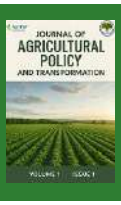

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Environmental Regulation and Financial Reallocation: Evidence from China's Incentive Penalty Policy

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ABSTRACT
This study examines the causal effects of China's Environmental Compensation Incentives and Penalties (ECIP) policy on corporate investment and financial behavior using panel data from Chinese A-listed firms (2013–2024) and a staggered difference-in-differences approach. The results show that ECIP significantly reduces corporate investment intensity and cash holdings while improving short-term profitability and operating cash flows. Mechanism analysis indicates that these outcomes are driven primarily by financing constraints and internal financial reallocation rather than productivity improvements, challenging the conventional Porter Hypothesis. Heterogeneity analysis reveals stronger effects among firms with limited pre-policy cash reserves, suggesting that financially constrained firms bear a disproportionate adjustment burden. Event-study and placebo tests confirm the robustness of the findings. Overall, although ECIP enhances short-term financial discipline, it may discourage long-term investment and intensify financial pressure. The study recommends complementary green finance initiatives and differentiated compliance mechanisms to mitigate the unintended financial consequences of environmental regulation while supporting sustainable corporate growth.

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1. INTRODUCTION

Environmental regulations, particularly policies that incorporate both incentives and penalties, are crucial instruments for controlling ecological degradation and promoting sustainable development. While a large body of literature examines single-instrument environmental policies, a substantial gap persists regarding the financial and investment implications of dual-instrument mechanisms. The Environmental Compensation Incentives and Penalties (ECIP) policy represents one of the most dynamic provincial-level environmental governance mechanisms in China, implemented between 2015 and 2022 with staggered adoption across provinces (Zhang et al., 2025). Unlike conventional firm-level regulatory mandates, ECIP operates indirectly by modifying local enforcement incentives and fiscal arrangements (Chen et al., 2025), creating a distinctive regulatory environment that affects corporate financial behavior through indirect channels. Specifically, ECIP functions as an inter-provincial fiscal transfer mechanism: provincial governments whose water quality outflows exceed negotiated benchmarks receive financial compensation from downstream provinces, while those failing to meet targets are required to make compensatory payments to their downstream counterparts. This dual incentive-penalty architecture creates powerful fiscal incentives for provincial governments to tighten environmental enforcement standards, which in turn exposes firms headquartered in regulated provinces to heightened compliance demands, resource reallocation pressures, and elevated regulatory costs. The staggered rollout of ECIP across Chinese provinces between 2015 and 2022 varied in its timing and stringency, with earlier-adopting provinces generally exhibiting stronger enforcement infrastructure and greater fiscal capacity to sustain compensation arrangements. Unlike direct firm-level environmental mandates, ECIP therefore shapes corporate behavior through indirect but powerful fiscal and enforcement channels, making it

a uniquely informative case for studying how hybrid environmental governance propagates through to firm-level financial decisions.

This study examines the impact of ECIP on investment and financial outcomes of Chinese A-listed firms from 2013 to 2024. Capital investment serves as the primary outcome variable, while profitability, operating cash flow, and cash holdings are examined as secondary outcomes. Financing pressure, cash buffer adjustment, and operational efficiency are investigated as transmission mechanism channels. This integrated framework allows systematic evaluation of the short-run economic consequences of environmental policies, with particular attention to firms facing financial constraints.

The theoretical framework of this study integrates three complementary perspectives. First, the compliance cost hypothesis predicts that environmental regulation imposes direct expenditure burdens and indirect opportunity costs on firms, crowding out productive capital investment as resources are diverted toward regulatory compliance (Gray & Shadbegian, 2003). Second, the financial constraint channel posits that regulatory pressure amplifies pre-existing financial frictions, particularly for firms with limited internal liquidity, forcing a prioritization of short-term operational sustainability over long-term capital formation (Campello et al., 2010). Third, the Porter Hypothesis offers a contrasting benchmark, predicting that well-designed environmental policies can stimulate compensating innovation and efficiency gains sufficient to offset compliance costs over time (Porter & van der Linde, 1995). The present study tests these competing predictions in the context of ECIP, where the indirect, province-level transmission mechanism may produce distinct firm-level financial responses. Four formal hypotheses guide empirical analysis. H1: ECIP adoption significantly reduces corporate capital investment intensity, consistent with a compliance cost crowding-out mechanism. H2: ECIP adoption improves short-run profitability and operating cash flows through internal financial reallocation rather than productive efficiency gains, inconsistent with the Porter Hypothesis. H3: ECIP adoption increases firms' external financing needs and accelerates internal cash buffer drawdown, consistent with the financial constraint channel. H4: The adverse investment and liquidity effects of ECIP are disproportionately concentrated among financially constrained firms with low pre-policy cash holdings. To identify causal effects, this study employs the staggered difference-in-differences estimator proposed by Callaway and Sant'Anna (2021). This approach addresses well-documented biases in conventional two-way fixed effects models arising from heterogeneous treatment timing (Guo et al., 2024). The estimator ensures causal credibility by comparing treated firms with contemporaneous controls and accommodates dynamic treatment effect estimation under the parallel trend's assumption.

