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State Ownership as a Moderator of the ESG and Financial Performance Relationship in Chinese Listed Steel Companies

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Abstract

This paper uses 134 A-share listed steel companies in China from 2014 to 2023 (804 firm-year observations) as research subjects. The primary research question asks whether state ownership moderates the association between ESG performance and accounting-based financial performance, and it is addressed through a two-way fixed-effects model incorporating an interaction between ESG performance and state ownership, with the analysis of individual ESG dimensions treated as a subsidiary examination that refines the ownership question rather than displacing it. ESG performance is significantly and positively associated with both return on assets (ROA) and return on equity (ROE), and state ownership is associated with a systematically weaker positive relationship, such that the ESG association within state-controlled steel companies falls to a magnitude that is no longer statistically distinguishable from zero while remaining robust among non-state-owned enterprises. A subsidiary analysis of the three ESG dimensions indicates that the attenuation associated with state ownership is concentrated on the environmental and social dimensions and is statistically indistinguishable from zero on the governance dimension, a pattern that qualifies the ownership finding by locating it in the dimensions carrying the greatest regulatory-compliance content. The interaction retains its negative sign across every specification in which it is estimable, covering alternative ESG ratings, instrumental-variable estimation, exclusion of ownership-transition firms and a continuous measure of state shareholding in the main analysis, together with alternative fixed-effects structures, propensity score matching, exclusion of the pandemic years and an untransformed rating scale reported in the Supplementary Material. The evidence pertains to A-share listed steel companies in China between 2014 and 2023 and is associational rather than causal, and on that basis the study delineates the ownership conditions under which accounting returns to ESG improvement are realised in a heavily polluting industry, a delineation of potential

relevance to Sustainable Development Goals 8, 9, 12 and 13 although the design does not measure progress toward any SDG target directly.

Keywords: ESG performance; accounting financial performance; state ownership; moderating role; Chinese steel industry; dimensional heterogeneity

1. Introduction

The deepening of the global sustainable development agenda has prompted institutional investors to incorporate environmental, social, and governance (ESG) factors into the core framework of capital allocation decisions. Related review studies show that this trend has gradually evolved from normative advocacy to mainstream practice (1). By the end of 2024, the global ESG asset management scale exceeded US\$50 trillion, and more than 5,370 institutions had signed the UN Principles for Responsible Investment (UN PRI). The standardization process of ESG disclosure and rating systems has also accelerated (2). Against this backdrop, China has established "carbon peaking and carbon neutrality" as a long-term national strategic goal and officially launched the national carbon emission trading market in 2021. The requirements for ESG information disclosure in A-shares have been continuously strengthened, and corporate ESG performance has increasingly become an important reference for green financing access, regulatory compliance assessment, and capital market pricing (3). At the same time, a large number of cross-market studies and meta-analyses have confirmed the positive correlation between ESG performance and financial outcomes from both theoretical and empirical dimensions (4, 48), so that the marginal contribution of the present study rests not on re-establishing this general association but on identifying the ownership conditions that govern its realisation within the theoretically distinctive context of the steel industry. The academic consensus on the value of ESG investment is gradually taking shape.

In the above-mentioned macro-transformation process, the steel industry is at the forefront of ESG policy pressure due to its special carbon emission attributes. China is the world's largest producer of crude steel, with a crude steel output of 1.019 billion tons in 2023, accounting for 54% of the global total. The carbon emissions of the steel industry account for about 15%-18% of the total carbon emissions of China's industrial sector, making it the second largest source of industrial carbon emissions after the power industry. More policy-wise, the Ministry of Ecology and Environment issued the "Work Plan for Covering the Steel, Cement and Aluminum Smelting Industries in the National Carbon Emission Trading Market" at the end of 2024. The steel industry will be officially included in the national carbon emission trading system from 2025. The internalization of carbon costs will fundamentally reshape the industry's cost structure and competitive landscape, and the financial transformation logic of ESG performance will enter a substantial window of change (5). In this context, relevant researchers have noted that for polluting industry enterprises, the relationship between ESG performance and market performance has shown new characteristics in the post-pandemic era (6). How to achieve the coordinated promotion of "green transformation" and "financial performance" has become a core issue that the steel industry urgently needs to answer, and it is also a frontier concern of international sustainable development research (7). The coordination of steel-sector decarbonisation with continued financial viability engages the concerns addressed by Sustainable Development Goals 8, 9, 12 and 13, and the ownership

conditions governing that coordination are consequently of interest beyond the single national industry examined here.

However, existing literature on ESG-financial relationships has obvious limitations in the following two dimensions. On the one hand, existing studies are mainly based on cross-industry comprehensive samples, and there is a lack of specific studies on heavily polluting industries. The estimation of average effects masks the heterogeneity of effects caused by industry environmental regulatory pressure and differences in asset intensity (8). On the other hand, there are a large number of state-owned holding enterprises (SOEs) and non-state-owned enterprises (NSOEs) in China's steel industry. The two have fundamental differences in governance logic, ESG motivation and performance goals. However, existing studies mostly use group comparisons rather than informal interaction term tests when dealing with heterogeneity of ownership. The lack of methodological level makes it difficult to accurately identify the statistical inference of the moderating effect (9).

Addressing the gap identified above, the present study takes 134 A-share listed steel companies observed over 804 firm-years from 2014 to 2023 as its research object and poses a single primary question, namely whether the ownership structure of the firm conditions the extent to which ESG performance is associated with accounting profitability, which is examined by constructing an ESG and state-ownership interaction within a two-way fixed-effects specification; the decomposition of ESG into its environmental, social and governance components and the comparison of the return-on-assets and return-on-equity specifications are subsidiary analyses whose function is to characterise the boundaries of that primary association rather than to introduce separate research questions. Prior work has already established that state ownership and political connection condition the financial consequences of ESG, so the introduction of state ownership as a moderator cannot by itself constitute the contribution of the present study, which instead rests on what the heavy-industry setting reveals about the form that this conditioning takes. In sectors where environmental performance is substantially administratively determined, the level of ESG effort is not the margin on which ownership operates, because compliance obligations are imposed on state-owned and non-state-owned producers alike; what differs is the extent to which a given level of effort is converted into priced outcomes, and the conversion margin is dimension-specific rather than uniform. The evidence developed here bears directly on that proposition, in that the attenuation associated with state ownership is confined to the environmental and social dimensions, which carry the heaviest regulatory-compliance content in the steel sector, and is statistically indistinguishable from zero on the governance dimension, which improves capital-allocation efficiency through channels that operate irrespective of who controls the firm. A generic agency account of state ownership predicts uniform attenuation across dimensions and is therefore not consistent with this pattern, whereas an account grounded in the compliance content of the underlying activity is; the resulting distinction between policy-laden and market-driven components of ESG is what the Chinese steel setting contributes beyond the confirmation of an already-documented moderating relationship, and it carries the further implication that regulatory attention to governance quality can raise the financial return to ESG improvement in state-owned producers without requiring any change in ownership structure.

2. Literature Review and Research Hypotheses

2.1 China's Institutional Background: Characteristics of Ownership Structure in the Steel Industry

China's steel industry has a highly differentiated ownership structure. Leading state-owned enterprises, represented by Baowu Group and Ansteel Group, are within the State-owned Assets Supervision and Administration Commission (SASAC) system, and are subject to systematic intervention by the state's will in terms of policy guidance, resource acquisition, and strategic decision-making. Private steel enterprises, represented by Shagang Group, are completely exposed to market competition pressure and rely on profitability as their bottom line for survival. This duality of ownership structure has led to fundamental differences in the motivations for ESG behavior and the financial transformation paths of enterprises within the same industry (24). Institutional research on state capitalism shows that state-owned ownership is the core mechanism for transmitting the state's will to micro-enterprise behavior, and it exhibits different patterns from market-oriented enterprises in terms of innovation input and performance transformation (24).

At the policy level, the Chinese government's ESG requirements for state-owned steel enterprises have a distinct administrative enforcement nature. From the capacity reduction policy in 2016 to the "Guiding Opinions on High-Quality Development of the Steel Industry" in 2022, and then to the inclusion of steel in the national carbon market in 2024, the adjustment of state-owned enterprises' ESG behavior has always been accompanied by policy directives rather than market incentives (5). Evidence suggests that the impact of the central environmental protection inspection system on the ESG performance of state-owned enterprises (SOEs) is mainly achieved through administrative pressure transmission rather than proactive corporate governance, with the latter having a relatively limited financial spillover effect (25). While the advancement of mixed ownership reform has adjusted the governance structure of SOEs to some extent, the crowding-out effect of policy objectives on financial objectives remains stubbornly persistent without fundamental changes in the nature of ownership (26).

In studies on the relationship between digitalization and ESG, relevant conclusions show that the promoting effect of digitalization on ESG is more significant in non-SOEs, and the administrative constraints on SOEs weaken the market-oriented operation efficiency of ESG signals (27). From the perspective of the relationship between corporate sustainable development and green innovation, the incentive effect of ESG performance on green innovation also shows significant differentiation across ownership structures, with non-SOEs exhibiting a more market-oriented approach to green innovation (28). Research on the impact of ownership heterogeneity on the CSR black box mechanism also confirms that the efficiency of ESG value transformation through stakeholder satisfaction channels is lower for SOEs than for non-SOEs (29). From the perspective of total factor productivity, the promoting effect of ESG improvement on the productivity of SOEs is also weaker than that of non-SOEs, indicating that the regulatory role of ownership structure has a certain degree of universality (30).

