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From Green Innovation to Legitimacy: The Roles of ESG Engagement and Institutional Context in China

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ABSTRACT

Environmental innovation does not automatically confer legitimacy: firms must also persuade institutional audiences that their actions merit recognition. This distinction matters in state-capitalist economies, where the state evaluates firms alongside investors and communities. Using panel data on Chinese A-share listed firms from 2010 to 2023, we examine the association between green innovation and state-oriented legitimacy (SOL), the mediating role of environmental, social, and governance (ESG) engagement, and the moderating role of regional institutional quality. We distinguish green innovation as a substantive activity, ESG engagement as a potential signal, and SOL as a state-oriented legitimacy measure. Green innovation is positively associated with SOL, partly through ESG engagement. Institutional quality appears to strengthen this indirect relationship mainly through the link between innovation and ESG engagement. The findings extend research on how institutional context shapes the relationship between environmental activity, corporate signalling, and legitimacy.

1 | Introduction

Firms increasingly rely on environmental strategies such as green innovation to respond to regulatory pressure and sustainability expectations (Bansal 2002; Chen et al. 2006; Thorlakson et al. 2018). However, whether such efforts translate into tangible organizational benefits depends not only on firms' environmental actions but also on how these actions are communicated and interpreted within institutional contexts (Eccles et al. 2014; Ioannou and Serafeim 2015). In emerging economies characterized by strong state involvement, firms must align their environmental strategies with policy priorities while signaling their commitment through formal disclosure mechanisms such as ESG reporting (Marquis and Qian 2014; Situ et al. 2021). This raises a critical question: how do firms convert environmental innovation into recognized legitimacy in state-led institutional environments?

China offers a setting to examine this question. As the world's largest emerging economy, China has placed green development at the center of its policy agenda, promoting corporate environmental innovation alongside rapidly expanding ESG disclosure practices (Liu et al. 2022; Zhang and Wang 2024). At the same time, the institutional environment is characterized by strong state influence, regional variation in governance quality, and limited reliance on bottom-up stakeholder pressure (Kostka 2016; Marquis and Qian 2014). In this context, firms do not gain legitimacy solely through environmental performance; they must also demonstrate alignment with state-defined sustainability priorities. Existing research, however, has largely examined these elements in isolation rather than as an integrated process. One stream investigates the effects of green innovation on firm performance, environmental performance, or ESG outcomes (Chen et al. 2006; Amore and Bennedsen 2016; Xu et al. 2022; Zheng et al. 2022), without examining whether

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or how these outcomes are translated into organizational legitimacy through institutional evaluation. A second stream examines legitimacy-related outcomes, including corporate social responsibility (CSR) disclosure-based reputation and corporate legitimacy, typically relying on survey-based or static proxies that do not distinguish the state as a distinct legitimating audience (Marquis and Qian 2014; Situ et al. 2021). Consequently, existing research has yet to conceptualize green innovation, ESG engagement, and organizational legitimacy as sequential stages of a single translation process or to examine whether this process operates uniformly across China's substantial subnational institutional variation.

Within China's state-led institutional environment, green innovation may not generate legitimacy unless firms communicate their environmental achievements through credible signals. ESG engagement provides such a mechanism by making sustainability activities visible and comparable to institutional audiences (Eccles et al. 2014; Ioannou and Serafeim 2015). However, regional institutional conditions may influence the effectiveness of this signalling process, suggesting that the translation of environmental innovation into legitimacy is institutionally contingent.

To examine institutional approval, we examine state-oriented legitimacy (SOL) as an outcome of firms' environmental strategies. Rather than relying on survey-based proxies or static indicators, we construct a panel-based measure of SOL using firm-level behavioral indicators that reflect alignment with state-defined sustainability priorities (Kang 2025; Situ et al. 2021). This approach allows us to capture legitimacy as a dynamic and multidimensional outcome shaped by firms' actions and their interpretation within a state-mediated institutional environment.

This study makes three contributions to the literature on corporate environmental strategy and sustainability in emerging markets. First, we explain how environmental innovation translates into organizational legitimacy in state-led institutional contexts. While prior research has examined the performance implications of green innovation, less is known about how such innovation generates external recognition. We show that the legitimacy effects of environmental strategies depend not only on substantive actions but also on how these actions are interpreted within institutional environments.

Second, we identify ESG engagement as a key mechanism linking environmental innovation to legitimacy. By demonstrating that ESG engagement mediates the relationship between green innovation and state-oriented legitimacy, we highlight the role of sustainability disclosure as a signaling channel that makes firms' environmental efforts visible and credible to external evaluators.

Third, we show that institutional quality conditions this process. Our findings indicate that regional institutional development primarily moderates the first stage of the ESG-mediated pathway, influencing how green innovation translates into ESG engagement. Evidence for the resulting conditional indirect effect is less consistent across specifications. This effect, however, varies across dimensions of institutional quality, highlighting the importance of subnational institutional heterogeneity in shaping the effectiveness of corporate environmental strategies.

Three conceptually distinct constructs underpin our framework. Green innovation represents firms' substantive environmental activities, while ESG engagement provides a signalling mechanism through which these activities become visible to institutional audiences (Chen et al. 2006; Eccles et al. 2014; Ioannou and Serafeim 2015). SOL captures the resulting institutional recognition within a state-mediated environment. Although constructed using firm-level behavioral indicators derived from CSR-related data, SOL is conceptually distinct from both ESG engagement and CSR activities.

The following section develops the theoretical framework and hypotheses underpinning these relationships.

2 | Conceptual Framework and Hypothesis Development

2.1 | Rethinking Legitimacy: From SLO to SOL

Corporate legitimacy refers to the generalized perception that a firm's activities are desirable and appropriate within a socially constructed system of norms, values, and beliefs (Suchman 1995). In liberal market economies, legitimacy is usually granted through societal consent, manifested in trust and approval from affected communities. The social licence to operate (SLO) represents this community-based mechanism of legitimacy, where approval depends on moral credibility, transparency, and social reciprocity (Bice and Moffat 2014; Gunningham et al. 2004). Firms acquire SLO by maintaining constructive relationships and by signaling their responsiveness to stakeholder expectations (Bitektine and Haack 2015).

However, SLO theory assumes a pluralistic society in which civil actors, rather than the state, determine legitimacy. This assumption is less applicable to state-capitalist systems, where the state functions as both rule-maker and resource allocator, rewarding compliance through preferential access and recognition (Musacchio and Lazzarini 2014; Wright and Bice 2017). Institutional voids may further shift legitimacy conferral toward state and quasi-state authorities (Ettalibi et al. 2025). Consequently, legitimacy may arise primarily through administrative and political endorsement rather than community-based approval.

To capture this state-mediated form of legitimacy, we conceptualize SOL as a firm's perceived alignment with the sustainability priorities and developmental objectives articulated by state authorities. SOL combines two interrelated forms of legitimacy. Substantive legitimacy arises from tangible environmental and social achievements that contribute to state policy goals, while symbolic legitimacy derives from communicative conformity—how effectively a firm translates those achievements into state-legible signals. Firms demonstrating both forms gain reputational credit within state-mediated institutions. In contrast to SLO, where legitimacy stems from public consent, SOL is earned through state validation; for example, inclusion in government

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sustainability rankings, official commendations, or access to green-finance incentives (Marquis and Qian 2014; People's Bank of China 2021).

This reconceptualization extends classical legitimacy theory by identifying the state as a distinct institutional audience whose evaluative criteria may differ from those of market and societal audiences, consistent with institutional perspectives emphasizing contextual embeddedness (Kostova et al. 2020; Kostova et al. 2008) and with signaling theory (Connelly et al. 2011). Under state capitalism, ESG disclosure, green innovation, and compliance certifications make firms' environmental actions visible to institutional evaluators, reflecting institutional pressures rather than solely voluntary stakeholder responsiveness (Ding and Wang 2025). SOL thus captures the institutional recognition arising when corporate actions and signals align with state-defined priorities.

