

Article

Green Initiatives and Financial Performance: ESG Associations and Corporate Life-Cycle Contingencies in China's Heavily Polluting Industries

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Abstract

This study examines how green initiatives are associated with financial performance through a statistical indirect pathway involving environmental, social, and governance (ESG) assessment and whether that pathway varies across life-cycle stages. Using an unbalanced panel of 6579 firm-year observations from 1114 Chinese A-share firms in heavily polluting industries during 2015–2024, the analysis compares green investment, green innovation, green subsidy, and ISO 14001 certification within a common framework. Firm and year fixed-effects models with firm-clustered inference are combined with 5000 firm-cluster bootstrap replications and Benjamini–Hochberg false-discovery-rate adjustment. All four initiatives are positively associated with Huazheng ESG ratings. ESG ratings are positively associated with ROA and ROE, whereas a positive association with Tobin's Q is not established. Each initiative exhibits a positive statistical indirect association with ROA through ESG, although total financial associations remain heterogeneous; green subsidy shows a negative contemporaneous total association with ROA. The mediated effects are economically modest: a one within-firm standard-deviation increase in each initiative corresponds to about 0.20–0.34% of a within-firm standard deviation of ROA through ESG. By contrast, a one within-firm standard-deviation increase in green subsidy is associated with a –0.133 percentage-point total ROA association. Corporate life cycle selectively conditions the pathway: ESG-mediated associations of green investment and green subsidy are significantly stronger in growth-stage firms than in mature or declining firms, while comparable stage differences are not established for green innovation or certification. The evidence distinguishes external sustainability assessment from immediate profitability and locates life-cycle dependence in resource-deployment-intensive green actions.



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1. Introduction

Corporate environmental transformation has become a central financial and strategic issue because firms are increasingly evaluated not only by realized earnings but also by their capacity to manage environmental liabilities, transition risks, stakeholder expectations, and long-horizon resource constraints. The accumulated literature generally finds that environmental, social, and governance (ESG) performance is non-negatively related to

financial performance, yet the magnitude and even the sign of the relationship depend on the outcome, institutional setting, measurement system, and research design (Friede et al., 2015; Gillan et al., 2021). Recent panel evidence also shows that ESG, green innovation, and financial outcomes can be connected through multiple channels rather than a single reduced-form relationship (Tripopsakul, 2025; Zheng et al., 2022).

Two gaps remain particularly important. First, the term “green strategy” often aggregates economically different activities. Environmental capital expenditure commits internal resources; green patenting reflects technological capability; environmental subsidies provide externally supplied policy resources; and ISO 14001 certification formalizes an environmental-management system. These activities may all improve external sustainability assessment, but they differ sharply in cash-flow consequences, implementation costs, timing, and informational content. Existing studies usually examine one activity at a time—for example, green innovation (Liu et al., 2024; Zheng et al., 2022) or green investment (Hou et al., 2025)—which makes cross-initiative comparisons difficult because samples, measures, and estimators vary across studies.

Second, the statistical indirect pathway through which green action is associated with financial performance is incompletely specified. ESG ratings can serve as an external-evaluation channel: observable environmental actions enter sustainability assessments, and those assessments can be associated with stakeholder confidence, financing conditions, supply-chain access, regulatory exposure, and reputation. However, a positive ESG-mediated association does not imply that the total contemporaneous financial association of a green initiative must be positive. Investment, research, compliance, matching expenditure, and designated-use constraints can coexist with stakeholder benefits. The distinction between a positive statistical indirect association and a weak or negative remaining direct component is therefore economically meaningful rather than statistically anomalous.

A further issue is whether this statistical indirect pathway is equally strong across stages of corporate development. Firm life cycle captures systematic variation in financing needs, investment opportunities, organizational routines, and resource-integration capacity. Prior accounting and finance research documents life-cycle differences in financial resources, governance, and corporate social-responsibility behavior (Habib & Hasan, 2019; Hasan & Habib, 2017). Recent evidence from China also shows that life-cycle conditions can alter relationships among green innovation, financial performance, and ESG reporting (Rauf et al., 2026). Yet the moderator is often used as a broad subgroup device rather than located at a specific point in the association structure. This study specifies the life cycle on the first stage—green initiatives to ESG performance—because resource deployment and implementation capacity are expected to determine how effectively a green action becomes externally visible sustainability performance.

The empirical setting is Chinese A-share firms in heavily polluting industries from 2015 to 2024. This population is particularly informative because pollution-control investment, green innovation, environmental subsidies, certification, and ESG assessment are simultaneously salient under strong regulatory pressure and rapid development of green-finance and sustainability-disclosure institutions. The final panel contains 6579 firm-year observations from 1114 firms. We estimate firm and year fixed-effects models with firm-clustered standard errors, use product-of-coefficients mediation with 5000 firm-cluster bootstrap replications, apply Benjamini–Hochberg false-discovery-rate adjustment to prespecified hypothesis families, and evaluate life-cycle differences through conditional indirect-effect contrasts.

The results show a layered pattern. All four initiatives are positively associated with ESG ratings. ESG performance is positively associated with the accounting outcomes ROA and ROE but not with the market-based outcome Tobin’s Q. All four initiatives

exhibit positive statistical indirect associations with ROA through ESG; however, the total contemporaneous association of green subsidy with ROA is negative, and the total associations for investment, innovation, and certification are not statistically distinguishable from zero. Life-cycle moderation is selective: the conditional indirect associations for green investment and green subsidy are significantly stronger in growth-stage firms than in mature and declining firms, while corresponding contrasts are not established for innovation or certification.

This study contributes in four ways. First, it compares four economically distinct green initiatives within the same firms, period, control structure, and estimator, thereby separating initiative-specific differences from cross-study design differences. Second, it positions ESG as an intermediate external-evaluation variable and explicitly decomposes total associations into ESG-mediated and remaining direct components without imposing temporal or causal ordering. Third, it locates corporate life cycle at a theoretically specified first stage and tests conditional indirect-effect contrasts rather than inferring moderation from subgroup significance. Fourth, it distinguishes accounting profitability from market valuation and retains qualified and null findings, which helps define the boundary of claims about ESG-related value creation. The study therefore emphasizes a statistical decomposition: green action can be associated with stronger ESG assessment without implying an immediate or uniform financial premium.

The remainder of the paper is organized as follows. Section 2 develops the theoretical framework and hypotheses. Section 3 describes the sample, variables, models, and inference procedures. Section 4 presents the empirical results and robustness evidence. Section 5 discusses the findings and their theoretical implications. Section 6 outlines practical implications, and Section 7 concludes with limitations and directions for future research.

2. Theoretical Framework and Hypothesis Development

2.1. Green Initiatives as Drivers of ESG Performance

Stakeholder theory argues that firms depend on relationships with shareholders, creditors, employees, customers, suppliers, governments, communities, and other groups whose claims extend beyond short-run profit (Freeman, 1984). In this setting, ESG ratings are a compact external representation of how firms manage environmental, social, and governance responsibilities. A firm's green actions can therefore affect financial outcomes indirectly when they change the information and signals available to stakeholders.

