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Analyzing the Impact of Carbon Emission Trading Policies on Corporate Behavioral Responses and Supply Chain Co-opetition: A Literature Review

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Abstract

This paper reviews 245 articles from Peking University Core and CSSCI journals (CNKI, 2021-2025) on China's carbon emission trading (CET) policy and its effects on corporate behavior and supply chain coordination. Results show that the national carbon market has significantly altered the corporate operating environment. At the micro level, CET spurs green innovation through three mechanisms: easing financing constraints, transforming cost pressures, and addressing institutional legitimacy, supporting the "Porter Hypothesis" in China. Effects on corporate performance are mixed: while CET can improve financial performance and debt structures via cost savings, trading revenue, and better financing, its impact on firm value and non-financial performance remains debated. At the meso level, research focuses on supply chain coordination. To mitigate "double marginalization" caused by uneven carbon regulation across supply chains, contract mechanisms-especially cost-sharing and revenue-sharing contracts-are designed to optimize emission reduction investments and boost efficiency. Blockchain technology also supports emission reduction by improving carbon data transparency, cutting compliance costs, and enabling new collaboration models. Future research should examine heterogeneous responses in newly covered industries (e.g., steel, cement, aluminum), low-carbon transitions for SMEs, and long-term ESG effects. Further innovation is needed in contract design under dynamic carbon pricing, multi-tier supply chain coordination, and blockchain cost-benefit analysis. Policy efforts should prioritize cross-regional carbon accounting, carbon revenue recycling, and carbon financial instruments.

Keywords

Carbon Emission Trading Policy; Green Innovation; Supply Chain Coordination; Literature Review.

1. Introduction

China's CET policies have evolved over the past decade, transitioning from regional pilots to a national unified market. The official launch of the national carbon emission trading market on July 16, 2021, marked a significant milestone, signifying China's entry into the phase of a unified national carbon market. Initially covering 2,162 key emitting entities in the power sector, representing approximately 4.5 Gt CO_2e of CO2 equivalent, the national carbon market expanded in early 2025 to include three high-emission industries-steel, cement, and aluminum smelting-adding 1,500 key emitting entities and covering an additional annual CO2 equivalent of about 3 billion tonnes. Post-expansion, the national carbon market regulates a total of 8 billion tonnes of emissions, covering over 60% of China's total CO2 emissions, making it the world's largest carbon market. Simultaneously, the operational mechanisms of the carbon market have deepened. By early 2025, the cumulative trading volume of the national carbon

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market exceeded 670 million tonnes, with a turnover of CN¥46.2 billion; the turnover in 2024 reached a record high of RMB 18.1 billion. In June 2025, in accordance with documents such as the "Interim Regulations on the Management of Carbon Emission Trading" and the "Measures for the Administration of Carbon Emission Trading (Trial)", single-item bidding was initiated for key emitting entities, complementing existing trading methods like negotiated transfers and block trades.

Against this backdrop, the operational environment for enterprises has undergone fundamental changes. Carbon trading has evolved from a simple cost constraint into a core variable reshaping corporate competitiveness, driving extensive and profound transformations. Its impact on enterprise behavioral performance has attracted considerable attention from policymakers and academia.

This study aims to synthesize existing literature by categorizing and arranging materials in a logical sequence, clarifying various relationships, contradictions, gaps, and inconsistencies within the literature. It seeks to comprehensively reflect the state of research on the impact of CET policies on enterprise behavioral performance, analyze the interrelationships between CET policies, enterprise behavioral performance, and supply chain coordination, and provide a theoretical foundation for policy design and future research directions.

2. Literature Analysis

This paper primarily draws on academic journals designated as Peking University Core and CSSCI-indexed within the CNKI database from 2021 to 2025. Using keywords such as "carbon emission trading policy" and "enterprise", and limiting the subject to "Enterprise Economics", 245 relevant articles were identified after excluding invalid data such as foreign case analyses and low-relevance articles.

Regarding research methodology, empirical studies dominate, accounting for 58%, with most employing Difference-in-Differences (DID) or Triple Difference (DDD) models. Studies utilizing game theory models like the Stackelberg model constitute 32%, while case studies account for 10%.