2.2 ESG Performance and Financial Performance: Theoretical Basis and Empirical Discrepancies

The theoretical explanation of the relationship between ESG and financial performance is rooted in two opposing paradigms. Stakeholder theory holds that by satisfying the needs of multiple stakeholders other than shareholders, companies can build differentiated reputation assets and stable cooperative networks, thereby achieving higher financial returns in the long term (11). The resource-based view, from the perspective of competitive advantage, regards high ESG performance as a process of companies accumulating heterogeneous and difficult-to-imitate resources: effective environmental management reduces energy consumption and pollution costs, sound corporate governance alleviates information asymmetry, and a sound social responsibility system attracts high-quality talents. The three together form a financial advantage over competitors (12). In contrast, agency theory provides a completely opposite logic: management may use ESG expenditures as a tool to seize private benefits, and excessive ESG investment corresponds to a net transfer from shareholder profits to social expenditures, which will inevitably drag down financial performance (13). The CSR supply and demand equilibrium theory further points out that there is an optimal level that maximizes the net return of ESG investment, and excessive investment will also produce efficiency losses (14).

Empirically, a meta-analysis of over 2,000 studies shows a predominantly positive correlation between ESG and financial performance, but the effect size varies significantly depending on industry, region, and measurement method (4). Evidence suggests that ESG performance has a robust positive impact on corporate market capitalization and profitability (15). Bibliometrics and meta-analysis further confirm that the quality of ESG disclosure is positively correlated with financial performance, and mitigation of information asymmetry is a crucial transmission channel (16). In the time dimension, the financial effects of ESG exhibit clear intertemporal characteristics: in the short term, ESG expenditures put pressure on profits, while in the long term, the value creation effect is more prominent, with the reduction of equity capital cost being the core mechanism (17). From the perspective of information asymmetry, high-ESG companies improve their financing conditions by reducing adverse selection risk, thereby translating into improved financial performance (18). In industry-specific samples, the positive financial spillover effect of ESG performance has been verified in industries such as aviation and energy (19). Other studies have found a significant positive correlation between ESG improvement and corporate total factor productivity, with operational efficiency being a crucial transmission channel for the financial value of ESG (20).

In the Chinese context, the financial effects of ESG present a more complex picture due to the characteristics of local institutions. Chinese ESG research differs systematically from mature markets in terms of scoring systems, data accessibility, and institutional externalities (3). Relevant evidence shows that the ESG performance of Chinese listed companies has a positive impact on corporate market value, and this effect is strengthened through two mechanisms: corporate reputation and green innovation (21). In a specific sample of the manufacturing industry, the overall ESG score is positively correlated with corporate value, and the effect is more pronounced in non-state-owned enterprises (22). Further research also shows that there is a significant threshold effect between ESG performance and investor attention—when the ESG score crosses a certain threshold, the marginal utility of investor attention increases significantly, thereby

amplifying the signaling effect of ESG on financial performance (23).

Based on the above theoretical and empirical logic, the positive financial effects of ESG investment should hold true in the specific context of the steel industry: strict environmental management reduces the risk of potential regulatory penalties, proactive social responsibility improves stakeholder relationships, and sound corporate governance enhances capital allocation efficiency; all three work together to improve ROA and ROE. Although agency theory and the corporate social responsibility supply-demand equilibrium perspective caution that ESG outlays exceeding the value-maximizing threshold may erode shareholder returns, the heightened regulatory intensity, energy-cost exposure, and green-financing constraints that characterize the steel sector make the marginal return to ESG improvement more likely to fall on the upward-sloping segment of this relationship, such that the net financial effect is expected to remain positive in this specific industry context. The prediction advanced in H1 therefore rests on stakeholder theory and the resource-based view, while agency theory and the supply-and-demand equilibrium perspective furnish the competing prediction, and the sign of the estimated coefficient adjudicates between them within this industry rather than in general.

Accordingly, this paper proposes the following research hypothesis:

H1: Among listed steel companies in China, ESG performance is significantly and positively associated with corporate financial performance measured by return on assets and return on equity.

2.3 State Ownership, Heavily Polluting Industries, and the Unresolved Question

Three strands of evidence bear on the question posed here, and their joint reading identifies what remains unsettled. The first, reviewed in Section 2.2, establishes a predominantly positive association between ESG performance and financial outcomes whose magnitude varies with industry, region and measurement (4, 16, 48). The second concerns the objectives of state-owned firms and converges on the finding that the financial returns to a given corporate action are lower where state ownership is present, whether the action is digital transformation (27), green innovation (28), stakeholder-oriented investment (29) or productivity-enhancing effort more generally (30). The third addresses heavily polluting industries, where environmental improvement and near-term financial outcomes stand in tension: evidence from Chinese high-carbon enterprises indicates that a tightening of green-finance constraints delivers measurable environmental gains while depressing economic performance in the short run through the crowding out of research expenditure (49), and evidence on environmental taxation points in the same direction (31). Read together, these strands establish that state ownership attenuates the financial returns to corporate effort and that heavy industry faces an environment-economy tension, yet they leave open the question of where within the ESG construct the attenuation is located. Should the attenuation reflect a generic agency or incentive deficiency attaching to state ownership itself, it would apply with comparable force to every component of ESG; should it instead reflect the administratively determined character of particular activities, it would be confined to those components carrying regulatory-compliance content and would be absent from components whose financial value arises through market channels common to all ownership types. Existing studies, which analyse composite ratings within cross-industry samples, cannot separate these possibilities, and it

is this unresolved question that the present study addresses.

Core literature, in examining the impact of political control on ESG-financial relationship in Chinese private enterprises, found that the proportion of state shareholding has a significant negative moderating effect on the positive effect of ESG performance, and the suppressive effect of political connections on ESG financial value has been verified in both financial performance and corporate valuation dimensions(10). This paper independently examines this proposition in the context of the steel industry and theorises three candidate moderating channels that differ from the political-connection agency problem observed in private enterprises, presenting them as possible explanations that the subsequent dimensional-heterogeneity evidence assesses indirectly rather than as mechanisms established through formal mediation testing.

The theoretical argument supporting H2 draws on two propositions that operate jointly rather than on a list of independent conjectures. The corporate social responsibility supply-and-demand equilibrium perspective holds that an optimal level of ESG investment exists at which marginal return equals marginal cost, and that expenditure beyond that level yields net efficiency loss (14); institutional accounts of state capitalism hold that state ownership is the mechanism through which state objectives are transmitted into firm behaviour (24). Combining the two yields the prediction that the quantity of ESG activity undertaken by a state-controlled steel producer is set by administrative targets rather than by the equilibrium condition, so that the marginal unit of that activity is systematically less likely to lie on the return-maximising segment of the relationship. A countervailing prediction deserves explicit attention, since state-controlled producers enjoy privileged access to credit, land and regulatory forbearance, and a resource-based reading would accordingly anticipate that state ownership strengthens rather than weakens the financial return to ESG improvement. The reason to expect weakening is that the binding constraint in this setting is not the availability of resources with which to undertake ESG activity but the conversion of that activity into priced outcomes, and conversion depends on the informational and competitive channels through which stakeholders reward it. Where ESG activity is administratively mandated and near-universal within an ownership class, its observed level conveys little incremental information about firm quality to lenders, customers or investors, and the reputational and cost-of-capital advantages that constitute the return in the stakeholder and resource-based accounts are correspondingly compressed (32, 34). The three considerations set out below are concrete expressions of this single argument, and they are advanced as theoretically plausible interpretations that the present design does not test directly.

Cost crowding-out arising from policy-driven ESG expenditure is the first of these considerations. The CSR supply and demand equilibrium theory points out that the optimal level of ESG input is endogenously determined by market demand and competitive landscape, and expenditures exceeding this level will result in net efficiency loss (14). The policy-driven expenditures undertaken by state-owned steel enterprises in environmental compliance, community investment, and employee welfare are not driven by efficiency improvement, but are the necessary cost of administrative compliance, and therefore cannot be compensated through reputational assets or market premiums (31). Under the mandatory information disclosure framework, institutional investors are hesitant to assess the information value of ESG reports from state-owned enterprises

(SOEs), further weakening the capital cost reduction effect that ESG improvements should bring (32).

The structure of managerial incentives is the second consideration. The promotion mechanism for SOE executives is highly tied to political goals, while its direct link to financial performance is relatively loose. This results in a lack of intrinsic incentive for ESG investment to transform from "compliance" to "value creation" (33). Studies on media coverage of ESG governance also found that SOEs' responses to external public opinion supervision are more symbolic information disclosures than substantive governance improvements, thus damaging the signal value of ESG actions (34).

The limited reach of market feedback is the third consideration. Under policy constraints, the ESG behavior of SOEs is difficult to fully internalize into market-based benefits such as consumer loyalty, supply chain stability, and financing convenience; while non-SOEs have a smoother path to reduce financing constraints and accumulate market reputation through ESG improvement (5, 12). The effective operation of market mechanisms allows ESG investment to be more directly transformed into financial returns. Taken together, the three considerations outlined above lead to the expectation that state ownership will be associated with a systematically weaker positive relationship between ESG performance and financial performance. Based on this, the following hypothesis is proposed:

H2: State ownership exerts a negative moderating effect on the positive relationship between ESG performance and financial performance, so that the positive association between ESG and financial performance is significantly weaker in state-owned steel enterprises.

Based on the above theoretical logic, the overall analytical framework of this paper is shown in Figure 1. Subsequent research will construct an empirical model based on this framework.