The resource-based view complements this logic by emphasizing heterogeneity in resources and in firms' ability to organize and deploy them (Barney, 1991; Wernerfelt, 1984). Environmental investment, technological knowledge, policy-supported resources, and formalized management systems are different resources or capabilities. Their value depends not only on acquisition but also on effective integration into operations. A dynamic resource perspective further suggests that the economic usefulness of a resource can change with organizational development and capability evolution (Helfat & Peteraf, 2003).

Green investment consists of expenditures on pollution control, cleaner production, wastewater treatment, desulfurization, denitrification, and related projects. Such investment is observable evidence that environmental objectives are backed by resource commitment. Prior evidence links green investment to pollution reduction and environmental outcomes (Ren et al., 2022), while recent firm-level research in China shows that environmental investment can be reflected in ESG ratings (Hou et al., 2025). Because rating agencies evaluate environmental governance and disclose environmental actions, increases in green investment should be associated with a stronger ESG assessment.

Green innovation is measured through green patent applications and captures technological activity directed toward cleaner production, resource efficiency, and environmental

protection. Prior studies show that green innovation is associated with environmental performance (Rehman et al., 2021; Tang et al., 2018) and, in Chinese listed firms, with ESG performance (Liu et al., 2024; Zheng et al., 2022). Patent applications do not guarantee commercialization or physical emission reduction, but they provide an externally observable signal of a firm's technological orientation.

Green subsidies are targeted government resources for environmental protection, energy conservation, emission reduction, cleaner production, or green technology projects. Subsidies can relax project financing constraints and signal policy recognition. Evidence from China links government environmental or R&D support to green innovation and environmental performance (Bai et al., 2019; Du et al., 2023; Han et al., 2024; Luo et al., 2024). Thus, even when subsidized projects impose complementary expenditures, the receipt and deployment of targeted support can be positively reflected in ESG assessment.

Green certification is represented by valid ISO 14001 environmental-management system certification. ISO 14001 formalizes procedures for environmental policy, monitoring, review, corrective action, and continual improvement (International Organization for Standardization [ISO], 2015). Certification provides third-party verification and can reduce information asymmetry about environmental-management processes. Prior work connects ISO 14001 with environmental and supply-chain practices (Arimura et al., 2011; Erauskin-Tolosa et al., 2020; Heras-Saizarbitoria et al., 2011; Potoski & Prakash, 2005), although certification status does not guarantee identical implementation quality across firms.

H1a. *Green investment is positively associated with corporate ESG performance.*

H1b. *Green innovation is positively associated with corporate ESG performance.*

H1c. *Green subsidy is positively associated with corporate ESG performance.*

H1d. *Green certification is positively associated with corporate ESG performance.*

2.2. ESG Performance and Corporate Financial Performance

ESG performance can influence financial outcomes through several stakeholder channels. Stronger sustainability assessment can reduce perceived compliance and reputational risk, improve access to creditors and supply chains, support customer and employee relationships, and signal management quality. Broad reviews find predominantly non-negative but heterogeneous ESG–financial-performance relationships (Endrikat et al., 2014; Friede et al., 2015; Gillan et al., 2021). The heterogeneity is important because accounting profitability and market valuation capture different economic objects.

ROA and ROE measure realized accounting performance and can reflect changes in operating continuity, financing costs, risk management, and asset utilization over a relatively short horizon. Tobin's Q, by contrast, reflects market expectations about future cash flows and is influenced by growth opportunities, industry prospects, discount rates, liquidity, and investor sentiment. ESG information may therefore improve accounting performance without being immediately capitalized into market valuation, particularly in pollution-intensive sectors where better sustainability assessment can coexist with expectations of future transition expenditure (Eccles et al., 2014; Fatemi et al., 2018).

H2. *Corporate ESG performance is positively associated with corporate financial performance, with outcome-specific evidence assessed for ROA, ROE, and Tobin's Q.*

2.3. ESG as a Statistical Intermediate Association

Combining the first two empirical associations yields a statistical indirect decomposition in which green initiatives are associated with externally assessed ESG performance and ESG performance is subsequently associated with financial outcomes in the same-year specification. This formulation is deliberately contemporaneous: it does not establish temporal ordering, mediation in the causal sense, or a production-efficiency mechanism. It instead captures an external-evaluation association through which green actions and stakeholder-facing ESG assessment are statistically connected to financial outcomes.

The remaining direct component can differ in sign across initiatives. Environmental capital expenditure can generate operating savings but also requires current resource commitment; green innovation can have commercialization lags; subsidy-supported projects can impose matching expenditure, designated-use restrictions, or administrative costs; and certification entails system design, audits, training, and ongoing compliance. Accordingly, the study predicts the direction of the indirect effect but does not impose a directional hypothesis on the remaining direct component. This distinction is consistent with evidence that sustainability-related benefits and resource costs can coexist (Endrikat et al., 2014; Heras-Saizarbitoria et al., 2011; Tang et al., 2018).

H3a. *Green investment has a positive statistical indirect association with ROA through ESG performance.*

H3b. *Green innovation has a positive statistical indirect association with ROA through ESG performance.*

H3c. *Green subsidy has a positive statistical indirect association with ROA through ESG performance.*

H3d. *Green certification has a positive statistical indirect association with ROA through ESG performance.*

2.4. Corporate Life Cycle as a First-Stage Boundary Condition

Corporate life cycle captures differences in investment opportunity, financing demand, asset structure, strategic orientation, and organizational routines. The cash-flow-pattern framework developed by Dickinson (2011) provides an observable classification that can be applied to listed firms, while the broader literature documents systematic stage differences in financial resources and corporate behavior (Habib & Hasan, 2019; Hasan & Habib, 2017). A resource-based interpretation predicts that the same increment in a green resource need not be converted into ESG performance with equal effectiveness across stages.

Growth-stage firms are expanding capacity and establishing operating systems. Environmental facilities and cleaner production technologies can therefore be embedded in new capacity, while policy-supported projects can complement expansion opportunities. Mature firms typically have more established environmental assets and systems, so additional environmental spending may involve retrofit or replacement and produce smaller marginal changes in externally observable ESG indicators. Declining firms face tighter cash-flow constraints and strategic contraction, making green expenditure more likely to focus on minimum compliance rather than broad capability building. These differences imply a stronger initiative-to-ESG conversion in growth-stage firms, particularly for initiatives that require current resource deployment.

By contrast, the second stage from ESG assessment to financial performance primarily reflects external stakeholder responses to ESG signals. Those responses are shaped by capital markets, creditors, customers, and supply-chain institutions and are not assumed ex ante to differ systematically with the firm's life-cycle stage. The moderator is therefore

located on the first stage. This specification is more precise than treating life cycle as an all-purpose subgroup variable and differs from research that examines broader life-cycle moderation of financial performance or ESG reporting (Rauf et al., 2026).