This research makes several contributions to literature. First, it delivers firm-level causal evidence on the financial consequences of a comprehensive hybrid environmental policy that simultaneously deploys carrots and sticks, addressing the gap left by studies examining incentives or penalties in isolation (He et al., 2022; Tian & Yae, 2024). Second, it documents a pattern of financial reallocation under ECIP: firms reduce capital investment and cash holdings while improving short-run profitability and operating cash flows, consistent with a conservative internal resource redistribution strategy rather than genuine productive upgrading. Third, it identifies financing pressure and liquidity management as the primary transmission channels and demonstrates that these effects are amplified for financially constrained firms with low pre-policy cash buffers, highlighting heterogeneous distributional impacts of environmental policy.

2. LITERATURE REVIEW

The relationship between environmental regulation and corporate financial behavior has attracted growing scholarly attention, particularly as governments worldwide escalate climate-related policy ambitions. The foundational debate centers on whether environmental regulation imposes net costs on firms or whether well-designed policies can stimulate innovation and efficiency gains sufficient to offset compliance burdens, a tension encapsulated in the Porter Hypothesis (Porter & van der Linde, 1995). Empirical evidence on this question remains contested, with outcomes varying substantially by regulatory type, industry, and institutional context.

A substantial strand of research focuses on the differential effects of environmental penalties versus subsidies on corporate behavior. He et al. (2022) examines whether penalties or subsidies are more effective in promoting corporate environmental governance in China and find that penalties generate stronger compliance responses but may crowd out investment in non-targeted activities. Li and Ramanathan (2024) further show that the interactive effect of penalties and subsidies on corporate environmental innovation is non-linear, with excessively punitive or subsidy-heavy approaches each producing diminishing returns. Tian and Yae (2024) document unintended consequences of environmental penalties, finding that stringent sanctions can adversely affect green patent activity, suggesting that regulatory design must carefully balance compliance pressure with innovation incentives.

The role of green finance in mediating the relationship between environmental regulation and corporate investment has also received increasing attention. Wang and Shao (2024) find that green finance pilot zone policies in China significantly improve the efficiency of corporate investment, suggesting that financial system support can amplify the positive productivity effects of environmental regulation. However, as El Ouadghiri et al. (2023) demonstrate,

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language and disclosure practices around environmental commitments also shape corporate behavior, indicating that the financial and behavioral consequences of environmental policy extend well beyond direct compliance costs.

Research on China's specific environmental governance architecture highlights the importance of understanding how policies interact with local fiscal and enforcement structures. Chen et al. (2025) examine inter-provincial ecological compensation initiatives and show that these mechanisms meaningfully alter local government incentive frameworks, with downstream effects on firm-level regulatory exposure. Zhang et al. (2025) extend this analysis to the ECIP policy specifically, documenting its role in fostering collaborative green governance across provincial boundaries. Guo et al. (2024) demonstrate that digital infrastructure development complements environmental policy in driving enterprise green transformation, suggesting that the effectiveness of regulations like ECIP depends partly on broader technological and institutional conditions.

Beyond China-specific studies, a broader international literature establishes that environmental regulation consistently reshapes corporate investment and financing decisions. Gray and Shadbegian (2003) provide influential evidence from U.S. manufacturing plants that environmental compliance expenditure crowds out productive investment, while Greenstone (2002) shows that the Clean Air Act Amendments significantly reduced capital formation in regulated U.S. industries. In Europe, Calel and Dechezlepretre (2016) find that the EU Emissions Trading Scheme stimulated low-carbon patenting among regulated firms, offering partial support for the Porter Hypothesis in an innovation context, though investment-level effects remain contested. Jaffe et al. (1995) provide an early but comprehensive review concluding that environmental regulations impose non-trivial compliance costs across regulatory settings, with investment crowding-out being one of the most consistent empirical findings. The international evidence also highlights that financial consequences of environmental regulation are heterogeneous across firm size, financial capacity, and institutional environment, a pattern that motivates the heterogeneity analysis in this study. A key unresolved debate in this literature concerns whether the financial costs of environmental regulation represent temporary adjustment costs or durable structural burdens. Ambec et al. (2013) argue that long-run adaptation allows firms to recover compliance costs through innovation and process improvement, while Tian and Yae (2024) find sustained adverse effects on green innovation in China, suggesting potential long-term investment distortions. The present study contributes to resolving this debate by providing medium-run causal evidence under a staggered adoption design that allows dynamic treatment effect estimation. While prior studies provide valuable insights into isolated dimensions of environmental policy, the financial reallocation consequences of hybrid dual-instrument policies combining incentives and penalties remain underexplored. This study addresses that gap by providing firm-level causal evidence on how ECIP reshapes corporate investment, liquidity, profitability, and financing behavior, with explicit attention to transmission mechanisms and firm heterogeneity.