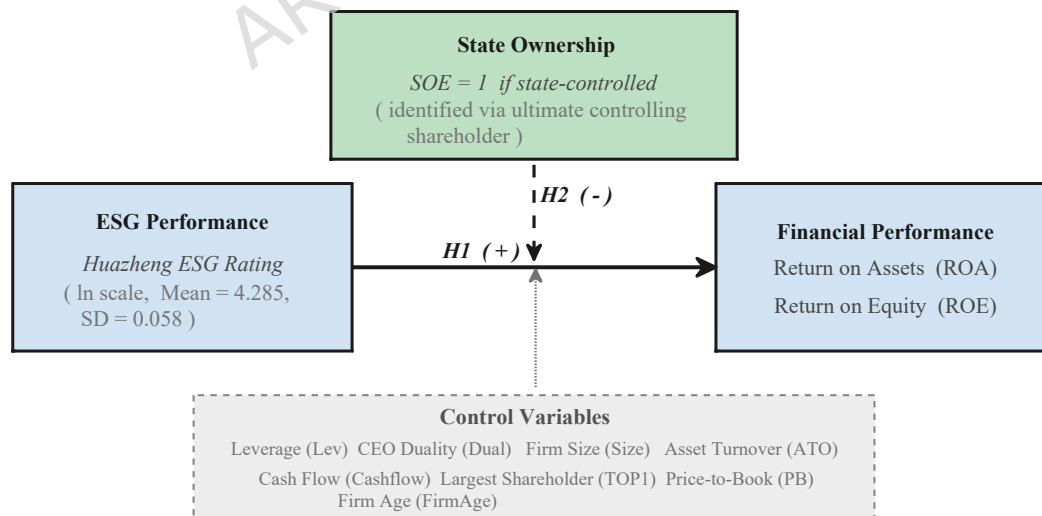


Figure 1. Theoretical Analysis Framework. Note: $N = 804$ firm-years; 134 A-share listed steel companies, China, 2014–2023. Solid arrow: H1 (hypothesised positive association).

Dashed arrow: H2 (hypothesised negative moderating association). Dotted arrow: control variable adjustment.

3. Research Design

3.1 Sample Selection and Data Sources

This study focuses on listed steel companies in the Chinese A-share market over the ten annual periods from 2014 to 2023. Steel companies are identified on two criteria applied in sequence. All A-share firms classified under code C31, ferrous metal smelting and rolling processing, in the 2012 industry classification of the China Securities Regulatory Commission are included; the population is then extended to listed companies whose steel-related revenue, comprising ironmaking, steelmaking, steel rolling processing and steel structure products, exceeds fifty per cent of main business income, which captures firms whose classification code changed during the period as a result of industry reclassification, backdoor listing or a shift in principal business. ESG scores are drawn from the Huazheng ESG Rating System through the Wind Financial Terminal, and financial, ownership and control-variable data are drawn from the CSMAR database. Application of the two criteria yields 134 firms, of which approximately 35 are core smelting-and-rolling enterprises under C31 and the remainder are upstream and downstream firms whose principal business is steel. Because the financial dynamics and regulatory exposure of integrated smelters and steel-structure fabricators differ, this compositional heterogeneity is absorbed by the firm fixed effects, and the firm-size analysis reported in Section 4.4 characterises the systematic differences between the larger integrated producers and the smaller downstream processors.

The 134 firms and the ten-year window define 1,340 potential firm-years, of which 804 enter the estimation, so that the panel is unbalanced and each firm contributes six observations on average. The 536 unavailable firm-years arise from four sources, reported here in the order in which the criteria are applied. Firms that listed after 2014 or were delisted before the end of 2023 are observable only for part of the window and contribute correspondingly fewer years, which accounts for the largest share of the shortfall. Huazheng coverage of A-share steel firms expands over the sample period rather than being complete from the outset, so early years are unavailable for firms rated only from a later date. Firm-years carrying a special-treatment designation, namely ST, *ST and PT status, are excluded because the financial ratios of firms under delisting risk warning are not comparable with those of ongoing operations, as are firm-years with missing values on any regression variable. Because the ESG rating and all control variables enter with a one-period lag, the first year in which a firm is otherwise observable cannot be used, which removes one further observation per firm. All continuous variables are winsorised at the 1st and 99th percentiles.

Ownership nature is determined from the ultimate controller reported in the annual report: a firm is classified as state-controlled (SOE = 1) where the ultimate controller is the State-owned Assets Supervision and Administration Commission or a government shareholding platform at any administrative level, and as non-state-controlled (SOE = 0) otherwise. On this basis 223 firm-year observations, or 27.7 per cent of the sample, are state-controlled and 581, or 72.3 per cent, are not. Seven firms changed ownership nature during the period through mixed-ownership reform or a change of actual controller, involving 29 firm-year observations or

3.6 per cent of the sample; these firms are retained with a time-varying indicator that switches in the year the change is disclosed, rather than being assigned to a single category for the whole period or excluded, and they supply the within-firm variation from which the SOE main effect is identified under firm fixed effects. Section 4.3 reports a re-estimation excluding these firms in order to confirm that the interaction of interest does not depend upon them.

3.2 Variable Definition and Measurement

Dependent Variable. Financial performance is measured through two accounting-based indicators, namely return on assets and return on equity. The choice follows from the research question, which asks whether a given level of ESG activity is converted into realised profitability and whether that conversion differs by ownership; accounting returns record realised conversion directly, whereas market-based measures such as Tobin's Q record investor expectations of future cash flows. The distinction is consequential in this particular setting rather than merely conceptual, because valuations of Chinese state-controlled firms incorporate expectations of implicit government support and policy-driven demand, so that a market-based outcome would confound the ownership-conditional conversion of ESG activity, which is the object of the study, with an ownership-related valuation premium arising independently of ESG. The study is therefore delimited as an analysis of accounting profitability and does not establish how capital markets value ESG activity in the steel sector; consistent with that delimitation, the market-to-book ratio and the operating cash-flow ratio enter the models as control variables rather than as outcomes, and extension to market-based outcomes is identified as a complementary line of inquiry. ROA is equal to the ratio of earnings before interest and taxes (EBIT) to total assets at the end of the year, measuring the overall operational efficiency of a company's assets; ROE is equal to the ratio of net profit to shareholders' equity at the end of the year, measuring the return on equity (35). Using two indicators helps to identify the financial effects of ESG from different levels and reduces the impact of measurement errors of a single indicator (36).

Core Explanatory Variable. ESG performance is measured using the composite score published by the Huazheng ESG rating system. The Huazheng ESG rating uses a base score range of 0-100 points, with differentiated scores corresponding to 9 letter ratings (C to AAA). This paper takes the natural logarithm of the composite score $\ln(\text{ESG_score})$ as the explanatory variable to alleviate the right skewed distribution of the original score in the high score range and to interpret the regression coefficient as an approximate percentage elasticity. The median of the original ESG score in the sample is approximately 73 points, and the mean after logarithmic transformation is 4.285 (SD = 0.058). It should be noted that Huazheng Ratings' rating of the steel industry shows a significant intra-industry compression characteristic (the intra-group SD is less than that of cross-industry samples by about 60%), which reflects the rating squeeze phenomenon of rating agencies on homogeneous heavily polluting industries. This may lead to the estimated ESG effect in this paper being slightly lower than the actual effect—this tendency constitutes a conservative estimate for the test of H1. Because this compression simultaneously narrows the variation available for identifying the moderating term; the interaction estimate underlying H2 is attenuated in the same direction, so that a statistically detectable weakening effect under such restricted dispersion should be

interpreted as a conservative lower bound rather than an inflated estimate of the true moderation.

Moderating variable. State ownership enters the analysis in two forms. The primary specification employs a binary state-control indicator (SOE) equal to one where the ultimate controller of the firm is the State-owned Assets Supervision and Administration Commission at central, provincial or municipal level, a government department, or a state-owned shareholding platform, and zero otherwise; ultimate control is determined from the ultimate-controller field of the CSMAR database and cross-checked against the equity-structure disclosure in each annual report, so that control exercised indirectly through a chain of intermediate holding entities is attributed to the terminal state entity rather than to the immediate registered shareholder. The indicator is time-varying and switches in the reporting year in which the change of actual controller is disclosed, which applies to the seven firms and twenty-nine firm-year observations described in Section 3.1. The binary form is adopted as the primary specification because state influence over the objectives of Chinese listed firms is exercised principally through control rights, and in particular through the appointment of senior management and the transmission of policy targets, rather than in proportion to cash-flow rights, so that a firm passing from minority state participation into state control experiences a discrete change in its objective function that a linear percentage measure would understate. The continuous proportion of state-held shares (SOE_ratio) is nonetheless employed as an alternative moderator in Section 4.3, where the marginal association between ESG and financial performance is evaluated across representative levels of state shareholding rather than being inferred from the interaction coefficient alone. The interaction term is the object of interest under both forms, and the sign and significance of its coefficient β_3 constitute the test of H2.

Control variables. Following the relevant research conventions (7), this paper controls the following variables: debt-to-equity ratio (Lev); dummy variable of chairman and general manager combined (Dual); enterprise size (Size, natural logarithm of total assets); asset turnover ratio (ATO); operating cash flow ratio (Cashflow); shareholding ratio of the largest shareholder (TOP1); price-to-book ratio (PB); enterprise age (FirmAge, natural logarithm of years listed). All control variables are lagged by one period to partially alleviate the problem of reverse causality. The complete definitions of each variable are shown in Table 1.

Table 1. Variable definitions.

Variable Type	Variable Name	Symbol	Definition
Dependent	Return assets	on ROA	EBIT / total assets at year-end
	Return equity	on ROE	Net income / shareholders' equity at year-end
Explanatory	ESG performance	ESG_{t-1}	Natural log of Huazheng ESG composite score (lagged one period)
Moderator	State	SOE	= 1 if state-controlled, 0 otherwise (by

Variable Type	Variable Name	Symbol	Definition
	ownership		ultimate-controller field)
Interaction	Moderating term	$ESG \times SOE$	Product of ESG and SOE for testing H2
Controls	Leverage	Lev_{t-1}	Total liabilities / total assets (lagged)
	CEO duality	$Dual_{t-1}$	= 1 if chairman also serves as CEO, 0 otherwise (lagged)
	Firm size	$Size_{t-1}$	Natural log of total assets (lagged)
	Asset turnover	ATO_{t-1}	Revenue / average total assets (lagged)
	Operating cash flow	$Cashflow_{t-1}$	Net operating cash flow / total assets (lagged)
	Largest shareholder	$TOP1_{t-1}$	Shareholding of the largest shareholder (lagged)
	Price-to-book	PB_{t-1}	Market capitalisation / book value of equity per share (lagged)
	Firm age	$FirmAge_{t-1}$	Natural log of years since listing (lagged)

Note: ESG data come from the Huazheng ESG Rating System via the Wind Financial Terminal; financial and ownership data are from the CSMAR database. The sample spans 2014–2023, comprising 804 firm-year observations. All explanatory and control variables are lagged by one period.