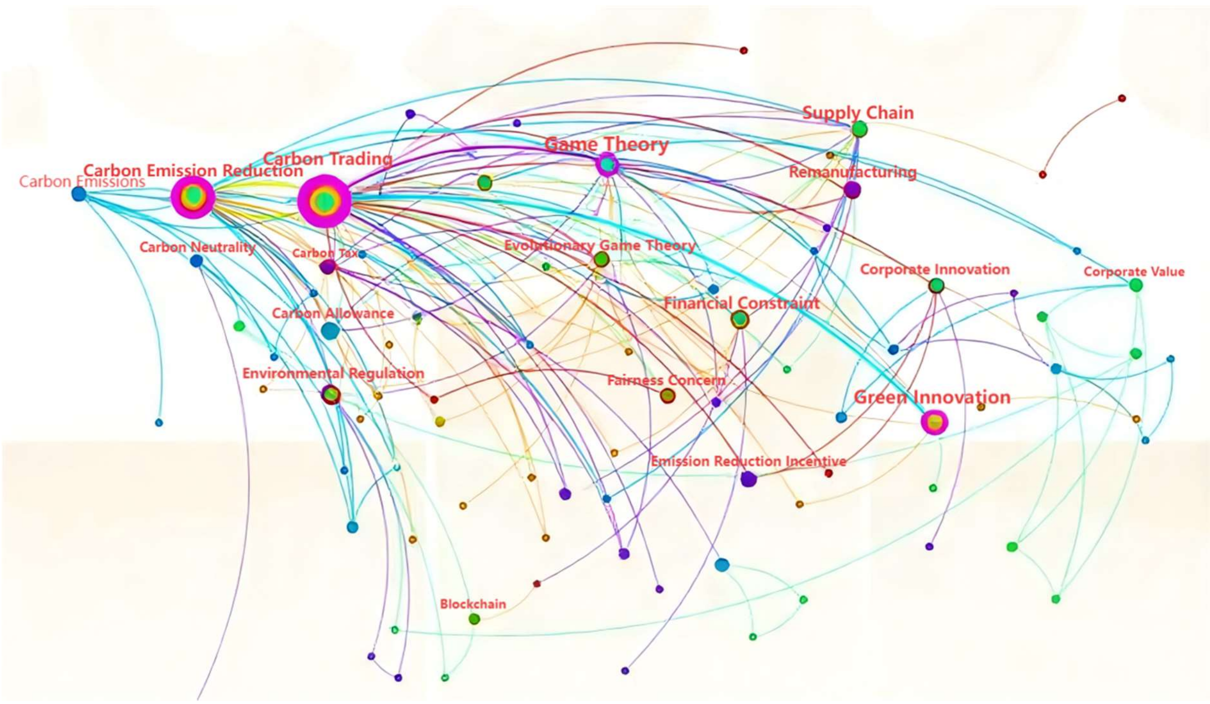

Figure 1. Keyword clustering analysis of 245 references

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Based on a keyword co-occurrence cluster analysis of 245 references conducted via CiteSpace (as shown in Figure 1), the existing literature is found to focus primarily on areas such as carbon trading, carbon emission reduction, supply chain, game theory, environmental regulation, and green innovation. In recent years, with advancements in this field, certain keywords related to emerging technologies (e.g., blockchain) have gained prominence, along with research themes exploring relationships with various corporate aspects, such as corporate reputation.

3. Micro-level Effects of CET Policies - Impact on Enterprise Behavioral Performance

Existing research primarily examines the impact of CET policies on enterprises from two perspectives: enterprise behavior and corporate performance.

3.1. Enterprise Behavior - Green Innovation Policy Response

Regarding enterprise behavior, current research suggests that CET policies primarily drive technological and operational green innovation, as well as strategic decision-making changes resulting from integrating carbon considerations.

3.1.1. Validation of the Porter Effect

Numerous studies have sought to validate the Porter Hypothesis, which posits that appropriate environmental regulation can stimulate technological innovation, enhance production efficiency, reduce costs, and ultimately strengthen competitiveness. For instance, Guoping Qiao, using a DID design, revealed that CET incentivizes innovation through the "cash flow → long-term investment" and "ROA → long-term return" pathways [1]. Dayuan Li et al. confirmed the applicability of the "weak" Porter Hypothesis in the Chinese carbon market [2]. Nanfeng Liu et al. demonstrated that technology-driven emission reduction yields positive net unit reduction benefits through energy cost savings and carbon sales revenue, supporting the Porter Hypothesis [3]. Conversely, Qian Ma et al. segmented the Porter Hypothesis into "cost pressure" and "innovation motivation" stages, arguing that the current "R&D innovation motivation" cannot fully offset the "cost pressure," placing CET policies still in a compliance cost stage [4].

