Paths of Risk: Carbon Transmission Through Supply Chain Networks and the Cost of Equity Capital

Executive Summary

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Full paper available on SSRN

August 2025

Abstract

This study investigates the transmission of carbon risk through supply chain networks and its impact on a firm's implied cost of equity capital (ICOE), focusing on the Indian market from 2014 to 2024, one of the world's largest and most rapidly developing economies, characterized by high climate transition risk and a highly interconnected supply chain structure. Leveraging dyadic firm-level datasets, we document that carbon risk originating from customers (upstream) is positively and significantly associated with the focal firm's ICOE, while emissions from suppliers (downstream) exhibit no such effect. We identify cash flow volatility as a key transmission channel, whereby customer carbon risk increases uncertainty in the focal firm's cash flows, leading investors to demand a higher risk premium. Higher network criticality of customers, more central role in supply chain networks and the focal firm's sales structure, amplifies the pricing of upstream carbon risk, while India's Net Zero 2070 announcement in 2022, a more gradual policy commitment, attenuates this impact. Sectoral heterogeneity analysis further reveals that the upstream effect within the power sector supply chain is significantly stronger, approximately three times higher, than the baseline estimates for the full sample. Our findings suggest that policymakers should closely monitor the interdependence of carbon risk across value chains, with particular attention to high-emission sectors such as the power sector supply chain.

Acknowledgement

The views expressed in this paper are solely the responsibility of the authors and do not necessarily reflect the opinions of the acknowledged individuals. This research was conducted as part of the India Transition Finance Program (ITFP) and the Environmental Stress Testing and Scenarios Project (ESTS).

Executive summary

Introduction

Carbon risk has become an increasingly important determinant of firms' cost of equity. Accelerating decarbonization pathways and transition policies, particularly in developing economies with a high concentration of emissions-intensive industries, expose high-carbon firms to greater transition risks. Regulatory tightening, technological disruption, and shifts in market preferences heighten uncertainty over future financial performance, driving equity markets to demand higher expected returns from such firms. This repricing effect increases the cost of equity capital by applying a carbon (green) premium that influences capital allocation, firm valuation, and strategic financing decisions in the low-carbon transition.

There is little empirical evidence on how value chain carbon risk exposure influences the cost of equity. Firms are embedded in complex and highly interconnected value chains, where carbon exposure can propagate upstream from customers and downstream from suppliers, extending well beyond direct operations. These indirect exposures may require firms to reallocate substantial financial resources toward mitigation or adaptation. Investors may incorporate such network-based carbon risks into equity pricing.

We examine the impact of carbon risk transmission on the cost of equity capital within the Indian context from 2014-2024. India is a relevant research context given substantial exposure to carbon risk and intricate supply chain networks. Carbon risk is measured using Scope 1 and 2 carbon intensity (tons of CO_2 per million USD revenue) obtained from S&P Trucost, while Indian supply chain relationships are drawn from the FactSet Revere Supply Chain Relationship database. We measure cost of equity capital by forward looking indicators, implied cost of equity capital (**ICOE**), defined as the internal rate of return that equates the firm's stock price with the present value of expected future cash flows.

We investigate the mechanisms through which carbon risk is transmitted and the moderation impacts of firm–network characteristics and policy shocks**.** Specifically, we hypothesize that cash flow volatility is a key transmission channel. While network criticality of supply chain partner may amplify the pricing of indirect carbon risk, the India's Net Zero 2070 announcement in 2022, more gradual policy commitment, may attenuate this impact.

The power sector, with firms with high carbon footprints, requires focused analysis. With India's commitments to achieve net zero by 2070 and expand renewable capacity to 500 GW by 2030, the power sector is pivotal in the national energy transition. Given its high emissions intensity and strategic importance, the transmission effect of carbon risk is expected to be more pronounced within the power sector supply chain.

Key findings

First, customer emissions are positively associated with a firm's ICOE, while supplier emissions show no such effect. A one standard deviation increases in customer Scope 1 carbon intensity (i.e., 3369.71 tons of CO_2 per million USD of revenue) is associated with a 0.328 percentage point (32.8 basis points) increases in the focal firm's ICOE, ceteris paribus (see Figure 1). Relative to the average firm's ICOE of approximately 10.35 percentage point, this corresponds to a 3.17% increase, indicating an economically significant impact on firm valuation, discount rate, and financing cost. These findings suggest that investors price carbon exposure originated from customers. The results remain robust across multiple selection bias and sensitivity tests.