Distinguishing action, signal, and outcome is particularly important given the debate over whether ESG engagement reflects substantive environmental practice or symbolic compliance. Previous research suggests that ESG engagement may involve ceremonial compliance, whereby standardized disclosures become decoupled from underlying organizational practices (Ansari et al. 2013; Bartley 2018; Heugens and Lander 2009). Accordingly, we distinguish green innovation as substantive environmental action, ESG engagement as a potentially imperfect signal, and SOL as the institutional outcome arising from its evaluation. Our mediation framework (H3a, H3b) allows us to examine the relationship among these constructs rather than assume that substantive environmental action and symbolic communication are aligned.

Although SOL is operationalized using CSR-related behavioral indicators, it is conceptually distinct from ESG engagement and CSR performance. ESG engagement is a market-facing disclosure construct primarily intended for institutional investors and other capital-market audiences (Eccles et al. 2014; Ioannou and Serafeim 2015). By contrast, SOL emphasizes state-facing dimensions, particularly political embeddedness and the absence of social conflict, which receive the highest weights in our index. This distinction is supported empirically: Section 3.1.5 shows SOL shares under 3% of its variance with the ESG measure used as our mediator. Thus, green innovation captures substantive environmental action, ESG engagement captures its market-oriented signalling, and SOL captures state-oriented institutional recognition.

More broadly, distinguishing ESG engagement from SOL highlights the audience-specific nature of legitimacy. Conventional legitimacy and SLO frameworks emphasize societal audiences, including investors, communities, and civil society (Bitektine and Haack 2015; Suchman 1995). Under state capitalism, however, the state constitutes an additional legitimating audience with distinct evaluative criteria. Political embeddedness and conflict avoidance may be important in bureaucratic evaluation but less relevant to investors, whereas market-oriented ESG disclosure may carry less weight in domestic policy evaluation. Consequently, state- and market-oriented legitimacy may diverge, with different institutional audiences evaluating the same corporate behavior differently. SOL therefore extends rather than merely relabels SLO by recognizing that legitimacy depends on who confers it and according to which criteria.

If SOL depends on recognition by a distinct institutional audience, firms' capacity to obtain such recognition may vary with their political and institutional positioning. In China, state-owned enterprises (SOEs) generally benefit from established political relationships, whereas private firms may rely more heavily on visible sustainability practices to compensate for weaker political linkages (Li 2019). Recent evidence further suggests that SOE status and regional market development jointly influence the ESG-innovation relationship (Wan et al. 2024). Regional institutional conditions also shape this process: stronger market institutions and transparent governance facilitate the verification and recognition of substantive environmental actions, while informal institutions, such as social trust, may compensate for weaker formal governance (Sun et al. 2023). Thus, SOL is both audience-specific and institutionally contingent, depending on firms' political positioning and regional institutional capacity.

Building on this conceptualization, we adapt the processual logic of the SLO pyramid (Boutilier and Thomson 2011) to reflect China's hybrid institutional environment. Drawing on CSR evaluation systems widely applied in China, we operationalize SOL across six complementary dimensions: trust, procedural fairness, environmental performance, community acceptance, conflict avoidance, and political embeddedness. Together, these dimensions capture legitimacy's substantive basis in sustainability outcomes (Clarkson et al. 2008; Patten 1992) and its symbolic expression through alignment with state priorities and institutional networks (Hillman et al. 2004; Marquis and Qian 2014).

2.2 | Hypothesis Development

2.2.1 | H1: Green Innovation and State-Oriented Legitimacy

Green innovation—the development and deployment of environmentally beneficial technologies and practices—reflects a firm's substantive environmental capabilities and commitment to sustainable development (Provasnek et al. 2017; Wu et al. 2023). Beyond its environmental benefits, green innovation can also convey firms' responsiveness to institutional expectations and their alignment with broader sustainability priorities.

In China's state-capitalist regime, green innovation contributes to SOL by demonstrating alignment with national sustainability agendas, including the "Beautiful China" initiative and dual-carbon targets (Kostka 2016; Marquis and Qian 2014). Unlike conventional SLO, which emphasizes community consent, SOL reflects recognition mediated through bureaucratic and policy channels. Green innovation therefore serves as an observable indicator of firms' contributions to state-defined environmental and development priorities.

The legitimacy value of green innovation depends not only on its environmental outcomes but also on how institutional evaluators interpret them. Consistent with signalling theory (Connelly et al. 2011) and legitimacy theory (Suchman 1995),

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sustainability-oriented actions generate reputational benefits when powerful institutional audiences recognize them as credible and appropriate. Green innovation can therefore enhance SOL by providing observable evidence of firms' contributions to state-defined environmental and developmental objectives.

The legitimacy returns to green innovation may vary across firms. Organizations with stronger existing institutional recognition, reflected in established ESG records, political embeddedness, or reputational capital, may be better positioned to have their innovations recognized as credible and policy-aligned (Delmas and Toffel 2008; Ioannou and Serafeim 2015). Recent evidence also associates institutional ownership with innovation efficiency, suggesting that ownership structure may influence firms' ability to realize the benefits of innovation (Li et al. 2024). Greater institutional visibility and established relationships with relevant evaluators may enable these firms to translate additional green innovation into SOL. Conversely, firms with weaker existing legitimacy may encounter difficulties obtaining similar recognition because of limited visibility, weaker bureaucratic connections, or skepticism regarding their motives.

This reasoning suggests that green innovation may reinforce existing legitimacy advantages rather than equalize them across firms. We therefore employ quantile regression to examine whether its association with SOL varies across the conditional SOL distribution. Specifically, we expect stronger positive associations at higher quantiles, where greater institutional visibility and established relationships with evaluators may amplify the legitimacy returns to green innovation.

Accordingly, we hypothesize:

H1. *Green innovation is positively associated with state-oriented legitimacy, with a stronger positive relationship at higher levels of the state-oriented legitimacy distribution.*

2.2.2 | H2: The Moderating Role of Institutional Context

While green innovation serves as a strategic signal of environmental commitment, its effectiveness in generating legitimacy depends critically on the institutional context in which firms operate. In China's hybrid governance system, the translation of innovation into SOL is not uniform but mediated by the regional institutional infrastructure that governs regulatory credibility, media framing, and stakeholder scrutiny.

Legitimacy theory suggests that the perceived authenticity of sustainability actions is filtered through institutional logics that shape how audiences interpret and evaluate corporate behavior (Suchman 1995; Bitektine and Haack 2015; Eccles et al. 2014; Ioannou and Serafeim 2015). Similarly, the institution-based view emphasizes that organizational outcomes depend on both firm-specific capabilities and the surrounding institutional environment (Peng et al. 2009). Recent evidence further indicates that institutional contexts influence corporate green investment decisions (Khan et al. 2024). In regions with stronger institutions, transparent enforcement and greater monitoring capacity facilitate the verification and recognition of green innovation. Conversely, weaker institutional environments may limit its legitimacy benefits because substantive environmental actions are more difficult to evaluate credibly.

This institutional heterogeneity is particularly salient in China, where national sustainability mandates (e.g., the "Beautiful China" campaign and dual-carbon targets) are centrally issued but locally implemented. Provincial governments vary substantially in their capacity to enforce environmental standards, validate corporate behavior, and reward credible ESG signals. In more marketized provinces, regulators and state-affiliated media are better equipped to identify authentic sustainability performance and to promote firms that align with policy priorities. Stakeholders in these regions also benefit from more developed information environments, enabling them to reward substantive environmental action and penalize symbolic compliance (Gong et al. 2023; Lin 2022).

