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Path Dependency and Sustainability: Corporate Strategy as a Catalyst in the Second-Largest Brown Economy

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Abstract

Purpose: This study examines whether path dependency (PD) constrains corporate sustainable performance (CSP) in China and whether corporate strategies, namely cost leadership (CL) and differentiation strategy (DS), condition this relationship. The study is motivated by the problem that firms may remain tied to historical routines even when sustainability pressures require strategic renewal.

Methodology: Using annual firm-level panel data from Chinese A-share listed firms from 2010 to 2022, the study estimates industry- and year-fixed-effects regressions and applies component-level validation, an alternative sustainability indicator, a change-on-change specification, and heterogeneity analysis to assess the stability of the findings.

Findings: The results show that PD is negatively associated with CSP, suggesting that historical routines, technological lock-in, and resource irreversibility restrict firms' ability to improve sustainability outcomes. Cost leadership strengthens this adverse relationship by reinforcing efficiency-oriented routines, whereas the differentiation strategy weakens it by encouraging innovation, flexibility, and resource reconfiguration.

Practical implications: The findings are useful for managers because they show that sustainability improvement requires not only green investment but also a careful review of inherited routines and strategic priorities. Cost-oriented firms should ensure that efficiency pressures do not crowd out green experimentation, while differentiation-oriented firms can use innovation, eco-design, and market uniqueness to overcome path-dependent constraints.

Originality: This study is original because it connects path dependency with CSP and explains how competitive strategy changes the sustainability consequences of historical routines. Unlike prior studies that mainly examine green innovation, digital transformation, board characteristics, or environmental management systems as sustainability drivers, this study identifies PD as an organizational decision constraint and shows that CL and DS operate as opposite strategic boundary conditions.

Decision Sciences relevance: This study contributes to Decision Sciences by showing how strategic choices under historical constraints shape sustainability-related decision-making. It explains how managers' reliance on past routines narrows feasible decision alternatives and how cost leadership or differentiation can either reinforce or reduce this constraint.

Keywords: Path Dependency; Corporate Sustainability, Strategic Orientation; Cost Leadership; Differentiation Strategy

JEL Classifications: G41; G11; G15

1 Introduction

Climate change has evolved from a distant academic discussion into a defining global issue that now shapes development priorities, industrial adjustments, and national strategies worldwide (Umar & Safi, 2023). In the wake of this, China, as the world's largest developing economy and a central actor in global emission reduction, faces the dual challenge of improving domestic economic performance while meeting rising international expectations for environmental responsibility (He, 2016; Xian et al., 2023). To address this challenge, the country has committed to its "carbon peak and carbon neutrality" targets, aiming to reach peak emissions by 2030 and achieve full neutrality by 2060 (Wang et al., 2021). The realization of these goals relies heavily on how firms respond, since corporate production, innovation, resource usage, and emission behaviors directly determine whether policy ambitions translate into tangible results. As national strategies intensify, firms are encouraged to enhance green innovation, improve energy efficiency, reduce environmental impact, and rethink resource allocation (Y. Liu et al., 2024; Ye & Rasoulinezhad, 2023; Zhou et al., 2023). However, even with strong policy direction, organizational change is not instantaneous. Many firms continue to rely on long-standing internal routines, resource structures, and decision patterns shaped by years of past experience. These established behaviors influence current choices and affect long-term performance, even before new strategies fully mature. As a result, the shift toward green transformation is not only technological in nature but also strategic and organizational, requiring firms to balance regulatory pressure, market expectations, competitive demands, and internal capacity. This complexity sets the foundation for understanding why firms often demonstrate uneven progress in green development.

Although extensive empirical evidence confirms that green innovation enhances environmental outcomes, social responsibility performance, and financial gains (Hao & He, 2022; Lin et al., 2019; X. Liu et al., 2024), real-world practice suggests that firms do not always adopt green development with the same level of ambition. Instead of pursuing deep strategic transformation, many organizations continue to follow established innovation paths, preferring incremental improvements over more fundamental reforms. Research indicates that this pattern is widespread, as firms often repeat familiar technological models and innovation routines rather than experimenting with new directions (Coombs & Hull, 1998; Goldstein et al., 2023; Haftor & Costa, 2023). Incremental improvements can still generate benefits, such as stronger corporate responsibility outcomes (Xu et al., 2023) and enhanced reputation among customers, investors, and external stakeholders (Andreassen et al., 2024; Hillestad et al., 2010; Khan et al., 2023). However, in markets characterized by rapid technological change and evolving policy expectations, incremental innovation may not be sufficient to build stronger long-term competitiveness. In contrast, more ambitious approaches to green innovation can improve operational efficiency, open new business opportunities, and create measurable performance improvements (Jiang et al., 2020; Kuo et al., 2022; Wong et al., 2020). The comparison between incremental and transformative green innovation highlights an important practical reality: although policy directions are consistent across firms, organizational outcomes differ significantly depending on how firms interpret and act on the transition. This gap between policy intention and practical implementation raises critical questions regarding the factors that support or inhibit effective green transformation, leading to a closer examination of organizational decision behavior.

Among the factors that limit the effectiveness of corporate green transition, path dependency (PD) has emerged as a major constraint. PD occurs when firms continue to rely on familiar technologies, management structures, or innovation patterns, even when external conditions require new approaches (Coombs & Hull, 1998; Goldstein et al., 2023; Haftor & Costa, 2023). In some situations, PD can support stable performance, as accumulated experience and structured routines enable efficient and reliable operations (Hunt & Morgan, 1996; Jiang & Liu, 2022). However, when reliance on historical models becomes excessive, firms may lose flexibility, slow their ability to adjust, and struggle to engage with new environmental, technological, or regulatory demands. Over time, this can restrict green technological progress, narrow innovation space, and weaken the potential to achieve sustainability goals, especially under conditions of rapid external change (Brekke et al., 2024; Chen et al., 2024; Wenzig et al., 2023). Although studies demonstrate that effective green innovation can enhance corporate responsibility (Xu et al., 2023), strengthen stakeholder reputation (Andreassen et al., 2024; Hillestad et al., 2010; Khan et al., 2023), and generate operational and competitive advantages (Jiang et al., 2020; Kuo et al., 2022; Wong et al., 2020), there is limited evidence on how historical routines influence the ability to realize these benefits. Furthermore, it remains unclear whether strategic decisions such as cost leadership (CL) and differentiation strategies (DS) can reduce the negative effects of PD and support stronger sustainable development performance. This unresolved gap creates the motivation for further analysis of whether PD restricts or enhances sustainability outcomes, and under what strategic conditions firms can break historical inertia and achieve more meaningful green transformation.

The motivation of this study is therefore to explain why firms exposed to similar sustainability pressures may still differ in their ability to improve CSP. The central problem is that organizational routines accumulated through prior strategic choices may constrain the set of sustainability decisions that managers consider feasible. This problem is particularly relevant in China because firms operate under strong green-transition pressure while still relying on established industrial routines and resource commitments.

Recent Decision Sciences and emerging-market studies also emphasize that sustainability outcomes are shaped by strategic decision settings, governance arrangements, information transparency, green finance, and market orientation (Bagadeem & Aldawsari, 2026; Le et al., 2026; Miah et al., 2026; Nguyen et al., 2021). Building on this discussion, the present study focuses on a less-examined decision constraint: whether path-dependent routines restrict CSP and whether strategic orientation helps firms either remain locked into, or move beyond, historical development paths. To address these concerns, this study introduces a specific measure of PD in green innovation and defines its behavioral characteristics within corporate practice. Using Chinese A-share listed firms from 2010 to 2022, the research answers three key questions: (1) How does PD influence corporate sustainable performance (CSP)? (2) How do cost leadership (CL) and differentiation strategy (DS) condition the relationship between PD and CSP? (3) Under what circumstances is the influence of PD stronger or weaker? The empirical design combines benchmark industry and year fixed-effects regressions with component-level validation, an alternative sustainability indicator, change-on-change estimation, and heterogeneity analysis.

However, the findings show that the two strategic orientations operate differently. Cost leadership strengthens the negative influence of PD: when cost efficiency reinforces established routines and discourages uncertain, longer-horizon green investment, the adverse PD–CSP relationship becomes more pronounced. In contrast, a differentiation strategy weakens the negative relationship by encouraging innovation, strategic flexibility, and exploration of new technological paths. The heterogeneity analysis further indicates that the adverse association is more pronounced among low-pollution enterprises, where weaker external environmental pressure may allow established routines to persist. These findings show that the sustainability consequences of PD depend on both strategic orientation and external institutional pressure.

This study contributes to the literature and practice in four focused ways. First, it extends sustainability research by positioning PD as an organizational decision constraint that can weaken CSP. Second, it contributes to RBV and Organizational Inertia theory by showing that accumulated resources and routines may become barriers rather than advantages when sustainability demands strategic renewal. Third, it advances strategy-sustainability research by demonstrating that CL and DS condition the PD-CSP relationship in opposite directions. Fourth, it provides practical guidance for managers and policymakers by identifying when strategic routines should be reviewed, redesigned, or complemented with innovation-oriented capabilities. These contributions clarify what is original in the study and why the findings are relevant for academics, decision scientists, and practitioners.

