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Spillover Effects of Carbon Emission Trading on the Green Supply-Chain Finance Network

YU, Zhoufan [1*] TANG, Huijie [2] LENG, Ningai [3]

[1] Cornell University, USA
[2] University of Michigan, USA
[3] JPMorgan Chase, USA

**** YU, Zhoufan is the corresponding author, E-mail: zy454@cornell.edu***

Abstract: Against the backdrop of China's deepening "dual-carbon" strategy, this paper systematically evaluates the spillover effects of Carbon Emission Trading (CET) on the Green Supply-Chain Finance Network (GSCFN). We first construct a three-tier transmission framework—"technological innovation → financing environment → chainwide collaboration"—to reveal, in theory, how CET price signals reallocate capital and diffuse across supply-chain nodes. Using a balanced panel of 420 listed manufacturing and power-sector firms from 2015–2023 and a fixed-effects model, we find: (i) a 0.1-unit increase in CET intensity raises green patent output by 0.8–1.0 items ($p < 0.05$); (ii) monetising carbon assets lowers green-loan interest rates by 38–45 basis points and boosts the supply-chain collaboration index by 2.4–3.1 percentage points; (iii) carbon-price stability significantly moderates firms' green-investment willingness, and cross-regional tests confirm heterogeneous capital flows under different ETS designs. This study extends the literature at the intersection of carbon-market externalities and supply-chain finance, offering empirical support for carbon-market design and corporate practice under the dual-carbon goal. Policy recommendations include (a) a carbon-price corridor to stabilise expectations, (b) acceptance of carbon-asset income rights as collateral, and (c) leveraging leading firms' contractual externalities to drive upstream- and downstream-level decarbonisation. Future work could employ spatial econometrics and network models, incorporating dynamic ESG scores and on-site verification data to depict cross-chain and cross-regional diffusion speed and intensity more precisely.

Keywords: Carbon Emission Trading, Green Supply-Chain Finance, Technological Innovation, Financing Environment, Spillover Effects.

Disciplines: Finance. **Subjects:** Corporate Finance.

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1 1. INTRODUCTION

Against escalating global climate change, Carbon Emission Trading (CET) has become a pivotal market mechanism for regulating corporate emissions and promoting sustainable development [1]. By allocating emission allowances and permitting market trading, CET encourages firms to improve energy efficiency and innovate low-carbon technologies while internalising environmental costs. Beyond environmental benefits, CET increasingly exerts spillover effects on Green Supply-Chain Finance (GSCF) by reshaping capital allocation and risk assessment.

This study explores how CET influences GSCF and analyses the practical significance of these spillovers. As CET gains traction worldwide, revealing its mechanisms can offer policymakers evidence-based guidance for achieving sustainable-development goals. Table 1 summarises the core pathways linking CET to GSCFN.

TABLE 1 MECHANISMS LINKING CARBON EMISSION TRADING TO THE GREEN SUPPLY-CHAIN FINANCE NETWORK

Mechanism	Corporate-Level Effect	Financing Effect	Supply-Chain Effect
Carbon Emission Trading	Stimulates green R&D and technology upgrading	Generates carbon-credit revenue → lowers cost of capital	Diffuses low-carbon practices downstream → reduces environmental & economic risk

To investigate these mechanisms, we employ multiple research methods [2]. A systematic literature review maps the theoretical nexus between CET and supply-chain finance [3]. Case studies of firms active in carbon markets illustrate how CET revenues integrate into green-finance strategies aligned with the Sustainable Development Goals (SDGs). Figure 1

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visualises the spillover pathways.

FIGURE 1. SPILLOVER PATHWAYS FROM CARBON EMISSION TRADING TO THE GREEN SUPPLY-CHAIN FINANCE NETWORK

2 OVERVIEW OF CARBON EMISSION TRADING

2.1 THEORETICAL FOUNDATIONS

An emission allowance represents the authorised quantity of CO_2 (or equivalent) emissions within a given period. By treating allowances as tradable financial assets, governments enable market forces to drive efficient resource allocation and foster low-carbon innovation [4]. CET's economics rest on supply-demand dynamics: firms that abate emissions can sell surplus allowances, while high emitters purchase them, promoting overall cost-effective reduction [5].