3. METHODOLOGY

Data and Sample

Financial data for the primary empirical analysis are drawn from the China Stock Market and Accounting Research (CSMAR) database, covering Chinese A-listed firms over the period 2013 to 2024. Data cleaning involves dropping firms in the financial industry, firms with special treatment (ST) designation, observations with missing values for core variables, and outliers at the tails of main indicator distributions. The final sample comprises 49,670 firm-year observations, of which 45,627 originate from ever-treated provinces and 4,043 from never-treated provinces. While the distribution is unbalanced, it comprehensively captures the staggered ECIP adoption timeline across Chinese provinces. The relatively small share of never-treated observations reflects the near-universal ECIP adoption across Chinese provinces by 2022 rather than a sampling artifact. Importantly, the Callaway and Sant'Anna (2021) estimator explicitly accommodates such settings by using not-yet-treated firms as valid comparison units for each treatment cohort, thereby ensuring that the small number of never-treated observations does not undermine the reliability of the causal estimates. Sensitivity analyses restricting the comparison group exclusively to never-treated observations are also reported to validate the baseline findings. To mitigate the influence of extreme observations, all continuous variables are winsorized at the 1st and 99th percentiles, consistent with standard practice in corporate finance research (Li & Ramanathan, 2024).

Data on the provincial implementation of the ecological compensation incentive and penalty policy are collected from government official websites, local media sources, and the China Audit Yearbook. The main outcome variables are capital expenditure intensity (capex_ta), return on assets (roa), operating cash flow ratio (cfo_ta), and cash-to-total-assets ratio (cash_ta). Control variables include firm size (ln_assets, measured as the natural logarithm of total assets), financial leverage (lev_ta), and sales growth (sales_g), all of which are systematically associated with corporate investment and financial decisions (Wang & Shao, 2024). Descriptive statistics stratified by treatment group are presented in Table 1, which reveals observable differences in firm size and leverage between ever-treated and never-treated firms, underscoring the importance of controlling for firm-level heterogeneity in subsequent estimations.

Table 1. Descriptive Statistics

Variable	N	Mean	SD	Median	Max
Panel A: Never Treated (treat_ever = 0)					
capex_ta	4,033	0.051	0.053	0.033	0.248
Roa	4,043	0.058	0.079	0.059	0.212
cfo_ta	4,043	0.057	0.086	0.057	0.263
cash_ta	4,043	0.198	0.148	0.160	0.675
ln_assets	4,043	20.892	1.753	20.523	26.895
lev_ta	4,043	0.388	0.206	0.361	1.098
sales_g	3,472	0.157	0.440	0.094	3.087
ln_sales	4,033	20.260	1.725	19.944	26.542
Panel B: Ever Treated (treat_ever = 1)					
capex_ta	45,560	0.045	0.045	0.032	0.248
Roa	45,627	0.028	0.076	0.033	0.212
cfo_ta	45,627	0.045	0.071	0.045	0.263
cash_ta	45,325	0.183	0.131	0.148	0.675
ln_assets	45,627	22.322	1.514	22.061	31.519
lev_ta	45,627	0.432	0.221	0.415	1.098
sales_g	42,176	0.139	0.446	0.076	3.087
ln_sales	44,718	21.464	1.550	21.322	28.830

Note. capex_ta = capital expenditure / total assets; roa = return on assets; cfo_ta = operating cash flow / total assets; cash_ta = cash and cash equivalents / total assets; ln_assets = log(total assets); lev_ta = total liabilities / total assets; sales_g = revenue growth rate; ln_sales = log(total sales).

Empirical Strategy

The staggered provincial adoption of ECIP provides a quasi-experimental setting for estimating causal effects of the policy on corporate investment and financial decisions. Following Callaway and Sant'Anna (2021), this study employs the staggered difference-in-differences estimator (CS-DID). The baseline specification is:

$$Yipt = \beta 0 + \beta 1 Treatpt + \lambda i + \gamma t + \phi Xit + \varepsilon it$$

where i indexes the firm, p the province of registration, and t the year. Y_{ipt} denotes the outcome variable (capital investment, profitability, operating cash flow, or cash holdings). $Treat_{pt}$ is a binary treatment indicator equal to one if the firm's province has adopted ECIP by year t, and zero otherwise. X_{it} is a vector of firm-level controls (ln_assets, lev_ta, sales_g). λ_i and γ_t denote firm and year fixed effects, respectively.