3.3 Empirical Models

Two sets of empirical models are specified. The baseline model uses a two-way fixed-effects estimator:

$$FP_{it} = \beta_0 + \beta_1 ESG_{i,t-1} + \beta_2 X_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

where FP_{it} is the financial performance of firm i in year t (ROA or ROE); $X_{i,t-1}$ is the vector of lagged control variables; μ_i captures firm fixed effects, absorbing unobservable time-invariant firm-level characteristics; λ_t captures year fixed effects, absorbing common macroeconomic shocks; and ε_{it} is the error term.

The moderating-effect model extends the baseline by adding an SOE dummy and the interaction term:

$$FP_{it} = \beta_0 + \beta_1 ESG_{i,t-1} + \beta_2 SOE_i + \beta_3 (ESG \times SOE)_{i,t-1} + \beta_4 X_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

The test of H2 focuses on the sign and significance of β_3 : significantly negative β_3

indicates that state ownership is associated with a weaker positive association between ESG and financial performance, thereby supporting H2. Standard errors in all regressions are clustered at the firm level to correct the downward bias that arises from within-cluster residual serial correlation. The Hausman test ($\chi^2 = 42.17$, $p < 0.001$) rejects the random-effects assumption and supports the fixed-effects specification. To mitigate endogeneity, ESG is lagged by one period, and instrumental-variable estimation is further employed in the robustness checks. A one-period lag attenuates contemporaneous reverse causality but does not by itself eliminate the simultaneity that may arise when ESG ratings and financial performance reflect longer-horizon strategic alignments; for this reason the two-stage least-squares estimation reported in Section 4.3 is used to address this particular source of endogeneity more directly than the lag structure alone, though it is presented there as corroborative rather than as establishing causality. Two threats warrant separate treatment. Reverse causality, understood as more profitable firms subsequently purchasing higher ratings or funding more visible ESG activity, is addressed by lagging the rating and all controls by one period and by the instrumental-variable estimation reported in Section 4.3, though neither device removes it entirely where ESG performance and profitability respond jointly to a multi-year strategic reorientation. Time-varying unobserved factors are addressed only in part: firm fixed effects absorb permanent differences in managerial quality, corporate culture and regulatory exposure, year fixed effects absorb common macroeconomic and policy shocks, and the province-by-year specification reported in the Supplementary Material absorbs regional policy shocks that vary over time, but firm-specific determinants that themselves change during the sample period remain outside the specification. The estimates are accordingly interpreted throughout as conditional associations rather than as causal effects.

Although state ownership is time-invariant within most firms, seven firms in the sample underwent an ownership-nature transition during 2014 to 2023, involving 29 firm-year observations, which renders the SOE main effect identifiable within the firm fixed-effects framework. For firms whose ownership nature remains unchanged throughout the sample period, the SOE main effect is absorbed by the firm fixed effects, so that the identification of β_2 in Model 2 derives from the transition firms alone. The ESG $\times$ SOE interaction is identified on a different basis. It exploits the between-firm variation in ownership status interacted with the within-firm variation in ESG across all 223 state-owned firm-year observations, rather than the small number of transitions, and it therefore does not depend structurally on the transition subsample. This distinction is confirmed directly by robustness check (3) in Section 4.3, which re-estimates the model after excluding the transition firms, and it is corroborated from an independent direction by the continuous state-shareholding specification in check (4), in which state shareholding varies within firms over time and the ownership effect is accordingly identified from the full sample.

4. Empirical Results

4.1 Descriptive Statistics and Correlations

Table 2 summarises the statistical features of the main variables.

As shown in Table 2, the sample ROA has a mean of 0.039 and a standard deviation of 0.053, with a range from -0.158 to 0.201 ; the negative minimum is consistent with cyclical losses observed in the industry. ROE has a mean of 0.060 and a standard deviation of

0.120, a more dispersed distribution whose minimum of -0.425 reflects severe erosion of net assets among some firms during industry downturns. The mean ESG score is 4.285 (in logs), with a standard deviation of only 0.058; the compressed range between 4.073 and 4.426 reflects the inherent compression of the Huazheng rating scheme and is consistent with regularities reported in previous studies. The SOE dummy has a mean of 0.278, indicating that about 27.8 per cent of firm-year observations belong to state-owned firms, broadly matching the actual ownership composition of the steel industry. The mean leverage of 0.452 reflects the generally high level of financial leverage in this capital-intensive sector, with some firms exhibiting leverage as high as 0.862, suggesting non-trivial overleverage within the industry.

In terms of pairwise relations, the correlations of ESG with ROA and ROE are 0.183 and 0.156, respectively, both significant at the 1 per cent level, providing preliminary descriptive support for H1. The correlation between SOE and ESG is -0.142 , indicating that SOE steel firms have slightly lower ESG scores than NSOE peers. The correlation between Lev and ROA is -0.387 , reflecting the clear drag of high leverage on profitability. No pairwise correlation exceeds 0.65, and the variance-inflation factors reported alongside the correlation matrix reach a maximum of 1.581, well below the conventional threshold of ten, confirming the absence of serious multicollinearity. The complete pairwise correlation matrix for all regression variables, together with the variance-inflation factors, is reported in Table S1 of the Supplementary Material.

Table 2. Descriptive statistics (N = 804).

Variable	Mean	SD	Min	Median	Max
ROA	0.039	0.053	-0.158	0.035	0.201
ROE	0.060	0.120	-0.425	0.058	0.412
ESG	4.285	0.058	4.073	4.286	4.426
SOE	0.278	0.448	0.000	0.000	1.000
Lev	0.452	0.186	0.068	0.452	0.862
Dual	0.256	0.437	0.000	0.000	1.000
Size	22.614	1.283	19.842	22.486	26.175
ATO	0.756	0.356	0.087	0.702	2.184
Cashflow	0.053	0.063	-0.163	0.051	0.256
TOP1	0.381	0.142	0.085	0.377	0.771
PB	2.634	2.183	0.527	1.862	16.284
FirmAge	3.019	0.342	1.792	3.091	3.497

Note: Continuous variables are winsorised at the 1st and 99th percentiles. SOE and Dual are dummy variables. ESG is the natural logarithm of the Huazheng ESG composite score. Variance-inflation factors for all regression variables are reported in Table 3; the maximum is 1.581, well below the conventional threshold of ten.

4.2 Baseline Regression and Moderating Effect

Table 3 reports the estimation results for the baseline and moderating-effect models. For ease of comparison, Columns (1) and (2) present the baseline models without the interaction term, while Columns (3) and (4) present the moderating-effect models; the dependent variables are ROA and ROE, respectively.

As shown in Table 3, the baseline models (Columns (1) and (2)) indicate that ESG performance has a coefficient of 0.087 ($p < 0.01$) on ROA and 0.186 ($p < 0.05$) on ROE. After controlling for two-way fixed effects, improvements in ESG performance are significantly and positively associated with both ROA and ROE, thereby supporting H1. For the ROA specification, a one-unit increase in log-ESG (roughly a substantive upgrade in rating) is associated with an approximate 8.7-percentage-point rise in ROA; given that the industry mean ROA is only 3.9 per cent, this association is economically meaningful. With respect to the control variables, leverage (Lev) is significantly and negatively associated with both ROA and ROE, with a coefficient of -0.196 ($p < 0.01$) for ROA, confirming that high leverage markedly constrains profitability in the steel sector. Operating cash flow (Cashflow) carries the largest coefficient (0.428 , $p < 0.01$), reflecting its decisive role in short-run profitability. The CEO-duality coefficient (Dual) is insignificant ($\beta = 0.003$, $p > 0.10$), a pattern consistent with the bifurcated governance structure of the Chinese steel industry: SOEs typically operate under a coordinated arrangement among the Party secretary, chairperson, and CEO, whereas private steel firms rely heavily on centralised decision-making by their founding owners; as a result, formal duality arrangements are only weakly correlated with actual power concentration, and have no independent explanatory power for financial performance. This pattern is consistent with evidence on the Dual variable reported by Jiang et al. (37) in their study of Chinese corporate governance. The firm-age coefficient is negative but insignificant, suggesting only a small difference in ESG-to-financial conversion between mature firms and more recently listed ones.

Table 3. Baseline and moderating-effect regressions of ESG performance on financial performance.