Grounded in the Resource-Based View (RBV) and Organizational Inertia theory, this study explains that while firm resources and accumulated experience can strengthen an organization, they may also limit strategic progress when they lead to path dependency. This shows that past capabilities do not always result in competitive advantage, especially when environments change. As a result, such rigidity can hinder green practices and ultimately reduce sustainable performance. Moreover, it also advances research on path dependency by analyzing its impact on corporate sustainable performance, which extends the findings of previous studies on sustainability (Aklin & Urpelainen, 2013; Redding, 2002; Wang et al., 2022; Zhang et al., 2022). The current study explicitly examines how path dependency shapes sustainable performance outcomes. while prior studies have identified various determinants of sustainable performance, including innovation (Zhang et al., 2022), CEO attributes (Mukherjee & Sen, 2022), digital supply chain network (Sharma et al., 2022), digital transformation (Li, 2022), board characteristics (Disli et al., 2022), and environmental management control systems (Rehman et al., 2021), this study extends the literature by highlighting path dependency as a critical factor influencing sustainability outcomes. Finally, the study shows that strategic orientation can either reinforce or offset the adverse effects of path dependency: cost leadership may intensify them, whereas differentiation can mitigate them.

Empirically, this research contributes by developing a measurable operational definition of path dependency in the context of green innovation and testing it using panel data from Chinese A-share firms between 2010 and 2022. Component-level validation, an alternative sustainability indicator, change-on-change estimation, and heterogeneity analysis are used to assess the stability of the main findings. Practically, the results caution managers against excessive reliance on established routines: cost-oriented firms should ensure that efficiency pressures do not deepen inertia or crowd out green investment, whereas differentiation-oriented firms can use innovation and flexible resource reconfiguration to overcome historical constraints. Policymakers can support this transition by rewarding innovation and reducing the cost of green experimentation.

The study is also relevant to decision sciences because it examines how firms make strategic choices under historical constraints, information limits, and changing policy pressure. PD represents a decision constraint because previous routines narrow the set of alternatives that managers consider feasible. CL and DS represent strategic decision logics that may either reinforce this constraint or help firms move away from it. By connecting these decision logics with measurable sustainability outcomes, the study offers evidence on how corporate decision processes can support or hinder green transformation.

This framing is consistent with recent work in Advances in Decision Sciences that examines green finance and biodiversity risk, digital orientation and competitive advantage, and governance-related strategic decision-making in emerging markets (Bagadeem & Aldawsari, 2026; Le et al., 2026; Miah et al., 2026).

2 Theoretical Foundations

The Resource-Based View (RBV) was formally introduced by Barney (1991), who argues that firms achieve sustained competitive advantage when they possess valuable, rare, inimitable, and non-substitutable resources. In this study, RBV provides a lens for understanding how path dependence (PD) can restrict corporate sustainable performance (CSP) when historical routines prevent firms from renewing capabilities, knowledge structures, and operational processes required for sustainability. The moderating results further show that cost leadership (CL) and differentiation strategy (DS) condition this relationship in opposite directions. CL can reinforce reliance on established efficiency-oriented resources and routines, whereas DS encourages capability renewal, experimentation, and the development of new sustainability-related assets. The stronger negative association observed in low-pollution enterprises is also consistent with the persistence of legacy resource configurations when external pressure for renewal is weaker.

Organizational Inertia theory, originally introduced by Hannan and Freeman (1984), posits that established organizational systems, structures, and standard operating routines generate internal resistance to change. This view aligns with the evidence that PD is negatively associated with CSP because firms embedded in legacy practices may exhibit structural rigidity, slower decision cycles, and weaker responsiveness to environmental expectations. The moderation results indicate two distinct mechanisms: cost leadership can reinforce inertia when cost minimization favors familiar processes and discourages costly experimentation, whereas differentiation can counter inertia by encouraging innovation, flexibility, and exploration of alternative technologies. The stronger adverse association in low-pollution enterprises is also consistent with inertia remaining less challenged when external pressure is weaker.

Taken together, RBV and Organizational Inertia theory provide a balanced explanation. RBV suggests that accumulated capabilities can support performance, whereas Organizational Inertia theory explains why the same accumulated routines may become rigid when sustainability demands new technologies, resource recombination, and strategic experimentation. This integrated view clarifies why PD may have negative sustainability consequences and why corporate strategy can change the strength of this relationship.

3 Literature Review and Hypotheses

This section reviews pioneer works on path dependence and organizational inertia, including Arthur (1989), David (1985), Pierson (2000), and Hannan and Freeman (1984), together with RBV-based arguments on resource accumulation and competitive advantage (Barney, 1991; Hunt & Morgan, 1996; Lockett et al., 2009). It also engages with recent sustainability and decision-oriented studies showing that green innovation, digital transformation, board characteristics, environmental management control systems, green finance, digital orientation, governance, and information transparency shape sustainable performance and strategic decision-making (Bagadeem & Aldawsari, 2026; Disli et al., 2022; Le et al., 2026; Li, 2022; Miah et al., 2026; Nguyen et al., 2021; Rehman et al., 2021; Sharma et al., 2022; Zhang et al., 2022). Building on these works, the present study focuses on whether historically embedded routines restrict CSP and whether strategic orientation alters this relationship.

3.1 Path Dependency (PD) and Corporate Sustainable Performance (CSP)

The following hypothesis is developed from a balanced reading of the literature. Path dependence may preserve valuable accumulated experience, but it may also restrict adaptation when external sustainability demands require new investments, new technologies, and new organizational routines. Therefore, the study treats PD as a potential constraint on CSP rather than assuming that past capabilities automatically generate sustainable advantage. To situate this study within existing scholarly work, the following empirical literature review examines the theoretical foundation and prior evidence relevant to the relationship between path dependency and corporate sustainable performance. Lockett et al. (2009) noted that a firm's competitive advantage originates from its internal resource portfolio, which encompasses knowledge, technological capabilities, organizational systems, accumulated managerial experience, and the routines developed over time. These resources are valuable because they are scarce, difficult to imitate, and non-substitutable, enabling firms to pursue long-term performance outcomes not easily replicated by competitors. A key implication of RBV is that competitive advantage is not merely a product of current strategic decisions; rather, it reflects a continuous process of resource accumulation in which historical decisions and developmental trajectories exert a lasting influence. Chatterjee et al. (2024) argue that firms often reinforce their existing resource base by deepening established capabilities, investing in technological pathways already in use, and aligning their strategic actions with familiar organizational designs to maximize efficiency. Although such reinforcement may initially appear rational and optimal, it suggests that a firm's present and future decisions are embedded in an evolutionary path shaped by past choices. This notion closely mirrors the concept of path dependence, where historical strategic and technological accumulation binds firms to particular trajectories (Jin et al., 2025).

Bebchuk and Roe (2000) further explain that path dependence can itself become a strategic resource because long-term learning, institutional knowledge, and cultural embedding create organizational features that competitors struggle to replicate. In sustainability contexts, firms may capitalize on established technological pathways to reduce experimentation costs, refine existing green technologies, and deliver consistent innovation outputs (Rycroft & Kash, 2010). Thus, path dependence, viewed through the RBV lens, can function as a resource with the potential to positively influence sustainable performance under certain conditions, especially when existing technological capabilities remain relevant and continue generating environmental and operational improvements.

However, the theory of organizational inertia provides an important counter-perspective, emphasizing that the same accumulated resources and routines that enhance short-term efficiency may simultaneously limit flexibility and long-term adaptation. Shimizu and Hitt (2005) note that as firms mature, they build stable rules, processes, and behavioral patterns that help to reduce external uncertainty and streamline operations. While such stability supports operational consistency, it can also increase dependence on existing capabilities and strategic pathways, restricting the organization's willingness or ability to experiment with new approaches. Over time, this dependence transforms into organizational inertia, making it difficult for firms to recognize environmental changes or shift away from well-established resource configurations (Huang et al., 2013). Consequently, although organizational inertia provides short-term stability, it may weaken a firm's responsiveness to emergent sustainability pressures, technological opportunities, or regulatory demands. This condition directly aligns with the characteristics of path dependence, where historical choices lock firms into predictable behavioral and technological patterns (Heine & Rindfleisch, 2013).

