development: Empirical Evidence from Supply Chain Alliances. *Res. Econ. Manag.* **2024**, *45*, 58–80.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.