H4a. *The ESG-mediated association of green investment with ROA is stronger in growth-stage firms than in mature firms.*

H4b. *The ESG-mediated association of green innovation with ROA is stronger in growth-stage firms than in mature firms.*

H4c. *The ESG-mediated association of green subsidy with ROA is stronger in growth-stage firms than in mature firms.*

H4d. *The ESG-mediated association of green certification with ROA is stronger in growth-stage firms than in mature firms.*

H5a. *The ESG-mediated association of green investment with ROA is stronger in growth-stage firms than in declining firms.*

H5b. *The ESG-mediated association of green innovation with ROA is stronger in growth-stage firms than in declining firms.*

H5c. *The ESG-mediated association of green subsidy with ROA is stronger in growth-stage firms than in declining firms.*

H5d. *The ESG-mediated association of green certification with ROA is stronger in growth-stage firms than in declining firms.*

3. Materials and Methods

3.1. Data, Sample, and Institutional Setting

The study covers ten complete fiscal years from 2015 to 2024. The period begins with a phase of more systematic ecological-civilization reform in China and spans the subsequent development of green finance, the carbon-peaking and carbon-neutrality agenda, and progressively stronger sustainability-disclosure expectations. The ten-year window also provides within-firm variation for fixed-effects identification and sufficient temporal coverage for lagged and staggered-adoption sensitivity analyses.

The population consists of Shanghai and Shenzhen A-share firms operating in heavily polluting industries. Industry scope is identified using three-digit China Securities Regulatory Commission (CSRC) codes together with the scope of heavily polluting industries specified by environmental authorities. The final sample covers 16 three-digit industry categories, including chemicals, rubber and plastics, non-metallic mineral products, metal processing, electricity and heat production, textiles, paper, petroleum processing, chemical fiber, and mining-related industries.

Firm-year observations are screened to exclude financial and insurance firms, ST and *ST/delisting-risk observations, observations outside the firm's listed period, and observations missing variables required for the primary ESG and ROA models. The resulting unbalanced panel contains 6579 firm-year observations from 1114 firms. Tobin's Q is available for 6577 observations. The life-cycle composition is 2638 growth-stage observations (40.10%), 2960 mature-stage observations (44.99%), and 981 decline-stage observations (14.91%).

Data are integrated by stock code and year. CSMAR provides firm characteristics, accounting data, governance variables, market valuation, industry information, and detailed subsidy records. Huazheng provides the primary ESG rating, continuous ESG score, and component scores. Green patent applications are drawn from a patent research database and classified using relevant International Patent Classification codes; the underlying registrations are publicly verifiable through the China National Intellectual Property Administration. Environmental investment is constructed from annual-report note items and cross-checked against a corporate environmental-responsibility data source. ISO 14001 records are obtained from publicly accessible certification information and supplemented with annual reports and corporate social-responsibility reports. City-level macroeconomic controls are obtained from regional statistical sources. Refinitiv ESG data are used only for cross-provider sensitivity analysis because coverage is materially smaller. Table 1 summarizes the analytical sample composition by corporate life-cycle stage.

Table 1. Analytical sample composition.

Dimension	Category	Firm Years	Share
Life cycle	Growth	2638	40.10%
Life cycle	Mature	2960	44.99%
Life cycle	Decline	981	14.91%
Panel	Total	6579	100.00%
Firms	Distinct listed firms	1114	—
Period	2015–2024	10 years	—

Note. The panel is unbalanced. Life-cycle stage is assigned from the sign pattern of operating, investing, and financing cash flows following Dickinson (2011).

3.2. Variable Measurement

The primary financial outcome is return on assets (ROA), calculated as net profit divided by average total assets. Return on equity (ROE) is the secondary accounting outcome, and Tobin's Q is the market-based outcome. ROA is used for the total-association, mediation, and moderated-mediation decompositions because it provides a common asset-scaled profitability measure across the sample.

The four green initiatives are measured separately rather than aggregated into a composite index because their scales and economic meanings differ substantially. Green investment is environmental investment divided by operating revenue. Green innovation is the natural logarithm of one plus annual green patent applications. Green subsidy is the value of environmental government subsidies identified under a strict project-name rule divided by operating revenue. Green certification equals one when the firm holds a valid ISO 14001 environmental-management system certificate in a given year and zero otherwise.

The primary mediator is the Huazheng ESG rating coded from 9 for AAA to 1 for C. The rating is used because it represents the provider's final categorical assessment observed by external stakeholders. In the linear fixed-effects models, the nine ordered categories are entered numerically; the resulting coefficients are therefore interpreted as within-firm movements on the ordered rating scale rather than as evidence that every adjacent grade has identical economic distance. The continuous Huazheng ESG score is used as an alternative measure in second-stage sensitivity analysis to assess dependence on discretization. Refinitiv combined ESG and environmental-pillar scores provide a separate cross-provider check for the smaller 2019–2024 subsample. The Huazheng system aggregates three pillars—environment (E), social (S), and governance (G)—across 16 themes and 44 key indicators. The environmental pillar covers climate change, resource utilization, environmental pollution, environmental friendliness, and environmental management; the social pillar covers human capital, product responsibility, supply chain, social contribution,

and data security/privacy; and governance covers shareholder rights, governance structure, information-disclosure quality, governance risk, external punishment, and business ethics. The governance-risk component includes solvency capacity, so the composite rating can incorporate financial information in addition to environmental and social information (Sino-Securities Index Information Service [Shanghai] Co., Ltd., 2024). Huazheng's A-share series uses its 1.0 methodology for 2009–2018 and its 2.0 methodology from 2019 onward; this regime change is treated as a measurement limitation rather than harmonized through a newly estimated adjustment.

Corporate life cycle is classified from the signs of operating, investing, and financing cash flows following Dickinson (2011). The original introduction and growth patterns are combined as growth, the original maturity pattern remains maturity, and shake-out and decline patterns are combined as decline. This consolidation reflects the limited number of listed firms with true start-up patterns and the asset-disposal characteristics of shake-out observations in this population.

Controls include firm size (log total assets), leverage, firm age, operating cash flow scaled by assets, revenue growth, ownership concentration, CEO duality, board size (log number of directors), city-level GDP (log), and industrial structure upgrading (tertiary-industry value added divided by secondary-industry value added). Continuous variables are Winsorized at the 1st and 99th percentiles on duplicated analysis variables; indicator and ordinal variables remain untransformed. All main models are repeated with raw continuous variables as a sensitivity check. Table 2 summarizes the definitions and measurements of the variables used in the empirical models.

Table 2. Variable definitions.

Variable	Role	Measurement
ROA	Outcome	Net profit/average total assets
ROE	Outcome	Net profit/average shareholders' equity
Tobin's Q	Outcome	Market value/replacement cost of capital
Green investment	Independent	Environmental investment/operating revenue
Green innovation	Independent	ln(green patent applications + 1)
Green subsidy	Independent	Strictly identified green subsidy/operating revenue
Green certification	Independent	Valid ISO 14001 certificate: 1 = yes, 0 = no
ESG rating	Mediator	Huazheng rating coded AAA = 9 to C = 1
Life-cycle stage	Moderator	Growth, maturity, decline based on cash-flow sign patterns
Controls	Covariates	Firm characteristics, governance, and regional macro controls

Note. Green investment and green subsidy are revenue-scaled ratios; coefficient magnitudes across the four initiative variables are therefore not directly comparable.

