Compliance or Profit? Decomposing Green Investment and Firm Performance

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Abstract*—Green investment is often treated as a single aggregate measure, which can obscure whether firms are building underlying capabilities or primarily paying for compliance. This paper proposes a dictionary-based textual measure that extracts and decomposes capitalized environmental expenditures disclosed by Chinese A-share firms from 2018 to 2023 into pollution-prevention and pollution-control investments. The measure is constructed by mapping investment-related disclosure text to these categories, retaining only capitalized environmental expenditures and aggregating them to the firm-year level. Using panel regressions with industry and year as fixed effects, we find that total green investment is positively associated with contemporaneous profitability. When decomposed, both prevention-oriented and control-oriented investments are significantly associated with better environmental performance. The decomposition yields an important insight: prevention-oriented investment exhibits a stronger association with both environmental and financial performance, consistent with efficiency and capability-building channels. These findings are associative rather than strictly causal. This pattern suggests that, in China's regulatory and policy environment, compliance-oriented spending can generate near-term financial benefits through lower expected enforcement costs and disruption risk, greater access to policy-linked subsidies or financing, and stronger signals of regulatory credibility that ease financing frictions. Results are robust across alternative specifications and policy-based analyses. Overall, the study shows that measurement choice matters. Moving from an aggregate measure to a decomposition into investment types leads to different conclusions and provides a practical way to evaluate green investment portfolios and inform policy design. More broadly, the approach offers a measurement framework that can be extended to international settings with comparable corporate disclosure regimes.

***Keywords*—Green investment, dictionary-based textual analysis, firm performance, disclosure of environmental protection, regulatory environment.**

I. Introduction

Environmental constraints increasingly shape how firms define responsibility and strategy. The World Commission on Environment and Development (WCED) defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs," implying that economic activity must operate within environmental limits [1]. In this context, corporate social responsibility has shifted toward a stakeholder-oriented view in which firms are expected to internalize part of the social and environmental costs they generate [2]. Corporate green investment, environmental capital expenditures intended to deliver both environmental and economic benefits, is a concrete manifestation of this shift [3]. However, prior research reports mixed performance consequences, suggesting that measurement and investment composition may be central to inference.

This question is especially salient in China, where climate and local pollution pressures have intensified regulatory and stakeholder demands for a low-carbon transition. As firms face increasing pressure to upgrade processes and invest in environmental initiatives, it remains unclear whether such spending serves primarily as a compliance cost or also delivers operational and strategic benefits.

Using Chinese A-share listed firms from 2018 to 2023, this study examines total green investment (GI) and its decomposition into pollution-prevention investment (GPI) and pollution-control investment (GTI), consistent with the preventive versus remedial spending framework in prior domestic work [4]. Prevention includes process/product redesign, cleaner inputs, and on-site efficiency upgrades, while control captures end-of-pipe equipment such as filters and wastewater treatment units. The empirical tests compare how these two components relate to environmental performance (EP) and financial performance, and further examine whether EP mediates the investment–performance link and whether innovation input, measured as research and development intensity (RD), moderates firms' ability to convert GI into performance improvements.

II. Conceptual Framework and Hypothesis Development

A. Green Investment: Concept and Typology

Green investment refers to firm-level environmental capital expenditures that aim to improve environmental outcomes through tangible projects, including cleaner production assets and pollution abatement equipment [3]. Prior studies often measure green investment as a single aggregate. This approach can mask heterogeneity because different projects follow different economic logics and entail different timing of costs and benefits.

This study distinguishes two components of green investment identified in prior work: GPI and GTI. GPI focuses on source reduction through process redesign and efficiency improvement. It is closely linked to capability building because it can shift the production frontier and generate persistent cost savings. GTI focuses on end-of-pipe treatment and compliance with current standards. It is primarily associated with risk mitigation, as it reduces expected penalties and regulatory exposure without necessarily improving core production efficiency [4]. Recent macro-level evidence confirms that the distinction between prevention and control spending matters for understanding policy effects [5].

This decomposition helps explain why the same level of total GI can be associated with different performance outcomes across firms. At the macro level, additional evidence suggests that green capital accumulation interacts with public R&D to enhance productivity, highlighting the importance of measurement granularity [6].

B. Green Investment and Environmental Performance

Green investment is intended to improve environmental outcomes. Pollution prevention investment addresses emissions at the source through changes in inputs and production processes, whereas pollution control investment reduces realized violations by expanding treatment capacity and strengthening compliance execution. Both channels are therefore expected to enhance environmental performance, particularly when it is proxied by fewer environmental violations [7].