Schreyögg and Sydow (2011) emphasize that path dependence may reduce the diversity of innovation and restrict exploration of more effective or cleaner technologies, ultimately narrowing the menu of solutions available to firms. In sustainability settings, this can cause enterprises to persist with familiar environmental practices or established green technologies, even when external stakeholders expect new approaches or higher sustainability standards (Wenzig et al., 2023). For example, firms may continue committing resources to proven green systems rather than exploring breakthrough innovations with potentially greater long-term benefits. Such inertia can erode the firm's long-term competitiveness during green transitions and gradually undermine improvements in environmental, social, and economic outcomes. Therefore, organizational inertia highlights the challenge of declining adaptability that firms encounter when pursuing sustainability objectives while remaining anchored to the efficiencies of historical resource configurations (Heine & Rindfleisch, 2013). On behalf of prior studies, we propose the following hypothesis:

H1: There is a negative and significant relationship between path dependence and corporate sustainable performance

3.2 Path Dependency, Cost Leadership, and Corporate Sustainable Performance

The moderating role of cost leadership is important because it represents a managerial decision logic centered on efficiency, standardization, and cost control. Under such a strategic orientation, path-dependent routines may be reinforced because managers have stronger incentives to exploit existing processes rather than experiment with uncertain sustainability investments. Cost leadership strategy is a widely adopted approach that enables firms to gain a competitive advantage by enhancing operational efficiency and reducing production and management costs (Amit, 1986). However, this strategy may inadvertently magnify the negative effects of path dependence on sustainable performance. Theoretically, cost leadership emphasizes the optimization of existing resources and processes to achieve economies of scale and cost minimization (Banker et al., 2014). This focus typically involves standardized production, fixed operational procedures, and the efficient reuse of established resources, thereby reinforcing a firm's reliance on historical technological paths and business models (Li & Li, 2008). Given that path dependence reflects the continuation of past resource allocation and decision-making patterns, the adoption of cost leadership can further entrench these historical choices. Consequently, the strategy may restrict a firm's flexibility to pursue green innovation or explore alternative business models, as managers prioritize operational efficiency over experimentation and adaptation. In this way, cost leadership, while beneficial for short-term efficiency, may inadvertently intensify the constraints imposed by path-dependent organizational routines, creating a potential conflict between cost-focused strategies and sustainability objectives.

Empirical literature further suggests that cost leadership strategies often prioritize short-term gains, potentially overlooking long-term investments in innovation and diversification (Baack & Boggs, 2008). Green innovation, by contrast, generally requires sustained investment and longer return horizons, which can be underfunded when cost control dominates strategic priorities (Abubakar et al., 2024). For instance, firms may rely excessively on existing low-cost resources and proven technological paths rather than taking on the risk of developing new green technologies or reconfiguring business models. This behavior amplifies the influence of path dependence, reducing organizational flexibility and innovation diversity, and limiting responsiveness to emerging environmental regulations or market demand for sustainable products (Aklin & Urpelainen, 2013). While cost leadership may secure short-term operational advantages, it can weaken long-term competitiveness and sustainable performance in the green transformation process (Heine & Rindfleisch, 2013). Studies indicate that when strategic emphasis is placed heavily on cost efficiency at the expense of innovation, the negative relationship between path dependence and sustainable performance becomes more pronounced (Caron & Turcotte, 2009). Understanding the interaction between cost leadership and path dependence thus provides crucial theoretical and practical understandings, highlighting how strategic choices can either mitigate or exacerbate barriers to sustainability-oriented innovation. Based on this rationale, we propose the following hypothesis:

H2: Cost leadership strategy strengthens the negative relationship between path dependence and corporate sustainable performance.

3.3 Path Dependence, Differentiation Strategy, and Corporate Sustainable Performance

The moderating role of differentiation strategy is examined because it represents a contrasting decision logic. Differentiation encourages product uniqueness, innovation, and market responsiveness; therefore, it may help firms overcome path-dependent constraints by widening the range of sustainability-related choices available to managers. Differentiation strategy is a strategic approach through which firms seek competitive advantage by offering unique products or services that meet specific customer needs (Semuel et al., 2017). Unlike cost leadership, differentiation emphasizes innovation, flexibility, and dynamic adaptability, which can potentially mitigate the negative effects of path dependence on sustainable performance. Theoretically, differentiation requires firms to maintain acute awareness of market demands and to continuously introduce novel solutions (Luciano & Cruz, 2010). Implementing this strategy often entails breaking through existing organizational boundaries in technology, processes, design, and branding, thereby fostering greater diversity and flexibility in innovation (Banker et al., 2014). In doing so, differentiation contrasts with the rigid behavior patterns reinforced by path dependence and helps firms to overcome the inertia that may limit responsiveness to emerging environmental and market challenges (Aylward, 2007). By promoting experimentation and the exploration of multiple technological pathways, differentiation enables firms to diversify their capabilities, reduce overreliance on historical routines, and increase the breadth of options available for sustainable innovation initiatives.

Empirical literature further suggests that differentiation strategy encourages dynamic resource allocation, cross-functional collaboration, and continuous organizational learning, all of which help mitigate the entrenchment effects of path dependence (Mosakowski, 1993; Redding, 2002). In the context of green innovation and sustainable development, this approach enables firms to prioritize long-term innovation value rather than relying solely on established low-cost paths, thereby enhancing sustainable performance (Thrane et al., 2010). Differentiation also improves a firm's responsiveness to social and environmental demands by fostering innovation diversity and supporting the adoption of green technologies and sustainable supply chains (Danso et al., 2019). Unlike path-dependent innovation, which often follows narrow technological trajectories, differentiation promotes a wider range of technological and managerial options, reducing organizational rigidity and strengthening adaptability (Banker et al., 2014). Consequently, the strategy serves as a mechanism to counteract the constraints imposed by historical resource accumulation and entrenched decision-making patterns. By driving innovation diversity and dynamic adaptability, differentiation strategy enables firms to sustain competitiveness and enhance long-term sustainable performance. Based on this reasoning, we propose the following hypothesis:

H3: Differentiation strategy weakens the negative relationship between path dependence and corporate sustainable performance.

Figure 1 shows the conceptual framework where, PD is the explanatory variable, CSP as the outcome variable, CL and DS as moderating strategic orientations, and firm characteristics as control variables. The theoretical lenses are explained in the text to keep the diagram focused on the empirical relationships.

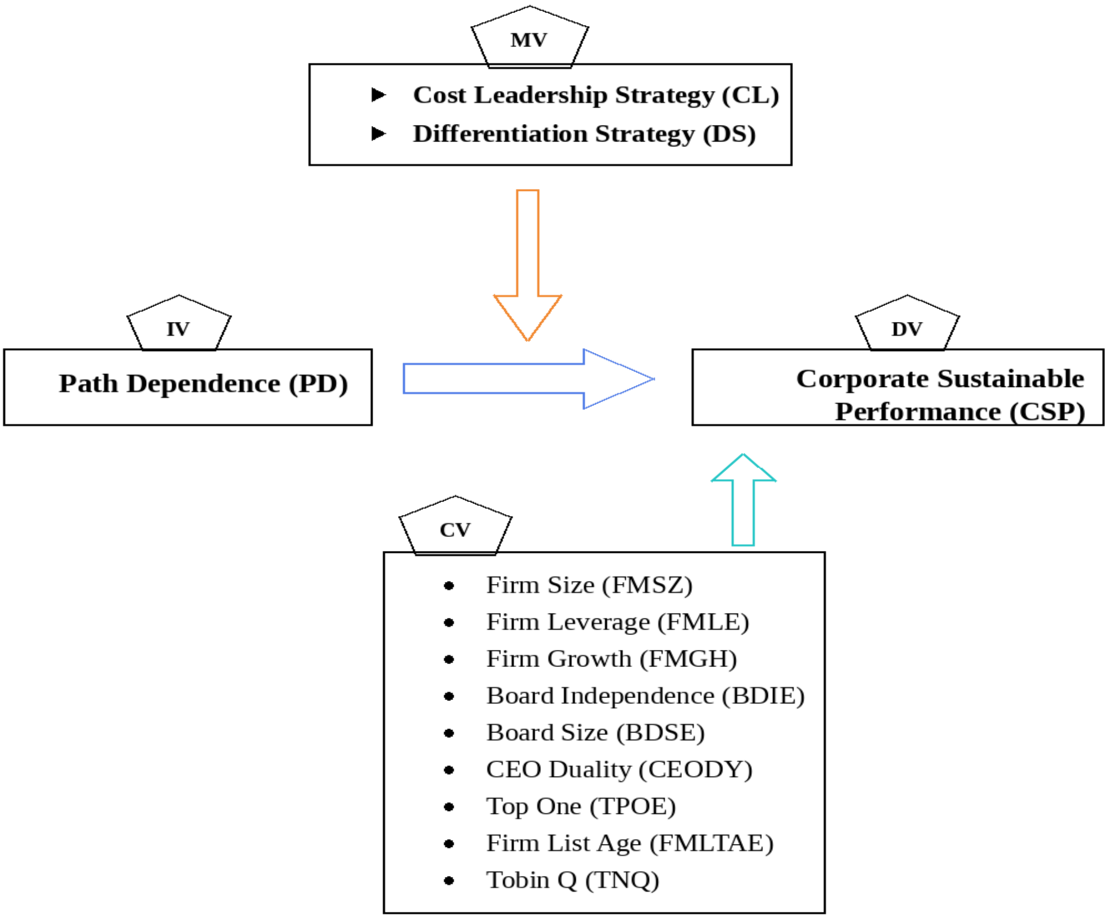

Figure 1. Conceptual Framework

Note: IVs are the predictors, DVs are the outcomes, MVs influence the relationships, and CVs control for other factors.