3.3. Econometric Specification

The baseline specification uses firm and year fixed effects. Firm effects absorb time-invariant heterogeneity in business models, managerial capability, and industry niches, while year effects absorb common macroeconomic, regulatory, and capital-market shocks. Standard errors are clustered at the firm level because residuals may be serially correlated and heteroskedastic within firms. This approach follows standard panel-data inference practice in corporate finance (Petersen, 2009).

$$ROA_{it} = \alpha + \beta Green_{it} + \gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Equation (1) estimates the total association of each green initiative with ROA. The first-stage model for H1 replaces the outcome with the ESG rating:

$$ESG_{it} = \alpha_1 + aGreen_{it} + \gamma_1'X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

H2 is evaluated by estimating ESG separately against ROA, ROE, and Tobin's Q. For mediation, the initiative-specific second-stage model includes both ESG and the focal initiative:

$$ROA_{it} = \alpha_{2m} + b_m ESG_{it} + c'Green_{it} + \gamma_{2m}'X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

The statistical indirect effect is $a \times b_m$, the remaining direct component is c' , and the total association is $a \times b_m + c'$. Because the sampling distribution of the product term is generally asymmetric, inference is based on 5000 bootstrap replications resampled at the firm-cluster level rather than on a normal approximation (Efron & Tibshirani, 1993; Preacher & Hayes, 2008).

All mediation specifications are contemporaneous: the initiative, ESG rating, and financial outcome are measured in the same fiscal year. The lagged ESG-to-performance specifications reported below are therefore sensitivity tests rather than the primary mediation design.

The moderated-mediation model places corporate life cycle on the first stage. Growth is the reference group, and Mature and Decline are indicator variables:

$$ESG_{it} = \alpha_3 + a_1Green_{it} + a_2(Green_{it} \times Mature_{it}) + a_3(Green_{it} \times Decline_{it}) + a_4Mature_{it} + a_6Decline_{it} + \gamma_3'X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (4)$$

Conditional indirect effects are computed as $a_1 \times b_m$ for growth, $(a_1 + a_2) \times b_m$ for maturity, and $(a_1 + a_3) \times b_m$ for decline. H4 and H5 are tested using growth-minus-maturity and growth-minus-decline contrasts of these conditional indirect effects. The contrasts and their confidence intervals are obtained from the same firm-cluster bootstrap samples, ensuring internally consistent inference.

Multiple related tests raise the probability of false positives. The four H1 tests form one family, the four H3 indirect effects form a second family, and the eight H4/H5 life-cycle contrasts form a third family. Benjamini–Hochberg false-discovery-rate adjustment is applied within these prespecified families (Benjamini & Hochberg, 1995). H2 is retained as one substantive proposition with outcome-specific reporting.

3.4. Model Diagnostics and Sensitivity Design

The robustness program varies measurement, outcome, control set, fixed-effects structure, sample, timing, and treatment of extreme values. It includes a broader subsidy rule, an alternative source investment measure, continuous Huazheng ESG, Huazheng environmental-pillar scores, Refinitiv ESG measures, alternative profitability measures, industry-by-year effects, exclusion of 2020, alternative heavy-pollution flags, one- and two-year lags, and raw variables. First ISO 14001 certification is additionally analyzed through a cohort-robust staggered difference-in-differences design because certification has an identifiable adoption date (Callaway & Sant'Anna, 2021). System GMM is reported only as a supplementary diagnostic for persistence and potential reverse causality (Blundell & Bond, 1998; Windmeijer, 2005). Generative AI was used only in manuscript preparation, as further detailed in the following paragraph; it was not used to generate or alter the underlying data or statistical estimates.

All data cleaning, variable construction, diagnostics, estimation, bootstrap inference, multiple-testing adjustment, and robustness analyses were implemented programmatically in Stata 18, with scripts and execution outputs retained for reproducibility. During prepara-

tion of this journal manuscript, ChatGPT (OpenAI, GPT-5.6 Sol) was used to assist with article organization, drafting, and language refinement. The empirical design, variable definitions, source data, statistical models, estimates, and tables were supplied from the authors' pre-existing research workflow; the tool was not used to generate, modify, or independently analyze the research data. All AI-assisted text was reviewed and verified by the authors.

4. Results

4.1. Descriptive Statistics and Within-Firm Variation

The main variables display sufficient within-firm variation for fixed-effects identification. The within-firm standard deviation of the ESG rating is 0.7704, while those of ROA, green investment, green innovation, green subsidy, and certification are 0.0410, 0.02838, 0.6395, 0.000618, and 0.3083, respectively. These reported within-firm standard deviations permit economic-magnitude calculations without re-estimating the models. The four green initiatives are only weakly correlated with one another, supporting their treatment as distinct dimensions rather than a single composite index. The strongest pairwise correlation among explanatory variables is between firm size and green innovation (Pearson $r = 0.624$), but the corresponding VIF values remain well below conventional concern thresholds. Table 3 presents selected descriptive statistics for the principal study variables.

Table 3. Selected descriptive statistics.

Variable	N	Mean	SD	Min	Max
ROA	6579	0.0406	0.0581	−0.1606	0.2135
ROE	6579	0.0612	0.1203	−0.5144	0.3882
Tobin's Q	6577	1.7396	0.9591	0.7887	6.1635
Green investment	6579	0.01608	0.04358	0.0000	0.2960
Green innovation	6579	1.0000	1.1546	0.0000	4.6052
Green subsidy	6579	0.000323	0.000926	0.0000	0.00670
Green certification	6579	0.3909	0.4880	0.0000	1.0000
ESG rating	6579	4.0702	1.1057	1.0000	9.0000

Note. Continuous variables are Winsorized at the 1st and 99th percentiles; indicator and ordinal variables are shown in raw form.

4.2. Green Initiatives and ESG Performance

Table 4, Panel A, reports the first-stage fixed-effects estimates. Green investment, green innovation, green subsidy, and green certification are each positively associated with the ESG rating at the 1% level. The separate-model estimates are 1.8021, 0.0942, 68.7565, and 0.2385, respectively. Using the reported within-firm standard deviations, one within-firm standard-deviation increase corresponds to 0.0511, 0.0602, 0.0425, and 0.0735 ESG-rating points, or 6.64%, 7.82%, 5.52%, and 9.54% of the within-firm standard deviation of the ESG rating. Because the four variables use different measurement scales, the raw coefficient magnitudes should not be interpreted as a ranking of substantive importance. In an additional joint specification, all four coefficients remain positive and statistically significant (1.7757, 0.0962, 63.3822, and 0.2463, respectively), indicating that the first-stage findings are not driven by pairwise overlap among the initiative measures. All four H1 statements remain significant after within-family false-discovery-rate adjustment.

Table 4. Core two-way fixed-effects estimates.