To capture this variation, we adopt the Marketization Index for China's Provinces developed by the National Economic Research Institute (n.d.). This widely used measure reflects differences in legal institutions, financial development, government–market relations, and administrative efficiency. It allows us to examine whether regional institutional development moderates the relationship between green innovation and SOL.

Accordingly, we propose the following hypothesis:

H2. *The positive relationship between green innovation and SOL is stronger in provinces with higher institutional quality.*

2.2.3 | H3: ESG Engagement as a Mediating and Moderated Mechanism

While green innovation can directly enhance SOL, as proposed in H1, substantive environmental actions may not gain institutional recognition unless they are visible and interpretable to relevant audiences. ESG engagement provides a signalling mechanism through which firms communicate their environmental efforts and demonstrate alignment with institutional expectations. This mechanism is particularly relevant in China's hybrid governance system, where firms must demonstrate their responsiveness to evolving state sustainability priorities through visible and standardized forms of communication.

From a legitimacy theory perspective, ESG engagement reduces information asymmetry by rendering firms' sustainability practices more visible, comparable, and interpretable to key evaluators, including regulators, state-affiliated media, institutional investors, and the public (Eccles et al. 2014; Ioannou and Serafeim 2015). ESG disclosure and performance metrics translate environmental efforts into standardized information that external audiences can evaluate. By improving the observability of these efforts, ESG engagement may facilitate their recognition as consistent with institutional expectations, thereby connecting green innovation with SOL.

This signalling function is especially salient in China, where firms face growing pressure to demonstrate compliance with

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state sustainability priorities through formalized evaluation systems. As sustainability disclosure requirements have strengthened under the China Securities Regulatory Commission (CSRC) (2024) and the Shanghai and Shenzhen Stock Exchanges, ESG reporting has increasingly become a standardized means of communicating corporate sustainability activities and policy alignment. ESG engagement may consequently make green innovation more visible to institutional evaluators, facilitating its translation into SOL.

Empirical evidence supports this mechanism. Xu et al. (2022) show that green innovation significantly enhances ESG performance among Chinese listed firms, particularly under heightened stakeholder expectations. Zheng et al. (2022) find that ESG ratings mediate the relationship between innovation and stakeholder-oriented outcomes such as reputational capital and public trust, which are closely related to legitimacy. Zhang and Chen (2023) further demonstrate that ESG improvements are associated with stronger stakeholder support and enhanced firm reputation. Abdullah et al. (2024) provide additional evidence that ESG performance transmits the reputational effects of innovation, particularly in high-trust institutional environments. Collectively, these findings suggest that ESG engagement functions as an active mechanism through which innovation is translated into legitimacy outcomes.

Accordingly, we propose the following hypothesis:

H3a. *ESG engagement mediates the relationship between green innovation and state-oriented legitimacy (SOL) by translating firms' innovation efforts into visible and credible signals of sustainability alignment within China's institutional framework.*

Yet, the effectiveness of this ESG-mediated pathway may vary across institutional environments. Drawing on contingency perspectives in legitimacy theory and the institutional voids literature, we argue that regional institutional quality conditions this mediation process. In provinces with stronger legal enforcement, greater non-state sector participation, and more competitive product and factor markets, green innovation and ESG disclosures are more likely to be credibly interpreted and rewarded by key stakeholders.

Institutional quality may moderate both stages of the mediation process. First, stronger institutions enhance the translation of green innovation into ESG performance by improving transparency, data availability, and governance responsiveness. Second, high-quality institutional environments strengthen the legitimacy effects of ESG engagement, as regulators, media, and other evaluative audiences are better able to identify and reward credible sustainability signals aligned with state priorities.

This logic is consistent with the moderated mediation framework (Hayes 2018), in which the indirect effect of an independent variable on an outcome via a mediator is contingent on contextual conditions affecting multiple stages of the causal pathway.

H3b. *The indirect effect of green innovation on state-oriented legitimacy* via *ESG performance is moderated by institutional quality. Specifically, higher institutional quality strengthens both* (1) *the relationship between green innovation and ESG performance and* (2) *the relationship between ESG performance and state-oriented legitimacy, thereby amplifying the overall mediation effect.*

These hypotheses establish a framework linking green innovation, ESG engagement, institutional quality, and SOL. As illustrated in Figure 1, green innovation enhances SOL both directly and indirectly through ESG engagement, while institutional quality conditions these relationships at multiple stages. This framework reflects the dual logic of legitimacy formation in China's state-capitalist context, where firms must not only innovate substantively but also communicate credibly within institutionally differentiated environments.

3 | Data and Methodology

3.1 | Data and Variable Construction

This study uses an unbalanced panel of Chinese A-share listed firms from 2010 to 2023. Data are obtained from China Research Data Services (CNRDS), China Stock Market & Accounting Research (CSMAR), Wind, and the National Economic Research Institute (NERI, n.d.) Marketization Index. The merged dataset

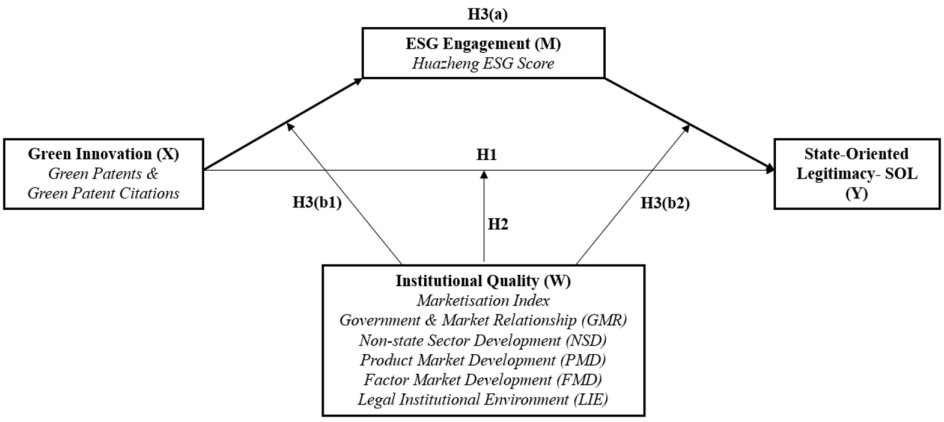


FIGURE 1 | Conceptual framework of the relationships among green innovation, ESG engagement, institutional quality, and state-oriented legitimacy (SOL).

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provides firm-year observations covering green innovation, ESG performance, firm financials, corporate governance, and regional institutional characteristics.

We exclude financial firms and remove firm-year observations with missing key variables. All continuous variables are winsorized at the 1st and 99th percentiles to reduce the influence of outliers. The resulting sample covers China's major industrial sectors and provinces.

3.1.1 | Independent Variable: Green Innovation

We employ two complementary measures of green innovation. The first, Green Patent (CNRDS), measures the number of green patents filed by firm *i* in year *t*, capturing annual innovation activity. The second, Green Patent Citations (CSMAR), measures the total citations received by green patents, reflecting their technological influence. Together, these two measures capture the *activity* and *impact* dimensions of green innovation relevant to ESG performance and SOL.

3.1.2 | Mediating Variable: ESG Engagement

ESG engagement is measured using firm-level ESG performance scores obtained from Wind. Specifically, we use the Huazheng ESG composite score. As a firm-year indicator, this measure captures the extent of a firm's sustainability practices and allows us to empirically assess its mediating role in the relationship between green innovation and SOL.

3.1.3 | Moderator: Institutional Quality

Institutional quality is measured using the province-level Marketization Index developed by the National Economic Research Institute (NERI). This annually updated index captures regional institutional development and market orientation across five subdimensions: the government–market relationship (GMR), development of the non-state sector (NSD), product market development (PMD), factor market development (FMD), and legal and institutional environment (LIE).