4 Data and Methodology

Using a panel of Chinese A-share listed enterprises from 2010 to 2022, this study investigates how path dependence (PD) shapes corporate sustainable performance (CSP). China provides an ideal context for this analysis because it has undergone an unprecedented transition towards sustainability, driven by ambitious national policies, strict environmental regulatory reforms, and growing emphasis on green and high-quality development. As one of the world's largest emerging economies and a major contributor to global carbon emissions, the Chinese market offers a rich institutional environment in which firms face strong pressure to improve their environmental behavior, innovate sustainably, and integrate long-term ecological considerations into corporate strategies. Therefore, the Chinese setting enables an in-depth examination of how accumulated routines, strategic inertia, and historical decision patterns influence contemporary sustainability outcomes. To ensure accuracy and consistency, we applied several data selection criteria. First, we excluded enterprises in the financial sector. Second, firms with ST and ST* status were removed due to abnormal financial conditions that could bias the analysis. Finally, observations with missing variables were omitted. After applying the sample-selection criteria, the main complete-case sample contains 50,916 firm-year observations. The panel is unbalanced because the availability of firm-level information differs across firms and years. The number of observations also varies in supplementary analyses when an alternative dependent variable, a first-difference specification, or subsample classification is used. A reconciliation of the sample sizes across all empirical tests is provided in Table A2 (Appendix). Financial information was sourced from the CSMAR database, while sustainability and green innovation indicators were collected from CNRDS and Hexun, ensuring comprehensive and high-quality data coverage.

The dataset is annual firm-year panel data rather than monthly or daily data. The sample contains 50,916 firm-year observations after excluding financial firms, ST and ST* firms, and observations with missing key variables. The large firm-year sample provides sufficient variation across firms, industries, and years for fixed-effects estimation and is comparable to recent firm-level sustainability studies using Chinese listed companies (Li, 2022; Liu et al., 2024; Zhang et al., 2022). The Chinese setting is important because the country combines intensive industrial activity, strong policy pressure for green development, and substantial heterogeneity in firm strategies and sustainability outcomes.

4.1 Variables Details

In this study, corporate sustainable performance (CSP) serves as the dependent variable. Following Zhang et al. (2022), CSP is evaluated through three complementary indicators that reflect the multidimensional nature of sustainability. First, social performance is measured using the firm's CSR score, which captures the extent of its engagement in social responsibility initiatives. Second, environmental performance is assessed through the environmental responsibility score, providing insight into the firm's commitment to ecological protection and green development. Finally, economic performance is proxied by return on assets (ROA), reflecting the firm's ability to generate financial returns while maintaining sustainable practices. To create a comprehensive and balanced measure of sustainable performance, we apply a Shannon entropy-weighting method. This approach enables the integration of the three dimensions into a unified index while minimizing information loss and ensuring an objective weighting structure. By employing this methodology, the study captures the overall sustainability profile of enterprises in a manner that is both statistically robust and theoretically consistent with Zhang et al. (2022). ROA is used only as the economic component of CSP and is not entered separately as a regression control, thereby avoiding mechanical overlap between the dependent variable and the controls.

The core explanatory variable in this study is path dependency, and to distinguish whether a firm's green strategy in a given year represents continuity rather than new experimentation, we adopt a framework grounded in the defining attributes of path dependency. This study focuses on its three key dimensions: historical inertia, irreversibility, and lock-in, to identify and construct the path dependency variable. First, in examining historical inertia, we assess whether a firm's current green strategy is a natural extension of its accumulated innovation behavior, technological choices, and historical development trajectory. Second, when evaluating the lock-in effect, we consider whether, even when alternative technological or innovation paths become available, the firm opts to persist with its previous route due to established routines, experience advantages, or reduced uncertainty. Third, we incorporate irreversibility, considering whether firms have made resource commitments such as long-term investments, technologies, or capabilities that constrain short-term strategic change and make shifting direction costly (Arthur, 1989; David, 1985; Mahoney, 2000; Pierson, 2000; Schreyögg & Sydow, 2011; Teece, 1986).

If an enterprise consistently follows traditional innovation approaches and invests resources that are not easily transferable, this behavior is considered path-dependent. To strengthen the rigor and objectivity of this determination, we combine quantitative indicators with a multi-year dynamic trend analysis, allowing us to capture how past choices continue to shape ongoing green strategic decisions.

We employ Models 1, 2, and 3 to measure path dependency.

$$Path\ continuity = \left({Frequency\ of\ traditional\ innovation\ in\ prior\ three\ year} / {Total\ Innovation} \right) * 100. \quad (1)$$

Equation 1 discloses that the frequency of traditional innovation in the prior three years refers to the number of innovations developed within the firm's existing technological domains during the preceding three years. The total innovation denotes the total number of innovations, and higher values indicate stronger path continuity in innovation activities. In all equations, i denotes firms and t denotes year. The subscripts i and t are used because the dataset is an annual firm-level panel. Equation punctuation and symbol definitions have been checked so that variables and parameters are defined before their use.

$$Innovation\ Herfindahl\ Index = \sum_{j=1}^{J} p_j^2 . \quad (2)$$

Equation 2 shows that the Innovation Herfindahl Index is calculated as the sum of the squared proportions of innovations across all technology areas. Specifically, $\mathrm{p_j}$ denotes the proportion of innovations in technology area j, while J represents the total number of technology areas. Higher values indicate a greater concentration of innovation activities within a limited number of technological domains, whereas lower values reflect a more diversified innovation portfolio.

$$\text{Resource Lock} - \text{in Ratio} = {\text{Fixed Asset Investment}} / {Total\ Asset\ Investment} . \quad (3)$$

Equation 3 reveals that fixed asset investment represents investment in tangible long-term assets, total asset investment denotes the firm's overall investment expenditure, and a higher resource lock-in ratio indicates a greater commitment of resources to existing asset structures. Furthermore, we combine these three dimensions and construct a comprehensive index of path dependency using the Shannon entropy-weighting approach, so that the measure reflects the collective influence of historical inertia, irreversibility, and lock-in. For comparability, the three component indicators are standardized to a common scale before forming the empirical composite; therefore, the reported PD index can take negative values, which indicate below-reference levels of path dependence rather than negative path dependence in a literal sense. A higher value indicates that a firm’s green strategy is more strongly shaped by past decisions and therefore demonstrates a greater degree of path dependency. However, following Zhang et al. (2022), we also incorporate a set of control variables that may affect sustainable performance. These include firm size, leverage, growth rate, board size, proportion of independent directors, CEO duality, ownership concentration (top one shareholder), Tobin’s Q, and the number of years since listing. Detailed definitions and measurement methods for all variables are provided in Table A1.

Construct validity is addressed in two ways. First, PD is not treated as a single proxy for operational rigidity or repeated innovation; it is constructed from historical inertia, lock-in, and irreversibility so that the measure captures the broader behavioral logic of path-dependent decision-making. Second, CL and DS are measured from annual-report texts as strategic orientations rather than single financial outcomes. Cost-leadership words capture managerial emphasis on efficiency, cost reduction, scale, and process control, whereas differentiation words capture emphasis on innovation, uniqueness, product quality, branding, and market distinction. The textual measures are normalized by total annual-report words to reduce bias caused by report length. Following Wen et al. (2022) and Lu et al. (2025), we construct cost leadership and differentiation strategy measures using the normalized frequency of relevant strategy-related words in firms’ annual reports. This approach improves construct clarity because it links strategic language to the firm’s stated decision orientation while recognizing that strategy is expressed through managerial priorities as well as accounting outcomes.

Table A1. Variables Measurements

Variables	**Acronyms**	**Measurements**
Explained Variable		
Corporate Sustainable Performance	CSP	Entropy-weighted composite index of social performance, environmental performance, and economic performance, where ROA is used only as the economic component.
Explanatory Variable		
Path Dependence	PD	Entropy-weighted index constructed from historical inertia/path continuity, innovation lock-in effect, and irreversibility/fixed-asset lock-

		in after standardization.
Moderating Variables		
Cost Leadership Strategy	CL	Normalized frequency of cost-leadership-related words in annual reports, capturing managerial emphasis on efficiency, cost reduction, scale, and process control.
Differentiation Strategy	DS	Normalized frequency of differentiation-related words in annual reports, capturing managerial emphasis on innovation, uniqueness, product quality, branding, and market distinction.
Control Factors		
Firm Size	FMSZ	Natural logarithm of total assets.
Firm Leverage	FMLE	Total liabilities divided by total assets.
Firm Growth	FMGH	Firm growth rate.
Board Independence	BDIE	Proportion of independent directors on the board.
Board Size	BDSE	Natural logarithm of total board members.
CEO Duality	CEODY	Dummy variable equal to 1 if the CEO also serves as board chair, and 0 otherwise.
Top One	TPOE	Shareholding percentage of the largest shareholder.
Firm List Age	FMLTAE	Natural logarithm of the number of years since listing.
Tobin Q	TNQ	Market-to-book asset ratio.