H1: *Green investment is positively associated with environmental performance.*

C. Green Investment and Financial Performance

The financial implications of green investment are ambiguous in aggregate because pollution prevention and pollution control investments involve different cost–benefit profiles. Pollution control investment is primarily compliance-oriented and is associated with higher capital intensity, depreciation, and operating costs. As a result, its short-run financial impact can be negative when cost burdens dominate efficiency gains [8]. However, such investments may still generate financial benefits by reducing expected penalties, mitigating disruption risk, and improving firms' regulatory standing.

In contrast, pollution prevention investment is more closely linked to efficiency improvement and capability accumulation. By upgrading production processes and reducing resource intensity, such investments can lower operating costs and enhance productivity. Environmental pressure may also stimulate innovation that offsets compliance costs and improves competitiveness [9], [10]. Recent evidence from China's environmental protection tax reform supports this mechanism, showing that well-designed environmental regulation can simultaneously improve green total factor productivity and stimulate innovation [11], [12]. Over time, environmental technologies and routines can become valuable and difficult to imitate resources, supporting sustained competitive advantage [13].

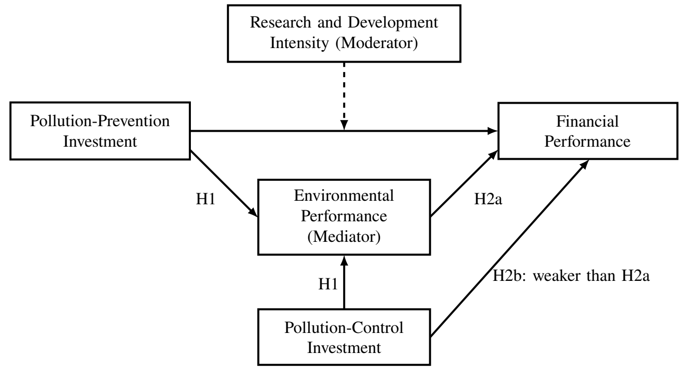

Fig. 1. Research framework and hypotheses.

Prior evidence suggests that prevention-oriented investments are more strongly associated with financial performance than control-oriented investments [14].

H2a: *Pollution prevention investment is positively associated with financial performance.*

H2b: *Pollution control investment is associated with financial performance, but the association is expected to be weaker and less robust than the association for pollution prevention investment.*

D. Mediating and Moderating Mechanisms

Environmental performance can mediate the effect of green investment on financial performance. Better environmental performance reduces regulatory exposure and can strengthen stakeholder support. This logic aligns with stakeholder theory and with prior evidence linking environmental performance to economic outcomes [2], [15].

H3: *Environmental performance can mediate the relationship between green investment and financial performance.*

Innovation capability is an important boundary condition for the performance effects of pollution prevention investment. Prevention-type projects often require technical adaptation and integration with existing production systems. Firms with higher research and development intensity are more likely to generate complementary innovations that convert prevention-type investment into efficiency gains and competitive advantage [16].

H4: *The relationship between aggregate green investment and financial performance depends on firms' innovation input. Competing mechanisms, including complementarity and crowding-out, make the direction an empirical question.*

Fig. 1 presents the conceptual framework and summarizes the hypothesized relationships among the study variables.

III. Research Design

A. Sample Selection and Data Sources

This study examines how green investment affects corporate environmental and financial performance among A-share listed firms from 2018–2023. The sample period reflects a policy phase in which China strengthened the institutional basis for environmental compliance and green finance: the Environmental Protection Tax Law was adopted in 2016, implementation regulations were issued in 2017, and ecological civilization was incorporated into the constitutional framework through the 2018 constitutional amendment [17]–[19]. During this period, corporate environmental capital expenditures became more standardized and comparable.

Financial and governance data are obtained from the China Stock Market and Accounting Research (CSMAR) database. Firms designated as ST or *ST (special-treatment status for financially distressed or otherwise abnormal firms), as well as observations with missing key variables, are excluded. To mitigate the influence of outliers, continuous variables are winsorized at the 1% tails. The final sample consists of 1,214 firm–year observations.

B. Measurement

Table I defines all variables used in the empirical tests. GI is measured using a dictionary-based classification approach applied to itemized environmental investment records from the CSMAR environmental performance detail database. These records are extracted by CSMAR from firms' annual-report disclosures and provide transaction-level descriptions of environmental investment items. Investment items are mapped to pollution-prevention and pollution-control categories and then aggregated to the firm-year level. Monetary measures of investment are transformed as $\ln(1 + \textit{amount})$ to reduce skewness, and expensed items such as fines and penalties are excluded from the investment measure.