3.1.4 | Control Variables

Following prior literature, we include firm-, governance-, industry-, and region-level controls to reduce potential omitted variable bias. Firm-level controls include total assets (log-transformed), firm age, leverage, and profitability (measured by return on assets). Governance controls include institutional ownership, CEO–Chairman duality, and board independence, accounting for variation in oversight structures. To capture external pressures and knowledge diffusion, the model includes industry-level and region-level green innovation intensity, calculated as the average innovation activity within the same industry and province.

At the regional level, we control for economic development using GDP per capita and for industrial structure using the share of secondary industry in regional GDP. These variables account for local economic conditions that may shape both firms' innovation strategies and the salience of ESG signalling. All regression models incorporate year fixed effects to control for macroeconomic shocks and evolving regulatory conditions.

A full list of variable definitions and data sources is provided in Appendix A.

3.1.5 | Dependent Variable: Measuring SOL Index

The dependent variable, SOL, captures the firm's alignment with state-defined sustainability and governance priorities. Unlike traditional legitimacy measures emphasizing market approval or community acceptance, SOL reflects legitimacy within China's state-mediated institutional environment. Because standardized survey- and protest-based measures of public sentiment are difficult to obtain in this context, we construct SOL using observable firm-level behavioral indicators from the CNRDS corporate social responsibility database for 2010–2023. These indicators capture environmental initiatives, transparency practices, employee protections, and political embeddedness as observable proxies for state-oriented legitimacy.

The index is grounded theoretically in Suchman (1995), Freeman (2010), DiMaggio and Powell (1983), and the SLO Pyramid Model of Boutilier and Thomson (2011). It comprises six dimensions representing distinct bases of organization legitimacy: trust and reputation (cognitive), community acceptance (pragmatic), procedural fairness (moral), environmental legitimacy (normative), social conflict or opposition (legitimacy withdrawal), and political legitimacy (authoritative). Appendix B provides the complete indicator inventory.

Each dimension comprises binary indicators classified as advantage-type (legitimacy-enhancing) or concern-type (legitimacy-eroding). Eight concern-type indicators are reverse-coded: accounting violations, absence of female executives, and employee safety disputes under procedural fairness; environmental penalties and pollutant emissions under environmental legitimacy; and product disputes, financing disputes, and mass layoffs under social conflict. Consequently, higher social-conflict dimension scores indicate the absence of stakeholder opposition, allowing this dimension to enter the composite with a positive weight.

Each dimension score is calculated as the mean of its indicator contributions. Advantage-type indicators retain their original values, while concern-type indicators are reverse-coded as one minus their original values. Thus, each indicator contributes one when the firm exhibits a legitimacy-enhancing condition, and dimension scores range from zero to one. Appendix B, Table A2, provides a worked example. Dimension scores are then standardized across the panel and aggregated using context-sensitive weights reflecting the relative importance of each legitimacy dimension in China's institutional environment (Appendix B, Table A3).

Appendix B4 explains the theoretical rationale for the dimension weights and their relationship to the constructs developed

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in Section 2.1. The theory-weighted index serves as our primary dependent variable, while unweighted, principal-component, and factor-based alternatives are presented in Appendix B. Additional robustness analyses using alternative dimension aggregations are reported in Section 4.4.5.

3.1.5.1 | Construction Specification and Validation. SOL is specified as a formative composite rather than a reflective latent construct because its six dimensions represent conceptually distinct bases of legitimacy rather than interchangeable manifestations of a single underlying trait (Bollen and Lennox 1991; Diamantopoulos and Winklhofer 2001; Jarvis et al. 2003). The empirical results support this specification. Although the dimensions are sufficiently correlated for factor analysis, they are not unidimensional: two components exceed an eigenvalue of one, the first explaining 39.6% of variance and the first two 56.6%, and the state-facing dimensions (political legitimacy and social conflict) are essentially orthogonal to the stakeholder-facing dimensions ($r = -0.021$). Table 1 reports the full validation battery.

For formative composites, these results are consistent with the measurement specification because the dimensions capture distinct bases of legitimacy rather than manifestations of a common underlying trait. Consequently, Cronbach's alpha is not the appropriate primary validation criterion. Instead, we assess content coverage, indicator collinearity, and robustness across alternative index constructions. Variance inflation factors for the six dimensions range from 1.006 to 1.710, indicating limited collinearity. Although excluding political legitimacy would improve conventional fit statistics (alpha = 0.611; first component explaining 47.4% of variance), we retain this dimension on theoretical grounds because it captures the state-oriented component that distinguishes SOL from stakeholder-based legitimacy measures. Additional aggregation robustness tests are reported in Section 4.4.5.

Although SOL is constructed using CSR-related indicators, it differs from conventional ESG ratings in both its measurement approach and underlying data. SOL uses codified behavioral indicators from CNRDS, whereas ESG engagement is measured using composite ratings. During 2018–2023, when pillar-level ESG data are available, SOL correlates with the ESG mediator at $r = 0.170$, sharing less than 3% of its variance. Its correlations with the environmental, social, and governance pillars are 0.278, 0.235, and 0.063, respectively. The highest correlation between any SOL dimension and ESG pillar is 0.341, while the two state-facing dimensions correlate with all three pillars at absolute magnitudes below 0.06. Moreover, two independent commercial ESG providers exhibit a correlation of only $r = 0.354$ when evaluating the same firms, indicating considerable provider-specific variation. Additional robustness analyses examining the influence of ESG-overlapping dimensions are reported in Section 4.4.5.

3.2 | Empirical Strategy and Model Choice

To test H1–H3, we employ a unified firm-fixed-effects panel estimation strategy consistent with the conceptual framework of conditional process modelling (Hayes 2018). This approach maintains a common within-firm estimation framework across the direct effect (H1), moderation (H2), mediation (H3a), and moderated mediation (H3b) analyses. Firm fixed effects control for time-invariant firm characteristics, while year fixed effects account for common macroeconomic and policy shocks. Standard errors are clustered at the firm level, and continuous variables are mean-centered before constructing interaction terms to facilitate interpretation and reduce nonessential multicollinearity. H1 examines the direct relationship between green innovation and SOL, while H2 introduces its interaction with provincial institutional quality.

To test H3, we extend this framework using a two-step fixed-effects panel mediation approach. Both stages, green innovation to ESG engagement and ESG engagement to SOL, are estimated using firm fixed effects, year fixed effects, and firm-clustered

TABLE 1 | Construct validation of the state-oriented legitimacy index.

Diagnostic	Value	Conventional benchmark
Kaiser–Meyer–Olkin measure (overall)	0.770	> 0.60
Kaiser–Meyer–Olkin (item range)	0.737–0.830	> 0.60
Bartlett's test of sphericity	$\chi^2(15) = 12{,}272.4$***	$p < 0.05$
Eigenvalues	2.378, 1.017, 0.963, 0.678, 0.539, 0.426	—
Variance explained, first component	39.6%	—
Variance explained, first two components	56.6%	—
Cronbach's alpha	0.559	See note
Variance inflation factors (dimension range)	1.006–1.710	< 5
Correlation, state-facing vs. stakeholder-facing	−0.021	—
Firm-year observations	12,089	—

Note: SOL is specified as a formative composite. Internal-consistency reliability is not the appropriate criterion for such indices, since high alpha would indicate redundancy among dimensions intended to capture distinct legitimacy bases. Low inter-dimension collinearity (VIF 1.006–1.710) confirms that each dimension contributes independent information.
***$p < 0.01$.

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standard errors. We assess the indirect and conditional indirect effects using a firm-cluster bootstrap with 5000 replications and bias-corrected confidence intervals to accommodate the skewed sampling distribution of the product of coefficients (MacKinnon et al. 2004).

We further assess the robustness of the composite SOL measure through additional validation analyses, including alternative index constructions, weighting sensitivity tests, and an external legitimacy proxy, as reported in Section 4.4.5.