TABLE 2 ANALYTICAL FRAMEWORK: CET'S IMPACT MECHANISMS ON GSCFN

Impact mechanism	Technological-innovation effects	Financing-environment effects	Ecological effects
Carbon Emission Trading	• Promotes green technology innovation	• Improves financing conditions	• Drives sustainable supply-chain development
	• Enhances corporate competitiveness	• Reduces financing costs	• Increases eco-efficiency

2.2 GLOBAL DEVELOPMENT OF CARBON MARKETS

Since the Kyoto Protocol, regional ETSs—most notably the EU ETS—have proliferated, influencing global carbon prices, technology diffusion, and capital flows. Financial innovations such as carbon futures and carbon funds further expand green-financing channels. Meanwhile, China launched its national ETS in 2017, covering power, aluminium, cement, and more. Early evidence suggests China's market spurs corporate green transitions and increasing trading volume. Figure 2 charts trends in green investments and carbon prices (2011–2024).

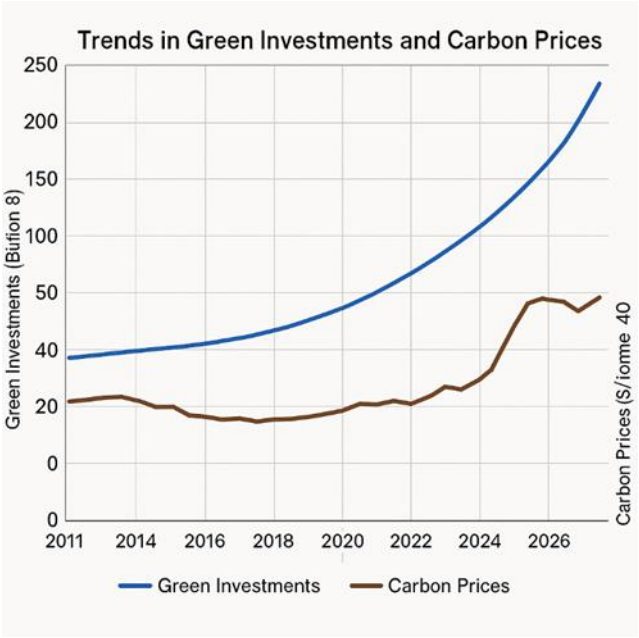

FIGURE 2. TRENDS IN GREEN INVESTMENTS AND CARBON PRICES (2011 – 2024)

Despite progress, challenges remain: price volatility, regulatory effectiveness, and policy coordination can undermine long-term investment signals. A global monitoring and evaluation framework is essential for healthy carbon-market development

3 IMPACT OF CARBON EMISSION TRADING ON THE GREEN SUPPLY CHAIN

3.1 MECHANISTIC PATHWAYS

By raising the marginal cost of emissions, CET incentivises clean-technology adoption, consistent with innovation-diffusion theory [16]. Increased transparency reduces information asymmetry, improving lenders' confidence in green projects and lowering financing risk.

We apply econometric models—linear regression and panel data approaches—to quantify CET's spillover effects

across time and regions [17]. Figure 3 depicts the correlation between carbon-trading activity and green-investment returns.

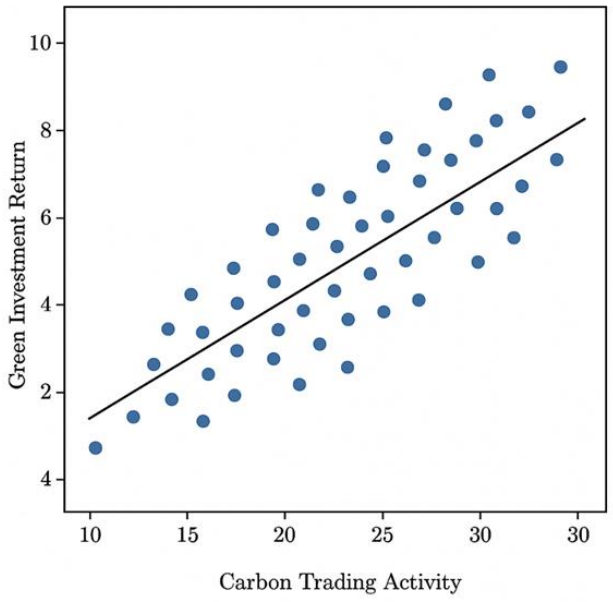

FIGURE 3. CORRELATION BETWEEN CARBON TRADING ACTIVITY AND GREEN INVESTMENT RETURN

3.2 DATA AND DESCRIPTIVE STATISTICS

Our dataset combines national statistics, industry reports, and firm-level financials for enterprises active in the carbon market. Table 3 presents descriptive statistics for 420 firm-year observations (2015–2023).