Fig. 2 summarizes the measurement procedure. Specifically, the analysis starts from CSMAR's item-level environmental investment detail records, which provide transaction-level descriptions of environmental investment activities. A dictionary-based classification approach is then applied to these records. The dictionary is constructed from domain-specific environmental investment terminology drawn from prior literature and regulatory classifications, and it separates GPI and GTI categories. Each investment item is classified using keyword-based matching rules: descriptions containing prevention-related terms (e.g., process upgrades, cleaner production, resource efficiency) are assigned to GPI, whereas those referring to end-of-pipe treatment or compliance equipment (e.g., filtration, wastewater treatment) are assigned to GTI.

C. Model Specification

Let $\mathbf{X}_{i,t}$ denote the control variables, including Tobin's Q (TobinQ), leverage (Lev), ownership concentration (Top10), and firm growth (Growth). All models include industry and year fixed effects.

1) Main Effects: Financial performance is measured using return on assets (ROA) and, in decomposed specifications, return on equity (ROE). Equation (1) examines the effect of aggregate green investment on ROA. Because the decomposed specification in (2) separates GPI and GTI, we use ROE as the dependent variable to capture both operating efficiency and the leverage channel through which green investment may affect shareholder returns; ROA-based results are qualitatively similar and reported in Section V. Equations (3)–(4) test effects on EP.

$$ROA_{i,t} = \beta_0 + \beta_1 GI_{i,t} + \boldsymbol{\beta}'\mathbf{X}_{i,t} + \mu_j + \tau_t + \varepsilon_{i,t} \quad (1)$$

$$ROE_{i,t} = \beta_0 + \beta_1 GPI_{i,t} + \beta_2 GTI_{i,t} + \boldsymbol{\beta}'\mathbf{X}_{i,t} + \mu_j + \tau_t + \varepsilon_{i,t} \quad (2)$$

$$EP_{i,t} = \alpha_0 + \alpha_1 GI_{i,t} + \boldsymbol{\alpha}'\mathbf{X}_{i,t} + \mu_j + \tau_t + u_{i,t} \quad (3)$$

$$EP_{i,t} = \alpha_0 + \alpha_1 GPI_{i,t} + \alpha_2 GTI_{i,t} + \boldsymbol{\alpha}'\mathbf{X}_{i,t} + \mu_j + \tau_t + u_{i,t} \quad (4)$$

2) Mediation and Moderation: Equation (5) tests whether environmental performance mediates the green investment–ROA link. (6)–(7) test moderation by R&D intensity using mean-centered values.

$$ROA_{i,t} = \theta_0 + \theta_1 GI_{i,t} + \theta_2 EP_{i,t} + \boldsymbol{\theta}'\mathbf{X}_{i,t} + \mu_j + \tau_t + e_{i,t} \quad (5)$$

$$ROA_{i,t} = \gamma_0 + \gamma_1 \widetilde{GI}_{i,t} + \gamma_2 \widetilde{RD}_{i,t} + \gamma_3 (\widetilde{GI}_{i,t} \times \widetilde{RD}_{i,t}) + \boldsymbol{\gamma}'\mathbf{X}_{i,t} + \mu_j + \tau_t + \xi_{i,t} \quad (6)$$

$$EP_{i,t} = \delta_0 + \delta_1 \widetilde{GI}_{i,t} + \delta_2 \widetilde{RD}_{i,t} + \delta_3 (\widetilde{GI}_{i,t} \times \widetilde{RD}_{i,t}) + \boldsymbol{\delta}'\mathbf{X}_{i,t} + \mu_j + \tau_t + \nu_{i,t} \quad (7)$$

IV. Main Regression Results

A. Baseline Effects

Column (1) of Table II, corresponding to (1), shows a positive and statistically significant association between aggregate GI and contemporaneous profitability ($\beta_1 = 0.0015$, $t = 2.04$, $p < 0.05$), corresponding to a 0.15 percentage point increase in ROA. This estimate is correlational, but the positive sign is consistent with a setting in which environmental capex can reduce expected compliance costs and frictions in the near term, including lower enforcement risk and penalties and easier access to policy-linked financing. Throughout the discussion, significance levels follow the convention defined in the notes to Table II. Control variables behave as expected: leverage is strongly negative, and Tobin's Q is positive.

