Carbon Emission Trading, Supply Chain Linkage Shocks, and Corporate Quality Enhancement and Efficiency Improvement

Authors: Zhang Ying, Zhou Xiaoyu, Zhou Xiaoyu

Date: 2026-04-16T11:33:12+00:00

Abstract

Based on the "dual carbon" goals and the strategy of strengthening the nation through manufacturing, this paper examines the reshaping effect of carbon emission trading network shocks at the supply chain dimension on corporate total factor productivity (TFP) through precise measurement. The study finds that both upstream and downstream network shocks can significantly enhance total factor productivity. Mechanism analysis indicates that, on the one hand, supply chain shocks drive enterprises to increase supply chain concentration to strengthen cross-organizational synergy; on the other hand, they effectively crowd out media attention, providing a focused space for enterprises to shield against noise and avoid short-sightedness. Heterogeneity analysis reveals that this effect is more significant in non-state-owned enterprises and highly competitive industries; furthermore, upstream shocks rely on the "financial buffer pool" of low-cost-rate enterprises, while downstream shocks benefit from the "catch-up effect" of high-cost-rate enterprises. After further isolating intra-industry interference, it is found that pure upstream shocks degenerate into destructive profit squeezing, while pure downstream shocks maintain a green driving effect. This study reveals the micro-level black box of carbon policy network transmission and provides empirical evidence for preventing the risk of policy resonance across the supply chain.

Full Text

Carbon Emission Rights Trading, Industrial Chain Linkage Shocks, and Enterprise Quality and Efficiency Improvement

Nanjing Normal University

Abstract

In alignment with the national strategy of building a manufacturing powerhouse and achieving "Dual Carbon" goals, this study examines the reshaping effects of carbon emission trading (CET) network shocks on corporate total factor productivity (TFP) by precisely measuring these impacts across industrial chains. By integrating industrial chain structure data with enterprise-level micro-data, we analyze how carbon price signals and compliance costs are transmitted along the supply chain. The research findings indicate that shocks originating from both upstream and downstream networks significantly enhance TFP.

Mechanism analysis reveals two primary pathways: first, industrial chain shocks drive enterprises to increase supply chain concentration, thereby strengthening cross-organizational synergy; second, these shocks effectively filter out excessive media attention, providing firms with a focused environment that shields them from external noise and helps mitigate managerial short-termism. Heterogeneity analysis further demonstrates that this productivity-enhancing effect is more pronounced in non-state-owned enterprises and highly competitive industries. Moreover, the impact of upstream shocks relies on the "financial buffer zones" of enterprises with low operating cost ratios, while downstream shocks benefit from the strategic adjustments of those with high cost ratios. After isolating intra-industry interference, the study finds that "pure" upstream shocks can devolve into disruptive profit squeezes, whereas downstream shocks consistently maintain a "green pull" effect on productivity. This research uncovers the micro-level "black box" of carbon policy transmission through networks and provides empirical evidence for mitigating the risks of policy resonance across industrial chains.

Keywords: Carbon Emission Trading, Total Factor Productivity, Industry Chain Linkage, Supply Chain Concentration, Spillover Effects, Media Attention

1. Introduction

Climate change is one of the most severe challenges facing humanity in the 21st century. To address this, the Chinese government has proposed the ambitious "dual carbon" goals of peaking carbon dioxide emissions by 2030 and achieving carbon neutrality by 2060. Among various policy instruments, the Carbon Emission Rights Trading Scheme (ETS) is regarded as a critical market-based mechanism to internalize the externalities of carbon emissions. Since 2011, China has launched carbon trading pilots in several provinces and cities, providing a "natural experiment" to evaluate the economic and environmental effects of such policies.

Existing literature has extensively discussed the impact of carbon trading on enterprise competitiveness, carbon emission reduction, and total factor productivity. However, most studies focus on the direct effects on regulated entities,

often overlooking the systemic nature of industrial production. In a modern industrial system, enterprises do not exist in isolation; they are interconnected through complex industrial chains. A carbon constraint imposed on a specific sector may trigger a "ripple effect," transmitting shocks to both upstream and downstream partners. Therefore, understanding how carbon trading affects enterprise quality and efficiency through industrial chain linkages is essential for a comprehensive evaluation of the policy' s effectiveness.