3.2.1 | Testing H1: Direct Effect of Green Innovation on SOL

To test H1, we estimate the following firm-fixed-effects panel regression to examine the relationship between green innovation (GI) and SOL:

$$SOL_{it} = \alpha_i + \lambda_t + \beta_1 GI_{it} + X_{it}\Upsilon + \varepsilon_{it} \quad (1)$$

where:

SOL_{it} is the firm-level state-oriented legitimacy score for firm i in year t

α_i represents firm fixed effects

λ_t captures year fixed effects to control macro-level shocks

GI_{it} is green innovation of firm i at time t, measured alternatively by green patent counts and citations

$\boldsymbol{X}_{\mathrm{it}}$ is a vector of firm-, industry- and region-level control variables

μ_i *and* ε_{it} are the firm and year fixed effects introduced above

To explore distributional effects consistent with the hypothesis, we apply quantile regressions across different SOL quantiles. A positive and significant β_1 on green innovation supports H1.

3.2.2 | Testing H2: Moderating Role of Institutional Quality

To test H2, we interact GI with the province-level Marketization Index and its five dimensions. We also examine its five subdimensions to identify potential differences in their moderating effects. The model is specified as follows:

Since both green innovation and institutional quality are continuous variables, we mean-center them prior to constructing the interaction terms. This facilitates interpretation of the interaction coefficients and helps mitigate multicollinearity within the fixed effects framework.

$$SOL_{it} = \mu_i + \lambda_t + \beta_1 GI_{it} + \beta_2 IQ_{pt} + \beta_3\left(GI_{it} \times IQ_{pt}\right) + X_{it}\Upsilon + \varepsilon_{it} \quad (2)$$

where:

IQ_{pt} the institutional quality in province p in year t.

$GI_{it} \times IQ_{pt}$ is the interaction term between mean-centered green innovation and institutional quality.

β_3 captures the moderating effect of institutional quality on the relationship between green innovation and SOL.

A significant β_3 supports H2, indicating that the effect of green innovation on legitimacy is stronger in more institutionally developed provinces.

3.2.3 | Testing H3: ESG Mediation and Institutional Moderation

3.2.3.1 | Model Specification for H3a: ESG Engagement as a Mediator. To test H3a, we employ a two-step fixed-effects panel mediation approach to examine whether ESG engagement mediates the relationship between green innovation and SOL. Consistent with our baseline specification, industry fixed effects are excluded from the mediation models but considered in robustness tests to address concerns about multicollinearity and over-specification.

Step 1: estimates the effect of GI on ESG performance (path *a*):

$$\mathrm{ESG}_{\mathrm{it}} = \alpha_0 + \alpha_1 \mathrm{GI}_{\mathrm{it}} + \alpha_2 \mathrm{X}_{\mathrm{it}} + \delta_{\mathrm{i}} + \theta_{\mathrm{t}} + \varepsilon_{\mathrm{it}} \quad (3)$$

Step 2: estimates the effect of ESG performance on SOL, controlling for GI (paths *b* and *c′*):

$$\mathrm{SOL}_{\mathrm{it}} = \gamma_0 + \gamma_1 \mathrm{ESG}_{\mathrm{it}} + \gamma_2 \mathrm{GI}_{\mathrm{it}} + \gamma \mathrm{X}_{\mathrm{it}} + \delta_{\mathrm{i}} + \theta_{\mathrm{t}} + \varepsilon_{\mathrm{it}} \quad (4)$$

where:

ESG_{it} is the ESG performance score of firm i in year t.

A significant α_1 in Step 1 (Equation 3) and γ_1 in Step 2 (Equation 4) suggests an indirect effect of GI on SOL via ESG performance.

The magnitude of mediation can be approximated by multiplying $\alpha_1 \times \gamma_1$, and its significance is evaluated using bootstrapped standard errors with 5000 replications and firm-level clustering.

3.2.3.2 | Model Specification for H3b: Moderated Mediation via Institutional Quality. H3b proposes that institutional quality (IQ) moderates the indirect relationship between green innovation and SOL through ESG engagement. Specifically, IQ is expected to moderate both the first-stage pathway (GI → ESG) and the second-stage relationship (ESG → SOL), consistent with a moderated mediation structure as described in Model 58 of the PROCESS framework (Hayes 2018).

To test H3b, we extend the two-step fixed-effects panel mediation approach used for H3a by introducing interaction terms at both stages. Equation (5) models ESG engagement as a function of GI, IQ, and their interaction, while Equation (6) models SOL as a function of ESG engagement, GI, IQ, and the ESG × IQ interaction. Continuous variables are mean-centered before

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constructing the interaction terms, as described above. The equations are specified as follows:

$$ESG_{it} = \alpha_0 + \alpha_1 GI_{it} + \alpha_2 IQ_{rt} + \alpha_3 (GI_{it} \times IQ_{rt}) + \alpha_4 X_{it} + \delta_i + \theta_t + \varepsilon_{it} \quad (5)$$

$$SOL_{it} = \gamma_0 + \gamma_1 ESG_{it} + \gamma_2 GI_{it} + \gamma_3 IQ_{rt} + \gamma_4 (ESG_{it} \times IQ_{rt}) + \gamma_5 X_{it} + \delta_i + \theta_t + \varepsilon_{it} \quad (6)$$

The conditional indirect effect of GI on SOL is computed as:

$$\text{Indirect Effect}_{IQ} = (\alpha_1 + \alpha_3 \times IQ) \times (\gamma_1 + \gamma_4 \times IQ) \quad (7)$$

Because the conditional indirect effect involves a product of coefficients with a potentially non-normal sampling distribution, we use the bootstrap procedure described above to evaluate its significance at low (−1 SD), mean, and high (+1 SD) levels of IQ. This allows us to assess whether ESG-mediated

TABLE 2 | Quantile regression results for the effect of Green Innovation on state-oriented legitimacy (SOL)—H1.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Full fixed effect**	**Quantile 10**	**Quantile 25**	**Quantile 50**	**Quantile 75**	**Quantile 90**
Independent variable						
Green Innovation (GI)	0.0397***	0.0410**	0.0483***	0.0641***	0.0722***	0.0742***
	(0.0137)	(0.0176)	(0.0112)	(0.00915)	(0.00924)	(0.0114)
Control variable						
Firm Size	0.154***	−0.0283	0.0453***	0.104***	0.114***	0.107***
	(0.0406)	(0.0205)	(0.0130)	(0.0107)	(0.0108)	(0.0132)
Firm Age	0.00469	0.0733***	0.0524***	0.0320**	0.0688***	0.0818***
	(0.0490)	(0.0281)	(0.0178)	(0.0146)	(0.0147)	(0.0181)
Leverage	−0.440***	−0.122	−0.160*	−0.0970	−0.145**	−0.0902
	(0.132)	(0.138)	(0.0875)	(0.0716)	(0.0724)	(0.0890)
Return on Asset	0.190	0.909**	0.349	0.500***	0.631***	0.0611
	(0.229)	(0.360)	(0.229)	(0.187)	(0.189)	(0.232)
Board Independence	0.0826	−0.845***	−0.464***	−0.550***	−0.600***	−0.830***
	(0.155)	(0.260)	(0.165)	(0.135)	(0.137)	(0.168)
Institutional Ownership	0.00134	0.00452***	0.00460***	0.00331***	0.00345***	0.00346***
	(0.00157)	(0.000981)	(0.000623)	(0.000510)	(0.000515)	(0.000633)
CEO-Chair Duality	0.0244	−0.174***	−0.122***	−0.105***	−0.128***	−0.101***
	(0.0367)	(0.0496)	(0.0315)	(0.0258)	(0.0261)	(0.0320)
Regional DGP per Capita	−0.220	0.0814	0.0169	0.0915***	0.0863***	0.0768**
	(0.159)	(0.0500)	(0.0317)	(0.0260)	(0.0262)	(0.0323)
Industry Green Innovation Average (CNRDs)	−0.0338	0.0637***	0.0449***	0.0150	0.00125	0.0199
	(0.0255)	(0.0217)	(0.0138)	(0.0113)	(0.0114)	(0.0140)
Constant	−1.541	−2.011***	−2.562***	−4.075***	−3.771***	−2.998***
	(1.859)	(0.654)	(0.415)	(0.340)	(0.343)	(0.422)
Observations	9788	9788	9788	9788	9788	9788
R-squared	0.169					
Number of firms	1600					

Note: This table presents fixed-effects and quantile regression results for the effect of Green Innovation (Section 3.1) on SOL. Column (1) reports the baseline fixed-effects regression; Columns (2)–(6) report quantile regressions at the 10th, 25th, 50th, 75th, and 90th percentiles of SOL. Controls and year fixed effects follow Section 3.1. Robust standard errors in parentheses.

