Title: Integrating government subsidies and payment mechanisms for green investment in retail supply chains

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Abstract: Government subsidies are critical for promoting green technology adoption in supply chains. Simultaneously, retail operations are influenced by complex financing structures such as prepayment discounts and delayed payments. This study develops an integrated framework that combines environmental policy measures-Investment-Based Subsidies (IBS), Performance-Based Subsidies (PBS), and an emission tax (ET)-with financial structuring mechanisms in retail supply chains. The model examines retailers' optimal strategies for emission-control investment and inventory replenishment across three scenarios: (i) no green investment, (ii) green investment without subsidies, and (iii) green investment under IBS and PBS. Closed-form analytical solutions are derived for both full and partial prepayment settings, with convexity analysis confirming global optimality. To evaluate the financial efficiency of emission reduction, a new performance metric, Cost Saving per Unit Reduced Emission (CSURE), is introduced. Numerical experiments and sensitivity analyses demonstrate that with a fixed subsidy budget, PBS delivers greater cost savings, while IBS encourages larger emission reductions. Specifically, adopting green technology under IBS and PBS reduces total annual costs by up to 5.8% and 7.2%, respectively, and lowers emissions by approximately 18–20% in both prepayment contexts. These findings highlight the importance of aligning subsidy design with financing structures: IBS is more suitable for enforcing stricter emission controls in high-emission, developed industries, whereas PBS provides stronger incentives for cost-effective sustainability in emerging markets. This study advances the literature by integrating policy-driven subsidies with realistic payment mechanisms, offering both theoretical contributions and actionable insights for policymakers and practitioners.

Keywords: Inventory; Prepayment; Delay payment; Emission taxation; Government subsidy; Emission controlling investment

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