Variable	(1) ROA	(2) ROE	(3) ROA	(4) ROE
ESG	0.087*** (0.027)	0.186** (0.085)	0.096** (0.037)	0.215** (0.102)
SOE	—	—	-0.018** (0.008)	-0.048* (0.026)
ESG×SOE	—	—	-0.041* (0.022)	-0.133* (0.078)
Lev	-0.196*** (0.018)	-0.462*** (0.057)	-0.194*** (0.018)	-0.458*** (0.057)
Dual	0.003 (0.004)	0.008 (0.011)	0.003 (0.004)	0.008 (0.011)
Size	0.008**	0.022**	0.008**	0.022**

Variable	(1) ROA	(2) ROE	(3) ROA	(4) ROE
	(0.003)	(0.009)	(0.003)	(0.009)
ATO	0.028*** (0.008)	0.074*** (0.024)	0.028*** (0.008)	0.073*** (0.024)
Cashflow	0.428*** (0.042)	1.126*** (0.131)	0.426*** (0.042)	1.121*** (0.131)
TOP1	0.024 (0.023)	0.063 (0.072)	0.023 (0.023)	0.060 (0.072)
PB	0.003*** (0.001)	0.009*** (0.002)	0.003*** (0.001)	0.009*** (0.002)
FirmAge	-0.008 (0.006)	-0.019 (0.018)	-0.007 (0.006)	-0.018 (0.018)
Constant	-0.294** (0.118)	-0.796** (0.368)	-0.346** (0.163)	-0.924* (0.507)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	804	804	804	804
R ²	0.747	0.612	0.754	0.621

*Note: The dependent variable is the year- t value of ROA or ROE; ESG and all control variables are lagged by one period. Firm-clustered robust standard errors are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. The reported R^2 corresponds to the total coefficient of determination from the reghdfe default output, which incorporates variation absorbed by the firm and year fixed effects. The Hausman test ($\chi^2 = 42.17$, $p < 0.001$) supports the fixed-effects specification. In Column (3) the linear combination $\beta_1 + \beta_3$ equals 0.055 and in Column (4) it equals 0.082; a Wald test of each combination fails to reject the null of no association within state-controlled firms, and the associated 95 per cent confidence intervals span zero (see Section 4.2). The SOE main effect in Columns (3) and (4) is identified from the seven firms that experienced an ownership-nature transition during the sample period (see Section 3.3).*

With the SOE dummy and the interaction term introduced in Columns (3) and (4), the core findings become sharper. The ESG main-effect coefficient rises to 0.096 ($p < 0.05$) in Column (3) and to 0.215 ($p < 0.05$) in Column (4), reflecting the full strength of the ESG effect within the NSOE sample. The ESG $\times$ SOE interaction term has a coefficient of -0.041 ($p < 0.10$) in Column (3) and -0.133 ($p < 0.10$) in Column (4), both significantly negative at the 10 per cent level, lending statistical support to H2. Specifically, the marginal ESG coefficient for ROA falls from 0.096 among non-state-owned firms to $0.096 - 0.041 = 0.055$ among state-controlled firms, which is not statistically distinguishable from zero, and the corresponding coefficient for ROE falls from 0.215 to $0.215 - 0.133 = 0.082$, likewise not distinguishable from zero. Expressed in standardized terms, a one-

standard-deviation increase in the log-ESG score (0.058) is associated with a rise of approximately 0.56 percentage points in ROA among non-state-owned firms but only about 0.32 percentage points among state-owned firms, the latter being statistically insignificant; the corresponding figures for ROE are about 1.25 and 0.48 percentage points. The marginal ESG association is correspondingly smaller under state ownership, by roughly 43 per cent for ROA and 62 per cent for ROE. The association between ESG performance and financial performance is therefore statistically discernible among non-state-owned steel firms and is not distinguishable from zero among state-controlled firms.

Set against the sample means reported in Table 2, these magnitudes are economically material without being implausibly large. The increment of 0.56 percentage points in return on assets estimated for non-state-owned firms corresponds to approximately 14 per cent of the sample mean return on assets of 0.039, and the increment of 1.25 percentage points in return on equity corresponds to approximately 21 per cent of the sample mean of 0.060, whereas the counterpart increments of 0.32 and 0.48 percentage points estimated for state-controlled firms correspond to approximately 8 per cent of each mean and are not statistically distinguishable from zero. The claim that the association is not discernible within state-controlled firms rests on a formal test rather than on the interaction coefficient alone: a linear-combination test of $\beta_1 + \beta_3$ returns a combined return-on-assets coefficient of 0.055 (SE = 0.050, $p = 0.27$) and a combined return-on-equity coefficient of 0.082 (SE = 0.151, $p = 0.59$), with 95 per cent confidence intervals of $[-0.044, 0.154]$ and $[-0.217, 0.381]$ respectively, both of which span zero.

Figure 2 illustrates the ownership-based divergence in the marginal effects of ESG. In Panel (a) (ROA), the blue solid line for NSOE firms exhibits a markedly steeper slope than the red dashed line for SOE firms: NSOE predicted ROA rises from about 0.023 at the low end of ESG (around 4.10) to about 0.057 at the high end (around 4.40), with a 95 per cent confidence band that does not cover zero; SOE predicted ROA rises only modestly from 0.019 to 0.039, with a wider confidence band that covers zero, indicating that the positive effect of ESG on ROA is statistically not distinguishable from zero within the SOE sample. Panel (b) (ROE) exhibits an even sharper moderating pattern: the NSOE predicted line rises from about 0.02 at the low end to about 0.10 at the high end, whereas the SOE line remains relatively flat, rising only from about 0.04 to 0.06. At the lower end of the observed range ($ESG \leq 4.15$), the two confidence bands overlap substantially, so ownership is not statistically distinguishable at low levels of ESG; once ESG exceeds the sample mean (4.285), the NSOE predicted ROE is significantly higher than the SOE predicted ROE, and the confidence bands no longer overlap. This evolution from "statistically indistinguishable at low ESG" to "clearly diverging at high ESG" reveals that the realisation of ESG value depends critically on market-based incentive mechanisms: only when ESG improvements are substantive enough can non-state-owned steel firms convert them into observable financial advantages, whereas among state-owned firms this conversion is not statistically discernible.

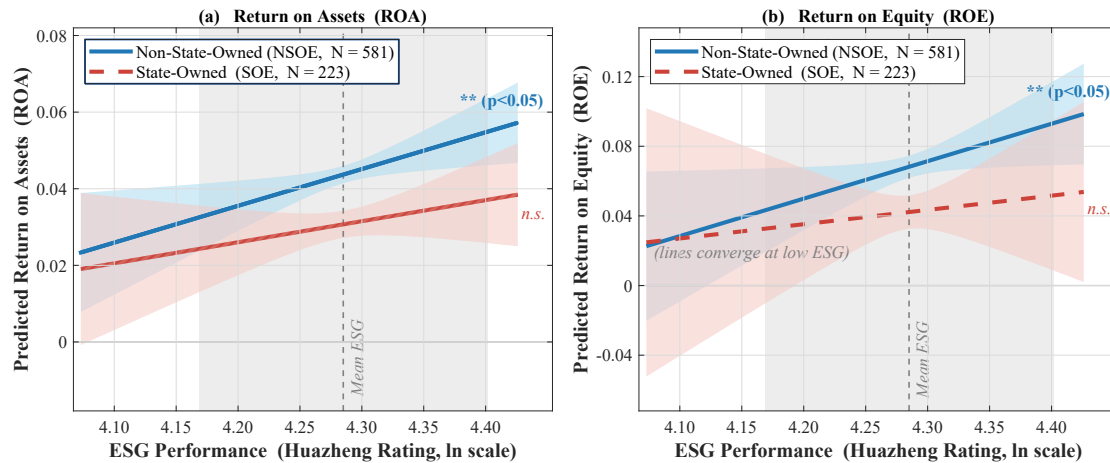


Figure 2. Marginal Effects of ESG Performance on Financial Performance: The Moderating Role of State Ownership. *Note: Predicted values computed with all continuous controls at sample means (Table 2): Lev = 0.452; Dual = 0.256; Size = 22.61; ATO = 0.756; Cashflow = 0.053; TOP1 = 0.381; PB = 2.634; FirmAge = 3.019. Shaded bands = 95% CI: $CI_{hw} = 1.96 * \sqrt{SE_{level}^2 + (ESG - mean_ESG)^2 * SE_{slope}^2}$. Gray shading = ESG mean $\pm$ 2 SD. Regression slopes from Table 3, Columns (3) and (4) (two-way fixed-effects model, firm-level clustered standard errors). ** $p < 0.05$; n.s. = not significant.*

4.3 Robustness Checks

Robustness is assessed against five distinct concerns rather than through an undifferentiated accumulation of tests, namely measurement of the ESG construct, model specification and omitted time-varying factors, endogeneity, sample composition, and the operationalisation of the moderator. Four analyses that speak most directly to the primary question are retained here and summarised in Table 4, and four further analyses addressing overlapping concerns are reported in Table S2 of the Supplementary Material, namely the province-by-year fixed-effects structure, propensity score matching, the exclusion of the pandemic years, and the untransformed rating scale.

(1) Alternative ESG rating system. To rule out the influence of rating-agency choice, the Huazheng score is replaced with the Bloomberg ESG Disclosure Score and Models 1 and 2 are re-estimated. Because Bloomberg's coverage of Chinese A-share steel firms is incomplete, the effective sample decreases to 537 observations (covering 89 firms). The two providers do not measure identical constructs, and the comparison should be read with that in mind. The Huazheng rating is a performance-oriented assessment constructed from mandatory and voluntary disclosure by Chinese listed firms together with regulatory-penalty and public-controversy records, calibrated within the domestic institutional setting; the Bloomberg score is a disclosure-completeness measure recording the breadth of items a firm reports against a global template, and it therefore rewards reporting practice as much as underlying environmental or social outcomes. Coverage differs correspondingly, in that the Bloomberg subsample is a strict subset of the estimation sample, comprising 537 of 804 firm-years and 89 of 134 firms, within which larger firms holding international investor bases are over-represented; the check is accordingly a joint test of sensitivity to the rating construct and to sample composition

rather than a test of the rating construct alone. On this subsample, the ESG coefficient is 0.094 ($p < 0.05$) for ROA and 0.197 ($p < 0.05$) for ROE, with $\text{ESG} \times \text{SOE}$ coefficients of -0.038 ($p < 0.10$) and -0.118 ($p < 0.10$), respectively. Both the sign and the significance are consistent with the baseline results, indicating that the conclusions are not sensitive to the choice of ESG rating system.