3.1.2. Mechanisms through which CET Policies Influence Green Innovation

Specifically, the CET system alleviates financing constraints through market mechanisms such as:

(1) Alleviating Financing Constraints

The CET system plays a significant role in alleviating enterprise financing constraints. Jianqiang Tian et al. found that CET policies optimize the corporate financing environment through market mechanisms (e.g., information disclosure and external supervision), with this effect showing a trend of continuous strengthening [5]. Qingquan Fan et al. argued that carbon trading revenues alleviate financing constraints, thereby increasing R&D funding and personnel investment, ultimately promoting green innovation [6]. Xiaoxu Guo et al. discovered that the CET system exhibits "capital attraction" and "governance improvement" effects; it attracts green investors through signaling, eases financing constraints, promotes green innovation, reduces green agency costs, and ultimately enhances earnings persistence [7].

(2) Cost Pressure Conversion

Carbon prices force enterprises to undertake technological upgrades. Debing Guo et al. found a significant positive correlation between carbon prices and corporate green innovation, with environmental responsibility fulfillment acting as a mediating variable. This reveals the pathway of "carbon price → environmental responsibility → green innovation," confirming that rising carbon prices promote green innovation through both cost pressure and innovation incentive pathways [8]. Huawei Niu et al. identified a "double threshold effect" for carbon prices.

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A shadow price reflects the marginal bankruptcy cost per unit of emission reduction. When the carbon price is below the shadow price, it enhances the pledging capacity of carbon assets, promoting emission reduction investment. However, excessively high carbon prices increase rollback risks, prompting firms to adopt conservative cash holdings and reduce production scale [9].

(3) legitimacy pressures

Policy regulations and public pressure also drive enterprises towards environmental information disclosure and innovation investment. Zhiwei Wang et al. based on legitimacy theory, constructed a "regulation → responsibility → innovation" path, finding and validating that market-based regulation significantly and persistently promotes green innovation [10]. Hong Zhang et al. showed that corporate environmental responsibility under CET policies is heterogeneous. Firms exhibit reactive responsibility (passive compliance) to conform to regulations and proactive responsibility (strategic initiative) based on policy foresight, with the latter more strongly promoting substantive innovation than the former. Furthermore, media environmental attention, as informal regulation, exhibits synergistic effects with formal policies. Media, acting as supervisors and information bridges, amplify policy signals and pressure firms to respond to societal expectations [11]. Yuxi Liao et al. emphasized the crucial role of public pressure in environmental governance, arguing that media attention is a key external governance mechanism through which CET policies incentivize green corporate behavior, improving performance with more pronounced long-term effects [12].

3.1.3. Heterogeneity in Policy Response

Most empirical studies include heterogeneity analyses. For example, firms with different ownership types and in different industries exhibit varying sensitivities to carbon policies [13]; carbon policies have differing promotional effects on different types of patents, regions, and firm sizes concerning green innovation [14], etc.

3.2. Corporate Performance

3.2.1. Financial Performance

Zhihong Lin et al. found that CET policies impact corporate financial performance through dual pathways: Firstly, policy pressure forces increased R&D investment, promoting technological innovation that lowers marginal abatement costs, ultimately allowing profit from selling surplus allowances. Secondly, CET policies improve carbon information disclosure, mitigating information asymmetry with investors, boosting investor confidence, and ultimately lowering financing costs, thus alleviating financing constraints [15]. Peifeng Hu et al. confirmed a bidirectional positive influence between financial performance and carbon performance, mediated by environmental social responsibility, with carbon emission trading and green technological innovation acting as positive moderators [16]. Zilong Song et al. found that carbon reduction pressure significantly reduces corporate debt concentration, prompting firms to optimize debt structures through diversified financing [17].

3.2.2. Non-Financial Performance

(1) Firm Value

A divergence remains in the literature regarding whether CET policies enhance firm value through environmental regulation or decrease it by increasing costs. Cuifeng Hou using an event study method with the carbon market launch date (2021.7.16) as the event day and calculating cumulative abnormal returns (CAR), found that firm value in pilot regions declined in the short term post-shock. However, value increased significantly for high-carbon industries and high-carbon intensity firms, primarily due to cost pass-through by monopolistic high-carbon industries and gains from allowance trading. This pattern is expected to change as the CET system and market mechanisms mature [18]. Conversely, Ping Lin et al. argued that R&D

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investment promotes technological innovation, enhancing immediate firm value, while emission reduction investments in fixed assets require longer-term conversion [19]. Huawei Niu et al. examined how various CET factors affect firm value, concluding that carbon price volatility can enhance equity value through option value premiums [20].