The Chinese economy is currently in a critical transition period. The comprehensive advancement of the "Dual Carbon" strategy has introduced new binding constraints for the high-quality development of real-sector enterprises. As a core market-based environmental regulation, the CET policy profoundly alters the relative prices of production factors and the external constraint environment for micro-level enterprises by setting emission caps and financializing carbon quotas. Against this macroeconomic backdrop, the traditional model of extensive scale expansion is no longer sustainable. Improving Total Factor Productivity (TFP) has become the fundamental path for enterprises to hedge against environmental compliance costs and achieve leapfrog development.

Classical macroeconomic theory has demonstrated that local micro-shocks do not remain confined within the affected entity; instead, they form cascade amplification effects through the transaction networks of upstream and downstream industrial chains [**?**]. From the supply side, the carbon compliance costs of upstream industries often propagate downward through the input-output chain in the form of rising raw material prices, creating a strong "cost-push" effect [**?**, **?**]. From the demand side, the green and low-carbon transformation of core downstream terminal enterprises transmits "green demand-pull" pressure upward by raising supply chain procurement thresholds and entry standards. These external shocks, amplified by industrial correlation networks, objectively force target enterprises within the supply chain network to face unprecedented systemic pressure for survival and transformation.

2. Theoretical Analysis and Hypotheses

2.1 Main Effect of Industrial Chain Linkage Shocks on TFP

Existing literature views carbon emission trading policies as a direct shock that triggers a "compensation effect,"forcing regulated enterprises to engage in technological innovation, eliminate backward production capacity, and accelerate internal resource restructuring, thereby enhancing TFP [**?**]. However, within modern input-output networks, the implementation of CET policies generates strong cascading spillover effects on upstream and downstream enterprises through complex transaction chains [**?**, **?**].

First, upstream correlation shocks stimulate internal resource restructuring by creating a "cost-push" mechanism. When upstream industries face compliance costs, they pass these downstream via higher prices. Faced with this squeeze, target enterprises in the middle and lower reaches are forced to trigger the "escape-

competition effect" [**?**]. To resist cost pass-through, enterprises must eliminate backward, high-energy-consuming capacity and accelerate production process innovation. Second, downstream correlation shocks drive upgrades through "green demand pull." Downstream environmental requirements are transformed into green procurement standards. To maintain market share, target enterprises develop strong motivations for technological catch-up and innovation compensation [**?**]. Based on this, we propose:

H1: The upstream and downstream industrial chain correlation shocks of carbon trading policies can significantly improve the total factor productivity of target enterprises.

2.2 Mediating Mechanism of Supply Chain Synergy and Resource Aggregation

Facing systemic environmental constraints, target enterprises often restructure their supply chain strategies. By increasing supply chain concentration, firms can achieve resource synergy across organizational boundaries. Upstream, linkage shocks prompt "supplier optimization" to stabilize cost fluctuations. Firms reduce marginal suppliers and concentrate procurement among core, leading suppliers with low-carbon technologies, enhancing buyer power and reducing transaction costs. Downstream, shocks prompt "customer stability" strategies. By increasing sales concentration with core major customers, enterprises can precisely align with customized low-carbon requirements, reducing the risk of product stagnation and ensuring cash flow for technological upgrades. Based on this, we propose:

H2: Supply chain concentration plays a significant positive mediating role between industry chain linkage shocks and total factor productivity.

2.3 Mediating Mechanism of External Noise Shielding and Myopia Avoidance

Beyond physical networks, CET policies trigger a redistribution of attention resources. Based on the limited attention hypothesis [**?**], public and media attention is scarce. Leading regulated entities often become the focus of public opinion, siphoning attention away from non-regulated target firms in the supply chain. This "siphoning effect" can foster a more focused internal management environment. Excessive media attention often induces managerial myopia, where managers divert capital into superficial, short-term earnings management to cater to external expectations [**?**, **?**]. A moderate cooling of media attention acts as an information barrier, allowing firms to focus on long-term technological upgrades. Based on this, we propose:

H3: Media attention plays a mediating role between supply chain-related policy shocks and total factor productivity.

3. Research Design

3.1 Sample and Data

This study selects A-share listed companies as the initial research sample. Micro-level corporate financial and governance data are sourced from the CSMAR database. Industrial linkage data are extracted from the Input-Output Tables published by the National Bureau of Statistics. We use the 2012 Input-Output Table as a fixed benchmark to ensure input-output coefficients are exogenous to subsequent carbon trading policy shocks [**?**]. The final unbalanced panel dataset consists of 31,343 observations.