Note: W_1, W_2, and W_3 represent the weights determined through the Shannon entropy method, while EP_{it}, SP_{it}, and ROA_{it} denote the environmental, social, and economic performance of firm i in year t, respectively, with economic performance measured using return on assets. Similarly, PD_{it} is the overall path dependency index for firm i in year t, while α_1, α_2, and α_3 are weights from the Shannon entropy method. HI_{it}, LI_{it}, and IR_{it} represent historical inertia, lock-in effect, and irreversibility, respectively. For moderating variables, cost-leadership words mean the number of cost-leadership words in the annual report, and total words mean the total words in the annual report. Similarly, differentiation words mean the frequency of differentiation words per 100 words in the annual reports.

4.2 Econometric Model

To empirically investigate the relationship between path dependency, corporate strategy, and sustainable performance, we estimate models that capture cross-sectional and temporal variation while controlling for observed firm characteristics, industry heterogeneity, and common year shocks across Chinese A-share listed firms over 2010–2022.

The empirical strategy is designed to match the structure of the data. Because the sample is a large annual firm-level micro panel with substantial cross-sectional variation and a shorter time dimension, the baseline model uses industry and year fixed effects to control for industry heterogeneity and common time shocks. The strategy variables and the PD index are firm-year measures, making fixed-effects panel estimation appropriate for examining robust associations between PD, strategy, and CSP.

$$\mathrm{CSP}_{i,t} = \beta_0 + \beta_1 \mathrm{PD}_{\mathrm{Index}_{i,t}} + \sum_{k=1}^{k} \gamma_k X_{k,i,t} + \text{Industry FE} + \text{Year FE} + \varepsilon_{i,t}. \quad (4)$$

Model 4 examines how firm path dependency affects corporate sustainable performance while accounting for the control variables. Consistent with the empirical tables, the baseline specification includes industry and year fixed effects. Firm fixed effects are not entered simultaneously with industry fixed effects because industry membership is largely time-invariant; sensitivity to time-invariant firm-level heterogeneity is examined separately using the change-on-change specification.

$$\mathrm{CSP_{i,t}} = \beta_0 + \beta_1 \mathrm{PD_{Index_{i,t}}} + \beta_2 \mathrm{MV_{i,t}} + \beta_3 \left(\mathrm{PD_{Index_{i,t}}} * \mathrm{MV}\right) + \sum_{k=1}^{k} \gamma_k X_{k,i,t}$$
$$+ \mathrm{Industry\ FE} + \mathrm{Year\ FE} + \varepsilon_{i,t}. \quad (5)$$

Model 5 extends the baseline specification by adding the moderating variable and its interaction with path dependency. The interaction coefficient shows how the marginal effect of PD changes with the moderator: a negative PD×CL coefficient makes the PD slope more negative, whereas a positive PD×DS coefficient offsets part of the negative PD effect.

In model 5, the interaction term $(\beta_1 \mathrm{MV} * \mathrm{PD\_Index}_{i,t})$ captures the moderating mechanism, showing how the effect of path dependency on sustainable performance changes depending on the level of the moderating variable. In other words, it allows to see whether and how the moderating factor strengthens, weakens, or alters the impact of path dependency on corporate sustainability.

To strengthen the reliability of the empirical design, the baseline industry- and year-fixed-effects regressions are supplemented by component-level PD regressions, an alternative sustainability indicator, a change-on-change specification, and heterogeneity analysis. The change-on-change model is used specifically to reduce the influence of time-invariant firm characteristics and common level-based trends. These analyses assess robustness, while causal interpretation remains cautious because the study does not impose an external instrumental-variable design.

Additional methodological caution is taken because statistically significant regressions may be affected by persistence, spurious-like relationships, nonlinearity, or omitted dynamics. Accordingly, the study supplements the level specification with component-level validation, an alternative sustainability indicator, change-on-change estimation, and heterogeneity analysis. The change-on-change model is particularly useful because it focuses on within-firm changes and reduces the influence of time-invariant firm characteristics.

Following methodological discussions on causality tests, nonlinearity, stationary and non-stationary regressions, and spurious-like regression concerns (Bai et al., 2010, 2011, 2018; Cheng et al., 2021, 2022; Hui et al., 2017; Wong et al., 2024; Wong & Yue, 2024; Wong & Pham, 2022a, 2022b, 2023a, 2023b, 2025a, 2025b, 2026a, 2026b; Wong, Pham, & Yue, 2024), the results are interpreted as robust associations rather than definitive causal effects. Future studies can extend this design using external instruments, quasi-experimental shocks, cointegration-based methods, or linear and nonlinear causality tests where the data structure permits.

Given that the dataset is a firm-level micro panel with a large cross-sectional dimension and a relatively short time dimension covering 2010–2022, formal unit-root concerns are less central than in macroeconomic or country-level panel datasets. The variables used in this study mainly represent firm-specific characteristics, governance structures, financial ratios, sustainability scores, and strategy-related textual measures, rather than aggregate macroeconomic series that commonly display strong stochastic trends. Nevertheless, to reduce the possibility of spurious relationships, the empirical models include industry and year fixed effects, which control for unobserved industry heterogeneity and common time shocks. In addition, the change-on-change model examines changes in path dependence and sustainable performance rather than relying only on level-based associations. This specification further limits the influence of common trends and time-invariant unobserved factors. Therefore, the empirical design is appropriate for the micro-panel structure of the data and reduces concerns related to nonstationary-driven spurious regression.

5 Empirical Results

5.1 Summary Statistics

Table 1 presents the descriptive statistics for the principal analytical sample of 50,916 firm-year observations. Corporate sustainable performance (CSP) and path dependence (PD) display substantial variation across firms and years. ROA is reported only as the economic component used in constructing CSP and is not included as a standalone regression control. The financial, governance, and strategic variables also show meaningful cross-firm dispersion, supporting multivariate analysis. The benchmark regressions use this complete-case sample, while sample changes in supplementary analyses are reconciled in Table A2. Table 1 is reported first to describe the distribution of the dependent variable, explanatory variable, moderators, and controls before moving to multivariate estimation.

Table 1. Descriptive Analysis

Variable	N	Mean	SD	Min	p50	Max
CSP	50916	0.096	0.936	-5.179	0.014	2.695
PD	50916	0.092	0.862	-1.303	-0.15	4.906
SP	50916	1.791	0.898	-4.605	1.816	3.955
EP	50916	0.296	0.870	0.000	0.000	3.401
ROA	50916	0.044	0.088	-1.880	0.042	0.686
HI	50916	0.052	0.108	0.000	0.018	1.000
CL	50916	0.425	0.106	0.000	0.420	1.088

DS	50916	0.276	0.128	0.000	0.250	1.238
GI	50916	2.593	1.710	0.000	2.485	6.848
FMSZ	50916	23.79	1.830	19.81	23.64	26.45
FMLE	50916	0.506	0.170	0.027	0.524	0.925
FMGH	50916	0.155	0.311	-0.610	0.107	3.894
BDSE	50916	2.179	0.223	1.609	2.197	2.708
BDIE	50916	0.380	0.057	0.286	0.364	0.600
CEODY	50916	0.337	0.473	0.000	0.000	1.000
TPOE	50916	0.360	0.178	0.081	0.323	0.758
TNQ	50916	1.612	0.881	0.802	1.348	9.817
FMLTAE	50916	2.196	0.865	0.000	2.398	3.401

Abbreviations: CSP = corporate sustainable performance; PD = path dependence; CL = cost leadership strategy; DS = differentiation strategy; SP = social performance; EP = environmental performance; GI = green innovation; HI = innovation Herfindahl index; FMSZ = firm size; FMLE = firm leverage; FMGH = firm growth; ROA = return on assets (CSP component); BDSE = board size; BDIE = board independence; CEODY = CEO duality; TPOE = top-one shareholder ownership; TNQ = Tobin's Q; FMLTAE = firm listing age; FE = fixed effects; Obs. = observations. Standard errors are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5.2 Correlation Statistics

Table 2 presents the correlation matrix for all key variables. CSP shows very weak correlations with most variables, suggesting limited risk of direct linear dependence. PD is positively correlated with CL and FMSZ, indicating that firms with stronger historical routines tend to be larger and more cost-oriented; however, PD is negatively associated with DS and CEODY, reflecting that path-dependent firms are less likely to adopt differentiation-oriented strategies or CEO duality. CL is positively correlated with PD and TPOE, but negatively related to DS, firm size, and leverage, suggesting that cost-focused firms operate with leaner structures. Conversely, DS is positively correlated with TNQ and CEODY but negatively associated with PD, CL, and FMSZ, indicating that differentiated firms pursue growth opportunities but tend to be smaller in size. Financial variables such as FMSZ, FMLE, and FMLTAE demonstrate strong internal correlations, consistent with expected firm-scale effects. Governance variables (BDSE, BDIE, CEODY) also show notable interrelationships. Overall, the correlations remain below critical thresholds (e.g., 0.7), suggesting no severe multicollinearity issues. Table 2 is included to assess preliminary associations among the variables and to check whether pairwise correlations suggest a severe multicollinearity problem.