***$p < 0.01$.

**$p < 0.05$.

*$p < 0.1$.

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legitimacy gains from green innovation vary across institutional environments.

4 | Empirical Results

4.1 | Results for Hypothesis 1: Green Innovation and SOL

Table 2 presents the fixed-effects estimates of the relationship between green innovation, measured using the CNRDS green patent proxy, and SOL. The results show a positive and statistically significant effect ($\beta = 0.0397$, $p < 0.01$), consistent with the predicted positive relationship between green innovation and SOL.

The quantile regression results plotted in Figure 2, show that this positive relationship strengthens toward higher levels of legitimacy: the coefficient of green innovation increases from 0.0410 at the 10th quantile to 0.0742 at the 90th quantile and remains statistically significant throughout. These findings are consistent with H1, suggesting that the positive association between green innovation and SOL is stronger among firms at higher legitimacy quantiles. One possible explanation is that firms with greater institutional visibility or closer alignment with state priorities may derive greater legitimacy benefits from green innovation.

4.2 | Results for Hypothesis 2: The Moderating Role of Institutional Quality

Table 3 presents the results for H2, examining the moderating role of institutional quality in the relationship between green innovation and SOL. Across all specifications, green innovation exhibits a consistently positive and statistically significant relationship with state legitimacy, providing further evidence consistent with H1.

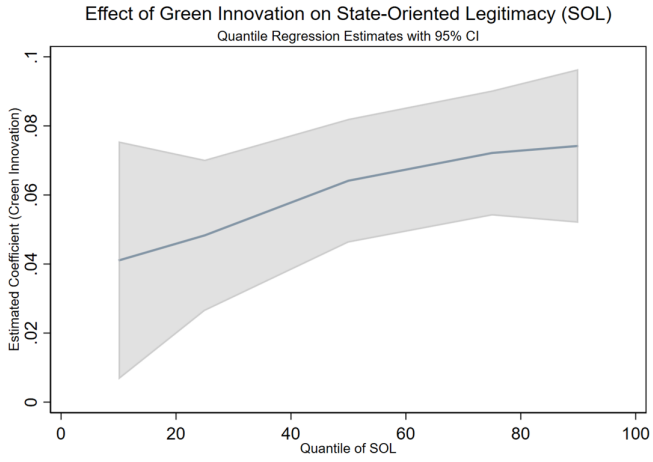


FIGURE 2 | Quantile regression estimates for the effect of Green Innovation on state-oriented legitimacy (SOL). *Note:* This figure plots the estimated coefficients of green innovation across different quantiles of SOL. Shaded areas represent 95% confidence intervals. The results show that the effect of green innovation becomes stronger and statistically significant at higher levels of legitimacy.

The results provide partial support for H2. Among the five subdimensions of institutional quality, only product market development (PMD) exhibits a positive and marginally significant interaction with green innovation, suggesting that provinces with better-developed product markets strengthen the positive effect of green innovation on legitimacy. The interaction terms for the remaining four dimensions are not statistically significant.

When using the composite marketization index as a moderator, its direct association with SOL is positive and statistically significant ($\beta = 0.0331$, $p < 0.05$), but its interaction with green innovation is not statistically significant ($\beta = 0.0026$, $p > 0.1$). Together with the dimension-level results, these findings provide partial support for H2, indicating the moderating relationship is evident for PMD but not for the composite index or the other institutional dimensions.

Figure 3 illustrates the estimated marginal effect of green innovation on SOL at different levels of institutional quality, proxied by the Marketization Index. Although the estimated marginal effect increases with institutional quality, the interaction coefficient is not statistically significant. Therefore, the figure illustrates the estimated pattern but does not provide sufficient statistical evidence that institutional quality strengthens the relationship.

4.3 | Results for Hypothesis 3: ESG Mediation and Institutional Moderation

4.3.1 | Results for Hypothesis 3(A): ESG Engagement as a Mediator

Table 4 reports the two-step fixed-effects panel mediation results for H3a. Panel A presents the relationship between green innovation and ESG engagement (Column 1) and the relationship between ESG engagement and SOL, controlling for green innovation (Column 2). Both specifications include firm and year fixed effects, with standard errors clustered at the firm level. Panel B reports the mediation estimates, evaluated using a firm-cluster bootstrap with 5000 replications.

Column (1) shows that green innovation has a positive and significant effect on ESG engagement ($\beta = 0.0023$, $p < 0.05$). In Column (2), both ESG engagement ($\beta = 0.469$, $p < 0.01$) and green innovation ($\beta = 0.0192$, $p < 0.01$) are positively and significantly associated with SOL, controlling for firm-level unobserved heterogeneity.

The estimated indirect effect of green innovation on SOL through ESG engagement is modest ($a \times b = 0.0011$). Following MacKinnon et al. (2004), we use the bias-corrected bootstrap confidence interval as the primary inferential criterion because the sampling distribution of the product of coefficients may be non-normal. The 95% bootstrap confidence interval [0.0002, 0.0025] excludes zero, indicating a statistically significant indirect effect despite the marginal normal-based test ($p = 0.064$). Both the direct effect ($\beta = 0.0192$, $p < 0.01$) and total effect ($\beta = 0.0202$, $p < 0.01$) remain positive and significant.

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TABLE 3 | Moderating effect of institutional quality on the relationship between Green Innovation and state-oriented legitimacy (SOL)—H2.

Variables	(1) SOL	(2) SOL	(3) SOL	(4) SOL	(5) SOL	(6) SOL
Independent variable						
Green Innovation (GI)	0.0207***	0.0229***	0.0246***	0.0234***	0.0222***	0.0229***
	(0.00734)	(0.00740)	(0.00747)	(0.00732)	(0.00741)	(0.00741)
Moderator						
Government-Market Relationship (GMR)	−0.0145*					
	(0.00834)					
Non-State Sector Development (NSD)		0.00933				
		(0.00589)				
Product Market Development (PMD)			−0.0111**			
			(0.00541)			
Factor Market Development (FMD)				0.0203***		
				(0.00481)		
Legal and Institutional Environment (LIE)					0.0163***	
					(0.00412)	
Marketization Index						0.0331**
						(0.0142)
Interaction term						
Green Innovation × GMR	−0.00351					
	(0.00343)					
Green Innovation × NSD		0.000834				
		(0.00284)				
Green Innovation × PMD			0.00387*			
			(0.00217)			
Green Innovation × FMD				−0.000865		
				(0.00153)		
Green Innovation × LIE					0.000511	
					(0.00143)	
Green Innovation × Marketization Index						0.00263
Control variable						
Firm Size	0.0998***	0.105***	0.104***	0.0936***	0.0974***	0.0992***
	(0.0215)	(0.0216)	(0.0216)	(0.0214)	(0.0215)	(0.0215)
Firm Age	0.0792***	0.0786***	0.0758***	0.0571**	0.0631**	0.0714***
	(0.0254)	(0.0256)	(0.0255)	(0.0261)	(0.0262)	(0.0262)
Leverage Ratio	−0.247***	−0.253***	−0.244***	−0.229***	−0.247***	−0.252***
	(0.0706)	(0.0707)	(0.0702)	(0.0703)	(0.0714)	(0.0712)
Return on Asset	0.0702	0.0485	0.0531	0.0711	0.0481	0.0580
	(0.121)	(0.121)	(0.121)	(0.120)	(0.120)	(0.120)