Path/Variable	Coefficient	Clustered SE	p-Value	Within R ²	Δ Outcome (1 Within-SD)	% of Within-SD Outcome
Panel A: Initiative → ESG rating						
Green investment	1.8021 ***	0.3307	<0.001	0.0954	0.0511	6.64%
Green innovation	0.0942 ***	0.0186	<0.001	0.0961	0.0602	7.82%
Green subsidy	68.7565 ***	15.5205	<0.001	0.0941	0.0425	5.52%
Green certification	0.2385 ***	0.0417	<0.001	0.0998	0.0735	9.54%
Panel B: ESG rating → financial performance						
ROA	0.00180 ***	0.00067	0.007	0.4054	0.00139 (0.1387 pp)	3.38%
ROE	0.00398 **	0.00158	0.012	0.3402	0.00307 (0.3066 pp)	3.32%
Tobin's Q	−0.01698	0.01040	0.103	0.3032	−0.0131 Q units	−2.14%
Panel C: Total association → ROA						
Green investment	0.00299	0.01733	n.s.	0.4043	0.0000849 (0.0085 pp)	0.21%
Green innovation	0.00064	0.00087	n.s.	0.4044	0.0004093 (0.0409 pp)	1.00%
Green subsidy	−2.15510 **	0.83835	<0.05	0.4053	−0.001332 (−0.133 pp)	−3.25%
Green certification	−0.00156	0.00165	n.s.	0.4045	−0.0004809 (−0.0481 pp)	−1.17%

Note. Panel A reports the initiative-to-ESG fixed-effects estimates; the economic-magnitude columns show the estimated change in the ESG rating for a one within-firm-standard-deviation increase in the initiative and the percentage of the within-firm ESG standard deviation. Panel B uses the within-firm standard deviation of ESG as the regressor change and scales the implied outcome change by the within-firm standard deviation of the dependent variable. Panel C reports total associations with ROA and applies the same within-firm-SD scaling to the initiative. The control set, firm fixed effects, and year fixed effects are included throughout. The four initiatives use different measurement scales and therefore should not be compared by raw coefficients alone. *** $p < 0.01$, ** $p < 0.05$. "n.s." denotes not statistically significant at 10%.

4.3. ESG and Financial Performance

Panel B shows that the ESG rating is positively associated with both accounting outcomes. A one within-firm-standard-deviation increase in the ESG rating is associated with a 0.00139 increase in ROA (0.1387 percentage points, 3.38% of the within-firm ROA standard deviation) and a 0.00307 increase in ROE (0.3066 percentage points, 3.32% of the within-firm ROE standard deviation). The Tobin's Q coefficient is −0.01698 ($p = 0.103$); a one within-firm-standard-deviation increase in the rating corresponds to −0.0131 Tobin's Q units, or −2.14% of the within-firm Tobin's Q standard deviation. Replacing the ordinal rating with the continuous Huazheng ESG score produces the same qualitative pattern in the full sample: the score is positive for ROA and ROE and statistically insignificant for Tobin's Q. H2 is therefore supported for accounting-based outcomes but not for the market-based outcome.

4.4. Total Associations of Green Initiatives with ROA

Panel C reports total associations before including the ESG mediator. Green investment (0.00299), green innovation (0.00064), and green certification (−0.00156) are not statistically significant in their separate total-association models. Green subsidy is negatively associated with ROA (−2.15510, $p < 0.05$). A one within-firm-standard-deviation increase in green subsidy (0.000618 in the subsidy-to-revenue ratio, equivalent to 0.0618 percentage points of revenue) corresponds to a −0.001332 change in ROA, or −0.133 percentage points and 3.25% of the within-firm ROA standard deviation. The negative subsidy relationship is not a mechanical artifact of grant income entering profit: when recognized green grants are removed from pre-tax profit, the subsidy coefficient becomes more negative (−3.4031), and it remains negative across operating ROA, pre-tax ROA, EBIT ROA, and operating margin specifications. A currency-valued profit-per-unit-of-subsidy conversion is not reported because the current analysis does not establish a single asset-to-revenue conversion basis

for such a calculation; using different conversion bases could produce different monetary interpretations.

4.5. ESG-Mediated Indirect Associations

The statistical decomposition provides the central indirect-association evidence. All four product terms are positive, their 95% percentile bootstrap intervals exclude zero, and their false-discovery-rate-adjusted *p*-values are approximately 0.010. The indirect association is 0.003251 for green investment, 0.000167 for green innovation, 0.131430 for green subsidy, and 0.000449 for green certification. For a one within-firm-standard-deviation increase in the initiative, these correspond to ROA changes of 0.0092, 0.0107, 0.0081, and 0.0138 percentage points, respectively, or 0.225%, 0.260%, 0.198%, and 0.338% of the within-firm ROA standard deviation. H3a–H3d are therefore supported, but the economic magnitudes are modest.

The decomposition also shows why total-association regressions alone are incomplete. For green investment, the positive statistical indirect association (0.003251) is larger than the small negative remaining direct estimate (−0.00026), leaving a small and imprecise positive total association. For green innovation, both the indirect and remaining direct point estimates are positive, but only the indirect component is statistically precise. For green subsidy, the positive ESG-mediated association (0.131430) is substantially smaller than the negative remaining direct component (−2.28653), yielding a negative total association (−2.15510). For certification, the positive indirect component (0.000449) partially offsets a negative but imprecise direct component (−0.00201). Thus, external ESG assessment and contemporaneous profitability can move in different directions. Replacing the ordinal rating with the continuous Huazheng ESG score in the reported continuous-score sensitivity analysis gives positive indirect effects of 0.003572, 0.000169, 0.128897, and 0.000495 for investment, innovation, subsidy, and certification, respectively (BH-adjusted *q* = 0.008 for the four effects), confirming the sign and significance of the full-sample indirect associations. Table 5 reports the initiative-specific decomposition of the associations with ROA into ESG-related indirect and remaining direct components.

Table 5. Decomposition of initiative-ROA associations through ESG.

Initiative	Path a	Path b	Direct	Indirect	95% CI	Total	ΔROA (pp); % Within-SD
Green investment	1.8021 ***	0.00180 **	−0.00026	0.003251 **	[0.00080, 0.00608]	0.00299	0.0092; 0.225%
Green innovation	0.0942 ***	0.00178 ***	0.00047	0.000167 ***	[0.000039, 0.000316]	0.00064	0.0107; 0.260%
Green subsidy	68.7565 ***	0.00191 ***	−2.28653 ***	0.131430 ***	[0.03477, 0.25210]	−2.15510 **	0.0081; 0.198%
Green certification	0.2385 ***	0.00188 ***	−0.00201	0.000449 ***	[0.000126, 0.000811]	−0.00156	0.0138; 0.338%

Note. Percentile confidence intervals and bootstrap standard errors are based on 5000 replications resampled over the 1114 firm clusters. The indirect association is $a \times b$. The economic-magnitude column reports the implied change in ROA from a one within-firm-standard-deviation increase in the initiative and the corresponding percentage of the within-firm ROA standard deviation. These quantities describe statistical indirect associations and do not identify temporal or causal mediation. *** $p < 0.01$, ** $p < 0.05$.

4.6. Corporate Life Cycle and Conditional Indirect Associations

Life-cycle differences are concentrated in green investment and green subsidy. The panel contains 5024 strict consecutive-calendar-year pairs among 935 firms observed for at least three years; 2384 pairs show a life-cycle-stage change, and 846 firms have at least one

such stage change. These observations provide within-firm stage-change support for the interaction design; the same 6579 observations and 1114 firms enter the four moderated-mediation models, so the 846 firms should not be interpreted as a separate regression sample. For green investment, the conditional indirect association is 0.00489 in growth, 0.00151 in maturity, and 0.00007 in decline. The growth-minus-maturity contrast is 0.00338 with a 95% CI of [0.00064, 0.00686], and the growth-minus-decline contrast is 0.00482 with a 95% CI of [0.00094, 0.00974]. After adjustment across the eight life-cycle contrasts, both differences remain significant (adjusted $p = 0.026$). H4a and H5a are supported. The growth-minus-maturity and growth-minus-decline contrasts correspond to 0.0096 and 0.0137 percentage points of ROA, respectively, or 0.234% and 0.334% of the within-firm ROA standard deviation.

