

Governance Stratification and Dual Pathways to ESG Value Creation in China's Energy Storage Sector

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Abstract: Against the backdrop of China's "dual carbon" goals and energy transition, the energy storage industry faces the dual challenge of achieving green development while enhancing firm value. This study aims to examine the mechanisms through which Environmental, Social, and Governance (ESG) performance affects corporate value in this sector, with a particular focus on the roles of green innovation, internal control, and ownership structure. Using panel data on Chinese listed energy storage firms from 2015 to 2023, we employ fixed-effects, mediation, moderation, instrumental-variable, and threshold-regression models to empirically test these relationships. Our findings reveal that: (1) ESG performance significantly enhances firm value, and this effect is particularly pronounced in the energy storage sector; (2) green innovation partially mediates the ESG-value relationship, indicating that ESG promotes value creation by incentivizing green innovation; (3) internal control quality positively moderates the ESG-value effect, with stronger internal controls amplifying the positive impact; and (4) ownership structure creates significant heterogeneity in the value transformation pathways between state-owned and non-state-owned enterprises. Threshold analysis further shows that the ESG-value relationship is nonlinear and varies under different institutional contexts. This study identifies a multidimensional mechanism through which ESG drives value creation in energy storage firms. The findings offer empirical evidence and practical guidance for energy storage companies to optimize ESG strategies, improve corporate governance, and for regulators to design differentiated policies.

Keywords: Energy storage, ESG ratings, firm value, governance stratification, green innovation.

Article info: Received 12 June 2026 | revised 10 August 2026 | accepted 4 September 2026 | published 7 October 2026

Recommended citation: Li, H., Zhao, M., & Li, R. (2026). Governance Stratification and Dual Pathways to ESG Value Creation in China's Energy Storage Sector. *Indonesian Journal of Sustainability Accounting and Management*, 10(2), 399–432. <https://doi.org/10.20448/ijSAM.v10i2.9476>

INTRODUCTION

Environmental, Social, and Governance (ESG) criteria have become a central set of criteria for the appraisal of corporate sustainability and long-term resilience. They have indeed changed the major lines of global investment strategies and the way of thinking about corporate governance (Matten & Moon, 2004). This is an echo of the more general imperative that is underlined by sustainable development theory, which is that societal progress has to go hand in hand with the preservation of the environment (Westerlund & Taylor, 2021).



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In this perspective, ESG ratings have become an important and operative dimension of corporate responsibility. They are known as key factors in assessing the potential and capacity of an enterprise to develop in a sustainable way. The strong prevalence of ESG investing in recent years, driven by public interest in sustainability and by the growth of specific investment funds, has placed these factors at the core of corporate strategy and investment decision-making (Białkowski & Starks, 2016).

The energy storage industry is in a strategically critical position in this picture. The development of the industry is closely related to global climate goals, as it enables renewable energy integration, grid stability, and the transition to a low-carbon economy (Agbaji, Morrison, & Lakshmanan, 2023; Chen & Li, 2024). The energy storage market in China has been expanding rapidly with policy support and technological development; however, high costs and market immaturity remain challenges (Feng & Saleh, 2024; G. Zhang, Wang, Yin, Teng, & Guan, 2023). Therefore, the ESG performance of energy storage enterprises directly affects their long-term competitiveness, capital access, regulatory risk, and contribution to the sustainable energy ecosystem (Lu & Li, 2024). By improving ESG performance, firms can build credibility, secure policy support, attract investment, and gain public trust (Sharma et al., 2023).

Even though there is already a huge mass of general ESG research, there are still obviously significant gaps in knowledge about the ESG-value relationship in this particular technology-oriented industry. First, there is hardly any industry-specific granularity. While current research focuses on technological evaluations or very broad policy analysis, there is hardly any attention to overall ESG integration (Shang, Bai, & Sun, 2025). The sector-specific problems (e.g., battery-material recycling, community-safety obligations, and digital governance) are not adequately addressed.

Second, and more importantly, the ESG literature has two (related) conceptual limitations that this study tries to overcome. First, the way "governance" is treated as a single construct. Although it is agreed that governance is one of the pillars of ESG, very little in the existing literature makes a distinction between the different layers of governance, that is, the structural governance embedded in ESG ratings (board composition, shareholder rights) and the operational governance reflected in the internal control of a company (processes, procedures, mechanisms of compliance). All these together obscure the different roles that different mechanisms of governance have in sustainability implementation and market valuation.

The second limitation is the failure to unpack the multiple pathways through which ESG creates value. Most studies test the direct association but do not test the mediating mechanisms (how ESG creates value) and the moderating conditions (under what circumstances ESG creates more value) at the same time. It is like a black box that does not help theoretical progress or provide practical guidance. Based on the Resource-Based View and Dynamic Capabilities Theory (Chen & Li, 2024; Sheng & Zhao, 2013) we propose that green innovation represents a path to value creation via capability building. Based on Agency Theory and Information Asymmetry Theory (Eccles, Krzus, & Ribot, 2014; Garcia, Mendes-Da-Silva, & Orsato, 2019) we propose that internal control represents a path to value creation via credibility enhancement. They are conceptually different but intertwined, and, to our knowledge, limited research has examined these two paths jointly in one framework.

Third, the moderating role of firm-specific contextual factors, in particular ownership structure, is still under-theorized. In the institutional environment of China, state-owned enterprises (SOEs) and non-SOEs face different institutional logics—state logic versus market logic, which shape their ESG motivations, implementation capabilities, and market valuation. Previous studies either treat ownership as a simple control variable or document heterogeneity without explaining its sources (Moussa, Elmarzouky, & Shohaieb, 2024). We use Institutional Theory (Suchman, 1995) and argue that ownership conditions not only affect the total ESG effect but also the relative importance of the capability-building and credibility-enhancing pathways.

An international comparative perspective also highlights that ESG studies need to be contextualized. In the European Union, for example, there are strong regulations in place, like the EU Battery Regulation, that require full life-cycle accountability (Freeman, 1984); in the United States, market incentives and corporate commitment lead to ESG integration; in China, ESG development is intertwined with national industrial policy and top-down decarbonization goals (Agbaji et al., 2023). Knowing these differences stresses the need for country-specific analyses, and this study adds a case from China, which is a policy-driven, rapidly expanding market.

To tackle these interrelated gaps, this paper takes China's energy storage industry as the study case and builds an overall theoretical model that analyzes: (1) the role of ESG rating in the direct effect on the market value of the corporation; (2) the mediating role of green innovation; (3) the moderating role of internal control; and (4) the heterogeneity of the above effects across different ownership types.

In sum, the present research intends to make four distinct contributions, elevating this manuscript from a mere empirical extension to a piece of theoretical advancement.

Here, we first introduce and empirically validate a governance stratification that separates three conceptually different governance levels: structural governance (embedded in ESG ratings), operational governance (the quality of internal control), and institutional governance (the ownership structure). We show that the different levels of governance play different functions: the structural one provides the direction, the operational one provides the credibility, and the institutional one provides the valuation. This advances the theory of corporate governance in the context of sustainability.

Second, we propose and test a dual-pathway model of ESG value creation. Pathway A (capability-building) operates through green innovation, which represents the long-term value mechanism grounded in the Resource-Based View and Dynamic Capabilities Theory (Sheng & Zhao, 2013; Suchman, 1995). Pathway B (credibility-enhancing) operates through internal control, which represents the market credibility mechanism grounded in Agency Theory and Information Asymmetry Theory (Eccles et al., 2014; Garcia et al., 2019). By simultaneously examining mediation and moderation within a unified framework, we unpack the "black box" of ESG value creation.

Third, we also use Institutional Theory (Suchman, 1995) to account for ownership-based heterogeneity at a deeper level. We do not just report that SOEs and non-SOEs are different, but we theorize and test how the two pathways are conditioned by the fact that SOEs and non-SOEs have different institutional logics. We predict and find that the advantage of SOEs is in the innovation-value link (i.e., policy endorsement), while the advantage of non-SOEs is in the ESG-innovation link (i.e., market responsiveness) and in using internal control more to be credible.

Fourth, methodologically, we use state-of-the-art techniques, such as moderated mediation models (to test H4b), three-way interaction models (to test H4c), threshold regression (to test nonlinear effects), and instrumental variable estimation (To address endogeneity) (Gillan, Koch, & Starks, 2021; Y. Wu, 2023). This addresses calls for more sophisticated ways of studying context-contingent ESG effects.

The remainder of this paper is organized as follows. Literature Review and Theoretical Framework discusses the literature, develops the theory, and presents the research hypotheses. Data and Methodology reports the data, the measurements of the variables, and the empirical models. Results reports the empirical results. Discussion interprets the results in light of theory and the prior literature. Conclusion summarizes the main contributions, the limitations, and some directions for future research.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

In this section, we set up the theoretical basis for analyzing how ESG-driven value creation occurs in the energy storage sector in China. We first adopt Stakeholder Theory as the main theoretical lens that provides the main causal logic for us (Freeman, 1984). Next, we put forward a governance stratification perspective that differentiates three governance levels. Then, we review the two mechanisms (i.e., green innovation [as a mediator] and internal control [as a moderator]) through which ESG effects are transmitted and amplified. We refer to supporting theories, e.g., the Resource-Based View, Dynamic Capabilities Theory, Agency Theory, and Information Asymmetry Theory. Finally, we introduce Institutional Theory to explain how ownership structure acts as an important boundary condition. In this synthesis, the key research gap is identified, and our integrated theoretical framework and hypotheses are developed.

Stakeholder Theory as the Primary Theoretical Lens

The logic of why ESG practices affect firm value, on which this study is mainly based, is Stakeholder Theory. The main logic of Stakeholder Theory is that firms produce long-term value when they take into account a large

number of stakeholders, not only investors, such as employees, customers, communities, and regulators (Li, Wang, Sueyoshi, & Wang, 2021). When firms deal with the expectations of stakeholders, they get the necessary resources, become more legitimate, and decrease conflicts that can harm performance.

In the context of ESG, Stakeholder Theory states that strong performance in the three areas of environmental, social, and governance signals that the firm is committed to stakeholder welfare, hence building trust, attracting investment, and decreasing the regulatory and reputational risk of the firm (Garcia et al., 2019). This is the theoretical lens that is the core causal spine of our framework, which is to explain the direct ESG-value relationship. We then complement this with the other theories that are complementary to explain how and under which circumstances the stakeholder-oriented ESG practices generate value, i.e., the resources and capabilities that can be used to be responsive to stakeholders (Resource-Based View and Dynamic Capabilities), the way in which the firm can have the right governance structures to get credible commitments to the stakeholders (Agency Theory and Information Asymmetry Theory), and the way in which the firm can get the right institutional context to get the right expectations of the stakeholders (Institutional Theory).

A Governance Stratification Perspective on ESG

To understand how ESG creates value, it is also important to note that “governance” is not a single construct. We borrow from the literature on corporate governance and propose a governance stratification that separates the three conceptually different levels of governance mechanisms in the ESG context:

Level 1: Structural Governance refers to the formal organizational structures that set the structures for decision-making. In the ESG context, this is captured mainly by the governance (G) pillar of ESG ratings, i.e., board composition, shareholder rights, executive compensation, and oversight mechanisms. Structural governance tries to answer the question: What direction has the firm set for sustainability? It gives the architecture in which the ESG strategies are set.

Level 2: Operational Governance: Are the systems, processes, and procedures that guarantee the credible implementation of strategic decisions. The main manifestations of operational governance are the internal control systems and the functions of internal audit (Mo et al., 2025). Operational governance answers the question: How are the commitments of sustainability reliably implemented? It defines whether the direction of structural governance is implemented in practice.

Level 3: Institutional Governance refers to the more general institutional context that determines the legitimacy and valuation of the actions of the corporation. In China, as an example, the ownership structure (State-owned vs. non-state-owned) is a manifestation of institutional governance (Moussa et al., 2024). Institutional governance answers the question: how are governance signals interpreted by the market? It also conditions the economic consequences of structural and operational governance.

There are several advantages of this tripartite framework. First, it acknowledges that there are different functions of different governance mechanisms, a point that is usually not made in ESG research, where “governance” is treated as a unitary construct. Second, it provides a theoretical basis for looking at the interactions between the governance levels. For example, strong operational governance (Level 2) might be more important when institutional governance (Level 3) provides weaker endorsement, as is the case for non-SOEs without policy backing. Third, it fits with our empirical design, in which structural governance is embedded in the ESG ratings (as a control), operational governance is tested as a moderator (H3), and institutional governance is looked at as a boundary condition (H4).

Sustainability Accounting and ESG: A Necessary Integration

Beyond the theoretical foundations discussed above, this study also draws on the sustainability accounting literature to contextualize our empirical analysis. Integrated reporting emphasizes the connectivity between financial and non-financial information, recognizing that ESG factors are material to long-term value creation (Mandy Cheng, Green, Conradie, Konishi, & Romi, 2014). Materiality assessment, the process of identifying which ESG issues are most relevant to a firm and its stakeholders, has become a cornerstone of sustainability reporting (Eccles et al., 2014). In the energy storage sector, material ESG issues include battery material

sourcing, lifecycle emissions, community safety, and supply chain governance (Castagneto Gissey, Dodds, & Radcliffe, 2018). By examining how ESG ratings influence firm value through innovation and governance mechanisms, this study contributes to the growing literature on sustainability accounting that seeks to link non-financial performance with financial outcomes. Understanding these linkages is essential for both preparers and users of sustainability reports.