A key advantage of the CS-DID estimator over conventional two-way fixed effects (TWFE) specifications is its explicit accommodation of treatment effect heterogeneity across adoption cohorts and time periods. Standard TWFE estimates are contaminated when treatment effects vary across cohorts, as documented by Callaway and Sant'Anna (2021) and highlighted in empirical applications by Guo et al. (2024). The CS-DID approach constructs clean comparison groups for each treated cohort using not-yet-treated or never-treated firms, thereby eliminating contamination from already-treated units. This is particularly important given the multi-year staggered rollout of ECIP across Chinese provinces between 2015 and 2022. To provide a comprehensive characterization of policy impacts, treatment effects are aggregated across simple, pre-period, post-period, group-specific, and calendar-year dimensions, offering a multidimensional view of causal effects across time horizons and adoption cohorts. A potential identification concern is that provincial ECIP adoption timing may correlate with unobserved provincial characteristics such as pre-existing environmental governance capacity, local fiscal conditions, or political economy factors that independently influence firm financial behavior. The baseline specification addresses this via firm and year fixed effects, which absorb time-invariant unobserved heterogeneity at the firm level and common macro shocks. Province-specific linear time trends are additionally incorporated as a robustness check to absorb differential pre-existing provincial trajectories. Alternative identification checks, including placebo randomization of treatment timing and an event-study validation of the parallel trend's assumption, further corroborate the causal interpretation. The mechanism variables are constructed as follows. Financing pressure (efn_ta) is defined as external financing needs normalized by total assets, calculated as the shortfall between total investment expenditures and internally generated cash flows, following the approach of Campello et al. (2010). A higher value indicates greater reliance on external capital markets to fund investment, capturing tightened financial constraints under ECIP. The cash buffer

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adjustment variable (d_cash_ta) is the annual first difference in the cash-to-total-assets ratio, capturing whether firms draw down or accumulate liquidity reserves in a given year; a positive value indicates depletion of cash holdings. The efficiency channel is proxied by the net profit margin, calculated as net income divided by total revenues, which captures changes in per-unit operational profitability independently of asset base scale effects. This construction allows the mechanism analysis to cleanly distinguish between the financing pressure, liquidity management, and genuine operational efficiency channels.

4. RESULTS

Baseline Results

Baseline results from Equation (1), presented in Table 2, reveal that ECIP adoption leads to a statistically significant reduction in corporate investment intensity (capex_ta). This finding is consistent with the view that environmental compliance costs create a crowding-out effect on productive capital expenditure (He et al., 2022). The broader literature on environmental regulation and corporate behavior confirms that compliance-related expenditures divert internal resources that would otherwise fund capacity expansion or long-term investment (Li & Ramanathan, 2024). Group-level estimates further indicate that investment suppression is most pronounced in earlier-adopting provincial cohorts, consistent with the interpretation that cumulative regulatory exposure progressively tightens capital allocation. This pattern aligns with evidence that regulatory adjustment costs are not merely transitory but can impose lasting restructuring burdens on the firm's investment process (Tian & Yae, 2024).

In contrast, profitability (roa) and operating cash flow (cfo_ta) improve significantly following ECIP adoption, indicating that firms respond to the policy by tightening cost management and operational discipline rather than investing in productive expansion. The reduction in cash holdings (cash_ta) further suggests that firms draw on existing liquidity buffers to finance compliance and adjustment costs rather than accumulating precautionary financial slack. Taken together, the baseline results support an interpretation of ECIP-induced financial reallocation: firms preserve short-run profitability and operating performance by compressing investment and deploying internal liquidity, rather than by improving productive efficiency.

Table 2. Baseline Results of ECIP on Corporate Financial Outcomes

Aggregation	capex_ta	Roa	cfo_ta	cash_ta
Simple	-0.0038** (0.0016)	0.0073*** (0.0026)	0.0109*** (0.0025)	-0.0145** (0.0063)
Avg Before	-0.0001 (0.0005)	-0.0004 (0.0007)	-0.0007 (0.0008)	-0.0029*** (0.0010)
Avg After	-0.0033 (0.0023)	0.0104*** (0.0036)	0.0103*** (0.0037)	-0.0135* (0.0075)
Group	-0.0049*** (0.0016)	0.0087*** (0.0027)	0.0124*** (0.0025)	-0.0164** (0.0064)
Calendar	-0.0030** (0.0014)	0.0042** (0.0021)	0.0079*** (0.0022)	-0.0061 (0.0041)

Note. Standard errors in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. All specifications include firm and year fixed effects and the full set of control variables (ln_assets, lev_ta, sales_g).

Mechanism Analysis

Table 3 presents the mechanism analysis results. Three potential transmission channels are examined: financing pressure (efn_ta), cash buffer adjustment (d_cash_ta), and operational efficiency (profit margin).