Table 2. Correlation Analysis

	CSP	PD	CL	DS	FMSZ	FMLE	ROA	FMGH	BDSE	BDIE	CEODY	TPOE	TNQ	FMLTAE
CSP	1													
PD	0.005	1												
CL	-0.062***	0.202***	1											
DS	-0.071***	-0.390***	0.194***	1										
FMSZ	0.216***	0.127***	-0.127***	-0.137***	1									
FMLE	0.068***	-0.056***	-0.226***	-0.114***	0.509***	1								
ROA	-0.020***	-0.050***	-0.060***	0.020***	-0.058***	0.022***	1							
FMGH	0.064***	-0.038***	0.026***	0.020***	-0.037***	0.029***	0.028***	1						
BDSE	0.126***	0.185***	0.059***	-0.224***	0.289***	0.083***	-0.114***	-0.042***	1					
BDIE	-0.036***	0.045***	-0.095***	0.010**	0.136***	0.043***	0.088***	-0.039***	-0.425***	1				
CEODY	0.079***	-0.221***	-0.085***	0.257***	0.020***	0.017***	0.124***	0.081***	-0.212***	0.114***	1			
TPOE	0.038***	0.162***	0.218***	-0.249***	0.190***	-0.102***	-0.068***	-0.065***	0.114***	0.047***	-0.217***	1		
TNQ	-0.044***	-0.159***	0.045***	0.239***	-0.367***	-0.314***	0.050***	0.176***	-0.189***	-0.009**	0.113***	-0.175***	1	
FMLTAE	0.032***	0.179***	-0.040***	-0.189***	0.512***	0.355***	-0.175***	-0.176***	0.197***	0.018***	-0.194***	-0.028***	-0.184***	1

Abbreviations: CSP = corporate sustainable performance; PD = path dependence; CL = cost leadership strategy; DS = differentiation strategy; SP = social performance; EP = environmental performance; GI = green innovation; HI = innovation Herfindahl index; FMSZ = firm size; FMLE = firm leverage; FMGH = firm growth; ROA = return on assets (CSP component); BDSE = board size; BDIE = board independence; CEODY = CEO duality; TPOE = top-one shareholder ownership; TNQ = Tobin's Q; FMLTAE = firm listing age; FE = fixed effects; Obs. = observations. Standard errors are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5.3 Benchmark Outcomes

We estimate Models 4 and 5, and the results are reported in Table 3. Column 1 presents the direct effect of path dependence (PD) on sustainable performance (CSP). The findings show a significant negative relationship between these variables, supporting H1. This pattern suggests that PD may lock firms into established technological and managerial routines, and as a result, they may overlook emerging external requirements for new green technologies or management approaches. Over time, this rigidity can weaken firms' green innovation capacity and limit improvements in sustainable performance. In other words, firms that consistently follow historical decision-making paths may struggle to innovate or to enhance their environmental initiatives. These observations align with the theoretical arguments related to organizational inertia and are consistent with the evidence documented by (Heine & Rindfleisch, 2013; Wang et al., 2022; Wenzig et al., 2023). Table 3 is the central empirical table because it reports the direct association between PD and CSP and the moderating roles of CL and DS.

Columns 2 and 3 of Table 3 present the moderating effects of cost leadership and differentiation strategy. In Column 2, the interaction PD×CL is negative and significant (−0.131, $p<0.01$). Because the baseline PD coefficient is already negative, higher cost leadership makes the marginal effect of PD more negative and therefore strengthens the adverse PD–CSP relationship, supporting H2. This result is consistent with cost-focused firms prioritizing established efficiency routines and being less willing to undertake uncertain, longer-horizon green investments.

By contrast, the interaction PD×DS is positive and significant (0.160, $p<0.01$), offsetting part of the negative PD effect. Differentiation strategy, therefore, weakens the adverse PD–CSP relationship, supporting H3. Its emphasis on innovation, product uniqueness, and market responsiveness gives firms stronger incentives to explore new technologies and move away from entrenched routines. As a robustness consideration, the moderating effects of cost leadership and differentiation strategy are estimated separately to clearly distinguish their respective roles in conditioning the relationship between path dependence and corporate sustainable performance. A specification incorporating both moderators and their interaction terms simultaneously could provide further evidence on their independent moderating effects and represents a useful avenue for future research.

These results provide two important inferences. First, historical routines are not merely neutral background characteristics; they can become active constraints on sustainability-related decision-making. Second, the opposite signs of the two interaction terms show that strategic orientation matters: cost efficiency may deepen routine dependence, while differentiation may create incentives to explore new green capabilities.

Table 3. Impact of PD on CSP: Moderating Influence of CL and DS

	(1) **CSP**	**(2) CSP**	**(3) CSP**
PD	-0.092***	-0.034*	-0.128***
	(0.005)	(0.018)	(0.012)
CL		-0.205***	
		(0.038)	
PD*CL		-0.131***	
		(0.040)	
DS			0.425***
			(0.038)
PD×DS			0.160***
			(0.040)
FMSZ	0.202***	0.200***	0.198***
	(0.003)	(0.003)	(0.003)
FMLE	-0.478***	-0.486***	-0.465***
	(0.030)	(0.030)	(0.030)
FMGH	0.106***	0.106***	0.115***
	(0.013)	(0.013)	(0.013)
BDSE	-0.122***	-0.126***	-0.087***
	(0.022)	(0.022)	(0.023)
BDIE	-0.837***	-0.883***	-0.726***
	(0.075)	(0.074)	(0.076)
CEODY	0.097***	0.098***	0.097***
	(0.008)	(0.008)	(0.008)
TPOE	-0.182***	-0.154***	-0.167***
	(0.026)	(0.025)	(0.026)
TNQ	0.026***	0.028***	0.021***
	(0.004)	(0.004)	(0.004)
FMLTAE	-0.007	-0.005	0.003
	(0.005)	(0.005)	(0.005)
Constant	-3.562***	-3.375***	-3.709***
	(0.143)	(0.145)	(0.145)
No. of Observations	50916	50916	50916
R^2	0.294	0.294	0.287
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Abbreviations: CSP = corporate sustainable performance; PD = path dependence; CL = cost leadership strategy; DS = differentiation strategy; SP = social performance; EP = environmental performance; GI = green innovation; HI = innovation Herfindahl index; FMSZ = firm size; FMLE = firm leverage; FMGH = firm growth; ROA = return on assets (CSP component); BDSE = board size; BDIE = board independence; CEODY = CEO duality; TPOE = top-one shareholder ownership; TNQ = Tobin's Q; FMLTAE = firm listing age; FE = fixed effects; Obs. = observations. Standard errors are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 3A provides additional evidence regarding the validity of the composite path-dependency measure; the three underlying indicators were standardized and subjected to exploratory factor analysis. The Kaiser–Meyer–Olkin statistic was 0.652, while Bartlett's test of sphericity was statistically significant χ^2 =17,846.320, $p<0.001$), indicating that the correlation structure was suitable for factor analysis. Historical inertia, lock-in, and irreversibility produced factor loadings of 0.812, 0.794, and 0.810, respectively. The first factor had an eigenvalue of 1.947 and explained 64.900% of the total variance. Cronbach's alpha was 0.731, showing acceptable internal consistency across the three dimensions. Historical inertia, lock-in, and irreversibility represent conceptually distinct but related dimensions of path dependency. Therefore, internal consistency is used as supplementary validation rather than as the sole basis for aggregation. The entropy-weighted composite is retained because it combines the information contained in the three dimensions while assigning objective weights according to their observed variation. Table 3A validates the multidimensional PD construct before substantive interpretation is drawn from the regression models.

Table 3A. Validation of the Path-Dependency Construct

Indicator	**Acronym**	**Factor loading**	**Communality**
Historical inertia/path continuity	HIR	0.812	0.659
Innovation lock-in effect	LIE	0.794	0.630
Irreversibility/fixed-asset lock-in	IRR	0.810	0.656

Construct-validation statistic	**Value**
Kaiser–Meyer–Olkin statistic	0.652
Bartlett's test of sphericity, χ^2	17,846.320
Bartlett's test probability	0.000
First-factor eigenvalue	1.947
Variance explained by first factor	64.900%
Cronbach's alpha	0.731
Mean inter-item correlation	0.475

Notes: All three indicators were standardized before factor analysis. A one-factor solution was retained. HIR represents historical inertia or path continuity; LIE represents the innovation lock-in effect measured through the Innovation Herfindahl Index; and IRR represents irreversibility measured through the fixed-asset lock-in ratio.

To determine whether the negative relationship between path dependency and corporate sustainable performance is driven by a single underlying component, the benchmark specification in Column 1 of Table 3 was re-estimated using historical inertia, the lock-in effect, and irreversibility separately in Table 3B. Each component was standardized before estimation so that differences in coefficient magnitude were not caused solely by differences in measurement scale. Table 3B examines whether the baseline PD effect is driven by one component or by the combined effect of historical inertia, lock-in, and irreversibility.