(2) Instrumental-variable estimation (2SLS). Following the leave-one-out peer-mean IV design, the two-period-lagged average ESG score of other firms within the same province and industry (excluding the focal firm), $\text{ESG_peer}_{\{t-2\}}$, is used as the instrument. The relevance of this instrument derives from region-specific imitation in ESG practices and local policy spillovers in the steel industry; using a two-period lag further rules out contemporaneous common shocks as a threat to the exclusion restriction. The exclusion restriction is defended on both theoretical and falsification grounds. On theoretical grounds, the twice-lagged ESG performance of geographically and industrially proximate peers shapes a focal firm's own ESG choices through imitation and shared regulatory pressure yet has no direct channel to that firm's current return on assets or return on equity once its own ESG performance and the full set of controls and fixed effects are held constant, and on falsification grounds the insignificance of the non-steel placebo instrument corroborates that the operative transmission runs through within-industry ESG behaviour rather than through generic regional economic conditions. The first-stage F-statistic is 28.46, well above the Stock–Yogo 10 per cent maximal IV bias critical value of 16.38, indicating no weak-instrument problem; the Kleibergen–Paap rk LM statistic is 23.78 ($p < 0.001$), rejecting the under-identification null. The first-stage coefficient on the instrument is $\beta = 0.42$, $\text{SE} = 0.079$, $t = 5.33$, positive and significant at the 1 per cent level, which together with the first-stage F-statistic of 28.46 establishes relevance. Because a single instrument is employed for a single endogenous regressor, the specification is exactly identified and no overidentification test is available; the exclusion restriction therefore rests on the theoretical argument and on the non-steel placebo falsification set out above rather than on a statistical test. The 2SLS estimate of ESG is 0.103 ($\text{SE} = 0.038$, $p < 0.01$) for ROA and 0.241 ($\text{SE} = 0.108$, $p < 0.05$) for ROE. The point estimates are slightly larger than the fixed-effects baseline and the signs and significance are consistent with it, so the conclusions are not overturned once this particular source of endogeneity is addressed; the estimates are nonetheless presented as corroborative of the baseline rather than as conclusive evidence of causality, since their validity is conditional on an exclusion restriction that cannot be tested in an exactly identified specification. In addition, this study conducts a placebo test using the lagged ESG average of firms in the same province but in non-steel industries as a pseudo-instrument; the coefficients are insignificant (ROA: $\beta = 0.021$, $p = 0.28$; ROE: $\beta = 0.048$, $p = 0.34$), providing supportive evidence that the genuine instrument operates only through within-industry transmission channels and that the exclusion restriction is plausible.

(3) Exclusion of ownership-transition firms. To confirm that the interaction result is not disproportionately driven by the seven firms that changed ownership nature during the sample period, the moderating model is re-estimated on the 775 firm-year observations that remain once these firms and their 29 observations are removed. The $\text{ESG} \times \text{SOE}$ coefficient is -0.042 ($\text{SE} = 0.025$, $p < 0.10$) for ROA and -0.135 ($\text{SE} = 0.054$, $p < 0.05$) for ROE, both closely comparable in magnitude to the baseline estimates of -0.041 and

–0.133 and retaining statistical significance, with the ROE interaction estimated more precisely on the restricted sample and therefore significant at the 5 per cent level, so that the attenuating role of state ownership is confirmed to be a feature of the full ownership contrast rather than an artefact of the transition subsample. Because state ownership becomes strictly time-invariant within every remaining firm once these cases are excluded, the SOE main effect is absorbed by the firm fixed effects and is not separately identified in this specification, a consequence that follows directly from the identification structure set out in Section 3.3 and that leaves the interaction term of interest unaffected.

(4) Continuous specification of state ownership. To verify that the findings are not artefacts of how the moderator is operationalised, the binary state-ownership indicator is replaced with the continuous proportion of state-held shares (*SOE_ratio*) and the interaction is respecified as $ESG \times SOE_ratio$. The ESG main effect is 0.098 (SE = 0.021, $p < 0.01$) for ROA and 0.245 (SE = 0.121, $p < 0.05$) for ROE, while the interaction is –0.099 (SE = 0.045, $p < 0.05$) and –0.356 (SE = 0.117, $p < 0.01$) respectively, indicating that the estimated marginal association between ESG and financial performance declines monotonically as state shareholding rises rather than shifting discretely at an arbitrary control threshold. Evaluated at the mean state shareholding of state-controlled firms, the implied marginal association between ESG and ROA is 0.056, closely reproducing the 0.055 obtained under the binary specification in Table 3. Because state shareholding varies within firms over time, this specification also identifies the ownership term from within-firm variation across the full sample rather than from the transition firms alone, corroborating from an independent direction the identification argument set out in Section 3.3, and the interaction is estimated more precisely here than under the binary indicator. Because the interaction coefficient alone does not convey how the association varies over the observed range of state participation, the marginal association is evaluated at representative levels of state shareholding and reported in Table S3 of the Supplementary Material. The estimated marginal association between ESG and return on assets declines from 0.098 at zero state shareholding to 0.088 at ten per cent, 0.078 at twenty per cent, 0.068 at thirty per cent, and 0.056 at the mean shareholding of 42.4 per cent observed among state-controlled firms, and the corresponding values for return on equity are 0.245, 0.209, 0.174, 0.138 and 0.094; the confidence intervals reported alongside these point estimates exclude zero across the lower range of state participation for return on assets and include zero once state shareholding approaches the level typical of state-controlled producers, whereas for return on equity the interval already includes zero at moderate levels of state participation, reflecting the larger interaction coefficient relative to the main effect in that specification. A further variant in which the natural logarithm of the Huazheng composite score is replaced with the untransformed score is reported as check (S4) in the Supplementary Material.

Across the eight analyses, H1 is supported in every specification, the ESG coefficient retaining its positive sign and conventional significance throughout. The negative moderating association posited by H2 is consistently signed in every specification in which the interaction is estimable and attains conventional significance in six of the seven, the exception being the untransformed-score variant reported in the Supplementary Material, where the interaction retains its negative sign without reaching conventional

levels, a pattern consistent with the compression of the raw Huazheng score within a single industry reducing the variation available for identifying the interaction. Propensity score matching employs a binary treatment indicator, contains no interaction term, and therefore speaks to H1 alone. These analyses establish that the findings are not artefacts of particular measurement, specification or sample choices; they do not, individually or in combination, establish causality, and the implications of the untransformed-score result for the interpretation of H2 are recorded among the limitations.

Table 4. Robustness analyses retained in the main text.

Concern addressed	Analysis	Dep. var.	ESG coef.	ESG × SOE coef.	Obs.
Measurement of the ESG construct	(1) Bloomberg ESG Disclosure Score	ROA	0.094** (0.039)	−0.038* (0.021)	537
		ROE	0.197** (0.089)	−0.118* (0.067)	537
Endogeneity	(2) Two-stage least squares	ROA	0.103*** (0.038)	−0.049* (0.027)	804
		ROE	0.241** (0.108)	−0.142* (0.082)	804
Sample composition	(3) Excluding ownership-transition firms	ROA	0.096** (0.037)	−0.042* (0.025)	775
		ROE	0.217** (0.105)	−0.135** (0.054)	775
Operationalisation of the moderator	(4) Continuous state shareholding	ROA	0.098*** (0.021)	−0.099** (0.045)	804
		ROE	0.245** (0.121)	−0.356*** (0.117)	804

*Note: Firm-clustered robust standard errors are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. The four analyses retained here address, in turn, measurement of the focal construct, endogeneity, sample composition, and the operationalisation of the moderator. Four further analyses addressing overlapping concerns, namely the province-by-year fixed-effects structure, propensity score matching, the exclusion of 2020 and 2021, and the untransformed rating scale, are reported in Table S2 of the Supplementary Material. In check (3) the SOE main effect is absorbed by firm fixed effects because state ownership is time-invariant within all remaining firms. In check (4), SOE_ratio is the proportion of state-held shares and the interaction is ESG × SOE_ratio; because this variable varies within firms over time, the ownership term is identified from the full sample rather than from the ownership-transition*

firms. The first-stage F-statistic (28.46) and the Kleibergen–Paap LM statistic (23.78, $p < 0.001$) are reported for check (2) in Section 4.3.

4.4 Heterogeneity Analysis

The analyses reported in this subsection are subsidiary to the primary ownership question and serve to characterise the conditions under which the association documented above varies; three dimensions are examined, namely firm size, listing age, and the decomposition of the composite rating into its environmental, social and governance components. The results are reported in Table 5.

(1) Size heterogeneity. Using the annual median of total assets as the cut-off, the ESG coefficient on ROA is 0.112 ($p < 0.01$) in the large-firm subsample and 0.063 ($p < 0.10$) in the small- and medium-sized subsample. The Chow test for between-group differences yields $F = 4.82$ ($p = 0.028$), significant at the 5 per cent level, and the ROA elasticity of ESG among large firms is about 1.78 times that of smaller firms. This result is consistent with the resource-based view: large steel firms possess more ample resources and more developed ESG governance structures, enabling them to translate the reputational assets and informational advantages accumulated through ESG into durable competitive barriers more effectively; at the same time, large firms face higher institutional-investor attention and tighter green-credit constraints, which reinforces the cost-of-capital-reduction effect of ESG improvements (38).

(2) Listing-age heterogeneity. Using the median years since listing as the cut-off, firms listed for a shorter period (at or below the median) have an ESG-to-ROA coefficient of 0.094 ($p < 0.05$), compared with 0.081 ($p < 0.05$) for firms listed longer. The Chow test yields $F = 0.43$ ($p = 0.51$), statistically insignificant. Although theory suggests that younger firms may have stronger ESG signalling incentives to build credibility in the capital market, this effect finds no empirical support in the steel-industry sample. A plausible explanation is that the capital-intensive nature of the steel sector leads ESG behaviour to be driven more by industry-wide regulatory pressure than by listing-age-related reputation-building needs, so that any marginal listing-age effect is absorbed by industry-wide factors. This channel awaits further verification in larger or cross-industry samples.