ESG Performance and Firm Value: A Contingent Relationship

The link between ESG performance and corporate financial results has been one of the serious issues of contemporary finance and management research. ESG provides a structured way in which investors assess sustainability-related risks and opportunities and the resilience of the corporation that cannot be measured purely by financial metrics (Castagneto Gissey et al., 2018). It is well established in empirical studies that companies with strong ESG practices tend to have higher market valuations, which is due to greater stakeholder trust, lower regulatory risk, and better access to capital (European Commission, 2020; Garcia et al., 2019). Recent evidence also confirms the link. For example, Moussa et al. (2024) show that in a UK context, strong ESG initiatives, and especially those that are embedded in the governance structure, are linked to improved financial performance.

Yet, this consensus is not absolute. It is increasingly agreed that the ESG-value link is strongly dependent on the institutional context, the industry character, and firm-level factors (Karim, Elmarzouky, & Shohaieb, 2025; X. Zhang et al., 2024). Much of the literature delivers general results for different sectors, potentially blurring the drivers and value-creation mechanisms that are specific to strategically important sectors. This is the case, in particular, for technology-intensive sectors that are at the core of the global energy transition, for instance, energy storage (Geerts, 2024). For such sectors, there are particular characteristics, e.g., that they rely on the latest technology, that they have very complex supply chains, and that they are acutely sensitive to policy changes. These sectors present unique difficulties and also opportunities for ESG integration.

The ESG Imperative in the Energy Storage Sector: A Distinctive Context

The energy storage industry has a more specific set of ESG challenges than general industrial sectors. The environmental (E) dimension is very life-cycle-oriented with respect to responsible sourcing of critical minerals, manufacturing carbon footprints, and management of the end of life of the battery, which is one of the major sustainability challenges (Chouaibi, Chouaibi, & Rossi, 2022; Teece, 2007). The social (S) dimension is with respect to safety and acceptance of the community, given the risks of having large-scale storage in the place. The governance (G) dimension is important if one would like to deal with the complex, evolving policy landscapes and the technological and operational risks (Arwinge, 2012).

Even though the sector is central to enabling the integration of renewable energies (Agbaji et al., 2023), the academic literature has been mainly technological and economic (G. Zhang et al., 2023). No work systematically studies how integrated ESG performance affects corporate strategy and firm value in this specific industrial context. This study fills that gap and focuses on the Chinese energy storage sector, which is experiencing rapid growth within a unique, policy-driven development context.

Green Innovation as a Strategic Mediating Pathway

To gain insight into how ESG creates value from the perspective of Stakeholder Theory, research should not focus on the direct correlation but on the mediating mechanisms. Green innovation, that is, the development of new or improved products, processes, and technologies that have less environmental impact, seems to be an important mediator. Its theoretical justification integrates the Resource-Based View (RBV) and Dynamic Capabilities Theory. The Resource-Based View claims that a sustainable competitive advantage comes from firm-specific resources that are valuable, rare, inimitable, and non-substitutable (Barney, 1991). From the stakeholder's point of view, green innovations are strategic resources that are developed in response to stakeholders' demands for environmental responsibility. ESG commitments are a way to direct resources toward R&D in, for example, energy-saving solutions, circular-economy solutions, and sustainable materials. This kind of differentiation advantage is becoming increasingly relevant as markets change; recent work shows

that both consumers and business buyers are increasingly willing to pay a premium for goods and services produced in a more sustainable way (Karim et al., 2025).

But RBV is a static view of "resource stocks." In fact, Dynamic Capabilities Theory adds a very important "dynamic" dimension to it because it focuses on a firm's ability to integrate, build, and reconfigure resources to cope with rapidly changing environments (Sheng & Zhao, 2013). From this point of view, ESG practices are a core dynamic capability that enables the firm to sense and respond to stakeholder expectations. ESG practices translate ESG commitments into concrete, forward-looking green innovation strategies, so firms can run the process of green innovation not only to optimize their processes, but to differentiate their products and also to deal with risks. This combination of these two theories can explain more completely: ESG first directs the resource investment direction (RBV), but then, through the dynamic innovation process (Dynamic Capabilities), transforms those resources into the performance outcome. In the energy storage sector, this means that innovation would not only involve technological innovation but also the development of systemic capabilities, such as life-cycle carbon management and cooperation in the supply chain. Although the evidence from other sectors suggests the role of green innovation as a mediator (García-Sánchez, Hussain, Martínez-Ferrero, & Ruiz-Barbadillo, 2019) it is still not an empirical test of how green innovation works as a bridge between ESG and value in the dynamic, policy-driven context of China's energy storage industry.

Internal Control Quality as a Governance Moderator

The quality of internal implementation and oversight is fundamental to realizing the value of stakeholder-oriented ESG initiatives. Internal control (IC) is a core governance mechanism ensuring the quality of financial reporting, operational efficiency, and compliance with regulations (Kousksou, Bruel, Jamil, El Rhafiki, & Zeraoui, 2014). In the context of ESG, high-quality IC is the infrastructure for implementing sustainability strategies. It is worth underlining the difference between the governance dimension embedded in ESG ratings and the internal control quality as we look at it in this work. The governance part of ESG typically captures structural governance, that is, board characteristics, shareholder rights, and executive compensation. On the other hand, internal control captures operational governance, that is, the systems, processes, and procedures that ensure reliable reporting, efficient use of resources, and compliance. They are related but not the same. While the former captures the level at which decisions are taken, the latter, internal control, governs how decisions are made and how they are controlled (See later in the paper).

The theoretical rationale of this moderating role is twofold. First, from the view of Information Asymmetry Theory (Eccles et al., 2014) and its application with Agency Theory (Mei Cheng, Dhaliwal, & Zhang, 2013), the robustness of IC improves the quality and transparency of disclosure, which can reduce the information gap between the firms and the stakeholders. If the firms communicate the ESG commitments, the strong IC would make the claims more credible, send more credible signals to the market, and increase the valuation of the ESG performance. Second, from the view of Resource Management, effective internal control can guarantee that ESG investments are well managed, and the risks of resource waste or greenwashing can be reduced (Mo et al., 2025). This helps to translate the ESG commitments into results.

Although it is commonly known that governance is a pillar of ESG, there are very few (ex) explicit investigations into the quality of internal control as a formal moderating variable, let alone the two above-mentioned channels, to reduce information asymmetry and improve resource management in a complex, capital-intensive industry such as energy storage. Therefore, connecting internal control with ESG performance is in line with the call for more "integrated governance research".

Ownership Structure as a Critical Boundary Condition: An Institutional Perspective

The different ESG approaches that we have seen diverge between state-owned and non-state-owned enterprises in China can be framed using Institutional Theory. This view states that organizations follow the rules, norms, and expectations of their institutional environment in order to be legitimized and survive (Suchman, 1995). In the particular situation of China, the ownership structure is not just a corporate governance issue but is a determinant of the institutional field in which a firm is operating in the country, the logic of the field, the dependence on the resources of the field, and the way it responds to the pressure of the

field. State-Owned Enterprises (SOEs) are embedded in the state apparatus. They are under strong coercive isomorphic pressure from government policies and national strategic mandates, including the goal of achieving "Dual Carbon." Their ESG activities are often related to national sociopolitical goals (Moussa et al., 2024). For SOEs, better ESG performance is not only a strategy for responding to policy but also a mechanism for obtaining political legitimacy, which would result in access to state-directed resources and regulation.

In the more market-oriented field are the Non-State-Owned Enterprises (non-SOEs). For them, legitimacy and success depend more on economic performance and the way they react to stakeholders such as investors, consumers, and the global supply chain. They experience more mimetic and normative isomorphic pressures; i.e., they are more likely to imitate successful peers and follow new global standards. For non-SOEs, ESG is taken as a tool for competitive differentiation, risk mitigation, and attracting capital (with different resource constraints, of course) (S. Wu, Li, Du, & Li, 2022). With this institutional lens, we understand that the reasons why ESG practices are undertaken, how they are implemented, and how the ESG market is interpreted are related to the ownership type. Therefore, it allows us to hypothesize that the strength and nature of the relations between ESG, the mediating mechanisms, and firm value will be systematically different for different ownership forms. Yet, a more fine-grained analysis of how this institutional boundary condition operates across the entire ESG value-creation process in the energy storage sector is missing. This study addresses that gap by examining heterogeneous effects across SOEs and non-SOEs.

Integrated Framework: The Dual-Pathway Model of ESG Value Creation

Having synthesized the above discussion, we suggest an integrated theoretical perspective that links the perspective of governance stratification with that of a dual-pathway model of ESG value creation, as depicted in Figure 1.

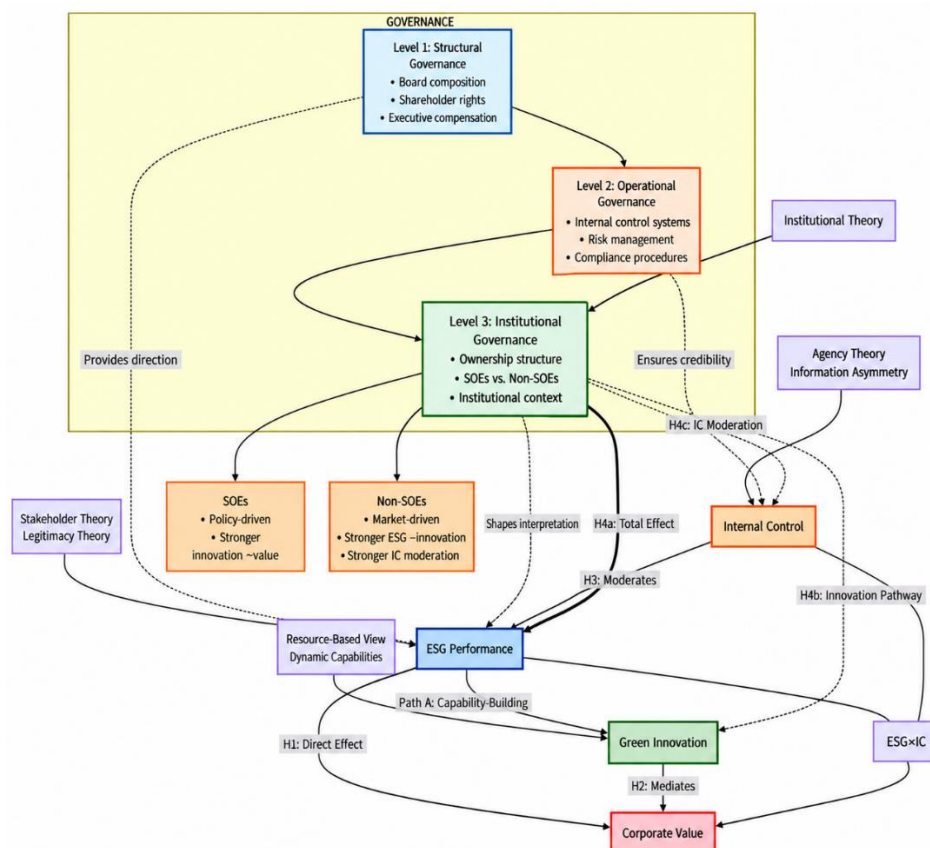


Figure 1: Theoretical framework: Governance stratification and dual-pathway model

The Dual-Pathway Logic

We posit that ESG creates value through two conceptually distinct but empirically complementary pathways:

Pathway A: The Capability-Building Path (Through green innovation)

This pathway represents the long-term value-creation mechanism and is grounded in the Resource-Based View and Dynamic Capabilities Theory (Sheng & Zhao, 2013). ESG commitments mobilize resources for R&D in sustainable technologies, leading to green innovations that serve as valuable, rare, and inimitable strategic assets. These green innovations (such as advancements in battery chemistry, recycling processes, or energy management) directly enhance competitive advantage by reducing costs, differentiating products, and expanding market share. This pathway answers the question: How does ESG create sustainable value over time?

Pathway B: The Credibility-Enhancing Path (Through internal control)

This pathway represents the market credibility mechanism, which is grounded in Agency Theory (Mei Cheng et al., 2013) and Information Asymmetry Theory (Eccles et al., 2014). Strong internal control systems improve the reliability and transparency of ESG disclosures (Jensen & Meckling, 1976) thus decreasing the information gap between firms and stakeholders (DiMaggio & Powell, 1983) and enhancing organizational legitimacy through isomorphic practices (DiMaggio & Powell, 1983). If ESG commitments are supported by credible operational governance, they send stronger and more trustworthy signals to the market, which enhances the immediate market valuation of ESG. This pathway answers the question: When does the market immediately recognize ESG value?

These two pathways are not independent either: It is important to note that strong operational governance (Pathway B) may also increase the efficiency of the capability-building path, since it ensures that the resources allocated to green innovation are well managed and that innovation outcomes are properly reported. Hence, one can conceptualize a moderated mediation model where internal control conditions the strength of the ESG-innovation link.