Table 3B. Component-Level Effects of Path Dependency on CSP

Variables	(1) Composite PD	(2) HIR	(3) LIE	(4) IRR
Composite PD	−0.092***			
	(0.005)			
Historical inertia (HIR)		−0.041***		
		(0.004)		
Lock-in effect (LIE)			−0.033***	
			(0.004)	
Irreversibility (IRR)				−0.026***
				(0.003)
FMSZ	0.202***	0.198***	0.200***	0.199***
	(0.003)	(0.003)	(0.003)	(0.003)
FMLE	−0.478***	−0.469***	−0.471***	−0.474***
	(0.030)	(0.030)	(0.030)	(0.030)
FMGH	0.106***	0.103***	0.104***	0.105***
	(0.013)	(0.013)	(0.013)	(0.013)
BDSE	−0.122***	−0.118***	−0.119***	−0.120***
	(0.022)	(0.022)	(0.022)	(0.022)
BDIE	−0.837***	−0.821***	−0.826***	−0.829***
	(0.075)	(0.075)	(0.075)	(0.075)
CEODY	0.097***	0.095***	0.096***	0.096***
	(0.008)	(0.008)	(0.008)	(0.008)
TPOE	−0.182***	−0.176***	−0.178***	−0.179***
	(0.026)	(0.026)	(0.026)	(0.026)
TNQ	0.026***	0.025***	0.025***	0.026***
	(0.004)	(0.004)	(0.004)	(0.004)
FMLTAE	−0.007	−0.006	−0.006	−0.007
	(0.005)	(0.005)	(0.005)	(0.005)
Constant	−3.562***	−3.511***	−3.528***	−3.541***

Variables	(1) Composite PD	(2) HIR	(3) LIE	(4) IRR
	(0.143)	(0.142)	(0.143)	(0.143)
Observations	**50,916**	**50,916**	**50,916**	**50,916**
R^2	**0.294**	**0.292**	**0.291**	**0.291**
Industry fixed effects	**Yes**	**Yes**	**Yes**	**Yes**
Year fixed effects	**Yes**	**Yes**	**Yes**	**Yes**

Notes: The dependent variable is corporate sustainable performance. Column 1 reproduces the benchmark specification using the entropy-weighted composite PD index. Columns 2–4 replace the composite index with each standardized component separately. HIR denotes historical inertia/path continuity; LIE denotes the innovation lock-in effect; and IRR denotes irreversibility/fixed-asset lock-in. Standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

As shown in Table 3B, historical inertia is negatively and significantly associated with corporate sustainable performance ($\beta = -0.041$, $p < 0.001$). This indicates that firms repeatedly following established innovation routes and familiar technological choices experience weaker sustainability outcomes. The lock-in effect also has a negative and significant coefficient ($\beta = -0.033$, $p < 0.001$), suggesting that concentration within a limited number of technological domains restricts firms' ability to explore alternative green solutions. Irreversibility is similarly negative and statistically significant ($\beta = -0.026$, $p < 0.001$). This result shows that long-term commitments to fixed assets and existing resource structures can make strategic redirection more costly and reduce firms' flexibility in adopting sustainability-oriented practices.

Among the three components, historical inertia has the largest individual coefficient. Nevertheless, all three dimensions are negative and statistically significant, and each individual coefficient is smaller in absolute magnitude than the composite PD coefficient of −0.092. The results, therefore, indicate that the adverse effect of path dependency is not driven exclusively by one component. Instead, historical continuity, technological lock-in, and resource irreversibility jointly explain why path-dependent firms achieve lower corporate sustainable performance.

5.4 Alternative Measure of CSP

In this study, we introduce a dummy variable for green innovation as an alternative measure of sustainable performance. The intention behind this approach is to capture a firm's actual sustainability efforts more accurately, especially in relation to its performance in green innovation. Green innovation serves as a central component of corporate sustainability because it reflects a firm's commitment to environmental protection and resource efficiency (Sun et al., 2023; Umar & Safi, 2023), and it also indicates its capacity to advance green technologies, products, and services (Dangelico, 2016; Hu et al., 2023; Rubel et al., 2021). By employing green innovation as an alternative sustainability indicator, we obtain a clearer view of a firm's concrete actions toward long-term environmental goals. Table 4 tests whether the baseline conclusion remains stable when green innovation is used as an alternative sustainability-related outcome instead of the composite CSP index.

In addition, the dummy variable for green innovation reduces the ambiguity and information asymmetry often observed in conventional sustainability indicators. Many external and internal factors shape a firm's reported sustainability performance, and incorporating green innovation helps to simplify this complexity. It allows for a more transparent assessment of how factors such as path dependence, firm size, and financial strength relate to sustainability outcomes. For this reason, the green innovation dummy variable provides a more focused and reliable foundation for analyzing corporate sustainable performance. Table 4 presents the results using this alternative measure. The coefficient for the path dependence index shows a negative relationship with green innovation, indicating that firms with stronger path-dependent characteristics are less inclined to pursue green innovation. This finding supports the idea that reliance on established routines may restrict a firm's willingness or ability to adopt new green technologies and practices. The alternative-indicator analysis uses green innovation rather than the composite CSP index as the dependent variable. Green innovation is available for 51,210 firm-year observations, including 294 observations for which one or more components required to construct CSP are unavailable. The larger sample in Table 4, therefore, reflects differences in dependent-variable availability rather than a change in the sample-selection criteria.

Table 4. Regression Outcomes with Alternative Indicators of Sustainable Performance

	(1) GI Dummy
PD	-0.018***
	(0.002)
FMSZ	0.002**
	(0.001)
FMLE	0.062***
	(0.012)
FMGH	-0.006
	(0.005)
BDSE	0.081***
	(0.008)
BDIE	0.241***
	(0.028)
CEODY	-0.013***
	(0.003)
TPOE	-0.024**
	(0.010)
TNQ	0.009***

	(0.002)
FMLTAE	0.000
	(0.002)
Constant	0.455***
	(0.052)
No. of Obs.	51210
R^2	0.047
Industry FE	Yes
Year FE	Yes

Note: The number of observations is larger than in the baseline regressions because green innovation is available for some firm-year observations for which the complete CSP composite cannot be constructed. Abbreviation: CSP = corporate sustainable performance; PD = path dependence; CL = cost leadership strategy; DS = differentiation strategy; SP = social performance; EP = environmental performance; GI = green innovation; HI = innovation Herfindahl index; FMSZ = firm size; FMLE = firm leverage; FMGH = firm growth; ROA = return on assets (CSP component); BDSE = board size; BDIE = board independence; CEODY = CEO duality; TPOE = top-one shareholder ownership; TNQ = Tobin's Q; FMLTAE = firm listing age; FE = fixed effects; Obs. = observations. Standard errors are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5.5 Change-on-Change Model: Regression Outcomes

To assess sensitivity to time-invariant firm-level heterogeneity and common trends, this study estimates a first-difference (change-on-change) specification. The change in corporate sustainable performance (ΔCSP) is regressed on the change in path dependency (ΔPD) and changes in the time-varying controls. Differencing removes time-invariant firm characteristics from the estimating equation and reduces reliance on level-based associations, although it does not by itself establish causality. Table 5 is included to reduce dependence on level-based associations by examining whether changes in PD are associated with changes in CSP.

The first-difference specification also reduces persistence and common-trend concerns in the firm-level series. Table 5 reports the results. The coefficient of ΔPD remains significantly negative, indicating that increases in path dependency are associated with declines in sustainable performance. The model requires two adjacent observations for the same firm with complete information for CSP, PD, and all differenced controls. This consecutive-pair complete-case requirement reduces the sample from 50,916 level observations to 8,333 usable changes, an 83.6% reduction. The reduction reflects the restrictive differencing requirement in the unbalanced panel rather than a different population definition; the sample reconciliation is reported in Table A2. Accordingly, the 8,333 observations represent the complete-case adjacent-pair sample after requiring all differenced regressors, not the number of adjacent pairs based only on PD and CSP.

Table 5. Results from the Change-on-Change Analysis

	(1) ΔCSP
ΔPD	-0.131***
	(0.013)
ΔFMSZ	0.224***
	(0.008)
ΔFMLE	-0.370***
	(0.070)
ΔFMGH	0.140***
	(0.033)
ΔBDSE	-0.171***
	(0.051)
ΔBDIE	-1.014***
	(0.186)
ΔCEODY	0.057***
	(0.021)
ΔTPOE	-0.250***
	(0.062)
ΔTNQ	0.040***
	(0.012)
ΔFMLTAE	0.011
	(0.013)
Constant	-1.162***
	(0.258)
No. of Obs.	8333
R^2	0.224
Industry FE	No
Year FE	YES

Note: Observations in this table represent valid consecutive firm-year changes rather than the firm-year levels used in the baseline regressions. Time-invariant industry effects are differenced out; year fixed effects are retained. Abbreviations: CSP = corporate sustainable performance; PD = path dependence; CL = cost leadership strategy; DS = differentiation strategy; SP = social performance; EP = environmental performance; GI = green innovation; HI = innovation Herfindahl index; FMSZ = firm size; FMLE = firm leverage; FMGH = firm growth; ROA = return on assets (CSP component); BDSE = board size; BDIE = board independence; CEODY = CEO duality; TPOE = top-one shareholder ownership; TNQ = Tobin's Q; FMLTAE = firm listing age; FE = fixed effects; Obs. = observations. Standard errors are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5.6 Heterogeneity Technique

Highly polluted industries face stronger environmental scrutiny and regulatory pressure than cleaner industries (Li et al., 2016). To examine whether the association between path dependence and sustainable performance differs across industry types, we divide the baseline sample into high-pollution (HP) and low-pollution (LP) firms. Table 6 shows PD coefficients of 0.014 (SE=0.009) for HP firms and −0.118 (SE=0.007) for LP firms. Because significance in one subsample and insignificance in another is not sufficient to establish a cross-group difference, we also test equality of the two coefficients. A Wald-type test based on the independent subsample estimates rejects equality (difference=0.132; z=11.58; p<0.001), supporting a more negative PD–CSP association among low-pollution firms. The two mutually exclusive subsamples contain 15,667 and 35,249 observations and sum to the full baseline sample of 50,916 observations. Table 6 examines whether external environmental pressure changes the PD-CSP relationship by comparing high-pollution and low-pollution industries.