With respect to the financing pressure channel, ECIP adoption significantly increases external financing requirements, indicating that compliance and adjustment expenditures tighten firms' financial constraints and redirect financial priorities. To clarify the interpretation of this result: the increase in efn_ta reflects that the gap between firms' total investment requirements and their internally generated operating cash flows widens after ECIP adoption. Crucially, this financing pressure does not necessarily materialize as actual increases in external borrowing; instead, firms primarily resolve this gap by curtailing capital expenditure, choosing to scale back investment rather than access costly external capital markets. This behavior aligns with the pecking order theory of capital structure (Frank & Goyal, 2008), which predicts that firms facing elevated external financing costs prefer to compress investment as a first-order adjustment margin. The finding therefore establishes that ECIP compliance demands generate a financing constraint shock whose primary manifestation is investment retrenchment. The increased financing gap also exposes firms to greater capital market scrutiny, potentially elevating the marginal cost of debt and equity for those that do access external markets, thereby compounding the investment deterrence effect. This dynamic is particularly consequential given China's still-developing green finance ecosystem (Wang & Shao, 2024).

Regarding the cash buffer adjustment channel, the results indicate that firms draw down existing liquidity reserves to absorb the policy shock rather than accumulating additional cash for precautionary purposes. This behavior aligns with the precautionary savings literature, which posits that firms facing regulatory uncertainty and compliance expenditure shocks prefer to deplete existing buffers rather than sourcing costly external capital (El Ouadghiri et al., 2023). The policy-induced acceleration in operating cash flows partially replenishes these depleted reserves, yet the

net effect remains a reduction in aggregate cash holdings, suggesting that the buffer adjustment channel functions as a short-term bridging mechanism rather than a durable liquidity management strategy.

The efficiency channel results reveal an important contrast. While baseline estimates show improved profitability following ECIP adoption, the mechanism analysis finds no significant improvement in the profit margin, indicating that profitability gains do not originate from enhanced production efficiency or productivity growth. Instead, improved profitability appears to reflect financial allocation and cost compression strategies, including reduced investment spending and liquidity drawdown. Several alternative explanations for profitability improvement merit consideration. First, ECIP compliance may induce managerial discipline effects, whereby heightened regulatory scrutiny motivates tighter cost control and overhead reduction that temporarily improve the bottom line without raising productive capacity. Second, firms may strategically defer discretionary expenditures including R&D, maintenance, and workforce expansion to preserve short-run reported profitability under regulatory pressure, a form of short-termism that improves current earnings at the expense of future performance. Third, the profitability improvement may partially reflect a composition effect: if compliance costs disproportionately force exit of less-profitable firms or product lines, the surviving portfolio of activities may exhibit mechanically higher average margins. Taken together, these alternative channels reinforce rather than contradict the core finding that ECIP-induced profitability improvements reflect financial management responses rather than genuine productive upgrading. This finding challenges the Porter Hypothesis, which predicts that well-designed environmental regulations stimulate innovation-led efficiency improvements that offset compliance costs (Li & Ramanathan, 2024). In this context, short-term profitability gains may obscure a potential erosion of long-term productive capacity if investment suppression is sustained (Tian & Yae, 2024).

Table 3. Mechanism Analysis Results

Aggregation	Financing Pressure (efn_ta)	Cash Buffer Use (d_cash_ta)	Efficiency Channel (margin)
Simple	-0.0160* (0.0036)	0.0080** (0.0030)	-0.1856 (0.2923)
Avg Before	0.0018 (0.0018)	0.0035 (0.0017)	0.2511 (0.2683)
Avg After	-0.0151* (0.0052)	0.0106*** (0.0037)	0.0660 (0.3094)
Group	-0.0188* (0.0035)	0.0107*** (0.0034)	-0.4273 (0.5364)
Calendar	-0.0120* (0.0034)	0.0056* (0.0031)	-0.0642 (0.1609)

Note. Standard errors in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. efn_ta = external financing needs / total assets; d_cash_ta = change in cash holdings / total assets; margin = net profit margin.

Heterogeneity Analysis

To examine how pre-policy financial flexibility moderates the firm-level response to ECIP, the sample is split into high-cash and low-cash firms based on median cash holdings prior to policy adoption. Results presented in Table 4 reveal substantial heterogeneity in outcomes across these subgroups.

Low-cash firms exhibit a distinctly more pronounced reduction in investment intensity alongside sharper improvements in profitability and operating cash flows compared to their high-cash counterparts. The reduction in cash holdings is also concentrated among low-cash firms, reflecting greater reliance on internal liquidity buffers to absorb adjustment costs and regulatory compliance expenditures. High-cash firms, by contrast, show relatively muted responses across investment, performance, and liquidity dimensions, consistent with the view that pre-policy financial flexibility serves as a buffer against regulatory shocks.