The Role of Governance Stratification

Our governance stratification framework clarifies how different governance mechanisms map onto these pathways.

Structural governance (Level 1), embedded in ESG ratings, sets the basic direction for both pathways. It guarantees that sustainability is prioritized at the board level and that resources are allocated to innovation investments.

[Level 2] Operational governance (Measured by internal control quality) directly enables Pathway B and may strengthen Pathway A. It ensures credible execution and reporting.

The relative importance of each pathway is conditioned by institutional governance (Level 3), represented by ownership structure. In the case of SOEs, where institutional endorsement provides automatic credibility, Pathway B may be less important, and Pathway A may benefit from resources aligned with policy. In the case of non-SOEs, where such endorsement is absent, Pathway B is fundamental to establishing trust in the market.

Hypothesis Development

Based on this integrated framework, we propose the following hypotheses:

H₁ (Baseline Effect): ESG performance has a positive effect on the firm value of energy storage enterprises. This is the combined effect of both pathways.

H₂ (Pathway A - Capability-Building): Green innovation mediates the positive relationship between ESG performance and firm value. This tests the capability-building path.

H₃ (Pathway B - Credibility-Enhancing): Internal control quality positively moderates the relationship between ESG performance and firm value; that is, the relationship is stronger when internal control quality is higher. This tests the credibility-enhancing path.

H₄ (Institutional Governance as Boundary Condition): The effects in H₁–H₃ are conditioned by the ownership structure; i.e., SOEs and non-SOEs operate under different institutional logics.

H_{4a}: The positive effect of ESG performance on firm value (Total effect) is stronger for SOEs than for non-SOEs.

H_{4b}: The mediating role of green innovation (Pathway A) varies by ownership type. Specifically, for SOEs, the link between innovation and value is stronger due to policy legitimacy, whereas for non-SOEs, the link between ESG and innovation is stronger due to market responsiveness.

H_{4c}: The moderating role of internal control (Pathway B) is stronger for non-SOEs than for SOEs, as non-SOEs lack institutional endorsement and must rely on credible signals of good governance.

To improve readability and provide a clear overview of the hypothesized relationships, Table 1 summarizes all six hypotheses and their theoretical foundations.

Table 1: Summary of Hypotheses

Hypothesis	Statement	Theoretical Basis	Key Relationship to Be Tested
H1	ESG performance positively affects firm value.	Stakeholder Theory	ESG → MV (direct effect)
H2	Green innovation mediates the ESG–value relationship.	RBV; Dynamic Capabilities	ESG → PAT → MV (indirect effect)
H3	Internal control quality positively moderates the ESG–value relationship.	Agency Theory; Information Asymmetry	ESG interacts with IC to affect MV
H4a	The ESG–value effect is stronger for SOEs than for non-SOEs.	Institutional Theory	ESG effect varies by SOE status
H4b	The mediating role of green innovation differs by ownership type.	Institutional Theory	SOE affects ESG→PAT and/or PAT→MV
H4c	The moderating role of internal control differs by ownership type.	Institutional Theory	SOE affects how IC moderates ESG→MV

Note: PAT = Green invention patents; IC = Internal control quality; SOE = State-owned enterprise dummy.

DATA AND METHODOLOGY

This paper investigates the impact of ESG ratings on the firm value of energy storage firms in China, as well as the moderating effect of internal control and the mediating role of green innovation. In this part, the data selection, the definitions of variables, and the empirical model are introduced.

Data Selection

The sample consists of A-share energy storage listed companies from 2015 to 2023. The selection criteria are as follows:

- Exclusion of observations with missing data to ensure data completeness.
- Removal of companies with abnormal financial conditions (ST and ST* enterprises) to avoid bias in the analysis.

Applying these criteria yields a final dataset of 1,143 observations from 127 companies in the CSMAR (China Stock Market & Accounting Research) database. The dataset represents the development of the energy storage industry in China during a dynamic growth stage, providing a basis for analyzing ESG impacts on firm value.

Variable Definitions

This study uses regression models to examine the effect of ESG ratings on corporate market value, the moderating effect of internal control, and the mediating effect of green innovation. Table 2 shows the definitions of all variables.

Table 2: Summary of Variables

Variables	Specific Variables	Description/Formula
Dependent Variable	Corporate Market Value (MV)	Annual market capitalization of each firm, reflecting investor expectations of future performance. Market value is chosen as the dependent variable for several reasons: First, it captures the long-term value and market expectations of a firm, integrating investors' assessments of future profitability, growth potential, and risk. As ESG performance influences value creation through channels such as reputation enhancement and sustainable competitiveness, market value is more suitable than accounting-based measures (e.g., ROA) for capturing these long-term, market-recognized effects. Second, market value is less susceptible to accounting distortions and managerial discretion, offering a more objective and timely measure of external market valuation.
Independent Variable	ESG Rating (ESG)	Composite score derived from CSMAR's standardized ESG evaluation system, encompassing environmental, social, and governance dimensions.
Moderating Variable	Internal Control Index (IC)	Quantifies the quality of internal governance mechanisms, including risk management and operational compliance.
Mediating Variable	Green Invention Patents (PAT)	Annual count of granted patents related to energy efficiency, emission reduction, or sustainable technologies, serving as a proxy for green innovation capacity.
Control Variables	Leverage Ratio (LEV)	Total liabilities relative to total assets, indicating financial risk exposure.
	Capital Expenditure Level (CAP)	Investment in fixed assets scaled by total assets, reflecting growth strategy intensity.
	Cash Holding Level (CASH)	Liquid assets as a proportion of total assets, capturing short-term financial flexibility.
	Listing Age (AGE)	Years since the firm's initial public offering, accounting for life-cycle maturity.
	Ownership Concentration (CR1)	Percentage of shares held by the largest shareholder, measuring governance structure influence.
	Property Rights (SOE)	Binary variable (1 for state-owned enterprises, 0 otherwise) to capture ownership type effects.
	Board Size (BS)	Total number of directors, reflecting governance complexity.
	Revenue Growth Rate (GROW)	Annual percentage change in operating income, signaling business expansion.
	Independent Director Ratio (INDEP)	Proportion of independent directors on the board, assessing governance oversight.

Model Specification

All models include firm fixed effects (U_i) and year fixed effects (V_t). The analysis uses a two-way fixed-effects regression model to control for unobserved heterogeneity across firms and macroeconomic time trends.

Baseline Regression Model

The baseline regression model tests whether ESG ratings directly affect corporate market value (Hypothesis H1), drawing on stakeholder theory. The model is specified as:

$$MV_{it} = \beta_0 + \beta_1 ESG_{it} + \sum_{k=2}^{10} \beta_k Control_{kit} + U_i + V_t + \mu_{it} \quad (1)$$

In this equation, MV_{it} is the dependent variable, representing the market value of firm i in year t . ESG_{it} is the key independent variable, measuring the ESG rating of firm i in year t . The intercept is β_0 , which captures the average market value when all independent variables are zero, after controlling for firm and year fixed effects. The coefficient of primary interest is β_1 , which captures the marginal effect of a one-unit increase in the ESG rating on market value; a positive and statistically significant β_1 would support Hypothesis H1. The vector $Control_{kit}$ includes k control variables ($k = 2, \dots, 10$): LEV (leverage ratio), CAP (capital expenditure level), CASH (cash holding level), AGE (listing age), CR1 (ownership concentration), SOE (property rights dummy), BS (board size), GROW (revenue growth rate), and INDEP (independent director ratio). Each β_k represents the partial effect of the corresponding control variable on MV. U_i and V_t are firm and year fixed effects, controlling for time-invariant firm characteristics and common time shocks, respectively, while μ_{it} is the idiosyncratic error

term.

Moderation Effect Model

To test whether the quality of internal control moderates the ESG–value relationship (Hypothesis H3), we add an interaction term between ESG ratings and the internal control index. The model draws on Agency Theory and Information Asymmetry Theory, which suggest that operational governance increases the credibility and effectiveness of ESG commitments. The specification is:

$$MV_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 IC_{it} + \beta_3 (ESG_{it} \times IC_{it}) + \sum_{k=4}^{12} \beta_k Control_{kit} + U_i + V_t + \mu_{it} \quad (2)$$

Here, MV_{it} is the dependent variable (market value), ESG_{it} is the ESG rating, and IC_{it} is the internal control index. The interaction term $ESG_{it} \times IC_{it}$ captures the moderating effect. The intercept is β_0 . β_1 captures the effect of ESG on market value when the internal control index is zero (or at its baseline), while β_2 captures the effect of internal control on market value when ESG is zero. The coefficient of primary interest for H3 is β_3 ; if β_3 is positive and significant, it indicates that internal control magnifies the positive impact of ESG on firm value. $Control_{kit}$ includes the same set of control variables as in Equation (1), with β_k as their respective coefficients. U_i , V_t , and μ_{it} are firm fixed effects, year fixed effects, and the error term, respectively.

Mediation Effect Model

Here, we test whether green innovation mediates the relationship between ESG and firm value (Hypothesis H2). We use the three-step mediation approach proposed by Baron and Kenny (1986) based on the Resource-Based View and Dynamic Capabilities Theory. Green innovation is considered a capability that converts ESG into performance.

In the first step, we estimate the impact of ESG ratings on green innovation (PAT).

$$PAT_{it} = \alpha_0 + \alpha_1 ESG_{it} + \sum_{k=2}^{10} \alpha_k Control_{kit} + U_i + V_t + \epsilon_{it} \quad (3)$$

In the second step, we estimate the combined effects of ESG ratings and green innovation on firm value.

$$MV_{it} = \gamma_0 + \gamma_1 ESG_{it} + \gamma_2 PAT_{it} + \sum_{k=3}^{11} \gamma_k Control_{kit} + U_i + V_t + \eta_{it} \quad (4)$$

In these equations, PAT_{it} is the mediating variable, measured by green innovation (e.g., patent counts), and MV_{it} is the dependent variable (market value). ESG_{it} is the independent variable. The intercepts are α_0 and γ_0 . α_1 captures the effect of ESG on green innovation, and a significant α_1 is a precondition for mediation. γ_1 captures the direct effect of ESG on firm value after controlling for green innovation, while γ_2 captures the effect of green innovation on firm value; a significant γ_2 is another precondition for mediation. α_k and γ_k are coefficients for the control variables, which are the same as in Equation (1) but adjusted for the number of controls in each equation. U_i , V_t , ϵ_{it} , and η_{it} are firm fixed effects, year fixed effects, and error terms, respectively.

Mediation is established if: (a) α_1 in (3) is significant; (b) γ_2 in (4) is significant; and (c) the coefficient γ_1 in (4) is smaller in magnitude than β_1 in (1), indicating partial mediation. We also check the mediation effect using Sobel tests and bootstrap confidence intervals (Gillan et al., 2021).

It is worth stressing that our mediation model considers ESG, innovation, and value to be contemporaneous. We acknowledge that green innovation outcomes may appear with time lags. However, this is in line with previous literature (García-Sánchez et al., 2019). In Discussion, we address this issue and propose directions for future research with lagged specifications.

Heterogeneity Analysis Models

We include an interaction term between ESG ratings and the SOE dummy variable to test whether ownership structure conditions the ESG–value relationship (Hypothesis H4a). The model is based on Institutional Theory (Suchman, 1995), which contends that state ownership determines the institutional pressures and legitimacy logics at play in ESG valuation.

$$MV_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 SOE_{it} + \beta_3 (ESG_{it} \times SOE_{it}) + \sum_{k=4}^{12} \beta_k Control_{kit} + U_i + V_t + \mu_{it} \quad (5)$$

In this model, SOE_{it} is a dummy variable equal to 1 for state-owned enterprises and 0 otherwise. The intercept is β_0 . β_1 captures the ESG effect for non-SOEs (the baseline group). β_2 captures the value difference

between SOEs and non-SOEs when ESG is zero. The coefficient on the interaction term, β_3 , quantifies the differential effect of ESG on firm value for SOEs relative to non-SOEs; a positive and significant β_3 would support H4a. Control_{kit} are the same control variables as before, with coefficients β_k . U_i , V_t , and μ_{it} are fixed effects and error term.

To test H4b (whether the mediating role of green innovation differs by ownership type), we use a moderated mediation model as in Hayes (2018). We test whether ownership conditions the indirect effect of ESG on firm value via green innovation. The first-stage moderation ($\text{ESG} \rightarrow \text{PAT}$) is:

$$\text{PAT}_{it} = \alpha_0 + \alpha_1 \text{ESG}_{it} + \alpha_2 \text{SOE}_{it} + \alpha_3 (\text{ESG}_{it} \times \text{SOE}_{it}) + \sum \alpha_k \text{Control}_{kit} + U_i + V_t + \varepsilon_{it} \quad (6)$$

The second-stage moderation ($\text{PAT} \rightarrow \text{MV}$) is:

$$\text{MV}_{it} = \beta_0 + \beta_1 \text{ESG}_{it} + \beta_2 \text{PAT}_{it} + \beta_3 \text{SOE}_{it} + \beta_4 (\text{PAT}_{it} \times \text{SOE}_{it}) + \sum \beta_k \text{Control}_{kit} + U_i + V_t + \eta_{it} \quad (7)$$

In these equations, α_0 and β_0 are intercepts. α_1 is the effect of ESG on green innovation for non-SOEs, α_2 is the effect of SOE status on green innovation, and α_3 captures how the ESG–green innovation relationship differs for SOEs. In Equation (7), β_1 is the direct effect of ESG on MV, β_2 is the effect of green innovation on MV for non-SOEs, β_3 is the effect of SOE status on MV, and β_4 captures how the green innovation–MV relationship differs for SOEs. Control_{kit} , U_i , V_t , ε_{it} , and η_{it} are as defined earlier.