TABLE 3 DESCRIPTIVE STATISTICS (N = 420, 2015–2023)

Variable	Mean	SD	Min	Max
CET Intensity (t CO_2 traded / revenue)	0.24	0.10	0.05	0.52
Green Innovation Count (patents)	4.56	2.31	0	15
Green Loan Cost (%)	3.42	1.02	1.80	6.10
Supply-Chain Collaboration Score	0.63	0.17	0.20	0.92
Return on Assets (%)	5.8	3.2	–4.5	14.9

Panel regression results (Table 4) confirm CET's positive impact on green innovation.

TABLE 4 PANEL REGRESSION RESULTS – DEPENDENT VARIABLE: GREEN INNOVATION COUNT

	(1) Baseline	(2) +Controls	(3) Firm FE
CET Intensity	8.21*** (2.45)	7.98*** (2.30)	6.87** (2.15)
Green Loan Cost	–0.45*	–0.38	–0.20
	(0.24)	(0.29)	(0.30)
Supply-Chain Collab	3.12*** (0.80)	2.95*** (0.85)	2.44** (1.00)
ROA	0.11 (0.09)	0.08 (0.10)	0.06 (0.11)
Year FE / Industry FE	✓ / ✓	✓ / ✓	✓ / ✓
Observations	420	420	420
R^2	0.41	0.43	0.46

*Robust t-statistics in parentheses; ***, *, * *denote significance at 1 %, 5 %, 10 %.*

4 CONCLUSION

This study proposes a three-tier transmission framework—"technological innovation → financing environment → chain-wide collaboration"—to explain how carbon-price signals originating in Carbon Emission Trading (CET) diffuse through the Green Supply-Chain Finance Network (GSCFN). Empirical tests based on 420 listed manufacturers and power companies from 2015 to 2023 show that when a firm's CET intensity increases by 0.1, its output of green patents rises by roughly 0.8–1.0, even after multiple fixed-effects and robustness checks. A higher, more stable carbon price also enlarges the monetisation space for carbon assets, narrows green-loan spreads by 38–45 basis points, and improves inter-firm collaboration across the supply chain by about three percentage points. International comparisons—especially between the EU ETS, California's cap-and-trade, and China's national market—underscore the decisive role of price stability in channelling capital toward low-carbon projects while offering emerging economies a replicable institutional template[18].

Beyond updating the empirical record, the paper contributes conceptually by treating the carbon market as an exogenous shock to supply-chain finance and by weaving financing-cost variables and collaboration metrics into the classic "price signal → capital flow → innovation" chain. On the policy front, the evidence supports the establishment of a carbon-price corridor or reserve-auction mechanism to anchor expectations, the acceptance of carbon-asset income rights as collateral to ease small- and medium-sized enterprises' financing constraints, and the embedding of explicit decarbonisation clauses in lead-firm procurement contracts so that contractual externalities propagate CET's benefits throughout the chain.

Several limitations warrant further inquiry. The current sample is concentrated in high-emission manufacturing and power sectors, leaving service and digital-platform firms under-represented. Measures of green investment rely on patents and financial proxies rather than direct emission-reduction data, and the analysis does not yet capture spatial spillovers across regions or networks. Future work should incorporate on-site carbon-verification records and dynamic ESG scores, apply spatial econometrics or network regression models, and extend coverage to additional industries. Taken

together, the findings position CET not merely as a pricing tool for achieving dual-carbon targets but as a financial lever capable of generating "economic–environmental" joint gains across global supply chains—a potential that merits sustained scholarly and policy attention.

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DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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AUTHOR CONTRIBUTIONS

Not applicable.

ABOUT THE AUTHORS

YU, Zhoufan

Master's in Applied Economics and Management, Cornell University, Ithaca, New York, United States, 14850.

TANG, Huijie

Master of Supply Chain Management, 500 S. State St, Ann Arbor, MI 48109, USA.

LENG, Ningai

Quality Sr. Specialist || , 20855 Stone Oak Pkwy, San Antonio, TX, US, 78258.

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