Second, the upstream effect within the power sector supply chain is significantly stronger. In economic significance, a one standard deviation increases in customer Scope 1 carbon intensity (i.e., 4112.76 tons of CO_2 per million USD of revenue) is associated with a 1.047 percentage point, corresponding with 10.12% increase relative to the average ICOE of all firms. This effect within the power sector supply chain is approximately three times higher than the baseline estimate across all sectors. This suggests that carbon risk is disproportionately priced into the cost of capital in sectors with deep fossil fuel. This suggests that carbon risk is disproportionately priced into the cost of capital in sectors with deep fossil fuel linkages. This suggests that carbon risk is disproportionately priced into the cost of capital in sectors with deep fossil fuel linkages.

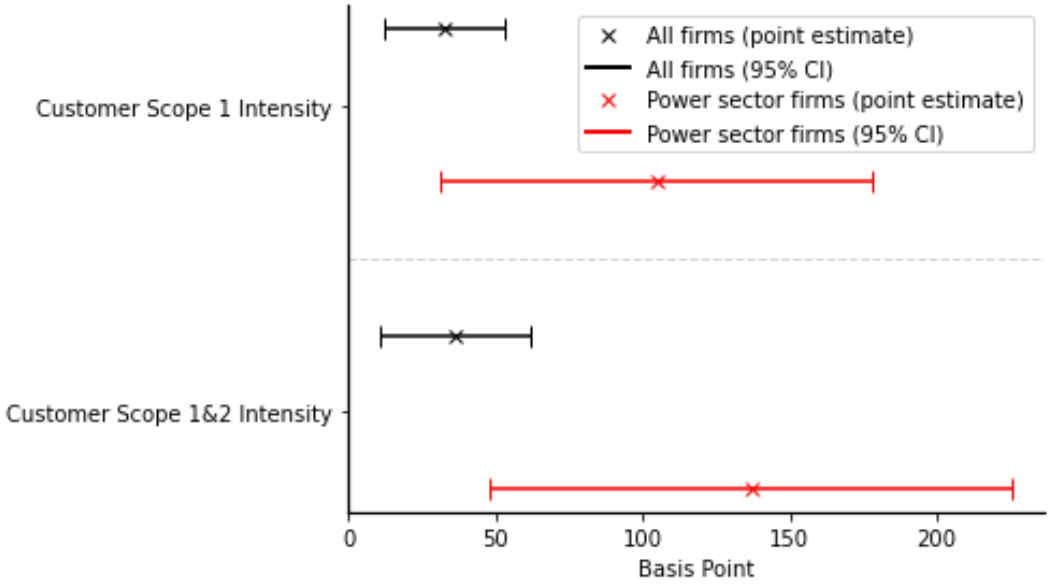

Figure 1: Effects of one standard deviation increases in customer carbon risk on the focal firms' ICOE

Third, cash flow volatility is a key transmission channel for the significant upstream effect. Carbon risks from customers directly affect upstream firms, whose revenues and cash flows are more sensitive to the financial and strategic behavior of their customers than their suppliers. Customer carbon risk can translate into greater cash flow volatility, which investors price by demanding higher expected returns, thereby increasing the focal firm's ICOE. Cash flow volatility is defined as the three-year standard deviation of operating cash flows over the period from year t–2 to t (backward) and from t to t+2 (forward). Results confirm the transmission channel with significant results of both cash flow volatility proxies. Economic significance, for instance, shows that a one standard deviation increases in customer Scope 1 carbon intensity (i.e., 3369.71 tons of CO_2 per million USD of revenue) is associated with a 0076-unit increases in forward cashflow volatility, corresponding with 14.23% increase relative to the average forward cashflow volatility of all firms.