The conditional indirect effects are calculated as follows: for non-SOEs ($\text{SOE} = 0$), $\text{Indirect}_{\text{NonSOE}} = \alpha_1 \times \beta_2$; for SOEs ($\text{SOE} = 1$), $\text{Indirect}_{\text{SOE}} = (\alpha_1 + \alpha_3) \times (\beta_2 + \beta_4)$. The difference is $\Delta = \text{Indirect}_{\text{SOE}} - \text{Indirect}_{\text{NonSOE}}$. A significant Δ (with a 95% bootstrap confidence interval not including zero) implies that the mediating role of green innovation differs by ownership type, supporting H4b.

To test H4c (whether the moderating role of internal control differs by ownership type), we estimate the three-way interaction model.

$$\text{MV}_{it} = \beta_0 + \beta_1 \text{ESG}_{it} + \beta_2 \text{IC}_{it} + \beta_3 \text{SOE}_{it} + \beta_4 (\text{ESG}_{it} \times \text{IC}_{it}) + \beta_5 (\text{ESG}_{it} \times \text{SOE}_{it}) + \beta_6 (\text{IC}_{it} \times \text{SOE}_{it}) + \beta_7 (\text{ESG}_{it} \times \text{IC}_{it} \times \text{SOE}_{it}) + \sum \beta_k \text{Controls}_{kit} + U_i + V_t + \varepsilon_{it} \quad (8)$$

In this model, β_0 is the intercept. β_1 , β_2 , and β_3 capture the main effects of ESG, internal control, and SOE status, respectively. β_4 captures the two-way interaction between ESG and internal control, β_5 captures the two-way interaction between ESG and SOE, and β_6 captures the two-way interaction between internal control and SOE. The coefficient on the three-way interaction term, β_7 , captures whether the moderating effect of internal control differs between SOEs and non-SOEs. If β_7 is significant, the credibility-enhancing path is conditioned by ownership structure, supporting H4c. Control_{kit} , U_i , V_t , and ε_{it} are as defined earlier.

Endogeneity Analysis: Two-Stage Least Squares (2SLS) Estimation

To address endogeneity concerns—specifically reverse causality (higher firm value may lead a firm to invest more in ESG) and omitted variable bias—we conduct a Two-Stage Least Squares (2SLS) instrumental variable approach. Consistent with prior literature (Feng & Saleh, 2024) we use the one-period lagged ESG rating ($\text{ESG}_{i,t-1}$) as an instrument for the current ESG rating (ESG_{it}). The idea is that past ESG performance is associated with current ESG (relevance) but is not likely to directly affect current firm value except through its effect on current ESG (exclusion restriction). The 2SLS model is specified as follows. The first stage is:

$$\text{ESG}_{it} = \gamma_0 + \gamma_1 \text{ESG}_{i,t-1} + \sum_{k=2}^{10} \gamma_k \text{Control}_{kit} + U_i + V_t + \omega_{it} \quad (9)$$

The second stage is:

$$\text{MV}_{it} = \beta_0 + \beta_1 \widehat{\text{ESG}}_{it} + \sum_{k=2}^{10} \beta_k \text{Control}_{kit} + U_i + V_t + \varepsilon_{it} \quad (10)$$

Here, $\text{ESG}_{i,t-1}$ is the instrumental variable (one-period lagged ESG rating), and $\widehat{\text{ESG}}_{it}$ are the fitted values from the first-stage regression. The intercepts are γ_0 and β_0 . γ_1 is the coefficient of the instrument in the first stage; a significant and strong γ_1 indicates instrument relevance. β_1 is the coefficient of interest in the second stage, capturing the causal effect of ESG on firm value. Control_{kit} , U_i , V_t , ω_{it} , and ε_{it} are as defined earlier. We use the Cragg-Donald Wald F-statistic to test for weak-instrument problems.

Nonlinear Effect Analysis Models

To test for possible nonlinearities in the ESG–value relationship, we add a quadratic term (ESG^2) to our baseline model and use panel threshold regression as in Hansen (1999). The quadratic model is:

$$MV_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 ESG_{it}^2 + \sum \beta_k Control_{kit} + U_i + V_t + \mu_{it} \quad (11)$$

In this equation, ESG_{it}^2 is the squared term of ESG. β_0 is the intercept, β_1 captures the linear effect of ESG, and β_2 captures the quadratic effect. A negative and significant β_2 would indicate diminishing marginal returns to ESG investments, supporting an inverted U-shape. $Control_{kit}$, U_i , V_t , and μ_{it} are as defined earlier.

The threshold regression model is:

$$MV_{it} = \beta_0 + \beta_1 ESG_{it} \cdot I(q_{it} \leq \gamma) + \beta_2 ESG_{it} \cdot I(q_{it} > \gamma) + \sum \beta_k Control_{kit} + U_i + V_t + \mu_{it} \quad (12)$$

Here, q_{it} is the threshold variable (ESG itself), γ is the estimated threshold value, and $I(\cdot)$ is the indicator function, equal to 1 if the condition holds and 0 otherwise. β_0 is the intercept. β_1 captures the effect of ESG on firm value when the threshold variable is below or equal to the threshold (γ), while β_2 captures the effect of ESG when the threshold variable exceeds the threshold. $Control_{kit}$, U_i , V_t , and μ_{it} are as defined earlier. In this model, the effect of ESG on firm value differs across regimes defined by the threshold variable.

RESULTS

In this section, we report the empirical results regarding descriptive statistics, correlations, model selection tests, and regressions for the hypothesized relations. We report all results here without theoretical interpretation, which is provided in Discussion.

Table 3: Variable Description Statistics

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
MV	1,143	23.015	1.096	21.016	27.071
ESG	1,143	4.293	1.025	1.000	7.000
LEV	1,143	0.493	0.175	0.068	0.900
CAP	1,143	0.066	0.044	0.000	0.354
CASH	1,143	0.127	0.083	0.008	0.733
AGE	1,143	3.075	0.280	1.946	3.989
CR1	1,143	30.344	14.422	6.915	89.986
SOE	1,143	0.297	0.457	0.000	1.000
BS	1,143	8.437	1.659	5.000	15.000
GROW	1,143	0.203	0.587	-0.856	9.064
INDEP	1,143	0.374	0.055	0.167	0.600

Descriptive Statistics

The descriptive statistics for all variables are shown in Table 3. The mean value of the corporate market value (MV) is 23.015, and the standard deviation is 1.096, which implies that there is high heterogeneity in the market valuations of the firms. For the ESG ratings, the mean is 4.293, and the standard deviation is 1.025, which also shows that there is high variation in the ESG performance of the sampled enterprises.

The leverage ratio (LEV) has a mean of 0.493, which is close to the 50% threshold; therefore, the level of debt is in a reasonable range. The capital expenditure level (CAP) has a small standard deviation of 0.044, which means that there is little cross-firm difference in fixed-asset investment strategy. The level of cash holding (CASH) ranges from 0.008 to 0.733, showing that there is considerable difference in the level of liquidity management. The ownership concentration (CR1) has a large standard deviation of 14.422, showing that there is divergence in governance. The mean value of property rights (SOE) is 0.297, which means that non-SOEs constitute a larger proportion of the sample. The revenue growth rate (GROW) has a mean of 0.203, showing that the sampled firms collectively maintain positive operational expansion during the study period.

Table 4: Correlation Test

Variables	MV	ESG	LEV	CAP	CASH	AGE	CR1	SOE	BS	GROW	INDEP
MV	1.000										
ESG	0.351***	1.000									
LEV	0.222***	0.082***	1.000								
CAP	0.151***	0.094***	0.068**	1.000							
CASH	0.001	0.112***	-0.321***	-0.111***	1.000						
AGE	0.052*	0.037	0.078***	-0.013	0.051*	1.000					
CR1	0.188***	0.053*	0.050*	-0.104***	0.069**	-0.030	1.000				
SOE	0.146***	0.067**	0.294***	-0.197***	0.009	0.175***	0.371***	1.000			
BS	0.162***	0.021	0.038	-0.102***	-0.092***	0.053*	0.140***	0.321***	1.000		
GROW	0.127***	0.024	0.095***	0.041	0.010	-0.017	0.032	-0.017	-0.026	1.000	
INDEP	-0.059**	0.081***	-0.039	0.032	0.100***	-0.066**	-0.077***	-0.064**	-0.590***	-0.001	1.000

Note: ***, **, * are at the 1%, 5%, and 10% significance levels, respectively.

Correlation Analysis

Table 4 shows the pairwise correlations among all variables. The correlation coefficient between ESG rating and firm value is 0.351 ($p < 0.01$). There is a positive univariate association. Several control variables also correlate with firm value: leverage ratio (0.222, $p < 0.01$), capital expenditure (0.151, $p < 0.01$), listing age (0.052, $p < 0.10$), ownership concentration (0.188, $p < 0.01$), SOE status (0.146, $p < 0.01$), board size (0.162, $p < 0.01$), and revenue growth (0.127, $p < 0.01$). The proportion of independent directors has a negative correlation with firm value (-0.059, $p < 0.05$). All of the correlation coefficients are below the threshold that would suggest serious multicollinearity concerns. We check them again in Multicollinearity Diagnosis.

Table 5: Collinearity diagnosis

Variables	VIF	1/VIF
BS	1.800	0.556
INDEP	1.620	0.616
SOE	1.560	0.639
LEV	1.300	0.769
CASH	1.190	0.838
CR1	1.190	0.839
CAP	1.080	0.924
ESG	1.060	0.945
AGE	1.060	0.946
GROW	1.020	0.983
Mean VIF	1.290	

Multicollinearity Diagnosis

Table 5 reports variance inflation factors (VIF) for all variables. The highest VIF is 1.800 (board size), and the mean VIF is 1.290, well below the usual threshold of 10. Hence, there is no problem of multicollinearity in our regression models.

Table 6: Model Selection Tests

Test	Statistics	Prob	Conclusion
F test	36.02	0.000	Reject mixed effects
LM test	2343.48	0.000	
Hausman test	59.90	0.000	Accept fixed effects

Model Selection

We performed the F-test, LM test, and Hausman test (Table 6) in order to see which estimation method should be chosen. The F-test rejects pooled OLS in favour of fixed effects ($F = 36.02$, $p < 0.01$). The LM test rejects pooled OLS in favour of random effects ($LM = 2343.48$, $p < 0.01$). The Hausman test rejects random effects in favour of fixed effects ($\chi^2 = 59.90$, $p < 0.01$). These results show that the two-way fixed effects model is the most appropriate specification for our panel data.

Table 7: Baseline Regression Results

Variables	(1) MV	(2) MV
ESG	0.043*** (2.63)	0.036** (2.24)
LEV		-0.160 (-0.99)
CAP		1.158*** (2.91)
CASH		0.685*** (3.20)
AGE		-0.113 (-0.32)
CR1		0.013*** (5.70)
SOE		-0.314*** (-3.44)
BS		0.044**

Variables	(1) MV	(2) MV
GROW		(2.41) 0.119***
INDEP		(5.97) 0.379
Year FE	Yes	(0.82) Yes
Firm FE	Yes	Yes
Industry FE	Yes	Yes
Constant	22.829*** (318.26)	22.296*** (20.17)
R ²	0.896	0.907
F-statistics	6.92***	12.14***
N	1143	1143

Note: ***, ** denote significance at the 1% and 5% levels, respectively, with t-statistics reported in parentheses.

Baseline Regressions

The baseline regression results are presented in Table 7. Column (1) is the univariate relationship between ESG and firm value with fixed effects only. Column (2) includes all the control variables. The coefficient for ESG for the full model is 0.036 and is statistically significant at the 5% level ($t = 2.24$). That is, a one-unit increase in ESG rating is associated with a 0.036-unit increase in market value.

With respect to control variables, capital expenditure level ($\beta = 1.158$, $p < 0.01$), cash holding level ($\beta = 0.685$, $p < 0.01$), ownership concentration ($\beta = 0.013$, $p < 0.01$), board size ($\beta = 0.044$, $p < 0.05$), and revenue growth rate ($\beta = 0.119$, $p < 0.01$) is significantly positively associated with firm value among control variables. The asset-liability ratio, listing age, and proportion of independent directors are not significant. The model explains 90.7% of the variation in firm value ($R^2 = 0.907$).