The subsidy pattern is similar but larger on its own scale. Conditional indirect associations are 0.26825 in growth, 0.08182 in maturity, and 0.08110 in decline. The growth-minus-maturity and growth-minus-decline contrasts are 0.18643 and 0.18715, respectively; both remain significant after adjustment (adjusted $p = 0.026$). These contrasts correspond to 0.0115 and 0.0116 percentage points of ROA, or about 0.281% and 0.282% of the within-firm ROA standard deviation. H4c and H5c are supported. In the first-stage interaction model, the growth-stage subsidy-to-ESG slope is 150.0953, while the interactions with maturity and decline are approximately -104 , consistent with a weaker association between subsidy intensity and ESG assessment outside the growth stage.

By contrast, the innovation and certification contrasts are not statistically established. Green innovation has conditional indirect associations of 0.000178, 0.000161, and 0.000074 in growth, maturity, and decline, but the adjusted p -values for the growth-stage contrasts are 0.765 and 0.107. Certification has positive conditional indirect associations in all three stages (0.000449, 0.000438, and 0.000277), but the growth-stage contrasts have adjusted p -values of 0.897 and 0.240. H4b, H4d, H5b, and H5d are not supported. The life cycle is therefore a selective, rather than universal, boundary condition. The present analysis does not include an alternative non-cash-flow life-cycle proxy or a life-cycle re-estimation without the operating-cash-flow control; these checks are therefore not presented as established robustness results. Table 6 summarizes the conditional indirect associations and the formal life-cycle contrasts.

Table 6. Conditional indirect associations by corporate life-cycle stage.

Initiative	Growth	Mature	Decline	Growth-Mature [95% CI]	Adj. p	Growth-Decline [95% CI]	Adj. p	Δ ROA (pp); % SD
Green investment	0.00489 **	0.00151 *	0.00007	0.00338 [0.00064, 0.00686]	0.026	0.00482 [0.00094, 0.00974]	0.026	G-M: 0.0096; 0.234% G-D: 0.0137; 0.334%
Green innovation	0.000178 **	0.000161 **	0.000074	0.000017 [-0.000072 , 0.000105]	0.765	0.000104 [-0.000005 , 0.000256]	0.107	G-M: 0.0011; 0.027% G-D: 0.0067; 0.162%
Green subsidy	0.26825 ***	0.08182 **	0.08110 **	0.18643 [0.04237, 0.38195]	0.026	0.18715 [0.04307, 0.38458]	0.026	G-M: 0.0115; 0.281% G-D: 0.0116; 0.282%
Green certification	0.000449 **	0.000438 **	0.000277 **	0.000011 [-0.000185 , 0.000220]	0.897	0.000173 [-0.000064 , 0.000514]	0.240	G-M: 0.00034; 0.008% G-D: 0.0053; 0.130%

Note. Growth is the reference stage. Confidence intervals use 5000 firm-cluster bootstrap replications. Adjusted p -values use the Benjamini–Hochberg procedure across the eight growth-stage contrasts. The economic-magnitude column reports the implied ROA difference for the growth-minus-maturity and growth-minus-decline contrasts after scaling the initiative by its within-firm standard deviation. Stars refer to unadjusted conditional indirect-effect tests; formal H4/H5 decisions are based on adjusted contrast p -values.

4.7. Supplementary Identification and Robustness Evidence

The robustness evidence is best presented as a hierarchy rather than uniform invariance. The contemporaneous first-stage initiative-to-ESG relationships are the most stable: the core coefficients remain positive under the broader subsidy definition, alternative investment measure, control-set changes, exclusion of 2020, and several timing specifications. Table 7 reports the principal first-stage sensitivity estimates, including the one-year lag results. The one-year lag first-stage coefficient remains positive and significant for innovation, subsidy, and certification, but not for investment; the two-year lag estimate for innovation remains significant. Raw-variable estimates for innovation and certification also remain positive.

Table 7. First-stage robustness and sensitivity estimates.

Specification	Path	Variable	Coefficient	SE	p-Value	N	Firms
Baseline	First stage	Green investment	1.8021	0.3307	<0.001	6579	1114
Baseline	First stage	Green innovation	0.0942	0.0186	<0.001	6579	1114
Baseline	First stage	Green subsidy	68.7565	15.5205	<0.001	6579	1114
Baseline	First stage	Green certification	0.2385	0.0417	<0.001	6579	1114
Broad subsidy rule	First stage	Green subsidy, broad	67.8104	15.5901	<0.001	6579	1114
Source investment measure	First stage	Green investment, source	1.5959	0.2902	<0.001	6579	1114
Uninterpolated macro controls	First stage	Green innovation	0.0926	0.0194	<0.001	6097	1112
Uninterpolated macro controls	First stage	Green certification	0.2392	0.0425	<0.001	6097	1112
Without macro controls	First stage	Green innovation	0.0944	0.0186	<0.001	6579	1114
Without macro controls	First stage	Green certification	0.2383	0.0416	<0.001	6579	1114
One-year lag	First stage	Green investment	0.3291	0.5149	0.523	5024	1026
One-year lag	First stage	Green innovation	0.0828	0.0221	<0.001	5024	1026
One-year lag	First stage	Green subsidy	33.7242	16.8353	0.045	5024	1026
One-year lag	First stage	Green certification	0.2766	0.0532	<0.001	5024	1026
Two-year lag	First stage	Green innovation	0.0710	0.0260	0.006	4071	927
Exclude 2020	First stage	Green innovation	0.1024	0.0197	<0.001	5984	1113
Exclude 2020	First stage	Green certification	0.2665	0.0427	<0.001	5984	1113
Raw variables	First stage	Green innovation	0.0901	0.0185	<0.001	6579	1114
Raw variables	First stage	Green certification	0.2372	0.0416	<0.001	6579	1114

Note. First-stage estimates are initiative-to-ESG fixed-effects coefficients. All models use firm-clustered standard errors and firm/year fixed effects unless the specification is explicitly a control or timing sensitivity. The table selects the sensitivity results most relevant to the reviewer's concerns; the full robustness matrix remains in the dissertation-derived appendix material. Lagged estimates are sensitivity checks and are not used to redefine the contemporaneous mediation design.

The second-stage ESG-to-financial-performance relationship is more specification-sensitive. Table 8 makes the main qualifications visible in the body of the paper. The continuous Huazheng ESG score remains positively associated with ROA and ROE, while the Huazheng environmental-pillar-only score is not significant for ROA or ROE in the existing dissertation output. One- and two-year lagged ESG coefficients are not significant, the raw-variable ROA model weakens, and the smaller Refinitiv sample does not reproduce the baseline second-stage result. Several alternative contemporaneous profitability measures retain positive ESG coefficients. These variations support a cautious interpretation of the contemporaneous accounting association rather than a claim of a persistent causal ESG premium.