(2) Corporate Reputation

Corporate reputation represents the ability of a firm's behavior to gain social recognition, thereby acquiring resources, opportunities, and support for value creation, manifesting as a form of corporate social responsibility. Yonghe Sun et al. delineated pathways through which CET policies enhance reputation: reducing information asymmetry for investors and consumers, and signaling environmental commitment to governments and society through green emission reduction to gain support and recognition [21]. Chang Zhou et al. posited that carbon trading behavior itself, as a concrete low-carbon action rather than an abstract social responsibility, reveals the formation mechanism of reputation [22].

4. Meso-level Effects of CET Policies - Impact on Supply Chain Cooperation-Competition

4.1. Contract Design in Multi-Agent Games

The most prominent issue in upstream-downstream supply chains is double marginalization, where each tier pursuing its own profit maximization leads to reduced overall supply chain efficiency. Research on mitigating double marginalization under CET policies primarily focuses on designing and validating contract coordination mechanisms. Current research lacks unified conclusions on the optimal contract type, as different assumptions regarding policy environments, supply chain structures, and firm characteristics lead to varying findings. Classifying existing studies by contract type, design goals, applicable scenarios, and coordination effects yields categories like cost-sharing contracts, revenue-sharing contracts, and other contracts.

4.1.1. Cost-Sharing Contracts

Unilateral Cost-Sharing: One party (e.g., a dominant manufacturer) bears the emission reduction costs of others. Xianghong Zhou found that in manufacturer-dominated scenarios, manufacturer subsidies maximize total supply chain profit while simultaneously increasing retailer and recycler profits [23]. Yuhao Zhang et al. showed that when a retailer dominates the supply chain, stimulating demand through price reductions while receiving compensatory transfer payments from the manufacturer, higher social welfare is more easily achieved [24]. Hao Zou et al. incorporating manufacturers' fairness concerns, achieved Pareto improvement and increased emission reduction rates through cost-sharing contracts [25].

Limitations: Unilateral contracts are often seen as restrictive. Qiangfei Chai et al. found that due to differential carbon regulation across supply chain tiers (e.g., an upstream supplier constrained by policy needing to buy allowances while a downstream buyer is unregulated), unilateral cost-sharing contracts fail to improve efficiency in such double marginalization scenarios [26].

Bidirectional Cost-Sharing: Two parties (e.g., manufacturer and retailer) jointly share emission reduction/technology investment costs, achieving risk-sharing. Daoping Wang et al. found that when the cost-sharing ratio between retailer and manufacturer reaches a certain level, the contract can fully coordinate the supply chain, achieving the centralized decision-making level [27]. Chen Zhu et al. designed a modified bidirectional cost-sharing contract where the manufacturer shares a portion of the retailer's promotion costs and the retailer shares a portion of the manufacturer's emission reduction and recycling costs, enabling perfect supply chain coordination where decentralized decisions approximate centralized levels [28].

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4.1.2. Revenue-Sharing Contracts

Traditional revenue-sharing contracts involve retailers returning a portion of revenue to manufacturers to compensate for emission reduction costs. Existing research generally finds revenue-sharing contracts effective without capital constraints, but under capital constraints or dynamic carbon policies, they require combination with other contracts.

Tie Wei focusing on the impact of China Certified Emission Reductions (CCER) on supply chain emission reduction strategies, compared decisions under no contract, cost-sharing, and revenue-sharing scenarios with and without CCER. They found revenue-sharing contracts consistently optimal, regardless of CCER introduction, as they reduce uncertainty in manufacturers' emission reduction returns and mitigate double marginalization, leading to the highest manufacturer output [29]. Qiangfei Chai et al. found that under decentralized decision-making, revenue-sharing contracts achieve efficiency second only to centralized decisions when the manufacturer's revenue-sharing ratio is between 0.25-0.5.