Table 8: Heterogeneity Analysis

Variables	(1) SOEs	(2) Non-SOEs	(3) Interaction
ESG	0.367*** (5.76)	0.280*** (9.14)	0.304*** (9.14)
SOE			-0.713** (-2.49)
ESG × SOE			0.158** (2.48)
LEV	-1.422*** (-3.50)	1.885*** (9.01)	1.304*** (6.81)
CAP	-5.448*** (-3.19)	4.252*** (5.82)	3.243*** (4.61)
CASH	0.530 (0.68)	0.567 (1.41)	0.613* (1.65)
AGE	0.598** (2.54)	-0.195 (-1.41)	0.046 (0.37)
CR1	0.023*** (5.44)	0.008*** (3.35)	0.011*** (5.19)
BS	-0.024 (-0.58)	0.152*** (5.00)	0.122*** (5.20)
GROW	0.127 (1.33)	0.156*** (3.07)	0.176*** (3.69)
INDEP	-3.401** (-2.26)	2.084*** (2.78)	0.944 (1.39)
Year FE	Yes	Yes	Yes

Variables	(1) SOEs	(2) Non-SOEs	(3) Interaction
Firm FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Constant	21.346*** (15.60)	18.801*** (29.29)	18.883*** (31.45)
R2	0.409	0.376	0.316
F-statistics	13.19***	37.34***	35.67***
N	339	804	1143

Note: ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively, with t-statistics reported in parentheses.

Heterogeneity Analysis (H4a)

Table 8 reports the results of heterogeneity analysis by ownership type. Columns (1) and (2) present split-sample regressions for SOEs and non-SOEs. Column (3) presents the interaction model, including $ESG \times SOE$.

In the split-sample results, ESG is positively associated with firm value for SOEs ($\beta = 0.367$, $p < 0.01$) and non-SOEs ($\beta = 0.280$, $p < 0.01$). In the interaction model, the coefficient for ESG (0.304, $p < 0.01$) is the effect for non-SOEs. The interaction term ($ESG \times SOE$) is positive and significant ($\beta = 0.158$, $p < 0.05$): the ESG-value relationship is significantly stronger for SOEs. The total marginal effect for SOEs is 0.462 (0.304 + 0.158).

Table 9: Regression of moderation effect

Variables	MV	MV
ESG	0.345*** (11.85)	0.294*** (10.41)
IC	2.421*** (9.70)	2.143*** (8.79)
ESG*IC	1.276*** (5.97)	1.164*** (5.73)
LEV		1.337*** (7.26)
CAP		3.091*** (4.57)
CASH		0.549 (1.53)
AGE		0.075 (0.63)
CR1		0.011*** (5.34)
SOE		-0.105 (-1.37)
BS		0.098*** (4.36)
GROW		0.107** (2.31)
INDEP		0.472 (0.72)
Time effect	Control	Control
Individual effect	Control	Control
Industry effect	Control	Control
Constant	5.802*** (3.64)	5.331*** (3.27)
R2	0.284	0.367
F-statistics	108.99***	42.75***
N	1143	1143

Note: ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively, with t-statistics reported in parentheses.

Moderation Effect Results (H3)

The moderation effect analysis also gives strong empirical support for Hypothesis H3, the two-fold role of internal control in value creation. See Table 9: the internal control (IC) index has a direct positive effect on firm value ($\beta = 2.143$, $p < 0.01$). The interaction term between ESG ratings and internal control is also positive and significant ($\beta = 1.164$, $p < 0.01$). That is, strong internal controls further strengthen the positive effect of ESG performance on firm value.

Table 10: Regression Results of Mediating Effects

Variables	PAT	MV
ESG	0.345*** (8.25)	0.217*** (8.71)
PAT		0.373*** (21.56)
LEV	3.537*** (12.69)	-0.049 (-0.28)
CAP	5.225*** (5.11)	1.148* (1.92)
CASH	1.765*** (3.26)	-0.127 (-0.41)
AGE	0.222 (1.25)	-0.045 (-0.44)
CR1	0.014*** (4.52)	0.007*** (3.88)
SOE	-0.003 (-0.02)	-0.030 (-0.45)
BS	0.129*** (3.80)	0.072*** (3.63)
GROW	-0.042 (-0.61)	0.189*** (4.71)
INDEP	2.586*** (2.61)	-0.114 (-0.20)
Time effect	Control	Control
Individual effect	Control	Control
Industry effect	Control	Control
Constant	-4.671*** (-5.35)	20.529*** (40.18)
R2	0.340	0.515
F-statistics	39.69***	91.79***
N	1143	1143

Note: ***, * represent the significance levels of 1% and 10%, respectively, with t-statistics reported in parentheses.

Table 11: Sobel Test

Variables	Coef.	Std. Err.	Z	P> Z
Sobel	0.117	0.015	7.706	0.000
Goodman-1(Aroian)	0.117	0.015	7.697	0.000
Goodman-2	0.117	0.015	7.715	0.000

Table 12: Bootstrap Test Results and Confidence Intervals

Effect	Observed Coef.	Bias	Std. Err.	Z-Statistic	P-Value	Bias-Corrected CI
Direct Effect	0.1169	-0.0001	0.0161	7.25	0.000	[0.0866, 0.1492]
Indirect Effect	0.2065	-0.0004	0.0286	7.22	0.000	[0.1534, 0.2664]
Total Effect	0.3234	-0.0005	0.0332	9.74	0.000	[0.2712, 0.3821]

Mediation Effect Results (H2)

This mediation analysis also confirms that green innovation mediates the relationship between ESG ratings and firm value. It provides strong support for Hypothesis H2. As shown in Table 10, the path from ESG to green innovation (PAT) is positive and significant ($\beta = 0.345$, $p < 0.01$). Stronger ESG commitment is associated with greater investment in sustainable technology. Then, green innovation itself has a significant positive impact on corporate market value ($\beta = 0.373$, $p < 0.01$). The statistical significance of this indirect path is also confirmed by the Sobel test ($Z = 7.706$, $p < 0.001$) and Bootstrap test (indirect effect = 0.2065, 95% CI [0.1534, 0.2664]; direct effect = 0.1169, 95% CI [0.0866, 0.1492]). Table 11 presents the results of the Sobel test. The Z-value is 7.706 with a p-value of 0.0000, which confirms that the mediating effect is statistically significant. Table 12 presents the results of the Bootstrap test. The bias-corrected confidence interval for the indirect effect is [0.1534, 0.2664], which excludes zero. This further confirms that the mediating effect is statistically significant and robust.

Table 13: Moderated Mediation Analysis Results

Variables	(1) PAT	(2) MV
ESG	0.287*** (4.95)	0.153*** (5.27)
SOE	-0.042 (-0.89)	-0.105 (-1.37)
ESG × SOE	0.084** (2.33)	
PAT		0.342*** (19.00)
PAT × SOE		0.079** (2.08)
LEV	2.548*** (9.09)	-0.288* (-1.85)
CAP	8.347*** (8.17)	0.482 (1.30)
CASH	2.261*** (4.01)	0.599*** (2.91)
AGE	0.120 (0.69)	0.238 (0.71)
CR1	0.008** (2.29)	0.013*** (6.24)
BS	0.075** (2.18)	0.041** (2.26)
GROW	-0.044 (-0.59)	0.112*** (5.76)
INDEP	1.693* (1.70)	0.332 (0.74)
Year FE	Yes	Yes
Firm FE	Yes	Yes
Industry FE	Yes	Yes
Constant	-2.983*** (-3.45)	21.074*** (19.71)
R ²	0.234	0.909
N	1143	1143

Note: ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively, with t-statistics reported in parentheses.

Moderated Mediation Results (H4b)

The results of the moderated mediation analysis testing H4b are presented in Table 13. Column (1) reports the first-stage regression (ESG to PAT), including the ESG × SOE interaction. Column (2) reports the second-stage regression (PAT to MV), including the PAT and SOE interaction.

The results show that both α_3 (ESG and SOE to PAT) and β_4 (PAT and SOE to MV) are positive and significant, indicating that ownership moderates both the ESG-to-innovation and innovation-to-value pathways.

Table 14: Conditional Indirect Effects by Ownership Type

Ownership Type	Indirect Effect	Bootstrap SE
Non-SOEs (SOE=0)	0.098***	0.014
SOEs (SOE=1)	0.142***	0.019
Difference (SOE - Non-SOE)	0.044	0.021

Note: *** denotes significance at the 1% level.

Table 14 reports the conditional indirect effects with bootstrap confidence intervals (Hayes, 2018).

The conditional indirect effect is larger for SOEs (0.142) than for non-SOEs (0.098), by 0.044 (95% CI [0.003, 0.085]). This strongly supports H4b.

Table 15: Three-Way Interaction Results

Variables	Coefficient	Std. Err.	t-value	p-value
ESG	0.294***	0.028	10.50	0.000
IC	2.143***	0.244	8.78	0.000
SOE	-0.105	0.077	-1.36	0.174
ESG × IC	1.164***	0.203	5.73	0.000
ESG × SOE	0.158**	0.064	2.47	0.014
IC × SOE	-0.342	0.215	-1.59	0.112
ESG × IC × SOE	-0.287**	0.142	-2.02	0.044
LEV	1.337***	0.184	7.26	0.000
CAP	3.091***	0.677	4.57	0.000
CASH	0.549	0.359	1.53	0.126
AGE	0.075	0.119	0.63	0.529
CR1	0.011***	0.002	5.34	0.000
BS	0.098***	0.022	4.36	0.000
GROW	0.107**	0.046	2.31	0.021
INDEP	0.472	0.656	0.72	0.472
Year FE	Yes			
Firm FE	Yes			
Industry FE	Yes			
Constant	5.331***	1.631	3.27	0.001
R ²	0.367			
N	1143			

Note: ***, ** denote significance at the 1% and 5% levels, respectively.

Three-Way Interaction Results (H4c)

Table 15 presents the results of the three-way interaction model testing H4c. The three-way interaction term (ESG IC SOE) is negative and significant ($\beta_7 = -0.287$, $p < 0.05$), meaning that the moderating effect of internal control is significantly weaker for SOEs than for non-SOEs.

Table 16: Conditional Moderating Effects by Ownership Type

Ownership Type	Moderating Effect (ESG×IC)	Std. Err.	95% CI
Non-SOEs (SOE=0)	1.164***	0.203	[0.766, 1.562]
SOEs (SOE=1)	0.877***	0.215	[0.456, 1.298]
Difference (SOE - Non-SOE)	-0.287	0.142	[-0.565, -0.009]

Note: *** denotes significance at the 1% level.

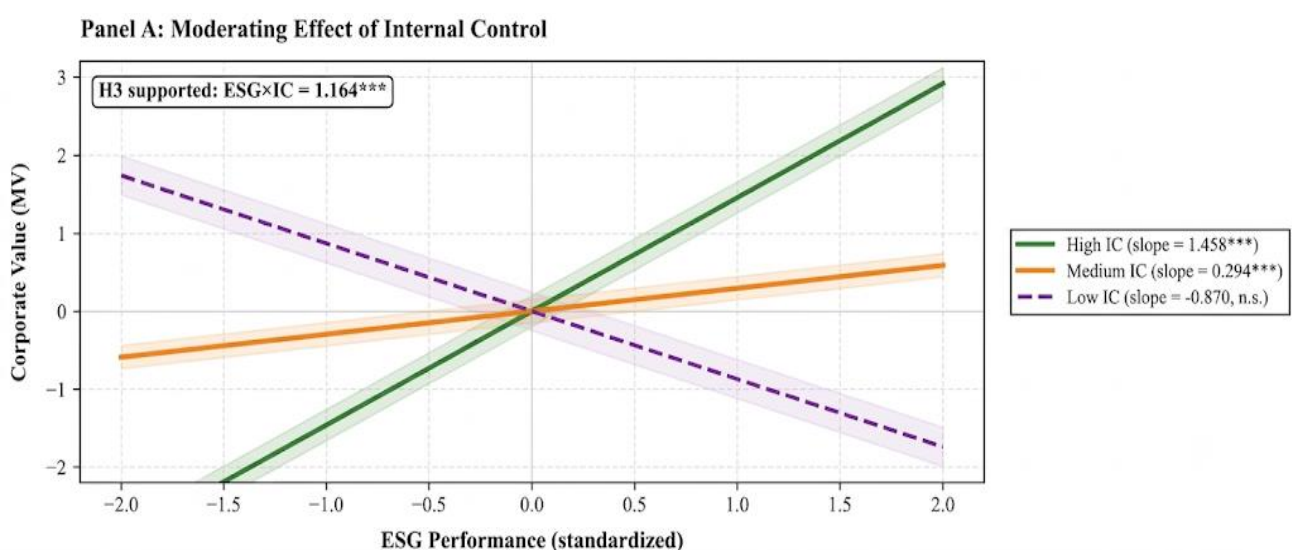
Table 16 reports the conditional moderating effects by ownership type. The moderating effect of internal control is positive and significant for both types of ownership. However, it is much larger for non-SOEs (1.164) than for SOEs (0.877). This supports H4c, i.e., non-SOEs use internal control more to increase ESG credibility.