(Continues)

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TABLE 3 | (Continued)

Variables	(1) SOL	(2) SOL	(3) SOL	(4) SOL	(5) SOL	(6) SOL
Board Independence	0.0223	0.0144	0.0125	0.0129	0.0120	0.0132
	(0.0831)	(0.0828)	(0.0826)	(0.0824)	(0.0824)	(0.0825)
Institutional Ownership	0.00108	0.00103	0.00102	0.000957	0.000895	0.000974
	(0.000851)	(0.000856)	(0.000859)	(0.000847)	(0.000851)	(0.000851)
CEO-Chair Duality	0.0130	0.0123	0.0124	0.0120	0.0123	0.0117
	(0.0201)	(0.0201)	(0.0200)	(0.0199)	(0.0199)	(0.0200)
Regional DGP per Capita	0.344***	0.328***	0.323***	0.240***	0.226***	0.283***
	(0.0431)	(0.0450)	(0.0444)	(0.0491)	(0.0511)	(0.0494)
Industry Green Innovation Average	−0.0201*	−0.0131	−0.0193*	−0.00548	−0.00539	−0.00951
	(0.0114)	(0.0112)	(0.0112)	(0.0107)	(0.0109)	(0.0112)
						(0.00342)
Constant	−6.245***	−6.195***	−6.098***	−4.943***	−4.875***	−5.552***
	(0.481)	(0.485)	(0.496)	(0.564)	(0.585)	(0.566)
Observations	9660	9660	9660	9660	9660	9660
R-squared	0.143	0.142	0.143	0.146	0.145	0.143
Number of firm	1572	1572	1572	1572	1572	1572

Note: This table tests Hypothesis 2: that the effect of Green Innovation (GI) on state-oriented legitimacy (SOL) is moderated by Institutional Quality. Each column introduces a different moderator—GMR, NSD, PMD, FMD, LIE, or the composite Marketization Index (Section 3.1)—and the GI × moderator interaction captures its conditional effect. Controls, fixed effects, and clustering follow the specification in Section 3.2. Robust standard errors are clustered at the firm level. Robust standard errors in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

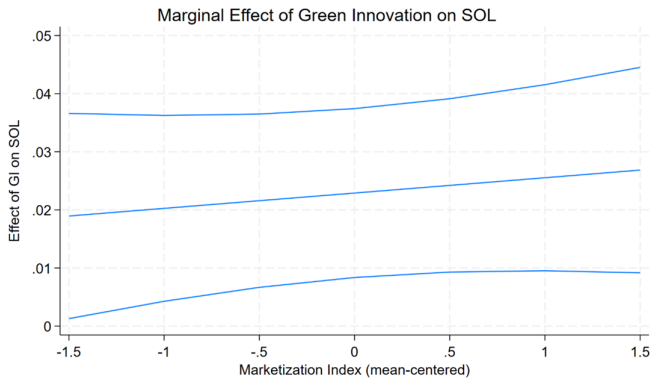


FIGURE 3 | The conditional effect of Green Innovation on state-oriented legitimacy across levels of institutional quality (Marketization Index).

These findings are consistent with partial mediation, with ESG engagement accounting for approximately 5% of the total estimated relationship.

Overall, these findings support H3a, indicating that ESG engagement partially mediates the relationship between green innovation and SOL. However, the estimated relationships should be interpreted as associations because firm fixed effects do not eliminate potential time-varying confounding.

4.3.2 | Results for Hypothesis 3b: Institutional Moderation of the ESG Mediation Pathway

Table 5 presents the moderated mediation results for H3b, using the composite Marketization Index to measure institutional quality. The corresponding results for its five sub-dimensions are reported in Appendix Tables C–G.

Panel A of Table 5 shows that green innovation is positively associated with ESG engagement ($\beta = 0.0022$, $p < 0.1$). The interaction between green innovation and the Marketization Index is positive and statistically significant ($\beta = 0.0014$, $p < 0.01$), indicating that institutional quality strengthens the first-stage relationship. ESG engagement ($\beta = 0.468$, $p < 0.01$) and green innovation ($\beta = 0.019$, $p < 0.01$) are also positively associated with SOL. However, the interaction between ESG engagement and the Marketization Index is not statistically significant ($\beta = 0.031$, $p = 0.526$), providing no statistical evidence of second-stage moderation.

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TABLE 4 | Two-step fixed-effects panel mediation analysis of the effect of Green Innovation on state-oriented legitimacy via ESG engagement—H3a.

Panel A: Regression results

Variables	(1) ESG engagement	(2) SOL
Independent variable		
Green Innovation (GI)	0.00228**	0.0192***
	(0.00106)	(0.00726)
ESG Engagement		0.469***
		(0.0980)
Control variables		
Firm Size	0.0258***	0.0610***
	(0.00295)	(0.0215)
Firm Age	0.00713*	0.00622
	(0.00374)	(0.0272)
Leverage	−0.0701***	−0.159**
	(0.0108)	(0.0681)
Return on Asset	0.0296	0.0174
	(0.0190)	(0.119)
Board Independence	0.0440***	0.0292
	(0.0107)	(0.0822)
Institutional Ownership	2.22e-05	0.000804
	(0.000123)	(0.000821)
CEO-Chair Duality	−0.000427	0.0120
	(0.00318)	(0.0194)
Regional GDP per Capita	−0.00736	−0.1000
	(0.0110)	(0.0844)
Industry Green Innovation Average (CSMAR)	−0.00189	−0.0167
	(0.00230)	(0.0135)
Constant	3.809***	−2.588***
	(0.133)	(1.042)
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
R-squared	0.065	0.174
Observations	9660	9660
Number of firms	1572	1572

Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)

Path	Coefficient	Bootstrap SE	z	*p*	95% CI (normal)	95% CI (percentile)	95% CI (bias-corrected)
a: GI → ESG	0.0023	0.00105	2.18	0.029	[0.0002, 0.0043]	[0.0002, 0.0044]	[0.0002, 0.0043]
b: ESG → SOL	0.4689	0.09868	4.75	< 0.001	[0.2755, 0.6624]	[0.2816, 0.6637]	[0.2825, 0.6660]

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TABLE 4 | (Continued)

Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)

Path	Coefficient	Bootstrap SE	z	*p*	95% CI (normal)	95% CI (percentile)	95% CI (bias-corrected)
Indirect effect (a × b)	0.0011	0.00058	1.85	0.064	[−0.0001, 0.0022]	[0.0001, 0.0024]	[0.0002, 0.0025]
Direct effect (GI → SOL)	0.0192	0.00722	2.65	0.008	[0.0050, 0.0333]	[0.0047, 0.0332]	[0.0046, 0.0331]
Total effect (Direct + Indirect)	0.0202	0.00726	2.79	0.005	[0.0060, 0.0345]	[0.0057, 0.0343]	[0.0056, 0.0342]