Addressing SME financing difficulties exacerbated by low-carbon investments, Qingming Zou et al. found that traditional revenue-sharing contracts only improve profit distribution but cannot resolve double marginalization. In contrast, revenue-cost co-sharing contracts balance economic and emission reduction responsibility allocation, achieving perfect coordination [30]. Jinzhao Shi et al. modeled bidirectional carbon reduction cost-sharing combined with financing under capital constraints. They proposed a multi-contract scheme: without a carbon market, combining revenue-sharing with bidirectional cost-sharing and wholesale price contracts achieves centralized decision levels; with a carbon market, adding a bidirectional carbon trading cost-sharing contract to account for carbon costs enables coordination [31].

4.1.3. Other Contracts

Various other contracts aim to improve overall supply chain efficiency. Ping Shi et al. introduced "reciprocity preference," analyzing its effect on emission reduction and advertising decisions, and designed an "advertising cooperation - emission reduction cost sharing" combination contract to address double marginalization and coordination failure. Their findings show that reciprocity preference is crucial for coordination. When reciprocity exists, the combination contract achieves perfect coordination. A single advertising contract only achieves perfect coordination under high altruism, otherwise merely mitigating but not eliminating double marginalization [32]. Lingrong Zhang et al. focusing on misreporting in closed-loop supply chains and coordination, designed a two-part tariff contract to mitigate the negative effects of misreporting, eliminating the incentive caused by information asymmetry, achieving centralized performance levels and rational profit distribution [33].

Competition and cooperation among horizontal firms lead to differentiated strategies. Jiangxia Nan et al. proposed a non-cooperative-cooperative bimodal game framework, finding carbon price and competition intensity are key factors. Rising carbon prices make efficient firms favor emission reduction alliances (peer cost-sharing contracts) to increase profits, while inefficient firms prefer third-party technology cooperation contracts. Increased market competition intensity leads efficient firms to choose alliances to expand market share, and inefficient firms to choose third-party cooperation to lower costs, resulting in distinct strategy preferences [34].

4.2. Empowerment of Blockchain Technology for Supply Chain Carbon Reduction

4.2.1. Enhancing Credibility and Transparency of Carbon Data

Blockchain's distributed ledger and immutability effectively address carbon data fraud. Daoping Wang et al. stated that blockchain can trace product carbon footprints, ensuring the authenticity of allowance allocation and transaction data [35]. Cong Shi et al. proposed replacing traditional carbon trading centers with a "full carbon chain" service center, putting

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the entire process of allowance declaration, verification, and trading on-chain, curbing supplier misreporting [35]. This feature also enhances consumer green trust. Bengang Gong et al. verified that blockchain disclosure of product green information increases consumer willingness to buy remanufactured goods [36]; Dan Xiao et al. further proved that blockchain technology increases the demand elasticity of low-carbon products by 15%-30% by improving transparency of carbon reduction information [37].

4.2.2. Reducing Regulatory and Transaction Costs

Feng Ji constructing a carbon asset management accounting system, showed that blockchain automates compliance processes like allowance settlement and cancellation through smart contracts, reducing manual intervention costs [38]. Ting Yang et al. in a supply chain finance case, demonstrated that blockchain's peer-to-peer transaction model eliminates the need for core enterprise credit endorsement, reducing operational risks and intermediary fees in financing chains [39].

4.2.3. Innovation in Carbon Reduction Mechanisms based on Blockchain

Ting Yang et al. proposed a blockchain-based carbon asset pledge financing model, using digital IDs for carbon allowance ownership verification, solving the duplicate pledge problem caused by unclear ownership in traditional models. Assisting supply chain finance synergy, Xiaoyong Wu et al. proved blockchain facilitates competitive manufacturers sharing emission reduction information, lowering cooperation costs, and increasing emission reduction investment efficiency by over 20% [40].

Cong Shi et al. designed a "negotiated transfer + blockchain" carbon trading mechanism using smart contracts to automatically match buyers and sellers, reducing carbon price premium volatility [41]; Jiangxia Nan et al. found blockchain increases the incentive effect of carbon prices on emission reduction levels by 1.8 times [41].

4.2.4. Blockchain's Restructuring of Supply Chain Collaborative Emission Reduction Models

For vertical collaborative emission reduction decisions, blockchain technology can optimize them. For instance, research by Daoping Wang et al. showed that applying blockchain to bidirectional cost-sharing contracts reduces contract execution costs by 12%. Regarding horizontal competitive strategy adjustments, research by Jiangxia Nan et al., using a non-cooperative-cooperative bimodal game model, found blockchain increases the probability of emission reduction technology cooperation among competitive manufacturers by 40%, achieving a "emission reduction-efficiency improvement" win-win (e.g., the blockchain collaboration between Volkswagen and Toyota on hybrid technology).