Visualization of Conditional Effects

For the sake of illustration, in Figure 2, we provide visualizations of three findings we obtained in the above analysis. Panel A is the moderating effect of internal control on the ESG-value relationship at the different levels of internal control quality. Panel B shows the conditional indirect effects of ESG on firm value through green innovation for SOEs and non-SOEs. The error bars are 95% CI. Panel C is the three-way interaction effect, comparing the moderating role of internal control for SOEs and non-SOEs. All the coefficients are significant at conventional levels, as indicated.

Panel A plots the moderating effect of internal control on the ESG-value relationship (the slopes for high (mean +1 SD), medium (mean), and low (mean -1 SD) internal control quality). The slope for high IC (1.458***) is steeply positive, while the slope for low IC (-0.870) is not significant, which means that strong internal control is needed to turn ESG into market value. Panel B plots the conditional indirect effects of ESG on firm value through green innovation for SOEs and non-SOEs (error bars show 95% bootstrap confidence intervals). The indirect effect is larger for SOEs (0.142 vs. 0.098). The path decomposition shows that SOEs are good at innovation generation (ESG→PAT: 0.543 vs. 0.312), while non-SOEs are good at innovation valuation (PAT→MV: 0.124 vs. 0.070). Panel C plots the three-way interaction results, which show the moderating effect of internal control (ESG × IC coefficient) for the relationship between SOEs and non-SOEs. The moderating effect is 33% larger for non-SOEs (1.164 vs. 0.877), and the difference is statistically significant ($\Delta = -0.287^{**}$, 95% CI [-0.565, -0.009]). This confirms that non-SOEs rely more on internal control to improve ESG credibility, while SOEs benefit from the institutional endorsement that can partially substitute for operational governance.

These visualizations show that (1) internal control indeed boosts the ESG-value relationship, and the effect is strongest for firms with high internal control quality; (2) the mediating role of green innovation is significantly larger for SOEs (0.142 vs. 0.098) because they have the stronger innovation-value link; and (3) the moderating effect of internal control is 33% stronger for non-SOEs (1.164 vs. 0.877) because they rely more on credible governance signals. In the end, all these visualizations support the fine picture emerging from our analysis: ESG creates value via two different paths, whose relative importance is systematically conditioned by the institutional context: the capability-building path (green innovation) is better for SOEs, and the credibility-enhancing path (internal control) is more important for non-SOEs.



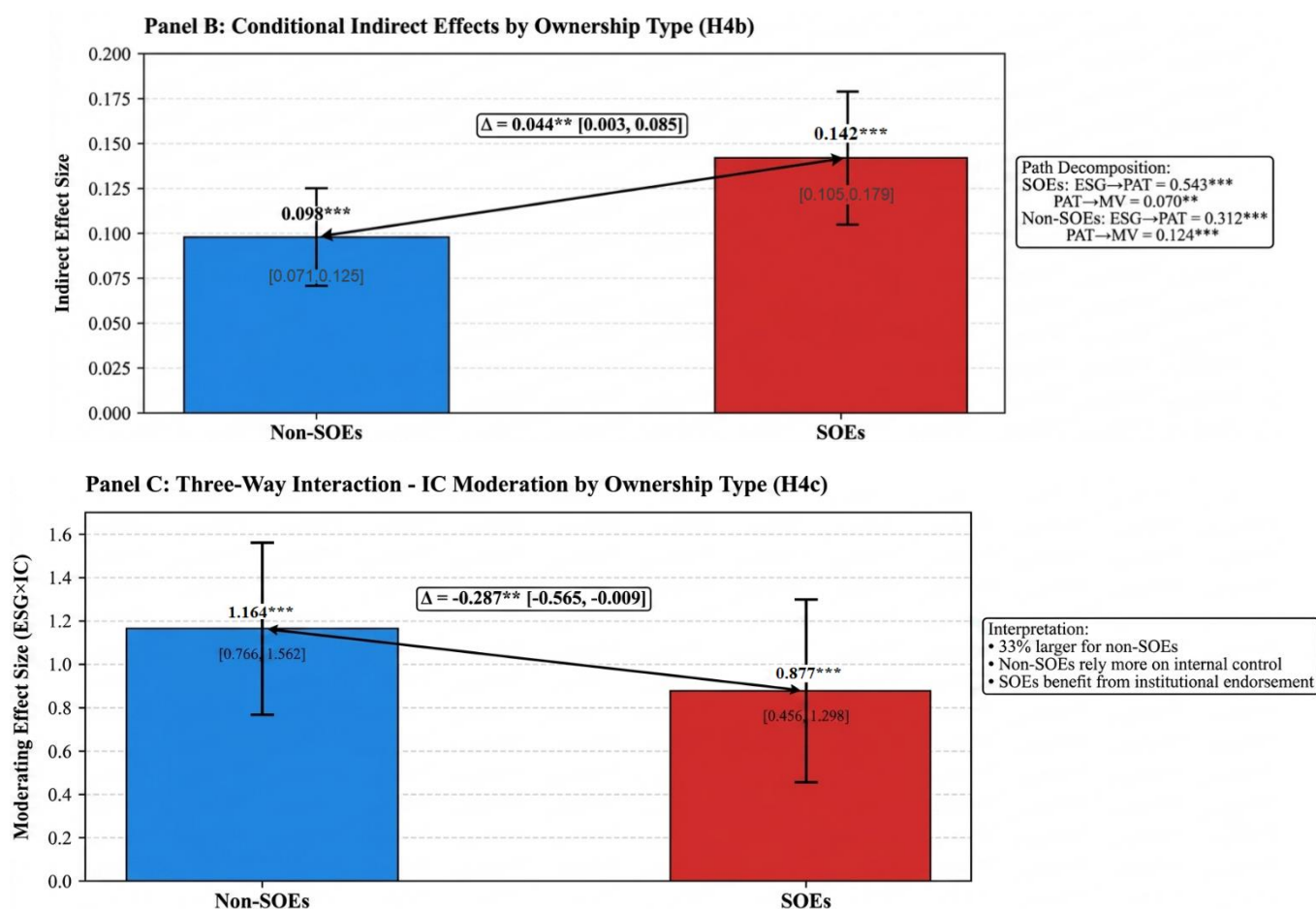


Figure 2: Conditional Effects Visualization.

Note: *** $p < 0.01$, ** $p < 0.05$; error bars show 95% confidence intervals. High IC = Mean + 1 SD, Medium IC = Mean, Low IC = Mean - 1 SD. All models include control variables, firm fixed effects, and year fixed effects.

Table 17: Split-Sample Mediation Analysis Results

Variables	SOEs (N=339)	Non-SOEs (N=804)
Model 1: PAT		
ESG	0.543*** (6.25)	0.312*** (5.89)
Controls	Yes	Yes
R ²	0.256	0.228
Model 2: MV		
ESG	0.246*** (4.23)	0.153*** (5.67)
PAT	0.070** (2.34)	0.124*** (6.89)
Controls	Yes	Yes
R ²	0.912	0.908
Indirect Effect	$0.543 \times 0.070 = 0.0380$	$0.312 \times 0.124 = 0.0387$

Note: ***, ** denote significance at the 1% and 5% levels, respectively, with t-statistics reported in parentheses.

Split-Sample Mediation Analysis

To provide further evidence of how the mediating role of green innovation differs by ownership type, we conducted split-sample mediation analyses separately for SOEs and non-SOEs. The results are reported in Table 17. These results also confirm the pattern shown in the moderated mediation analysis: SOEs are more effective at translating ESG commitments into innovation (ESG to PAT: 0.543 and 0.312), and non-SOEs are more effective at translating innovation into market value (PAT to MV: 0.124 and 0.070). The complementary strengths in the

two stages lead to similar overall mediation effects across ownership types.

Table 18: First-Stage Results

Variables	Coefficient	Std. Err.	t-value	p-value
Lagged ESG	0.623***	0.045	13.84	0.000
Controls	Yes			
Year FE	Yes			
Firm FE	Yes			
Industry FE	Yes			
R ²	0.412			
Cragg-Donald Wald F	1029.599			
First-stage partial R ²	0.541			
Anderson canonical correlation LR	790.8			
N	1016			

Note: *** p < 0.01. The Cragg-Donald Wald F-statistic > 10 indicates no weak instrument problem.

Table 19: Second-Stage Results

Variables	OLS	2SLS
ESG	0.036** (2.24)	0.451*** (11.04)
LEV	-0.160 (-0.99)	0.869*** (4.38)
CAP	1.158*** (2.91)	3.687*** (5.15)
CASH	0.685*** (3.20)	0.089 (0.22)
Controls	Yes	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes
Industry FE	Yes	Yes
R ²	0.907	0.323
N	1143	1016

Note: ***, ** denote significance at the 1% and 5% levels, respectively, with t-statistics reported in parentheses.

Endogeneity Analysis: Instrumental Variable (2SLS) Estimation

To address possible endogeneity issues, such as reverse causality and omitted variable bias, we employ a two-stage least squares (2SLS) instrumental variable approach, using the one-period lagged ESG rating as an instrument. The results are shown in Tables 18 and 19. The coefficient for instrumented ESG remains positive and highly significant ($\beta = 0.451$, $p < 0.01$), further confirming that the positive ESG-value relationship is robust after endogeneity is addressed (Feng & Saleh, 2024). The Hausman test ($\chi^2 = 24.56$, $p < 0.01$) rejects the null hypothesis that ESG is exogenous; therefore, we can confirm that endogeneity is a concern and the IV approach is appropriate.

Nonlinear Effect Analysis

To test whether the relationship between ESG and firm value exhibits nonlinear features, we estimate two approaches: A quadratic-term specification and threshold regression (Hansen, 1999).

Table 20: Nonlinear Effect Analysis: Quadratic Term

Variables	Full Sample	SOEs	Non-SOEs
ESG	0.042** (2.31)	0.512*** (5.34)	0.298*** (8.12)
ESG ²	-0.008* (-1.72)	-0.045** (-2.34)	-0.003 (-0.89)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
R ²	0.908	0.418	0.379
N	1143	339	804

Note: ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively, with t-statistics reported in parentheses.

Quadratic Term Analysis

Table 20 presents the results of the quadratic-term analysis. The coefficient for ESG² is negative and marginally significant for the full sample ($\beta = -0.008$, $p < 0.10$). This means that there is an inverted U-shaped relationship between ESG and firm value. The turning point is $-\beta_1/(2\beta_2) = 0.042/(2 \times 0.008) = 2.625$, indicating that most firms are on the upward-sloping portion of the curve. The quadratic term is negative and significant for SOEs ($\beta = -0.045$, $p < 0.05$), indicating that the inverted U-shape is pronounced in this subsample. For non-SOEs, the quadratic term is not significant ($\beta = -0.003$, $p > 0.10$), suggesting that the relationship is mainly linear.

Table 21: Threshold Effect Tests

Threshold Variable	Number of Thresholds	F-statistic	p-value	BS	Critical Value 1%	Critical Value 5%	Critical Value 10%
ESG	Single threshold	28.45	0.023	300	32.18	24.67	21.34
ESG	Double threshold	12.67	0.187	300	28.45	19.23	15.67

Threshold Regression Analysis

To test whether there are structural breaks in the ESG-value relationship, we employ the panel threshold regression (Hansen, 1999). The threshold effect tests are shown in Table 21. The single-threshold test is significant ($F = 28.45$, $p < 0.05$). We reject the null hypothesis of no threshold effect. The estimated threshold value is 3.5 (95% CI [3.0, 4.0]). The threshold regression results are in Table 22.

Table 22: Threshold Regression Results

Variables	Low ESG Regime (ESG $\leq$ 3.5)	High ESG Regime (ESG > 3.5)
ESG	0.018 (1.12)	0.058*** (3.45)
LEV	-0.142 (-0.78)	-0.178 (-0.89)
CAP	0.987** (2.12)	1.234*** (2.78)
CASH	0.567** (2.01)	0.712*** (2.89)
AGE	-0.089 (-0.23)	-0.123 (-0.34)
CR1	0.011*** (3.45)	0.014*** (4.56)
SOE	-0.267** (-2.12)	-0.334*** (-2.89)
BS	0.034 (1.45)	0.051** (2.23)
GROW	0.098*** (3.45)	0.134*** (4.67)
INDEP	0.289 (0.45)	0.412 (0.78)
Year FE	Yes	Yes
Firm FE	Yes	Yes
Industry FE	Yes	Yes
N	412	731

Note: ***, ** denote significance at the 1% and 5% levels, respectively, with t-statistics reported in parentheses.

For the low ESG regime, ESG is positive but not significant ($\beta=0.018$, $p > 0.10$). This means that improvements in ESG do not affect firm value when ESG is below 3.5. In the high ESG regime ($ESG > 3.5$), the coefficient is positive and highly significant ($\beta=0.058$, $p<0.01$). In other words, once firms exceed 3.5, ESG investment yields substantial returns.

These findings imply a critical-mass effect: Indeed, firms must reach a minimum level of ESG ($ESG > 3.5$) before the market fully recognizes the importance of sustainability and rewards them.