B. Mediation Analysis

Columns (2)–(3) of Table II, corresponding to (3) and (5), test whether environmental performance mediates the GI–ROA link. The point estimates are positive but not statistically strong: GI is weakly associated with EP ($\alpha_1 = 0.027$, $t = 1.05$), and EP is weakly associated with ROA conditional on GI ($\theta_2 = 0.0009$, $t = 1.11$). The GI coefficient decreases slightly from 0.0015 to 0.0014 when EP is included, but the Sobel test is not significant. Overall, neither path reaches conventional significance, so the mediation channel is not supported in this sample; other channels likely operate alongside environmental improvements not captured by EP.

TABLE I
VARIABLE DEFINITIONS

Type	Variable	Symbol	Definition	Construction and transformation
Dependent	Financial performance	ROA	Net profit (TTM) divided by average total assets	Level ratio
Dependent	Environmental performance	EP	Environmental score from Wind's environmental, social, and governance (ESG) ratings; higher values indicate better environmental performance	Continuous score from 1 to 10
Key independent	Total green investment	GI	Firm-year total green investment identified from corporate disclosures using a dictionary-based text approach	Aggregated amount, $\ln(1+amount)$
Key independent	Pollution control investment	GTI	Firm-year green investment mapped to pollution control keywords, reflecting end-of-pipe treatment and compliance-oriented capital expenditure	Aggregated amount, $\ln(1+amount)$
Key independent	Pollution prevention investment	GPI	Firm-year green investment mapped to pollution prevention keywords, reflecting source reduction, process upgrade, and efficiency-oriented capital expenditure	Aggregated amount, $\ln(1+amount)$
Mediator	Environmental performance	EP	Same as dependent environmental performance measure	Wind E-score (1 to 10)
Moderator	Research and development intensity	RD	Firm-year R&D expenditure used to proxy innovation input	$\ln(1 + amount)$
Controls	Investment opportunities	TobinQ	Market value divided by replacement cost	$\ln(TobinQ)$
Controls	Financial leverage	Lev	Total liabilities divided by total assets	Level ratio
Controls	Ownership concentration	Top10	Shareholding ratio of the top 10 shareholders	Level ratio
Controls	Firm growth	Growth	Revenue growth rate	(Total Revenue Current Year – Total Revenue Last Year) / Total Revenue Last Year
Fixed effects	Year	YearFE	Year indicator variables	Included in all models
Fixed effects	Industry	IndustryFE	Industry indicator variables	Included in all models

Notes: Monetary investment variables are constructed from disclosure text mapped by the dictionary and aggregated to firm-year totals. Only capitalized environmental investment items are retained, while expensed items such as fines and penalties are excluded. Continuous variables are winsorized at the 1% tails.

C. Disaggregated Effects

Columns (4)–(5) of Table II, corresponding to (4) and (2), decompose the effects of GI on EP and ROE, respectively. As shown in Table II and illustrated in Fig. 3, both prevention-oriented and control-oriented investments are positively and significantly associated with environmental performance. Prevention-oriented investment (GPI: $\alpha_1 = 0.055$, $p < 0.01$) exhibits a stronger association than control-oriented investment (GTI: $\alpha_2 = 0.045$, $p < 0.05$), supporting H1 and indicating that prevention investment, which targets source reduction and process redesign, yields a larger environmental benefit than end-of-pipe compliance equipment.

Column (5) confirms that this pattern extends to financial performance. Using ROE as the dependent variable, prevention-oriented investment (GPI: $\beta_1 = 0.0039$, $p < 0.01$) exhibits a stronger association than control-oriented investment (GTI: $\beta_2 = 0.0034$, $p < 0.05$), supporting H2a and offering qualified support for H2b.

The positive and significant GTI coefficient is noteworthy because it runs against a pure "compliance cost" view. A plausible interpretation is that, in this setting, control-oriented investment can generate near-term benefits through three complementary channels:

- *Penalty avoidance and disruption risk reduction:* compliance investments reduce expected enforcement costs (e.g., fines, production suspensions, remediation orders) and lower the risk of operational disruptions.
- *Policy-linked transfers and financing access:* such investments may qualify for subsidies, tax incentives, or green credit, partially offsetting costs and easing short-term financing constraints.
- *Compliance signaling:* visible control investments signal lower regulatory risk to lenders and counterparties, which can improve financing terms.

Taken together, the decomposition provides consistent evidence across both environmental and financial outcomes: prevention-oriented investment outperforms control-oriented investment, but GTI does not appear to function as a "pure cost" in the observed data.