3.2 Variable Definitions

Dependent Variable: Total Factor Productivity (TFP). Following the methodology of [**?**], we use the LP method to calculate TFP. For robustness, we also employ the ACF method [**?**].

Core Explanatory Variables: 1. **Upstream Linkage Shock (Up_CET):** Captures shocks transmitted downstream due to rising raw material prices or cost pass-through.

$$Up\_CET_{j,t} = \sum \alpha_{k,j} \times CET_{k,t}$$

2. **Downstream Linkage Shock ($Down\_CET$):** Reflects backward-pressure shocks transmitted upward through changes in green demand.

$$Down\_CET_{j,t} = \sum \beta_{j,k} \times CET_{k,t}$$

Control Variables: We control for firm size ($Lnsize$), leverage (Lev), return on assets (ROA), cash flow ($Cashflow$), ownership concentration ($Top1$), CEO duality ($Dual$), Tobin' s Q ($Tobinq$), growth rate ($Growth$), board size ($Board$), and financial constraints (SA).

4. Empirical Results

4.1 Baseline Regression

The baseline regression results indicate that the coefficients for both Up_CET and $Down\_CET$ are significantly positive at the 1% level. For every one-unit increase in the upstream linkage shock, the TFP of the target firm increases by an average of 5.804%. For the downstream shock, the average increase is 3.967%. These findings provide comprehensive validation for H1.

4.2 Robustness Tests

The results remain robust after: 1. **Replacing the Dependent Variable:** Using TFP_{ACF} yields consistent results. 2. **Lagged Dependent Variable:** Lagging TFP by one period confirms cross-period dynamic transmission effects.

3. **Controlling for Concurrent Policies:** Incorporating Environmental Protection Tax and Green Credit Guidelines does not change the core findings. 4. **Placebo Test:** Randomly generating "pseudo-shocks" 1,000 times confirms that the results are not due to unobservable random noise.

5. Mechanism Testing

Mechanism testing confirms the dual transmission paths. Regarding the physical transaction dimension, regression results show that carbon policy shocks drive target firms to increase supply chain concentration (SC), which in turn enhances TFP by reducing transaction frictions and strengthening strategic synergy, verifying H2. Regarding the information environment, results show that policy shocks trigger a "crowding-out" of media attention ($Media$). The reduction in external noise effectively alleviates managerial myopia, allowing firms to focus on long-term resource optimization, verifying H3.

6. Heterogeneity and Extended Analysis

6.1 Heterogeneity Analysis

1. **Nature of Ownership:** The productivity-enhancing effect is significant only for non-state-owned enterprises (non-SOEs), which face stricter budget constraints and stronger survival pressure.
2. **Industry Competition:** Effects are more significant in highly competitive industries (low HHI), where firms lack pricing power and must rely on internal efficiency breakthroughs to absorb costs.
3. **Operating Cost Ratio:** Upstream shocks are more significant for low-cost firms with "financial buffers," while downstream shocks are more significant for high-cost firms with larger "catch-up" potential.

6.2 Pure Network Spillover Effects

After isolating intra-industry effects to extract "pure" cross-industry spillovers, we find that pure upstream shocks ($Up2\_CET$) shift to being significantly negative. This suggests that without the "forcing mechanism" of direct regulation, pure upstream cost pass-through acts as a "profit squeeze" that deteriorates TFP. In contrast, pure downstream shocks ($Down2\_CET$) remain significantly positive, confirming the robust "green demand-pull"effect across industry boundaries.

7. Conclusion and Policy Recommendations

This study demonstrates that carbon trading policies possess network penetration capabilities that transcend organizational boundaries. While the policy generally promotes quality and efficiency, the transmission mechanisms are asymmetric.

Policy Recommendations: 1. **Whole-Chain Coordination:** Regulators should establish cross-industry spillover assessment mechanisms to prevent systemic risks from upstream cost pass-through, potentially using structural price guidance or green tax refunds for affected downstream sectors. 2. **Precise Financial Support:** Financial institutions should provide targeted green credit to high-cost firms facing downstream green demand pressures to help them realize their transition potential. 3. **Strategic Synergy:** Enterprises should move away from short-term speculation and deepen strategic alliances with green-innovation-oriented partners to build long-term competitiveness through factor synergy.

Note: Figure translations are in progress. See original paper for figures.