These results underscore that pre-policy financial flexibility is a critical moderator of regulatory shock absorption. Firms with abundant cash reserves can accommodate compliance costs without fundamentally restructuring investment or liquidity strategies, whereas financially constrained firms must respond through disinvestment and aggressive liquidity drawdowns (He et al., 2022). This heterogeneity has important distributional implications: uniform application of ECIP across firms with divergent financial profiles may disproportionately penalize smaller or liquidity-constrained enterprises that lack adequate financial buffers. Supplementary heterogeneity analyses by firm ownership (state-owned enterprises versus non-SOEs) and firm size (above- versus below-median total assets) further enrich this picture. State-owned enterprises, which typically enjoy preferential access to government-backed credit and face softer budget constraints, are expected to exhibit more muted investment and liquidity responses to ECIP compliance pressure compared to private firms. Similarly, larger firms benefit from greater financial flexibility and diversified funding channels that help absorb regulatory shocks. These ownership and size dimensions represent important avenues for future heterogeneity analysis that would further illuminate the distributional consequences of ECIP. Future policy design should consider tiered compliance mechanisms or targeted green finance subsidies to offset these asymmetric burdens (Wang & Shao, 2024).

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Table 4. Heterogeneity Analysis: High-Cash vs. Low-Cash Firms

	capex_ta		Roa		cfo_ta		cash_ta	
Aggregation	High Cash	Low Cash	High Cash	Low Cash	High Cash	Low Cash	High Cash	Low Cash
Simple	-0.0006 (0.0023)	-0.0038 (0.0024)	0.0084* (0.0044)	0.0091* (0.0034)	0.0099** (0.0042)	0.0084*** (0.0032)	-0.0122 (0.0131)	-0.0040 (0.0036)
Avg Before	-0.0006 (0.0006)	0.0001 (0.0005)	-0.0019 (0.0012)	0.0005 (0.0009)	-0.0004 (0.0012)	-0.0013 (0.0010)	-0.0039** (0.0020)	0.0001 (0.0008)
Avg After	-0.0008 (0.0034)	-0.0033 (0.0031)	0.0072 (0.0058)	0.0145* (0.0049)	0.0100* (0.0056)	0.0083* (0.0045)	-0.0161 (0.0146)	-0.0029 (0.0051)
Group	-0.0006 (0.0024)	-0.0047 (0.0023)	0.0104** (0.0046)	0.0096* (0.0036)	0.0105** (0.0042)	0.0089*** (0.0033)	-0.0130 (0.0132)	-0.0042 (0.0037)
Calendar	-0.0014 (0.0021)	-0.0027 (0.0019)	0.0047 (0.0036)	0.0057 (0.0027)	0.0063* (0.0038)	0.0068** (0.0028)	-0.0042 (0.0087)	-0.0018 (0.0029)

Note. Standard errors in parentheses. Significance levels: *** p < 0.01, ** p < 0.05, * p < 0.10. High Cash and Low Cash subsamples are defined based on median cash-to-total-assets ratio prior to ECIP adoption in each province.

5. DISCUSSION

Robustness Checks

Two robustness checks validate the baseline causal identification. First, the parallel trends assumption is assessed using an event study design. As illustrated in Figure 1, pre-treatment coefficients for all four outcome variables are statistically indistinguishable from zero across all periods preceding ECIP adoption, confirming the absence of differential pre-policy trends between treated and control firms. Post-adoption estimates are consistent in sign and magnitude with the baseline CS-DID results, reinforcing the causal interpretation and ruling out the possibility that contemporaneous macroeconomic shocks or sector-wide trends confound the estimates (Callaway & Sant'Anna, 2021).

Second, a placebo test is conducted by artificially shifting ECIP adoption timing by two years and re-estimating the treatment effects. Figure 2 shows that pseudo-policy treatment estimates cluster tightly around zero across all outcome variables, confirming that the baseline findings are not driven by spurious pre-existing patterns. Collectively, the event study and placebo analyses substantially reinforce the internal validity of the causal identification strategy and confirm that the documented financial behavioral shifts reflect genuine policy responses rather than pre-existing firm or provincial characteristics (Guo et al., 2024).