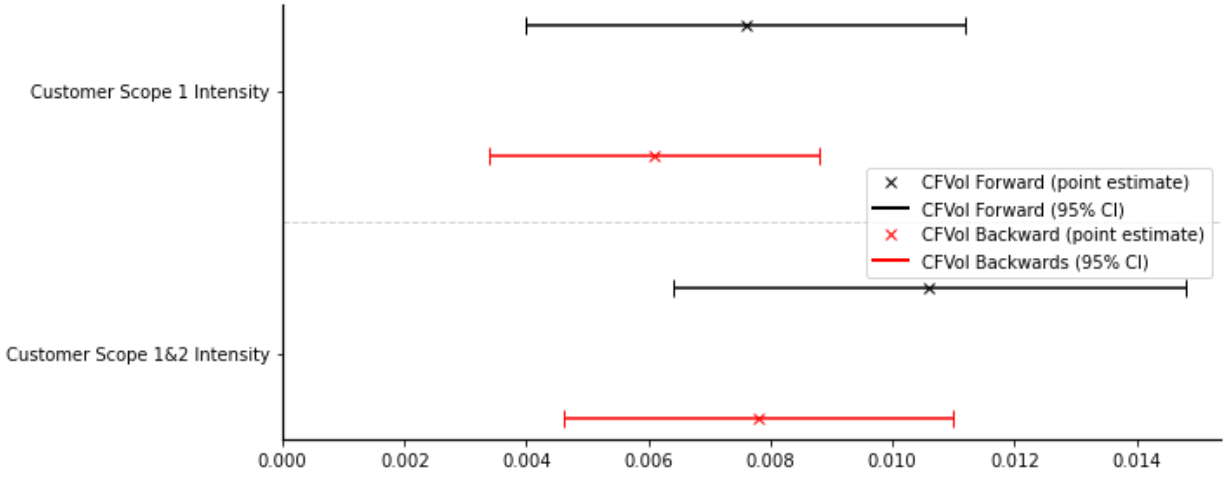

Figure 2: Effects of one standard deviation increases in customer carbon risk on the focal firms' cashflow volatility

Fourth, the effect of customer carbon risk on a firm's ICOE is influenced by the customers' network criticality[1] and climate policy.

- **Network Criticality:** Network criticality of customers amplifies the pricing of indirect carbon risk for the focal firm. In supply chain networks, the transmission of upstream carbon risk intensifies when customers hold greater strategic importance, indicating that investor assessments reflect both the magnitude and the structural position of carbon exposure.
- **Policy Shock**: India's announcement of its Net Zero 2070 target in 2022 reflects a more gradual policy commitment, thus potentially reducing the perceived urgency of customer carbon risk under investors' perspective. The policy announcement reduces the magnitude of the upstream effect to approximately one-quarter of its level prior to the announcement.

[1] Network criticality in this context refers to the relative importance of each customer to a given firm's sales structure (sales dependency)

Conclusions and Implications

We provide evidence that carbon risk transmits upstream through supply chain networks: Customer carbon risk increases the focal firm's cost of equity capital. We also show that customer carbon risk leads to greater cash flow volatility, a key channel through which investors price risk. This effect is more pronounced when customers are more central within the supply chain network and constitute a larger share of the firm's sales and less pronounced under gradual or deferred climate transition policies. The empirical evidence clearly demonstrates that the power sector supply chain in India experiences a significantly amplified transmission of customer carbon risk to the focal firm's cost of equity capital.

Our findings carry several policy implications.

For corporates and financiers

Firms should assess and manage customer carbon exposure. Firms should re-evaluate customer portfolios and actively manage carbon exposure in value chains—not just to meet climate goals, but to cut financing costs and protect shareholder value.

Investors should account for value chain emissions. Carbon risk assessment should go beyond firm-level emissions to include upstream exposure. Greater transparency on Scope 3 emissions will enable investors to shift capital toward firms less tied to high-carbon customers.

Investors should accelerate systemic capital reallocation from brown to green. Firms are facing growing incentives to shift away from fossil intensive value chains and instead prioritize greener and cleaner supply chain partnerships. Over time, such financial pressures could accelerate the reallocation of capital away from carbon-intensive sectors and toward lower-carbon alternatives, supporting a broader transition from brown to green economic activity.

For regulators and policy makers

Regulators should mandate standardized Scope 3 disclosure. Regulators and standard-setting bodies should require standardized, comprehensive, and verifiable reporting of Scope 3 emissions to strengthen climate risk assessments and improve the efficiency of capital allocation.

Policymakers should align policy with carbon risk pricing. National policies, such as India's Net Zero 2070 commitment, can shape how investors price both direct and supply chain carbon risks, influencing capital flows toward low-carbon firms.

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