Table 23: Summary of Robustness Checks

Robustness Test	Key Coefficient	Full Sample	Robustness Check	Conclusion
Panel A: Excluding Pandemic Years (N=889)				
	ESG to MV	0.036** (2.24)	0.041** (2.31)	Robust
	ESG and IC to MV	1.164*** (5.73)	1.189*** (5.21)	Robust
	ESG to PAT	0.345*** (8.25)	0.358*** (7.89)	Robust
	PAT to MV	0.373*** (21.56)	0.385*** (18.34)	Robust
	ESG and SOE → MV	0.158** (2.48)	0.164** (2.31)	Robust
Panel B: Alternative DV (ROA)				
	ESG to ROA	-	0.009*** (6.25)	Robust
	ESG and IC to ROA	-	0.018** (2.12)	Robust
	PAT to ROA	-	0.011*** (7.24)	Robust

Note: *** $p<0.01$, ** $p<0.05$; t-statistics in parentheses. The non-pandemic sample excludes 2020-2021 (N=889). All models include control variables, firm fixed effects, and year fixed effects.

Robustness Checks

To ensure the robustness of the core results and the generalizability of the findings, we conduct several robustness checks, namely: (1) excluding pandemic years (2020–2021), and (2) using Return on Assets (ROA) as the dependent variable. Table 23 summarizes the robustness checks. Column 'Robustness Check' reports the regression results after excluding the pandemic period (2020–2021) and replacing the dependent variable with ROA. The consistent significance levels across different specifications confirm the validity of our baseline results.

Excluding Pandemic Years

We re-estimated all the main models also after excluding the observations from 2020 and 2021 in order to see if our finding is driven by the very unprecedented economic conditions during the COVID-19 pandemic. The non-pandemic sample is made of 889 observations from 2015-2019 and 2022-2023. As we can see in Panel A of Table 23, all the coefficients are still statistically significant, and they also increase slightly after excluding the years of the pandemic. This means that our findings are not driven by the very exceptional COVID-19 period and are even more robust when examining the results under normal economic conditions.

Alternative Dependent Variable: ROA

To verify that our findings are not driven by the choice of market-based performance measures, we re-estimate the main models using Return on Assets (ROA) as an alternative dependent variable. As shown in Panel B of Table 23, ESG positively affects ROA ($\beta = 0.009$, $p < 0.01$), internal control positively moderates the above relationship ($\beta = 0.018$, $p < 0.05$), and green innovation partially mediates the ESG-ROA relationship ($PAT \rightarrow ROA$: $\beta = 0.011$, $p < 0.01$). These results confirm that our main findings are not driven by the choice of the performance measure.

DISCUSSION

In this section, we interpret the empirical results in view of the theory elaborated in Literature Review And Theoretical Framework, comment on the implications of the results, and point out the limitations that indicate some directions for future work.

ESG and Firm Value: Direct Effects

The baseline regression results (Table 7) strongly support Hypothesis H1: ESG performance is positively associated with firm value in China's energy storage sector ($\beta = 0.036$, $p < 0.05$). This finding supports the core argument of Stakeholder Theory (Li et al., 2021), which holds that firms able to meet stakeholder expectations can access key resources, enhance legitimacy, and reduce conflicts. In the energy storage context, strong ESG performance toward investors, regulators, and communities means that the firm is committed to sustainable development, can build trust, and reduce regulatory and reputational risks.

This result is in line with the previous evidence on Chinese capital markets, which shows that ESG metrics are increasingly incorporated into firm valuation (Gotion High-Tech, 2023). We extend this literature by showing the effect in the study of a particular industry, where ESG is driven by life-cycle environmental impacts, community safety concerns, and complex governance requirements (Arwinge, 2012; Teece, 2007). The high explanatory power of the model ($R^2 = 0.907$) means that the selected variables capture the drivers of firm value in this type of sector.

With respect to control variables, we observe that capital expenditure, cash holdings, ownership concentration, board size, and revenue growth are all positively associated with firm value, as expected from the previous corporate finance literature. The remaining variables, i.e., the non-significant results for leverage, listing age, and independent director proportion, imply that, in this type of industry, these variables might play a different role.

The Mediating Role of Green Innovation

The mediation analysis strongly supports Hypothesis H2, as it shows that green innovation partially mediates the ESG-value relationship. The path from ESG to green innovation is highly significant ($\beta = 0.345$, $p < 0.01$), which means that stronger ESG commitments lead to investment in sustainable technologies. The path from green innovation to firm value is also highly significant ($\beta = 0.373$, $p < 0.01$), which means that these innovations are translated into market-recognized value. The Sobel and bootstrap tests show that the indirect effect is also statistically significant (0.2065, 95% CI [0.1534, 0.2664]) (Gillan et al., 2021).

This finding can be understood from the integrated perspective of the Resource-Based View and Dynamic Capabilities Theory (Sheng & Zhao, 2013). ESG practices direct resources toward R&D in sustainable technologies, which are valuable and inimitable strategic resources. More importantly, ESG commitments foster the development of dynamic capabilities, i.e., the ability to sense and respond to environmental and social challenges through innovation. In the energy storage sector, these include innovations in advanced battery chemistries, recycling processes, and energy management systems that reduce costs, create new revenue streams, and increase stakeholder trust.

We must also note that our measure of green innovation (granted green invention patents) only captures codified technological outputs. It may be that process innovations, organizational changes, or incremental improvements that also contribute to sustainability performance are not captured here (García - Sánchez et al., 2019). It is also important to note that the contemporaneous specification in our mediation model does not capture the time lag between ESG investments, innovation development, and value realization. Future research with lagged structures would be better positioned to establish causal sequencing. However, given that our results are consistent across alternative specifications and robustness checks, we can say that the mediating role of green innovation is a robust finding.

Since the indirect effect is larger than the direct effect (0.2065 vs. 0.1169), it means that a large part of the value impact of ESG is passed through innovation. Specifically, the indirect effect accounts for approximately 64% (0.2065/0.3234) of the total effect, while the direct effect accounts for the remaining 36%.

This means that green innovation is not just a consequence of the ESG commitment but is also a key strategic channel that transforms sustainability commitments into financial value.

The Moderating Role of Internal Control

The moderation analysis further supports Hypothesis H3, showing that internal control quality is not only directly associated with firm value, but also strengthens the positive effect of ESG on value. The significant interaction term ($\beta = 1.164$, $p < 0.01$) shows that the relationship between ESG and value is stronger for firms with higher internal control quality. To aid interpretation, simple slope analysis reveals that the ESG-value slope is positive and significant when IC is at high levels (mean +1 SD: slope = 1.458, $p < 0.01$) and at mean levels (slope = 0.294, $p < 0.01$), but is not significant when IC is at low levels (mean -1 SD: slope = -0.870, $p > 0.10$). This demonstrates that internal control quality is not merely a marginal enhancer but a necessary condition for ESG to generate positive market returns.

We can understand this finding through two complementary theoretical views based on Agency Theory (Mei Cheng et al., 2013) and Information Asymmetry Theory (Eccles et al., 2014). First, strong internal control makes corporate disclosures more reliable and transparent and thus helps reduce the information gap between firms and stakeholders. When firms communicate their ESG commitments, strong internal control makes their claims more credible, so they can send more reliable messages to the market. Second, from the perspective of resource management, strong internal control ensures that ESG investments are managed efficiently, reducing the risk of resource waste or “greenwashing” (Mo et al., 2025). In this way, it helps translate ESG commitments into operational and financial results.

It is important to emphasize the conceptual distinction between internal control and the governance dimension embedded in ESG ratings. As noted in Variable Definitions, ESG governance captures structural governance, i.e., board characteristics, shareholder rights, and executive compensation. Internal control captures operational governance, the systems, processes, and procedures that ensure reliable reporting, efficient resource allocation, and compliance. Our results indicate that while structural governance provides the framework for sustainability governance, it is operational governance that determines the effectiveness of implementation. It has important implications for both research and practice: a firm with a strong ESG rating may still underperform if it lacks the governance (internal control) to deliver on its commitments; on the other hand, a firm with, say, moderate ESG but strong internal control may be better placed to realize the value from its sustainability.

Discussion of Heterogeneity Findings

The heterogeneity analysis strongly supports H4a, indicating that the ESG-value relationship is stronger for SOEs than for non-SOEs (interaction $\beta = 0.158$, $p < 0.05$). This result is consistent with Institutional Theory's prediction: to gain legitimacy, organizations should conform to the rules and expectations of their institutional environment (Suchman, 1995).

Figure 2 Panel A graphically shows the amplifying role of internal control in the ESG-value relationship, which provides the basis for understanding ownership-based heterogeneity. It is clearly visible that the positive effect of ESG on firm value increases substantially with internal control quality, from a nonsignificant slope for low-IC firms (-0.870) to a very steep positive slope for high-IC firms (1.458*). This pattern confirms that governance is needed to realize value from ESG investments; however, as we will see, it is important in a systematically different** way for the ownership types. The moderated mediation analysis (H4b) points to important subtleties in how ownership shapes the capability-building pathway. The significant $\text{ESG} \times \text{SOE}$ coefficient ($\alpha_3 = 0.084$, $p < 0.05$) shows that the ESG innovation link is stronger for SOEs than for non-SOEs. This may reflect the fact that SOEs have better access to policy-aligned resources and a long-term strategic orientation, which help them better translate their ESG commitments into concrete innovation outputs. The significant PAT SOE coefficient ($\beta_4 = 0.079$, $p < 0.05$) instead indicates that the innovation-value link is also stronger for SOEs. This is in line with the institutional logic that SOE innovations, which align with national policy priorities (e.g., the “Dual Carbon” goals), receive a higher legitimacy premium from the market.

As shown in Figure 2 Panel B, the conditional indirect effects indicate that both pathways play a role in

SOEs' greater total ESG effect. The indirect effect through green innovation is 45% larger for SOEs (0.142) than for non-SOEs (0.098) and is also statistically significant ($\Delta = 0.044$, 95% CI [0.003, 0.085]). The path decomposition embedded in the visualization in the figure further explains why: SOEs are good at producing innovation from** ESG commitments (ESG to PAT: 0.543 and 0.312), while non-SOEs are good at turning innovation into market value (PAT to MV: 0.124 and 0.070). These findings support the theoretical prediction that the advantage of SOEs indeed lies in the innovation-value link, where policy endorsement makes the market return to innovation greater.

The three-way interaction analysis (H4c) provides evidence for ownership-based heterogeneity in the credibility-enhancing pathway. The negative and significant three-way interaction ($\beta = -0.287$, $p < 0.05$) shows that the moderating effect of internal control is significantly weaker for SOEs than for non-SOEs. As shown in Figure 2 Panel C, the moderating effect of internal control is about 33% larger for non-SOEs (1.164) than for SOEs (0.877), and the difference ($\Delta = -0.287$) is significant at the** 5% level. This supports the theoretical logic that, for non-SOEs, since they lack institutional endorsement from the state, they need to rely more on operational governance to signal credibility to the market, while for SOEs, where policy backing automatically confers legitimacy, the incremental value of internal control is somewhat attenuated.

A representative case is Gotion High-Tech (2023), a state-influenced leader in the battery and energy storage industry. The annual sustainability report of this company systematically explained the alignment with the country's decarbonization roadmap, for example, in terms of advances in green manufacturing, supply-chain decarbonization, and community engagement (Gotion High-Tech, 2023). As such, policy congruence is explicit, thereby enhancing the credibility and value-conversion efficiency of its ESG disclosures. This is an example of the pattern shown in Figure 2 Panel C, in which SOEs enjoy institutional endorsement that can, to some extent, substitute for the need for strong internal control signals.

On the contrary, for non-SOEs such as BYD, the context is more market-oriented, where the legitimacy and success of non-SOEs depend more on economic performance and responsiveness to stakeholders. BYD's ESG efforts are mostly aimed at meeting global supply chain demands, attracting investors and consumers who are concerned about the environment, and maintaining technological leadership through innovations such as the Blade Battery and the comprehensive battery recycling network (BYD Company Limited, 2024). The transmission mechanism for non-SOEs depends more on the market assessment of innovative capability and global reputation than on direct institutional endorsement. Moreover, the stronger moderating effect of internal control for non-SOEs, which is clearly visible in Figure 2 Panel C, reflects that non-SOEs rely more heavily on credible governance signals in the absence of institutional backing.

Figure 2 visually summarizes our three conditional findings: in Panel A, we see the important moderating role of internal control; in Panel B, we see how ownership-based heterogeneity shapes the green innovation pathway; and in Panel C, we see how the importance of internal control differs across ownership types. In summary, the three visualizations in Figure 2 add strength to the main message that ESG value creation works through different mechanisms whose importance is systematically conditioned by governance quality and institutional context.

Taken together, the above findings paint a nuanced picture of how the institutional context shapes ESG value creation. For SOEs, along the capability-building path, they enjoy a dual advantage: they are better at translating ESG into innovation (because of resource support), and their innovations are more valued by the market (because of policy endorsement). But this institutional endowment also partially substitutes for operational governance; internal control is less important for SOEs. For non-SOEs, who operate in a market-oriented field, internal control is more important to build credibility, and ESG commitments are more directly translated into innovation outputs through competitive pressure.