Table 8. Second-stage robustness, measurement, and cross-provider evidence.

Specification	Outcome/Mediator	Coefficient	SE	p-Value	N	Firms
Baseline	ROA/ESG rating	0.0018	0.0007	0.007	6579	1114
Continuous Huazheng	ROA/ESG score	0.0004	0.00015	0.006	6579	1114

Table 8. Cont.

Specification	Outcome/Mediator	Coefficient	SE	p-Value	N	Firms
One-year lag	ROA/ESG rating	−0.0008	0.0009	0.350	5024	1026
Two-year lag	ROA/ESG rating	−0.0007	0.0009	0.415	4071	927
Raw variables	ROA/ESG rating	0.0008	0.0008	0.365	6579	1114
Industry-by-year FE	ROA/ESG rating	0.0014	0.0007	0.049	6579	1114
Without financial controls	ROA/ESG rating	0.0040	0.0009	<0.001	6579	1114
Size and age only	ROA/ESG rating	0.0029	0.0009	0.002	6579	1114
Alternative outcome	Operating ROA/ESG rating	0.0019	0.0007	0.010	6579	1114
Alternative outcome	Pre-tax ROA/ESG rating	0.0019	0.0008	0.011	6579	1114
Alternative outcome	EBIT ROA/ESG rating	0.0017	0.0007	0.019	6579	1114
Alternative outcome	Operating margin/ESG rating	0.0054	0.0015	<0.001	6579	1114
Huazheng E pillar	ROA/E score	0.0002	0.0001	0.071	6579	1114
Refinitiv combined	ROA/combined ESG	−0.0071	0.0136	0.603	908	237
Refinitiv E pillar	ROA/E pillar	0.0023	0.0106	0.830	908	237

Note. The second-stage coefficient is the ESG-to-financial-performance association. The baseline and sensitivity specifications use the existing dissertation outputs without new estimation. The Huazheng environmental-pillar row uses the existing pillar-specific score; it is not a newly generated re-estimation. Refinitiv results use the smaller 2019–2024 subsample and are therefore not treated as replacements for the primary mediator.

4.8. Staggered ISO 14001 Adoption

The staggered-adoption design uses recorded first-certification timing to construct an absorbing treatment state. Table 9 reports the cohort-robust estimates for the 547-firm estimation sample, including 225 firms with an observed untreated-to-treated transition, 19 firms contributing pre-certification comparison information only, and 303 firms with no recorded certification through 2024. The ATET is +0.26990 for ESG ($p = 0.004$), −0.00957 for ROA ($p = 0.036$), and −0.00521 for Tobin’s Q ($p = 0.943$). The ESG result reinforces the baseline certification-to-ESG association, while the financial results again separate external sustainability recognition from contemporaneous profitability. The joint pre-treatment tests are not rejected for ESG or ROA, but the Tobin’s Q test is marginal at the 10% level; individual pre-treatment estimates are not uniformly clean. The design therefore provides supplementary temporal evidence rather than definitive causal identification (Callaway & Sant’Anna, 2021).

Table 9. Staggered ISO 14001 adoption: ATET and pre-treatment diagnostics.

Outcome	ATET	SE	p-Value	95% CI	N	Firms	Observed Transitions
ESG rating	0.26990	0.09318	0.004	[0.08726, 0.45254]	3235	547	225
Winsorized ROA	−0.00957	0.00457	0.036	[−0.01852, −0.00061]	3235	547	225
Winsorized Tobin’s Q	−0.00521	0.07285	0.943	[−0.14801, 0.13758]	3234	547	225
Pre-treatment joint test: ESG	$\chi^2(36) = 44.190$		0.164		3235	547	—
Pre-treatment joint test: ROA	$\chi^2(36) = 43.149$		0.192		3235	547	—
Pre-treatment joint test: Tobin’s Q	$\chi^2(36) = 48.691$		0.077		3234	547	—

Note. Estimates use the cohort-robust staggered-adoption estimator of Callaway and Sant’Anna (2021). The estimation sample contains 547 firms, including 225 observed untreated-to-treated transition firms, 19 firms contributing pre-certification comparison information only, and 303 firms with no recorded certification through 2024. The pre-treatment rows report joint Wald tests of all pre-treatment group-time effects. These results provide supplementary temporal evidence, not definitive causal identification.

System GMM does not provide confirmatory evidence. Although the AR(2) tests are acceptable, Hansen tests reject the joint validity of the overidentifying restrictions for both ROA and ROE (Hansen $p = 0.002$ and <0.001). The GMM coefficients are therefore not used to claim robustness. Reporting this failure is important because estimator validity should govern interpretation rather than the sign of a coefficient alone.

5. Discussion

5.1. A Common ESG-Recognition Association Across Distinct Green Actions

The most stable empirical finding is that four economically different green initiatives are positively associated with ESG performance. This common first-stage association is theoretically important because it shows that external sustainability assessment can recognize capital commitment, technological activity, policy-supported projects, and institutionalized environmental management without implying that these actions are interchangeable. The result is consistent with recent evidence on green innovation and ESG in Chinese firms (Liu et al., 2024; Zheng et al., 2022) and with firm-level evidence that environmental investment is incorporated into ESG ratings (Hou et al., 2025).

At the same time, ESG ratings are external assessments rather than physical measures of environmental quality. A patent application may never be commercialized, an ISO 14001 system may differ in implementation depth, an investment may be inefficient, and a subsidy may be awarded to firms facing unusually high environmental burdens. The positive first-stage estimates should therefore be interpreted as associations with external ESG assessment, not proof that each measured initiative produces a specific quantity of emission reduction.

5.2. Why Accounting and Market Outcomes Diverge

The positive ESG coefficients for ROA and ROE are consistent with stakeholder channels involving financing conditions, compliance risk, operating continuity, customer relationships, and supply-chain access. These channels can influence realized profitability relatively quickly. The absence of a significant positive Tobin's Q coefficient indicates that market valuation does not mirror the accounting relationship one-for-one. This divergence is consistent with prior work emphasizing the role of disclosure, expectations, and measurement in the ESG-value relationship (Endrikat et al., 2014; Fatemi et al., 2018).

In heavily polluting industries, investors may interpret stronger ESG assessment as favorable information about governance, compliance, and transition capability while simultaneously anticipating continued capital expenditure or regulatory costs. The net market response can therefore be weak even when the current accounting performance is positively associated with ESG. The result is not evidence that ESG reduces firm value; rather, it shows that a positive market-based relationship is not established in this sample and specification.

5.3. Positive Statistical Indirect Associations Can Coexist with Weak or Negative Total Associations

The decomposition is particularly informative for green subsidy. Targeted environmental support is positively associated with ESG assessment, yet the contemporaneous total ROA association is negative and remains negative after removing the direct accounting contribution of grant income. The scale of the subsidy coefficient makes a selection-compatible interpretation especially important: firms that receive environmental subsidies may differ systematically before receipt in environmental burdens, remediation needs, project constraints, or other characteristics that also affect profitability. Matching expenditure, designated-use restrictions, and transition costs could also contribute. The current evidence does not identify among these explanations because the present design does not include a

pre-subsidy balance analysis or subsidy-entry model. The negative relationship therefore should not be interpreted as evidence that subsidies themselves causally reduce profitability, nor as a pure matching-cost estimate. Instead, the magnitude and robustness across alternative profitability measures motivate selection as an important interpretation to be tested in future work.