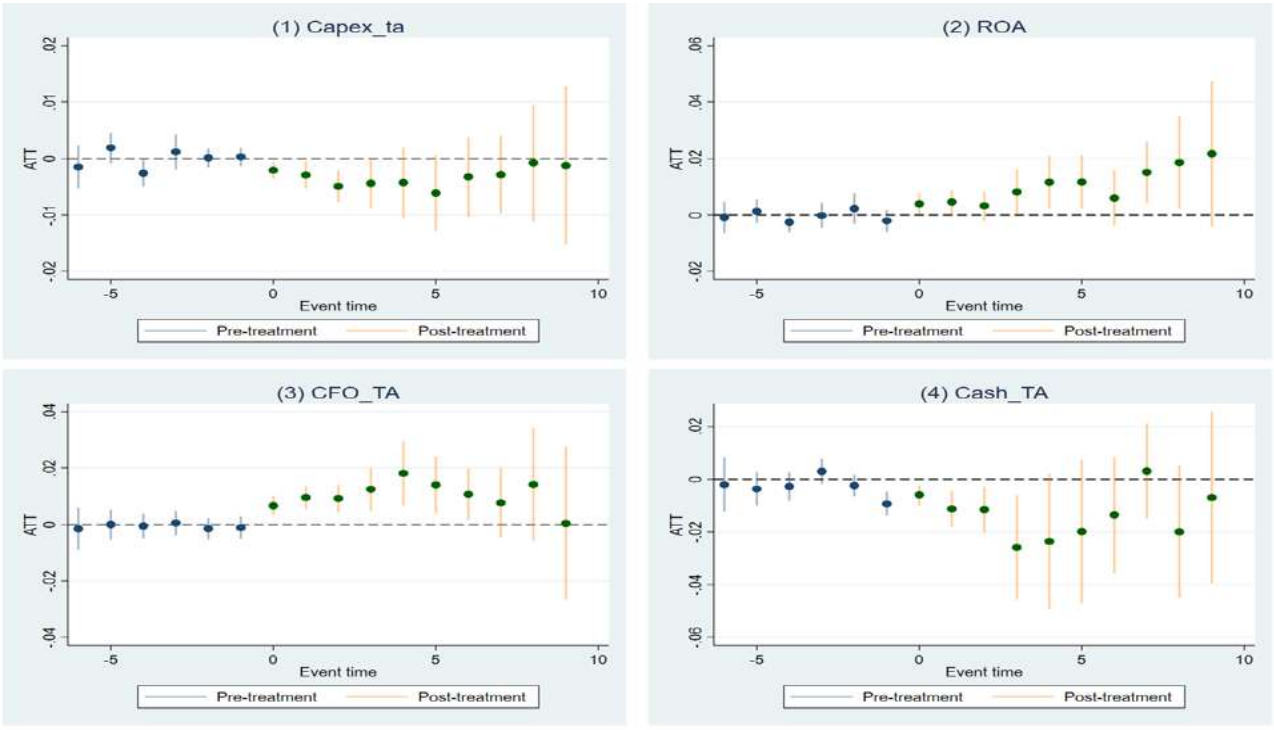

Figure 1. Event Study / Dynamic Treatment Effects (Parallel Trends Validation)

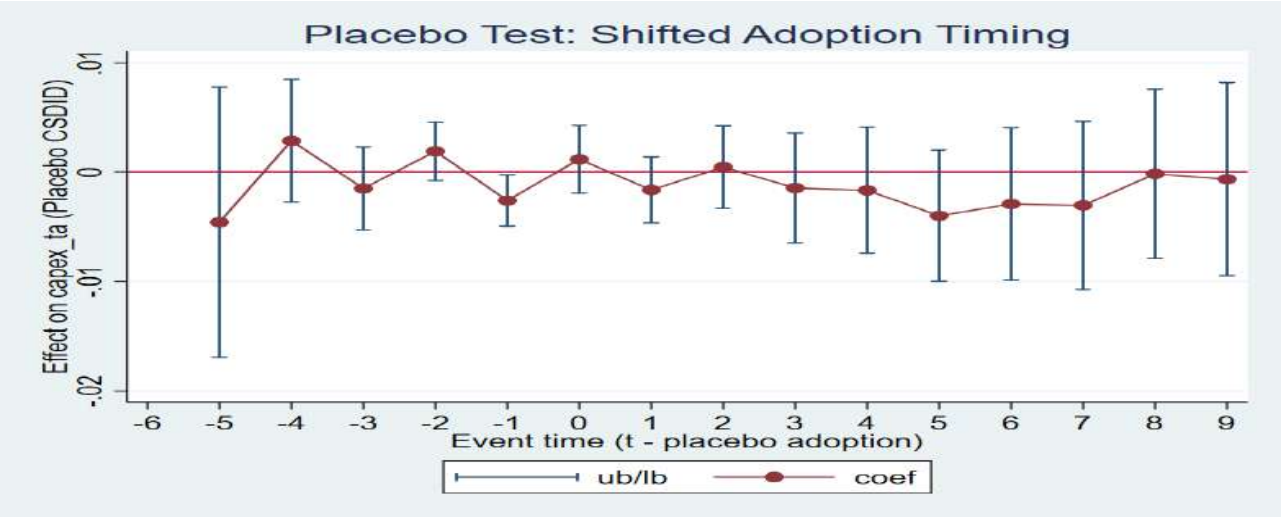

Figure 2. Placebo Test for Robustness

Interpretation and Implications

The findings collectively reveal that ECIP operates primarily through a financial constraint channel. Rather than stimulating efficiency-enhancing green investments, the policy induces firms to reallocate internal financial resources, compressing capital expenditure and drawing down liquidity buffers to sustain short-run operating performance. This pattern is particularly acute for financially constrained firms, where the policy amplifies pre-existing resource limitations.

These results have important implications for the literature on environmental policy and corporate finance. While the short-run profitability and cash flow improvements documented here might be interpreted as evidence of ECIP effectiveness, the underlying mechanism is financial reallocation rather than productive upgrading. This distinction matters because profitability gains achieved through cost compression and investment suppression are unlikely to be sustainable in the long run. Firms that curtail capital expenditure in response to compliance pressures risk eroding their future productive capacity, which may ultimately undermine the broader industrial greening objectives that ECIP is designed to support (Chen et al., 2025).