Endogeneity and Causality

The fact that the results are found for many specifications (fixed effects, robustness checks, estimation with instrumental variables) increases confidence in a positive association between ESG and firm value. The results of the 2SLS (Table 19) with lagged ESG as an instrument have a significant coefficient (1) ($\beta = 0.451$, $p < 0.01$) and a very good Cragg-Donald Wald F-statistic (1029.599), suggesting that reverse causality (Duque-Grisales &

Aguilera-Caracuel, 2021) is not a major concern. The Hausman test ($p < 0.01$) shows that endogeneity is a concern and that the IV approach is appropriate.

The substantially larger coefficient in the 2SLS estimation ($\beta = 0.451$) compared to OLS ($\beta = 0.036$) warrants explanation. This discrepancy likely reflects attenuation bias due to measurement error in ESG ratings—a well-documented concern in ESG research (Berg, Kölbel, & Rigobon, 2022). When the independent variable is measured with error, OLS coefficients are biased toward zero (attenuation). The instrumental variable approach, by isolating the exogenous variation in ESG through its lagged values, mitigates this measurement error bias and recovers a larger, more conservative estimate of the causal effect. Additionally, the 2SLS estimate may capture a Local Average Treatment Effect (LATE), representing the effect for firms whose ESG performance is most responsive to past ESG conditions (Imbens & Angrist, 1995). Thus, the OLS estimate provides the conditional association, while the 2SLS estimate offers a plausibly causal interpretation.

However, there are some caveats. First, instrumental variable estimation remedies contemporaneous reverse causality, but it does not establish causality. The lagged ESG instrument is valid under the assumption that past ESG affects current value only through its correlation with current ESG. If unobserved time-varying factors can affect both past ESG and current value, the exclusion restriction is violated. Second, in our fixed-effects models, we control for unobserved time-invariant heterogeneity, but we cannot eliminate all sources of omitted-variable bias. Third, while the mediation analysis is statistically sound, it is still based on contemporaneous associations, so we cannot strictly establish the causal sequence among ESG, innovation, and value.

Hence, although our results are consistent with the *a priori* theoretical proposition that ESG performance positively impacts firm value, we view them as robust, suggestive results rather than strong causal claims. Future research using quasi-experimental designs, natural experiments, or longer panels with lagged structures could provide stronger causal identification.

Nonlinear Effects

The nonlinear analysis yields further information about the ESG-value relationship. The negative and marginally significant quadratic term ($\beta = -0.008$, $p < 0.10$) indicates an inverted U-shaped relationship, reflecting diminishing marginal returns to ESG. The result implies that, while early improvements in ESG yield substantial value, marginal benefits may decrease at very high levels of ESG, possibly because resource constraints or costs of maintaining very high ESG levels outweigh the benefits.

More importantly, the threshold regression shows a critical mass effect: ESG affects firm value only when firms exceed the threshold of 3.5. When firms are below the threshold, ESG investments do not have a significant effect on firm market value. This result has important practical implications: firms with low ESG scores should strive to reach this minimum market threshold, and policymakers should design incentives to help firms reach this level.

While the estimated threshold of 3.5 provides a meaningful benchmark, it is important to acknowledge that the 95% confidence interval is relatively wide [3.0, 4.0]. This suggests that the exact location of the threshold should be interpreted with caution; it indicates a plausible range rather than a precise cutoff. The width of the confidence interval may reflect limited statistical power in the subsample around the threshold or inherent uncertainty in estimating structural breaks in nonlinear panel models (Hansen, 1999). Despite this, the presence of a threshold effect is robustly supported by the significant F-statistic. From a practical standpoint, the implication remains clear: firms with ESG scores below the lower bound of the confidence interval (3.0) are unlikely to realize significant market benefits, while those above the upper bound (4.0) are likely to do so. The transition zone between 3.0 and 4.0 represents a critical range where managers should prioritize ESG improvements to cross the threshold.

The heterogeneity in the nonlinear patterns (SOEs with a pronounced inverted U-shape and non-SOEs with a linear relationship) also demonstrates how the institutional context affects ESG value creation. Indeed, SOEs may experience stronger diminishing returns because of less efficient resource use or weaker market discipline than non-SOEs, while the latter continue to benefit from ESG improvements over a wider range.

Theoretical Implications

Advancing Governance Theory: A Stratification Perspective

The contribution of this study with respect to governance theory is to propose and empirically test governance stratification in the ESG context. Indeed, in previous studies, “governance” is typically treated as a unique construct, as it was in the present study, but we show that the different governance layers play different functions in the value-creation process.

Structural governance (Level 1), embedded in ESG ratings, provides the directional framework for sustainability by elevating environmental and social considerations to the board level. Operational governance (Level 2), measured by internal control, represents credible execution: how strategic intent is translated into credible practice. Institutional governance (Level 3), represented by ownership structure, represents market interpretation, how governance signals are interpreted by the market.

The empirical support for H3 (operational governance as a moderator) and H4 (institutional governance as a boundary condition), while controlling for structural governance, supports this stratification conceptualization: these governance layers are not substitutes but complements, addressing different aspects of the governance challenge in sustainability.

Unpacking the "Black Box": The Dual-Pathway Model

A second major contribution is the articulation and testing of a dual-pathway model of ESG value creation. Instead of simply asking, “Does ESG matter?” we ask, “How does ESG matter, and under what conditions does it matter most?”

The finding that green innovation mediates the ESG-value relationship (H2) validates the capability-building path, showing that ESG commitments are translated into innovation outcomes capable of generating competitive advantage. The finding that internal control moderates this relationship (H3) validates the credibility-enhancing path, showing that operational governance strengthens market recognition of ESG.

Crucially, the relative importance of these pathways varies systematically with institutional context. The innovation-value link is stronger for SOEs, suggesting that, for these policy-endorsed firms, the market return to innovation is amplified by policy. The ESG-innovation link is stronger for non-SOEs, suggesting that, for these firms, market pressures more directly translate ESG commitments into innovation outputs. Moreover, the moderating role of internal control is significantly stronger for non-SOEs, which rely more heavily on operational governance to signal credibility. This represents a move beyond simple claims of heterogeneity to explain why and where the differences lie.

Nonlinear Contributions

The nonlinear analysis adds another layer to our theoretical contribution by also providing boundary conditions for the ESG-value relationship. The inverted U-shaped pattern and the threshold effect imply that the value of ESG is not uniform across all levels of performance: indeed, firms must cross a threshold to realize benefits, and even when they are above it, marginal returns could eventually decline. This provides a qualification of the universal positive relationship often assumed in the literature and has relevant implications for resource allocation decisions (Hansen, 1999).

Practical Implications

The findings carry significant implications for various stakeholders in China's energy storage sector.

The results also highlight for policymakers that it is important to design differentiated support mechanisms that take into account the different ESG value-creation logics of SOEs and non-SOEs. For SOEs such as Gotion High-Tech (2023), policy could further support the integration of ESG targets into executive performance evaluations and help with access to long-term, low-cost “green” capital for projects aligned with national strategic goals. For non-SOEs such as BYD (BYD Company Limited, 2024), policy support could focus, for instance, on creating a level playing field in international markets, making certification for green technologies easier, and supporting participation in global sustainability standards-setting. Regarding the threshold effect, the results indicate that policies should help firms reach this minimum ESG threshold (3.5), so

that the market can recognize their sustainability efforts.

For corporate managers, the study shows that robust ESG performance is not only a cost center but also an investment. The case of Sungrow Power Supply Co (2023) illustrates this well. Sungrow has systematically linked its ESG management with the management of operations and risk-taking. It has communicated comprehensive information on product life-cycle management in its sustainability reports, which helps build brand trust and reduce regulatory and reputational risk (Sungrow Power Supply Co, 2023). In this sense, we show that, to realize value, it is critically important to embed ESG into the core of operations and governance (in particular, internal control). Managers should also be mindful of the nonlinear nature of ESG returns: if the goal is to reach the threshold of 3.5, low-ESG firms should focus on this target, while high-ESG firms should monitor for possible diminishing returns.

The findings also have implications for investors, stressing that they should not focus solely on the aggregate ESG score to evaluate the quality of underlying governance and innovation capabilities. The mediating role of green innovation suggests that metrics tracking R&D in sustainable technologies and patent outputs should be given greater weight in ESG assessments. The moderating role of internal control means that it is possible to assess, through an evaluation of firms' operational governance systems, whether they have credible ESG implementation. The threshold effect also means that investors should not be overly optimistic about firms with very low ESG scores, as their investments are not yet recognized by the market as value-creating.

CONCLUSION

This study examines how ESG ratings influence firm value in China's energy storage sector, proposing an integrated framework that positions green innovation as a mediator, internal control as a moderator, and ownership structure as a boundary condition. Using panel data from 127 A-share-listed firms over 2015–2023, we employ two-way fixed-effects models, mediation analysis, moderated mediation models, three-way interaction models, threshold regression, and instrumental-variable estimation to test our hypotheses.

The findings provide robust evidence that ESG performance positively affects firm value. Green innovation serves as a significant mediating pathway, while internal control quality strengthens this relationship. The ESG-value link is more pronounced for state-owned enterprises, reflecting their institutional alignment with national policy priorities. Additional analyses reveal an inverted U-shaped relationship with a threshold effect, suggesting that firms need to achieve a minimum ESG level (3.5) before the market fully recognizes their sustainability efforts. These results are consistent across multiple robustness checks, including excluding pandemic years and replacing the dependent variable with ROA.

This study makes three contributions. Theoretically, it introduces a governance stratification framework distinguishing structural, operational, and institutional governance and tests a dual-pathway model, innovation mediation plus control moderation, to unpack how and when ESG creates value. Practically, the findings offer actionable guidance for managers to strengthen internal control systems, especially in non-SOEs, and for investors to look beyond aggregate ESG scores toward innovation and governance quality. For policymakers, the threshold effect suggests designing differentiated support mechanisms to help firms reach the critical ESG level of 3.5, enabling market recognition of their sustainability efforts.

Limitations and Future Research

This study has some limitations that suggest possible lines for future research. Methodologically, our measure of green innovation (granted green invention patents) captures only codified technological outputs and may understate process innovations or unpatented green practices. Future research could use other complementary measures, such as R&D intensity or eco-efficiency indicators, to gain a better picture of this. Also, although our instrumental variable approach lessens concerns about reverse causality, the contemporaneous specification in our mediation model might not fully capture the time lags in ESG investment, innovation development, and value realization. Future research with a fully lagged mediation model, or with natural experiments such as regulatory shocks or ESG rating changes, could better establish causal sequencing

and improve identification.

Our focus on the energy storage sector in China, on the one hand, provides depth but also limits generalizability to other industries and institutional contexts. Studies comparing other countries or industries could identify which findings are contextual and which are generalizable. The sample period (2015–2023) also happens to be a period with many policy changes in China's energy sector; it would be interesting to have a longer sample period to see how regulatory dynamics might shape the ESG-value relationship over time. Although our moderated mediation analysis reveals considerable ownership-based heterogeneity, the SOE sample is relatively small ($N=339$), limiting our ability to conduct further fine-grained analyses within this group. The nonlinear threshold we identify ($ESG = 3.5$) and the interactions between governance layers should also be further investigated in larger samples.

Policy Recommendations

The findings of this study offer three practical recommendations for policymakers and corporate managers in China's energy storage sector.

First, policymakers are suggested to adopt ownership-specific policy designs. Our results show that SOEs and non-SOEs operate under different ESG value-creation logics. For SOEs, where the ESG-value link is stronger due to policy endorsement, policymakers should integrate ESG targets into state-owned enterprise performance evaluations and link access to subsidized green financing with demonstrated ESG improvements. For non-SOEs, which benefit more from innovation and internal control, policies should focus on leveling the playing field, reducing bureaucratic barriers to green technology certification, supporting participation in global sustainability standards, and providing tax incentives for R&D in sustainable technologies.

Second, policymakers are supposed to help firms reach the ESG threshold. The identified threshold effect ($ESG = 3.5$) suggests that firms with very low ESG scores derive limited market benefits. Policy interventions should be designed to help these firms overcome the initial barriers to ESG adoption, such as by providing technical assistance, subsidized ESG assessment tools, or capacity-building programs for small and medium-sized enterprises.

Third, corporate managers should prioritize internal control strengthening, especially in non-SOEs. The moderating role of internal control is particularly strong for non-SOEs, where institutional endorsement is absent. Managers should view internal control not merely as a compliance function but as a strategic investment that enhances the credibility and market value of ESG initiatives. This is especially relevant for energy storage firms seeking to attract international investors and participate in global supply chains.

FUNDING: This study received no specific financial support.

INSTITUTIONAL REVIEW BOARD STATEMENT: Not applicable.

TRANSPARENCY: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

COMPETING INTERESTS: The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

DISCLOSURE OF AI USE: Thanks to all reviewers' comments that helped improve the quality of this paper. The authors used OpenAI's ChatGPT-4o for language editing and grammar refinement of the manuscript. All substantive content, theoretical framework, empirical analysis, data interpretation, and conclusions are the original work of the authors.

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