For investment and innovation, the positive indirect pathway is statistically clearer than the total contemporaneous profitability relationship. Environmental capital projects can be visible to ESG raters before cost savings are realized, while patenting may precede implementation and commercialization. This sequencing is consistent with evidence that the performance effects of green innovation and environmental investment depend on type, organizational conditions, and time horizon (Eccles et al., 2014; Rehman et al., 2021; Tang et al., 2018).

Certification provides a similar separation between recognition and short-run return. ISO 14001 can strengthen credibility and formalize routines, which is reflected in the positive ESG relationship, but implementation and audit costs can offset immediate financial benefits. Selection into certification is also a long-standing concern in the literature (Heras-Saizarbitoria et al., 2011). The staggered-adoption evidence, which shows a post-certification ESG increase but a negative average ROA estimate, reinforces the need to analyze informational recognition and financial pay-off separately.

5.4. Life-Cycle Moderation Is Selective, Not Universal

The life-cycle results refine the resource-based explanation. Significant stage differences are concentrated in green investment and green subsidy, the two initiatives most directly dependent on current resource deployment and complementary implementation capacity. Growth firms can embed pollution-control facilities in new capacity and allocate targeted policy resources to expanding project portfolios. Mature firms are more likely to retrofit established assets, while declining firms face liquidity constraints and strategic contraction. Consequently, the marginal conversion of new investment or subsidy intensity into observable ESG improvement is stronger in growth.

This selective pattern refines the life-cycle literature by locating the boundary condition in the first-stage association. Rauf et al. (2026) show that firm life cycle can moderate relationships involving financial performance, green innovation, and ESG reporting in China. The present design asks a different question: whether the association between an incremental green initiative and ESG assessment differs by stage and whether that first-stage difference produces a different conditional statistical indirect association with ROA. The results suggest that “life cycle matters” is too general; it matters most for green activities whose effectiveness depends on immediate resource deployment.

5.5. Theoretical Contributions

First, the study contributes construct differentiation. It places four distinct environmental actions in one framework while preserving their economic meanings. The common ESG relationship demonstrates a shared external-recognition association, whereas divergent direct, total, and life-cycle patterns show why aggregation into a single green index could conceal meaningful heterogeneity.

Second, the study contributes a more explicit statistical decomposition. ESG is modeled as an intermediate stakeholder-evaluation variable rather than merely an outcome, explanatory variable, or control. The positive statistical indirect associations identify a common intermediate association without requiring a positive total effect or implying temporal or causal mediation.

Third, the study contributes boundary-condition precision by specifying corporate life cycle on the initiative-to-ESG first stage and testing conditional indirect-effect contrasts. The selective moderation of investment and subsidy, but not innovation and certification, refines the dynamic resource-based view by showing that stage dependence varies with the type of green resource.

Fourth, the study separates accounting and market performance and calibrates evidential strength. The strongest evidence concerns the first-stage initiative-to-ESG relationships; the second-stage ESG-to-financial relationship is positive in contemporaneous accounting models but more specification-sensitive. This hierarchy avoids treating all statistically significant coefficients as equally robust.

6. Practical Implications

For policymakers, the findings support differentiated evaluation of environmental policy, but the modest economic magnitude should be kept in view. Green investment, innovation, subsidy, and certification should not be evaluated with a single short-run profitability metric. Policy dashboards can distinguish (i) the amount or adoption of green action, (ii) changes in externally assessed ESG performance, and (iii) realized environmental and financial outcomes. The negative contemporaneous subsidy-profitability association is compatible with several explanations, including selection and transition costs; it should therefore not be used alone to infer policy effectiveness or failure.

For corporate managers, the results suggest that green activities should be evaluated as distinct projects rather than as a single financial-return category. The stronger growth-stage associations for investment and subsidy are consistent with differences in resource deployment and implementation capacity, but the estimated mediated effects are small relative to within-firm ROA variation. Managers should therefore avoid interpreting a higher ESG assessment as evidence of an immediate financial premium and should evaluate project-level costs, timing, and environmental objectives separately.

For investors and lenders, ESG information should complement rather than replace conventional financial analysis. The lack of a significant Tobin's Q relationship, the modest mediated magnitudes, the negative subsidy total association, and the cross-provider sensitivity all suggest that aggregate ESG scores should be interpreted alongside the underlying action, investment horizon, financing need, and evidence of realized environmental outcomes.

For ESG rating agencies and certification bodies, greater methodological transparency would improve interpretability. Users should be able to distinguish whether a rating change reflects investment inputs, technological outputs, disclosure, formal certification, governance changes, or realized environmental performance. Clearer certification histories—including validity, suspension, scope, and recertification—would also help separate nominal certification from persistent implementation.

7. Conclusions, Limitations, and Future Research

This study examines how four corporate green initiatives are associated with financial performance through ESG assessment and how the first-stage association varies across the corporate life cycle. In an unbalanced panel of 6579 firm-year observations from 1114 Chinese A-share firms in heavily polluting industries over 2015–2024, all four initiatives are positively associated with ESG performance. ESG is positively associated with ROA and ROE but not with Tobin's Q. Green investment, innovation, subsidy, and certification each exhibit positive statistical indirect associations with ROA through ESG. These indirect associations are statistically precise but economically modest: a one within-firm-standard-deviation increase in each initiative corresponds to about 0.20%–0.34% of the within-firm standard deviation of ROA through ESG. Their total contemporaneous financial associa-

tions differ, and green subsidy shows a negative total ROA association equivalent to -0.133 percentage points of ROA for a one within-firm-standard-deviation increase in the subsidy ratio. Life-cycle moderation is significant for the ESG-mediated associations of investment and subsidy, with stronger associations in growth-stage firms, but is not established for innovation or certification.

The central conclusion is therefore not that every green initiative produces an immediate financial premium. Rather, corporate green actions can be associated with a common external-recognition association while retaining distinct resource costs, timing profiles, and boundary conditions. ESG improvement and profitability are related but not equivalent outcomes. The empirical hierarchy is also important: the initiative-to-ESG associations are the most stable, whereas the ESG-to-financial association is contemporaneous and specification-sensitive. In pollution-intensive industries, environmental transformation may require substantial current expenditure even when external sustainability assessment improves.

Future research can strengthen identification by exploiting policy shocks, eligibility thresholds, regional regulatory changes, or other quasi-natural experiments. Richer project-level data could distinguish pollution-control investment from energy-efficiency or clean-production projects; patent quality and commercialization could refine innovation measures; subsidy objectives, pre-receipt characteristics, and matching requirements could clarify the negative total association; and certification histories could be linked to audit, penalty, emissions, and energy-intensity data. Alternative life-cycle measures and specifications that separate life-cycle classification from the operating-cash-flow control would also help test whether the selective moderation survives changes in measurement. Longer horizons and explicit modeling of life-cycle transitions could determine whether weak or negative contemporaneous financial associations represent temporary transition costs or persistent burdens.

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