D. R&D Moderation and Crowding-Out

Column (6) of Table II, corresponding to (6), examines whether innovation input changes the GI–ROA association. The interaction term is negative but not statistically significant (RD×GI: -0.0001, $t = -1.36$), providing no support for an enhancing role of R&D (H4 is not supported in this sample).

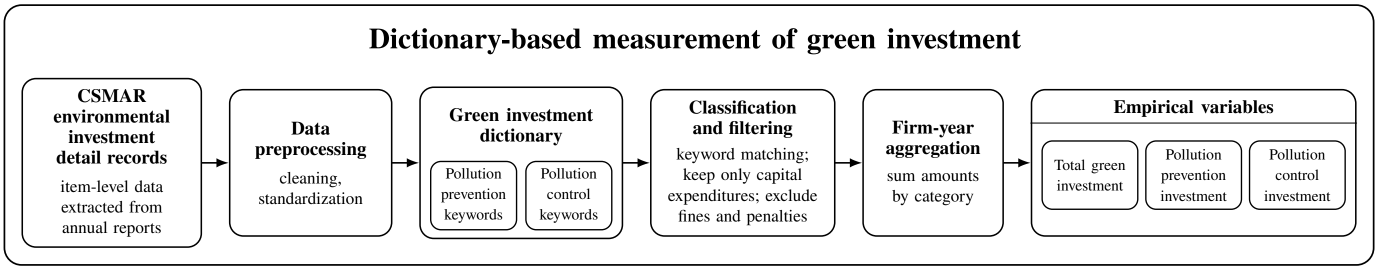

Fig. 2. Dictionary-based measurement of green investment. The procedure begins with itemized environmental investment records from the CSMAR environmental performance detail database, which are extracted from firms' annual-report disclosures. These records are then cleaned and standardized, classified using a dictionary that separates GPI and GTI items, filtered to retain only capitalized environmental expenditures, and aggregated to firm-year measures.

TABLE II
Comprehensive Regression Results

	(1) ROA	(2) EP	(3) ROA	(4) EP	(5) ROE	(6) ROA
GI (ln)	0.0015^{**}	0.027	0.0014^{**}			0.0024^{**}
	(2.04)	(1.05)	(2.00)			(2.45)
GPI (ln)				0.055^{***}	0.0039^{***}	
				(2.61)	(2.73)	
GTI (ln)				0.045^{**}	0.0034^{**}	
				(2.21)	(2.52)	
EP			0.0009			
			(1.11)			
RD (ln)						0.0009
						(1.54)
RD×GI						-0.0001
						(-1.36)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	1,214	1,214	1,214	1,214	1,212	1,214
Adj_R^2	0.297	0.161	0.297	0.165	0.137	0.297

Notes: t-statistics are reported in parentheses. Statistical significance is indicated by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$. All models include control variables (Lev, Top10, Growth, TobinQ) as well as industry and year fixed effects. Robust standard errors are clustered at the firm level. Column (5) uses ROE as the dependent variable to test the decomposed financial performance effect.

A plausible interpretation is resource crowding-out: when firms simultaneously commit to high R&D intensity and green capex, they may face binding financial or managerial constraints in the short run, which dampens the contemporaneous profitability gains associated with GI. This finding is consistent with recent evidence that environmental tax burdens can crowd out other productive investments in the short run [20].

V. Robustness Checks

A. Temporal Dynamics

Fig. 4 summarizes lagged responses across accounting- and market-based outcomes. Effects are strongest at the one-year lag and attenuate thereafter, consistent with benefits that emerge with a delay and weaken in the absence of sustained investment.