(3) ESG sub-dimension effects. To identify the independent financial effect of the environmental (E), social (S), and governance (G) dimensions and their ownership-based moderation, the composite ESG score is replaced with the log of each sub-dimension score (E_score, S_score, G_score) and Models 1 and 2 are re-estimated.

For the main effects, the coefficient on ROA is 0.043 ($p < 0.05$) for the E dimension, 0.028 ($p < 0.10$) for the S dimension, and 0.061 ($p < 0.01$) for the G dimension. In the steel-industry context, the governance (G) dimension displays the strongest financial association, followed by the environmental (E) dimension, and then the social (S) dimension. This ranking is consistent with industry-specific attributes: governance improvements reduce agency costs and enhance capital allocation efficiency through the most direct channel; environmental improvements operate through energy-cost savings and the avoidance of regulatory penalties, which are somewhat more indirect but remain significant in a heavily polluting sector; social improvements are mainly reflected in employee relations, community investment, and supply-chain responsibility, and have a

longer payoff horizon that accounting indicators capture only partially.

For the moderating terms, state ownership is associated with a significant negative moderation of both the E and S dimensions— $E \times SOE = -0.026$ ($p < 0.10$) and $S \times SOE = -0.031$ ($p < 0.10$)—whereas the corresponding term on the G dimension is insignificant ($G \times SOE = -0.011$, $p = 0.37$). This finding has an important theoretical implication: the attenuating role of state ownership operates primarily on policy-laden ESG behaviour (environmental and social) and has limited reach on market-driven governance improvements. Policy-driven expenditures borne by state-owned steel firms in environmental compliance and social responsibility cannot be recovered through market mechanisms, whereas governance improvements—such as board independence, informational transparency, and more rational managerial incentives—enhance capital allocation efficiency and reduce agency costs regardless of ownership structure, and therefore generate comparable financial value across ownership types. This result refines the theoretical content of H2: state ownership does not attenuate all dimensions of ESG homogeneously, and its moderating role exhibits pronounced dimensional heterogeneity.

Table 5. Heterogeneity analysis.

Grouping	Subsample	ESG coef. (ROA)	SE	Obs.	Between-group test
Firm size	Large	0.112***	(0.034)	402	F = 4.82, p = 0.028 (significant)
	Small/Medium	0.063*	(0.036)	402	
Listing age	Shorter	0.094**	(0.041)	398	F = 0.43, p = 0.510 (insignificant)
	Longer	0.081**	(0.038)	406	
ESG sub-dimensions	E_score (main)	0.043**	(0.021)	804	—
	S_score (main)	0.028*	(0.016)	804	—
	G_score (main)	0.061***	(0.019)	804	—
	E × SOE	-0.026*	(0.015)	804	Significant
	S × SOE	-0.031*	(0.018)	804	Significant
	G × SOE	-0.011	(0.012)	804	Insignificant

Note: Large/small firms are split by the annual industry median of total assets; longer/shorter-listed firms are split by the median years since listing (approximately 15 years). ESG sub-dimension scores are derived from the weighted composite of tertiary indicators in the Huazheng ESG rating system. All regressions adopt the two-way fixed-

effects specification with the control variables used in Table 3; firm-clustered robust standard errors are reported in parentheses. The Chow test assesses the null hypothesis that the ESG coefficients are equal across subsamples.

5. Discussion

5.1 The Association between ESG Performance and Financial Performance

The positive association between ESG performance and financial performance estimated in the baseline model is consistent with several theoretical considerations, since in the heavily polluting and heavily regulated steel industry three considerations offer plausible accounts of why ESG improvement and financial performance move together. In terms of operational efficiency, improvements in environmental management directly correspond to reduced energy consumption and reduced pollution costs, which has a direct cost optimization effect on energy-intensive steel production, consistent with the research findings on ESG improving total factor productivity (20). In terms of risk hedging, with the steel industry officially included in the national carbon market in 2024, leading ESG companies will gain a relative advantage in quota allocation, and the emission reduction performance accumulated through ESG improvement will become a substantial asset to resist rising carbon prices (5). In terms of reputation-financing, improved ESG performance helps attract ESG-oriented institutional investors, improves the financing conditions of companies in the green bond and green credit markets, and reduces the cost of equity capital (9). Related studies also indicate that, in the sample of listed companies in China, the promoting effect of ESG performance on corporate sustainable growth is partly achieved through improvements in trade credit financing channels (39), while the adjustment of media attention further amplifies the market transmission efficiency of ESG signals (40).

The ESG coefficient is estimated more precisely for return on assets than for return on equity, and the point estimate for return on equity is correspondingly larger in magnitude and wider in dispersion. This contrast cannot be read as evidence of an operating-efficiency channel to the exclusion of a financing channel, because the two ratios differ mechanically as well as substantively: return on equity is scaled by shareholders' equity and therefore embeds the leverage and equity structure of the firm, so that a comparison of coefficients across separate regressions confounds any difference in the underlying association with the arithmetic of the denominator. Given the high average leverage of the sector, with a sample mean of 0.452, the wider dispersion of the return-on-equity estimate is consistent with the amplification that leverage imparts to equity returns, and separating an operating channel from a financing channel would require direct measures of operating efficiency and of financing cost that the present design does not incorporate (15). Furthermore, measuring financial performance with accounting profitability indicators captures the short- to medium-term operational effects of ESG improvement, while related studies have found that the impact of ESG on corporate valuation has a stronger lag and dynamism (7, 21), which means that the estimated ESG-financial association reported here may understate the long-term market association. Regarding the pessimistic outlook on ESG in heavily polluting industries (6), the present findings indicate that across the period from 2014 to 2023 ESG improvement and financial performance moved together within the steel industry rather than in opposition, so that

green transformation has not been accompanied by a systematic erosion of financial competitiveness (5, 41). The apparent divergence from evidence that green-finance tightening depresses the near-term economic performance of high-carbon enterprises (49) is attributable to the different objects of measurement, in that the earlier finding concerns the short-run consequence of an exogenous financing shock whereas the present estimates describe the ten-year association between a firm's own rated performance and its profitability. The study on the synergistic promotion of ESG improvement and M&A activities also provides independent financial evidence for the integration and restructuring of the steel industry (41).

5.2 Theoretically Plausible Interpretations of the Ownership Moderation

The interpretations advanced in this subsection are not established by the present design, which tests whether the association between ESG performance and financial performance differs by ownership but does not measure policy-driven expenditure, executive incentive structures or market feedback, and they are accordingly presented as theoretically plausible accounts consistent with the estimated interaction rather than as verified explanations of it. The attenuation of the positive ESG and financial-performance association under state ownership is consistent with the conclusions reached in the core reference in the context of private enterprises: relevant researchers found that both the proportion of state shareholding and the political connections of CEOs have a systematic negative moderating effect on the positive effect of ESG performance (10). The present study examines the same proposition within the steel industry and obtains a pattern more consistent with a structural tension between administratively determined ESG objectives and market-determined financial objectives than with the political-connection agency account developed for private enterprises, although the design does not adjudicate between these interpretations directly.

The analytical framework of the CSR supply and demand equilibrium theory points out that there exists an optimal input level that maximizes the net return of ESG investment, and policy-oriented ESG expenditures exceeding this level would, on this account, be expected to yield net efficiency loss (14). Institutional studies of state capitalism understand state ownership as an institutionalized carrier for transmitting state will to corporate behavior (24). On this account, ESG would function less as a "market-oriented value creation" activity than as a "micro-response to policy signals," a reading that would imply a difference in financial conversion efficiency between the two. Although the deepening of mixed ownership reform has introduced market-oriented shareholders in some state-owned steel enterprises, the transformation of governance logic is lagging behind without a fundamental change in the nature of state ownership (26). From the perspective of executive incentives, the executive compensation of state-owned steel enterprises is more closely related to political promotion, resulting in a lack of motivation for ESG investment to upgrade from a "compliance tool" to a "value tool" (33). The dismantling study of the black box of corporate social responsibility also confirms that state ownership weakens the inherent logic of ESG creating value through stakeholder satisfaction channels, making ESG behavior in state-owned enterprises remain superficial and difficult to penetrate into the governance structure (29). This dimensional pattern is itself informative about the proposed channels. The weaker ESG–financial association under state ownership is concentrated on the environmental and social

dimensions, both of which carry a strong policy-compliance character in state-owned steel firms, whereas it is statistically indistinguishable from zero on the governance dimension. Such a concentration of the attenuation effect on policy-laden rather than market-driven ESG activity is consistent with the cost crowding-out and blocked-market-feedback channels theorized above, and provides indirect, data-grounded support for them in the absence of firm-level expenditure data that would permit a formal mediation test.

Figure 2 shows a wider ownership divergence in the return-on-equity panel than in the return-on-assets panel, a difference that is descriptive and does not by itself identify the locus of the attenuation, since the two ratios differ in their treatment of financing and equity structure as well as in the operating content they capture. Research from the perspective of green innovation shows that high-quality ESG signals can effectively activate green technology research and development in non-state-owned enterprises and build sustainable financial competitive advantages for enterprises by reducing carbon emission intensity (42). However, due to the low information content of ESG signals themselves, state-owned enterprises are more slow to respond to investors' market reactions to their ESG improvement behavior, and the channels for reducing capital costs are thus significantly compressed (42).

5.3 Institutional Background and Policy Prospects of ESG Transformation in the Steel Industry

The findings carry potential rather than demonstrated relevance to the 2030 Agenda in hard-to-abate industries. Because ESG performance and accounting profitability are observed to move together in this sample, the pursuit of responsible production and climate action need not be presumed to come at the expense of firm-level economic viability, and because that co-movement is attenuated under state ownership, the institutional conditions governing the conversion of environmental and social effort into financial returns appear to matter alongside the effort itself. These observations bear on the concerns addressed by Goals 8, 9, 12 and 13, but the study measures neither emissions, nor labour outcomes, nor resource intensity, and it therefore establishes no progress toward any SDG target.