5. Future Research Directions

5.1. Deepening Research on Enterprise Behavioral Performance and Heterogeneity

The heterogeneous green innovation response mechanisms of newly included industries (steel, cement, aluminum smelting) in June 2025 require further investigation.

Regarding firm size heterogeneity, existing research focuses on large enterprises, while the financing difficulties of SMEs persist. Future research needs to explore how SMEs can break through capital constraints via technology cooperation and green financial instruments to achieve low-carbon transitions.

For non-financial performance, there is a lack of research on the long-term impacts of ESG ratings, such as long-term financing costs and investor preferences.

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5.2. Innovation and Validation of Supply Chain Coordination Mechanisms

Existing contracts often assume static carbon prices. Future research could introduce stochastic differential game models to design contracts with dynamically adjustable cost/revenue sharing ratios, such as floating sharing mechanisms linked to carbon futures prices.

Regarding supply chain synergy, current research mainly designs contracts for two-tier (manufacturer-retailer) supply chains. Future work should explore joint emission reduction contracts for multi-tier supply chains.

For blockchain technology, empirical research and practical implementation are limited. Most studies simply calculate or estimate blockchain operational costs; more qualitative work is needed. Future research should assess the balance between blockchain deployment costs and gains in carbon management efficiency to identify applicability thresholds for firms of different sizes.

5.3. Optimization Directions for CET Policy Design

5.3.1. Cross-Regional Carbon Accounting System

A cross-regional carbon accounting system quantifies, monitors, and manages carbon emission data across administrative or geographical regions. Its core purpose is solving the accounting challenge of inter-regional carbon flows, providing data support for regional collaborative emission reduction and carbon market interconnections.

For current Chinese policy practice, such a system could address inconsistencies in regional accounting methods and reduce "nominal reduction, actual increase" carbon leakage risks caused by industries relocating from strict to lenient regulatory regions.

5.3.2. Carbon Allowance Auction Revenue Recycling

Carbon allowance auction revenue recycling refers to the process by which governments return revenue generated from auctioning carbon allowances to society, enterprises, and residents. It functions to alleviate social equity issues, promote economic efficiency and low-carbon investment, and enhance political feasibility. Recycling methods are flexible and diverse, tailored to specific policy goals and socio-economic conditions. Several countries have implemented such schemes (e.g., reinvesting revenue in climate/energy projects, direct cash rebates to households for carbon costs).

5.3.3. Further Opening of Carbon Financial Instruments

China's carbon financial instruments are still nascent. Key instruments like carbon futures are not yet traded. Research on and the launch of such instruments, along with empirical testing of their impact on emission reduction investment stability (especially SME hedging effectiveness), will be crucial future research foci.

6. Conclusion

This literature review synthesizes findings from 245 recent studies examining China's Carbon Emission Trading (CET) policy impacts. At the micro level, the review demonstrates robust evidence that CET policies stimulate corporate green innovation, primarily through alleviating financing constraints, transforming cost pressures into innovation impetus, and addressing institutional legitimacy concerns, largely supporting the Porter Hypothesis in the Chinese context. However, the effect on overall corporate performance is nuanced: while CET can enhance financial performance and optimize debt structures via cost savings and trading revenue, its impact on firm value and non-financial metrics remains debated.

At the meso level, research highlights the critical role of supply chain coordination in mitigating "double marginalization" stemming from uneven carbon regulation across tiers. Cost-sharing and revenue-sharing contracts emerge as dominant mechanisms for aligning incentives and

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optimizing emission reduction investments. Furthermore, blockchain technology shows significant potential to enhance supply chain co-operation by improving carbon data credibility, reducing compliance costs, and enabling novel collaboration models.

Key future research priorities include: (1) Investigating heterogeneous responses in newly covered industries (steel, cement, aluminum) and SMEs facing unique financing constraints; (2) Exploring dynamic contract designs that are responsive to fluctuating carbon prices and extending coordination models to multi-tier supply chains; (3) Conducting rigorous cost-benefit analyses of blockchain integration; and (4) Evaluating policy innovations like cross-regional carbon accounting systems, carbon revenue recycling mechanisms, and the development of carbon financial instruments to enhance market efficiency and equity. Further empirical validation of these mechanisms is essential.

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