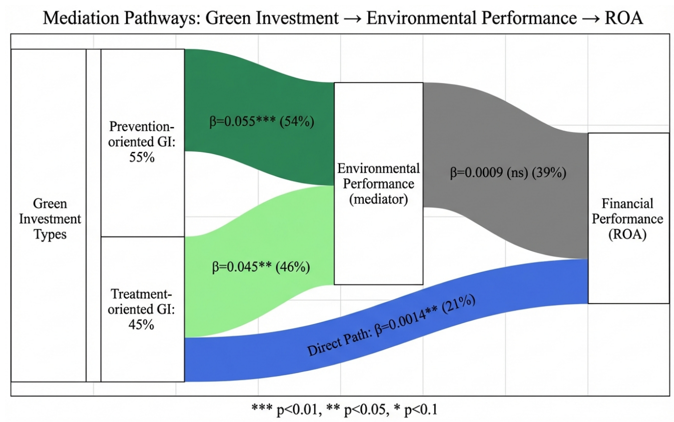

Fig. 3. Mediation mechanism: Decomposed green investment effects on environmental performance and the investment–profitability link. Prevention-oriented investment (GPI, 55% share, $\alpha = 0.055$, significant at the 1% level) exhibits a stronger environmental performance effect than control-oriented investment (GTI, 45% share, $\alpha = 0.045$, significant at the 5% level). Environmental performance as a mediator is not statistically significant ($\beta = 0.0009$), while the direct path from GI to ROA remains positive ($\beta = 0.0014$, significant at the 5% level).

B. Alternative Specifications and Policy Heterogeneity

Results are qualitatively unchanged when using alternative performance measures (e.g., ROE, Tobin's Q) and when restricting the sample window or excluding atypical years; the baseline positive association between GI and financial performance remains the central pattern. Across alternative specifications, lag structures, and subsamples, the main findings remain qualitatively unchanged, with prevention-oriented investment continuing to outperform control-oriented investment. Consistent with these findings, Fig. 5 shows a post-2020 increase in the GI–ROA association following the carbon neutrality pledge, particularly in pollution-intensive industries, non-state firms, and large enterprises.

VI. Conclusion and Future Directions

This paper develops a dictionary-based measurement framework that decomposes firm-level green investment into pollution prevention and pollution control, providing a more granular view of environmental capital allocation. Using firm-year panel regressions with industry and year fixed effects, we

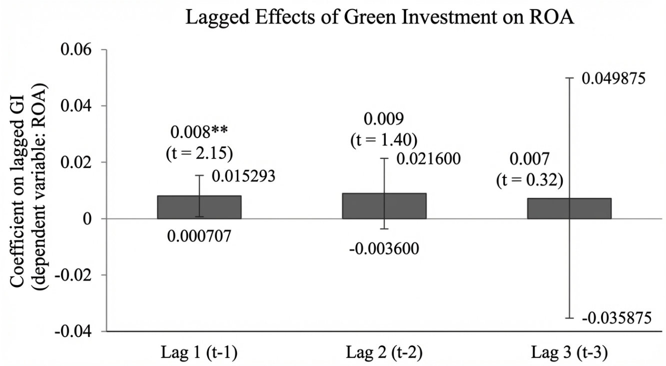

Fig. 4. Lagged effects of green investment on ROA. Bars report coefficient estimates from regressions of ROA on GI lagged by 1–3 years. Error bars denote 95% confidence intervals, and the horizontal line indicates zero. All specifications include standard firm-level controls as well as industry and year fixed effects.

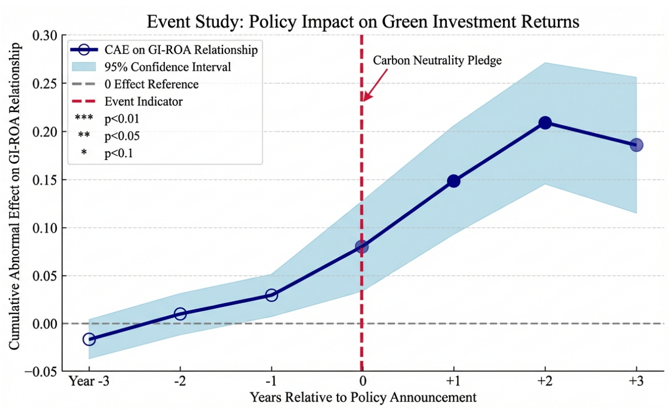

Fig. 5. Event study of policy impact on green investment returns. The vertical dashed line marks China's carbon neutrality pledge announced in September 2020 [21]. The line represents cumulative abnormal effects, and the shaded area denotes 95% confidence intervals.

find that aggregate green investment is positively associated with financial performance, and that the decomposed measures are significantly associated with environmental performance. The decomposition reveals that prevention-oriented investment exhibits stronger associations with both environmental performance and financial outcomes than control-oriented investment, highlighting the role of capability-building channels alongside compliance-driven activities.

These findings suggest that the economic value of green investment depends not only on its scale but also on its composition. Prevention-oriented investments are more closely linked to sustained performance improvements, whereas compliance-oriented investments can still generate short-term benefits, particularly under strong regulatory enforcement.

Future research can build on this framework by further improving measurement validity, exploiting quasi-experimental variation to strengthen causal identification, and extending the analysis to other institutional settings.

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