External supervision and the maturity of market-based rating mechanisms are both relevant to the conversion documented here, in that media scrutiny has been found to raise the substantive ESG performance of heavily polluting firms (43) while the informational quality of ratings conditions whether ESG improvement is registered by investors at all (44).

At the end of 2024, the steel industry was officially included in the national carbon emission trading system. This policy signal has a profound impact on the long-term evolution of the ESG-financial relationship. When carbon quotas become a rigid constraint, leading ESG enterprises will obtain direct financial returns through carbon quota surpluses. The problem of the dilution of ESG value by policy costs in state-owned enterprises is expected to be partially corrected under the carbon market mechanism (5). However, the huge gap between the domestic carbon price level (average price of RMB 68/ton in 2023) and the EU ETS (over 100 euros/ton) in the short term means that the differentiated incentive effect of carbon costs on ESG behavior has not yet been fully realized, and the path dependence of state-owned enterprises in fulfilling their ESG

obligations through policy channels rather than market channels is difficult to break in the short term (27). Evidence on the regional development of green climate finance indicates that environmental improvement arises where green technological progress and industrial agglomeration reinforce the price signal rather than from the availability of green capital alone (50), which suggests that carbon pricing will alter the conversion documented here only to the extent that it is accompanied by the technological and market conditions under which a price differential translates into a cost advantage.

From the perspective of green innovation mechanisms, the improvement of ESG performance can more effectively activate green technology R&D investment in non-state-owned steel enterprises and create long-term competitive advantages for enterprises by reducing carbon emission intensity (45, 46). Green innovation in state-owned enterprises is more policy-driven, with a lower degree of marketization, and the conversion cycle of green innovation results into financial returns is longer (47). The synergistic promotion path between green transformation and financial performance therefore shows systematic differences across ownership types, a pattern consistent with the ownership-differentiated ESG effects documented for green innovation and for total factor productivity (28,30). The recommendations that follow are bounded by what the evidence establishes, namely that the association between rated ESG performance and accounting returns is weaker in state-controlled steel producers and that this weakening is concentrated on the environmental and social dimensions. Nothing in the design supports the inference that reducing state shareholding would improve ESG outcomes, since the level of ESG performance is not the object of estimation and the ownership variable is not manipulated; the finding concerns the conversion of ESG activity into accounting returns and points toward improving that conversion within existing ownership arrangements. Three implications follow on that basis. Evaluation of state-owned steel management could give weight to the financial and operational outcomes of ESG investment alongside the completion of compliance targets, since an evaluation system recording only compliance provides no information about whether expenditure is directed toward its most productive use. Because the governance dimension is associated with comparable financial value irrespective of ownership while the attenuation is confined to the environmental and social dimensions, regulatory attention to board independence, disclosure quality and the rationalisation of managerial incentives offers gains that are ownership-neutral and available in the near term. Market-based instruments, and carbon-quota allocation in particular, are better matched to the environmental and social dimensions, where the attenuation is located and where a price signal can supply the market feedback that administrative mandates do not. For non-state-owned producers, whose ESG improvement is already associated with measurable accounting returns, lowering the cost of ESG disclosure and broadening access to green financing would allow that association to be realised more fully.

6. Conclusion

This paper uses 804 firm-year observations from 134 listed steel companies in China's A-share market from 2014 to 2023 as a sample. Under a two-way fixed-effects framework, it examines whether state ownership moderates the association between ESG performance and accounting-based financial performance, and reports subsidiary analyses of firm size, listing age and the three ESG dimensions in support of that primary

question. The findings can be summarized as follows:

At the level of the main association, ESG performance is significantly and positively associated with both ROA and ROE among steel companies, indicating that improvements in ESG performance and enhanced financial performance can occur simultaneously in heavily polluting industries. This finding does not support the expectation that high compliance costs necessarily erode profitability in heavily polluting industries. At the level of the moderating term, state ownership is associated with a systematically weaker positive relationship between ESG performance and financial performance: in state-owned steel companies, the ESG–ROA and ESG–ROE associations decline and are statistically insignificant; in non-state-owned enterprises, the positive ESG–financial association remains robust. This conclusion is confirmed under multiple robustness tests, and the interaction term regression results and the grouped marginal effects plot corroborate each other, supporting the validity of H2 on both statistical and intuitive levels. The evidence supporting these findings is drawn from A-share listed steel companies in China observed between 2014 and 2023, and its scope is bounded accordingly. The estimates describe a single heavily regulated and capital-intensive industry within one institutional system in which state ownership is exercised through a distinctive administrative apparatus, so they should not be extended to other industries, to unlisted or privately held producers, to other national settings, or to institutional systems in which state participation takes a different form; whether the dimensional pattern documented here recurs elsewhere is an empirical question that the present design cannot answer.

The contribution of this study lies less in establishing that state ownership conditions the relationship between ESG performance and financial performance, which prior work has documented, than in locating that conditioning within the ESG construct, since the attenuation is confined to the dimensions carrying regulatory-compliance content and is absent from the governance dimension, a pattern that a generic agency account of state ownership does not predict and that an account grounded in the compliance content of the underlying activity does. The dimensional pattern reported in Section 4.4 is consistent with, though it does not establish, the proposition that the administratively determined component of ESG activity in heavy industry is less readily converted into accounting returns, since the attenuation is confined to the environmental and social dimensions and is absent from the governance dimension. In practice, the findings indicate that the evaluation of ESG investment in state-owned steel producers could usefully extend beyond administrative compliance to the commercial outcomes of that investment, that ownership background is relevant information for investors who use ESG ratings in valuing firms within this industry, and that the returns to ESG improvement observed among non-state-owned producers are consistent with integrating ESG into competitive strategy rather than treating it as a reporting obligation.

The external validity of the findings is bounded. The sample is limited to the steel industry, so extrapolating the conclusions to other heavily polluting industries such as cement, electrolytic aluminium and petrochemicals requires careful evaluation, and the strength of the ownership moderation may differ across industries with varying densities of policy regulation. The sample is further restricted to A-share listed firms, which tend to be larger and subject to stricter disclosure obligations than the many unlisted enterprises that

populate the broader steel sector, so the magnitude of the estimates should be generalised to unlisted firms only with caution. The outcome measures constitute a further boundary on what the findings establish: because performance is measured through accounting returns alone, the results speak to realised profitability and not to the valuation that capital markets place on ESG activity, and a market-based replication is required before any inference about pricing can be drawn.

Rating disagreement constitutes a measurement limitation that the present design mitigates without resolving. Providers differ systematically in the indicators they collect, the weights they apply and the treatment of non-disclosure, with the consequence that the same firm may occupy materially different positions in different rating distributions. The replication using an alternative provider reported in Section 4.3 establishes that the findings are not an artefact of one particular rating, but it cannot establish which rating more accurately represents underlying ESG performance, and the two providers cover partially different samples. The estimates should accordingly be understood as describing the association between rated ESG performance and financial outcomes, with the divergence among raters constituting an unresolved source of measurement error that a replication drawing on a third provider, such as MSCI or Bloomberg sub-dimensional data, would help to bound. The compression of the domestic rating within a single industry also limits the moderating term, in that the ESG and state-ownership interaction retains its negative sign but loses conventional significance when the composite is entered untransformed, so H2 should be read as robust in direction across all specifications and in significance under those preserving sufficient variation.

The candidate interpretations are not formally tested. Although three ownership-related considerations are theorised in Section 2.3, the absence of firm-level data on environmental compliance expenditure, on the composition of executive incentive contracts and on the market response to ESG disclosure prevents formal mediation analysis, so these considerations are advanced as interpretations rather than as verified channels. A tractable path for such tests would operationalise the cost crowding-out consideration as the ratio of environmental investment or ESG-related operating expenditure to total assets and submit it to bootstrap mediation analysis once these disclosures become sufficiently complete. The same restriction applies to the comparison of the return-on-assets and return-on-equity specifications, which is reported descriptively and cannot separate an operating-efficiency channel from a financing channel in the absence of direct operating-efficiency and leverage measures.

The strength of causal identification is limited. Although instrumental-variable estimation and propensity score matching address particular sources of endogeneity, rigorous causal identification requires a quasi-experimental design, and the formal inclusion of the steel industry in the national carbon market from 2025 provides a difference-in-differences opportunity through which the ownership-conditional character of the association documented here could be examined against an exogenous policy shock. A further extension concerns the unit of analysis: because the design treats the firm as the unit of observation, it cannot capture the transmission of ESG and productivity outcomes between customers and suppliers, which evidence on supply-chain spillovers indicates may be substantial (51), and a customer-supplier linked panel would allow the ownership condition documented here to be examined at the level of the production chain rather

than the individual producer.

Declarations

Ethical approval: Not applicable. The study relies on publicly available secondary data from listed companies and involves neither human participants nor animal subjects, and ethical approval was therefore not required.

Consent to participate: Not applicable. This study does not involve human participants, human data, or human tissue, and no individuals were recruited or surveyed; informed consent to participate was therefore not required.

Consent to publish: Not applicable. The manuscript does not contain any individual person's data in any form, including identifiable images, videos, or personal details, and consent to publish was therefore not required.

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Data availability: The data that support the findings of this study are secondary data obtained from third-party commercial databases, namely the Wind Financial Terminal (Huazheng ESG Rating System) and the China Stock Market & Accounting Research (CSMAR) database. These databases are accessible to researchers through institutional subscription. The processed datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

Clinical trial number: not applicable.

Code availability: The Stata code used for the analyses in this study is available from the corresponding author upon reasonable request.

Author contributions: F.F.: Conceptualization, Methodology, Data curation, Formal analysis, Software, Writing – original draft, Visualization. A.M.: Conceptualization, Supervision, Validation, Writing – review & editing, Project administration. Both authors read and approved the final manuscript.

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