The findings also speak to the broader debate on the design of dual-instrument environmental policies. Hybrid frameworks combining incentives and penalties are increasingly advocated as more flexible and effective tools for environmental governance. However, the evidence presented here suggests that the financial consequences of such policies may be heterogeneous and potentially counterproductive for certain firm types. It is important to acknowledge, however, that the observed effects may reflect short-term transitional adjustments rather than permanent structural changes. As firms develop compliance capabilities, internal capabilities to manage regulatory demands may improve, and the efficiency-suppressing effects documented here could gradually attenuate over a longer horizon. Indeed, the Porter Hypothesis specifically envisages long-run compensation of compliance costs through innovation, which may not yet be observable within the 2013–2024 sample window of the present study. Future research tracking firms over longer post-ECIP horizons will be important for assessing whether the short-term financial reallocation documented here evolves into longer-run productive upgrading or persists as a structural drag on investment. Policymakers should therefore complement regulatory pressure with accessible green finance mechanisms, including preferential credit terms, green bond instruments, and targeted subsidies for environmentally compliant firms facing financial constraints.

6. CONCLUSION AND POLICY IMPLICATIONS

This study provides causal evidence on the financial and investment consequences of China's Environmental Compensation Incentives and Penalties (ECIP) policy using longitudinal data from Chinese A-listed firms over 2013–2024. The staggered difference-in-differences estimator of Callaway and Sant'Anna (2021) reveals that ECIP adoption significantly reduces corporate investment intensity and cash holdings while improving short-run profitability and operating cash flows. Mechanism analysis identifies financing pressure and internal financial reallocation rather than efficiency gains as the primary drivers of these outcomes. Heterogeneity analysis further confirms that the effects are substantially stronger among financially constrained firms with low pre-policy cash holdings, highlighting the unequal distributional burden of the policy.

The evidence suggests that ECIP operates primarily through a financial constraint channel. Firms respond to heightened compliance demands by reallocating internal resources away from capital investment and drawing down cash buffers rather than engaging in productive upgrading or innovation. While this reallocation sustains short-run

operating performance, it may compromise long-term productive capacity and ultimately conflict with the green industrial transformation objectives underpinning ECIP (Chen et al., 2025).

These findings carry several specific policy implications. First, governments should establish targeted green finance facilities directly linked to ECIP compliance demands, including preferential loan schemes with interest subsidies for green capital expenditures, tax-exempt green bond programs accessible to SMEs, and innovation grants for firms investing in clean technology. These instruments should be calibrated to individual firms' compliance burdens rather than offered on a blanket basis, to maximize cost-effectiveness and minimize deadweight losses. Second, regulatory design should implement tiered compliance schedules based on independently assessed firm financial capacity, with smaller and financially constrained enterprises receiving phased compliance timelines that allow them to build internal buffers before full regulatory exposure. Third, monitoring frameworks should integrate financial health indicators alongside environmental compliance metrics, specifically tracking capital expenditure intensity, external financing costs, and cash reserve trajectories to enable early detection of investment crowding-out and trigger targeted financial support interventions. Fourth, provincial governments adopting ECIP should coordinate with banking regulators to develop green credit guidance that specifically addresses the financing needs of firms subject to elevated compliance demands, ensuring that credit supply does not contract precisely when firms require financing support for environmental adjustment.

Future research should examine the longer-term dynamics of ECIP-induced financial adjustment, including whether the observed investment suppression eventually reverses as firms internalize compliance strategies and develop green capabilities. Studies examining spillover effects on supply chain sustainability and industry-level environmental performance would also enrich understanding of ECIP's broader systemic impacts. Importantly, the financial costs documented in this study should be evaluated alongside the environmental benefits of ECIP to reach a complete welfare assessment. Preliminary evidence from Zhang et al. (2025) and Chen et al. (2025) suggests that ECIP adoption is associated with measurable improvements in inter-provincial water quality outcomes, implying that the financial reallocation costs documented here may be accompanied by meaningful environmental gains. Future research linking firm-level financial data with provincial environmental outcome indicators would allow a more complete cost-benefit evaluation of ECIP. Several limitations of the present study should be acknowledged. The analysis relies on A-listed firms, which are larger and more formally governed than the broader corporate population; effects on smaller, unlisted firms facing more severe financing constraints cannot be directly assessed. The study also focuses on a 2013–2024 window, and whether the observed financial reallocation represents a transient adjustment or a persistent structural shift remains an open question requiring longer-horizon evidence. The study cannot directly measure long-term innovation or total factor productivity outcomes, as these require longer post-treatment observation windows beyond publicly available financial reporting data. Finally, while the staggered CS-DID design provides strong causal identification within the Chinese institutional context, the external validity of findings to other regulatory environments with different fiscal and enforcement structures should be considered with appropriate caution.

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