Table 6. Heterogeneity Approach

	HP	LP
	CSP	CSP
PD	0.014	-0.118***
	(0.009)	(0.007)
FMSZ	0.185***	0.207***
	(0.007)	(0.003)
FMLE	-0.324***	-0.618***
	(0.047)	(0.033)
FMGH	0.207***	0.021
	(0.024)	(0.014)
BDSE	-0.015	-0.174***
	(0.038)	(0.024)
BDIE	-0.550***	-0.962***
	(0.118)	(0.089)
CEODY	-0.101***	0.120***
	(0.018)	(0.009)
TPOE	-0.399***	-0.080***
	(0.051)	(0.030)
TNQ	0.036***	0.014**
	(0.010)	(0.005)
FMLTAE	-0.015	-0.004

	(0.010)	(0.006)
Constant	-2.571***	-3.556***
	(0.171)	(0.126)
No. of Obs.	15667	35249
R^2	0.331	0.323
Industry FE	Yes	Yes
Year FE	Yes	Yes

Note: The high-pollution and low-pollution subsamples contain 15,667 and 35,249 observations, respectively. Together, the two subsamples account for all 50,916 baseline observations. Cross-group PD-coefficient equality test: difference=0.132, z=11.58, p<0.001. Abbreviations: CSP = corporate sustainable performance; PD = path dependence; CL = cost leadership strategy; DS = differentiation strategy; SP = social performance; EP = environmental performance; GI = green innovation; HI = innovation Herfindahl index; FMSZ = firm size; FMLE = firm leverage; FMGH = firm growth; ROA = return on assets (CSP component); BDSE = board size; BDIE = board independence; CEODY = CEO duality; TPOE = top-one shareholder ownership; TNQ = Tobin's Q; FMLTAE = firm listing age; FE = fixed effects; Obs. = observations. Standard errors are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

6 Conclusion and Policy Recommendations

This study is motivated by the need to understand why firms facing similar sustainability pressures may still achieve different sustainability outcomes. It examines whether path dependence (PD), reflected in historical inertia, innovation lock-in, and resource irreversibility, is associated with corporate sustainable performance (CSP) among Chinese A-share listed firms from 2010 to 2022. The findings show that PD is negatively associated with CSP, indicating that established routines and inherited resource commitments may restrict firms' capacity to adapt to green-transition demands. Cost leadership strengthens this adverse association, while the differentiation strategy weakens it by encouraging innovation, market responsiveness, and resource reconfiguration. Component-level validation, an alternative sustainability indicator, change-on-change estimation, and heterogeneity analysis provide consistent support for the main pattern.

From a Decision Sciences perspective, the study shows that sustainability outcomes depend on how firms make strategic choices under historical constraints. This perspective complements recent decision-oriented studies on green finance, digital orientation, governance, and strategic decision-making in emerging markets (Bagadeem & Aldawsari, 2026; Le et al., 2026; Miah et al., 2026). PD narrows decision alternatives by reinforcing familiar routines, whereas CL and DS shape whether managers continue along existing paths or search for new sustainability-oriented solutions.

The study contributes to the literature by identifying PD as an organizational decision constraint that influences CSP, by integrating RBV with Organizational Inertia theory, and by showing that competitive strategies operate as boundary conditions. This differs from prior research that mainly emphasizes green innovation, digital transformation, board characteristics, or environmental management systems as direct sustainability drivers. The originality of this study lies in showing that the sustainability effect of historical routines depends on the strategic logic through which managers respond to those routines.

The findings are useful for practitioners because they show that managers should not treat established routines as automatically efficient when sustainability demands are changing. Cost-oriented firms should review whether efficiency routines are crowding out green experimentation, while differentiation-oriented firms can use innovation and eco-design to break path-dependent constraints. For policymakers, the findings suggest that green-transition support should not focus only on direct environmental regulation but also on helping firms overcome organizational inertia and the costs of strategic renewal.

The study has limitations that create directions for future research. First, because the evidence is based on Chinese listed firms, future studies may examine whether the findings hold in other emerging or developed economies. Second, although the change-on-change specification reduces time-invariant heterogeneity, residual endogeneity cannot be fully ruled out. Future research may use credible exogenous shocks, instrumental variables, natural experiments, survey-based designs, cointegration-based approaches, or linear and nonlinear causality tests to strengthen causal identification. Third, future work may examine additional strategic orientations and industry-specific mechanisms through which firms overcome path-dependent constraints.

The findings provide important implications for corporate managers. Managers should regularly review existing technologies, operational processes, investment patterns, and decision-making routines to identify practices that may restrict green transformation. Firms following a cost-leadership strategy should avoid treating short-term cost reduction as their only priority. Instead, efficiency initiatives should be combined with energy conservation, waste reduction, cleaner production, and low-carbon process improvement. Firms pursuing a differentiation strategy should use sustainability as a source of product uniqueness, brand value, and customer trust by investing in green research and development, eco-design, responsible supply chains, and transparent sustainability communication. In both cases, firms should establish flexible resource-allocation systems so that green projects are not constrained by historical routines.

The findings also indicate that policymakers should introduce measures that help firms move beyond outdated development paths and reduce the cost of green experimentation. Such measures may include targeted subsidies for cleaner technologies, tax incentives for green research and development, environmental disclosure requirements, and transition-support initiatives for firms that remain highly dependent on older technologies. Regulatory approaches should also consider differences across industries. High-pollution firms require strict environmental monitoring and stronger transition pressure, while low-pollution firms may require additional incentives because weaker external pressure can allow organizational inertia to persist. These measures can support firms in moving from rigid, routine-based development paths toward more flexible and sustainable strategies.

From a decision sciences perspective, the findings demonstrate that corporate sustainability is not only an environmental or strategic issue but also a managerial decision problem involving trade-offs between established routines, cost efficiency, innovation, and long-term value creation. The contrasting moderating effects of cost leadership and differentiation further highlight the importance of strategic choice in overcoming path-dependent constraints and improving sustainability-related decision-making.

This study has several limitations. Because the analysis focuses on Chinese listed enterprises, the generalizability of the findings may be limited. The baseline specifications use industry and year fixed effects rather than firm fixed effects; although the change-on-change analysis reduces time-invariant firm heterogeneity, residual endogeneity cannot be ruled out. The study also does not rely on an external instrumental-variable design, so the results should be interpreted primarily as robust associations rather than definitive causal effects. Future research can examine other emerging economies and exploit credible exogenous shocks, instrumental variables, or experimental and survey-based designs to strengthen causal identification and clarify the underlying mechanisms.

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Appendix

Table A2. Reconciliation of Sample Sizes Across the Empirical Tests

Analysis	**Table**	**Obs.**	**Explanation**
Descriptive statistics	Table 1	50,916	Baseline complete-case sample with non-missing corporate sustainable performance (CSP), path dependence (PD), and control variables.
Benchmark regressions	Table 3	50,916	Uses the same baseline estimation sample.
Alternative sustainability indicator	Table 4	51,210	Uses green innovation instead of CSP. Green innovation is available for 294 additional firm-year observations for which the complete CSP composite cannot be constructed.
Change-on-change estimation	Table 5	8,333	Restricted to usable consecutive firm-year changes. Complete adjacent-year information is required for CSP, PD, and all differenced controls; 8,333 changes are retained (16.4% of the baseline level observations; 83.6% reduction).
High-pollution subsample	Table 6, Column 1	15,667	Contains observations from firms classified as operating in high-pollution industries.
Low-pollution subsample	Table 6, Column 2	35,249	Contains observations from firms classified as operating in low-pollution industries.
Total heterogeneity sample	Table 6	50,916	The two mutually exclusive subsamples sum to the full baseline sample: 15,667 + 35,249 = 50,916.

Note: The baseline sample consists of firm-year observations with complete information for CSP, PD, and the control variables. Sample size changes only when the dependent variable, data transformation, or subsample definition changes.