Note: This table reports a two-step fixed-effects panel mediation model testing Hypothesis 3(a): that ESG engagement mediates the relationship between Green Innovation (GI) and SOL. Column (1) presents the first-stage regression (path a: ESG on GI and controls); Column (2) reports the second-stage regression (paths b and c′: SOL on ESG, GI, and controls). Fixed effects and clustering follow Section 3.2. The indirect effect (GI → ESG → SOL) is evaluated via a firm-cluster bootstrap with 5000 replications (Panel B). Bootstrap based on 5000 replications clustered on 1572 firms (stockcode). Given the known skewness in the sampling distribution of the indirect effect (a × b), the bias-corrected (BC) confidence interval is treated as the primary inferential criterion, following MacKinnon et al. (2004). The BC 95% CI for the indirect effect [0.0002, 0.0025] excludes zero, supporting a statistically significant, though modest, mediation effect, notwithstanding the marginal normal-based *p*-value ($p = 0.064$) Robust standard errors in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

Panel B reports the bootstrap pathway estimates, while Panel C presents the conditional indirect effects at low (−1 SD), mean, and high (+1 SD) levels of institutional quality. Using bias-corrected bootstrap confidence intervals as the primary inferential criterion, the indirect effect is not statistically significant at low institutional quality (95% CI [−0.0013, 0.0008]) but it is significant at the mean (95% CI [0.0001, 0.0024]) and high (95% CI [0.0010, 0.0053]) levels. These findings are consistent with the predicted strengthening of the ESG-mediated relationship as institutional quality increases. However, nonsignificant ESG × Marketization Index interaction provides no statistical support for the predicted second-stage moderation. Thus, the results provide partial support for H3b.

To examine variation across institutional dimensions, we estimate the moderated mediation model separately for each of the five Marketization Index sub-dimensions (Appendix Tables C–G). Non-State Sector Development, Factor Market Development, and Legal and institutional Environment exhibit significant positive first-stage interactions, consistent with the composite-index results. In contrast, Product Market Development exhibits a significant negative first-stage interaction ($\beta = -0.0012$, $p < 0.01$), with the conditional indirect effect significant at low rather than high levels of product market development. Government–Market Relationship shows no significant moderation at either stage. The second-stage interaction is not statistically significant in any of the six specifications, including the composite index.

4.4 | Robustness Tests

4.4.1 | Robustness and Endogeneity Check for H1

To assess the robustness of H1, we first re-estimate the baseline model using the number of green patent citations as an alternative measure of green innovation. Table 6 reports a positive and significant association between green patent citations and SOL ($\beta = 0.0245$, $p < 0.1$), consistent with the baseline findings using patent counts. The quantile results indicate a nonmonotonic pattern: the association strengthens toward the 75th quantile ($\beta = 0.0498$) before declining at the 90th quantile ($\beta = 0.0311$). Unlike the baseline specification, the legitimacy benefits associated with citation-based green innovation are therefore most pronounced among firms in the upper-middle range of the SOL distribution.

To address potential endogeneity arising from contemporaneous simultaneity, we re-estimate Equation (1) using a one-period-lagged specification, with green innovation and all time-varying controls measured at *t-1* relative to SOL at *t* (Equation 1a). Table 7 shows that lagged green innovation remains positively and significantly associated with SOL ($\beta = 0.0445$, $p < 0.01$), comparable to the contemporaneous estimate ($\beta = 0.0397$). This temporal separation reduces concerns about contemporaneous simultaneity but cannot eliminate reverse causality or time-varying omitted-variable bias.

The lagged quantile regressions reveal a broadly consistent distributional pattern. The coefficient increases from 0.0480 at the 25th quantile to 0.0686 at the 75th quantile. However, the coefficient at the 10th quantile ($\beta = 0.0287$) is no longer statistically significant, indicating weaker evidence of a persistent association among firms at the lowest end of the SOL distribution. Lagging reduces the estimation sample from 9788 to 8305 firm-year observations (1400 firms). Overall, the results indicate that the positive association between green innovation and SOL persists under temporal separation, although its statistical significance varies across the legitimacy distribution.

4.4.2 | Robustness and Endogeneity Check for H2

To assess the robustness of H2, we re-estimate the moderation models using green patent citation counts instead of patent application counts. Table 8 shows that the direct effect of green innovation remains positive but statistically insignificant across all specifications. Among the institutional dimensions, only the interaction between green patent citations and Government–Market relationship (GMR) is positive and statistically significant at the 5% level. This contrasts with the baseline findings,

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TABLE 5 | Moderated mediation analysis for Hypothesis 3b: indirect effect of Green Innovation on state-oriented legitimacy via ESG, conditional on Marketization Index.

Panel A: Regression results		
Variables	**(1) ESG Engagement**	**(2) SOL**
Independent variable		
Green Innovation (GI)	0.00221*	0.0189**
	(0.00115)	(0.00794)
Mediator		
ESG Engagement		0.468***
		(0.107)
Moderator		
Marketization Index	−0.000848	−0.0263
	(0.00250)	(0.0192)
Interaction term		
Green Innovation × Marketization Index	0.00143***	
	(0.000436)	
ESG × Marketization Index		0.0313
		(0.0539)
Control variables		
Firm Size	0.0251***	0.0606***
	(0.00322)	(0.0235)
Firm Age	0.00765*	0.00649
	(0.00405)	(0.0297)
Leverage	−0.0704***	−0.157**
	(0.0118)	(0.0743)
Return on Asset	0.0301	0.0191
	(0.0208)	(0.131)
Board Independence	0.0438***	0.0292
	(0.0116)	(0.0899)
Institutional Ownership	2.41e-05	0.000827
	(0.000134)	(0.000894)
CEO-Chair Duality	−0.000575	0.0122
	(0.00346)	(0.0212)
Regional GDP per Capita	−0.00605	−0.0802
	(0.0121)	(0.0937)
Industry Green Innovation Average	−0.00133	−0.0169
	(0.00247)	(0.0148)
Constant	−0.473***	−0.747
	(0.146)	(1.105)
Firm fixed effects	Yes	Yes

(Continues)

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TABLE 5 | (Continued)

Panel A: Regression results					
Variables	**(1) ESG Engagement**			**(2) SOL**	
Year fixed effects	Yes			Yes	
Observations	9660			9660	
Number of firms	1572			1572	
R-squared	0.501			0.564	
Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)					
Path	**Coefficient**	**Bootstrap SE**	***z***	***p***	**95% CI (normal)**
a1: GI → ESG	*0.0022*	0.00104	2.13	0.033	[0.0002, 0.0042]
a3: GI × IQ → ESG (first-stage moderation)	0.0014	0.00040	3.58	< 0.001	[0.0006, 0.0022]
b1: ESG → SOL	0.4681	0.09728	4.81	< 0.001	[0.2774, 0.6587]
b3: ESG × IQ → SOL (second-stage moderation)	0.0313	0.04937	0.63	0.526	[−0.0654, 0.1281]
Direct effect (GI → SOL)	0.0189	0.00709	2.67	0.008	[0.0050, 0.0328]
Panel C: Conditional indirect effects of GI on SOL via ESG, at levels of the Marketization Index					
Moderator level	**Indirect effect**	**Bootstrap SE**	**95% CI (normal)**		**95% CI (bias-corrected)**
Low (−1 SD)	−0.0002	0.00051	[−0.0012, 0.0008]		[−0.0013, 0.0008]
Mean	0.0010	0.00057	[−0.0001, 0.0021]		[0.0001, 0.0024]
High (+1 SD)	0.0025	0.00105	[0.0005, 0.0046]		[0.0010, 0.0053]

Note: This table tests Hypothesis 3b: that the indirect effect of Green Innovation on SOL via ESG is conditional on institutional quality (IQ), proxied by the Marketization Index. Column (1) models ESG as a function of GI, IQ, and their interaction (Equation 5); Column (2) models SOL as a function of ESG, GI, IQ, and the ESG × IQ interaction (Equation 6). Fixed effects, clustering, and mean-centering follow Section 3.2. Bootstrap based on 5000 replications clustered on 1572 firms. Consistent with the reporting convention established in Table 4, the bias-corrected (BC) confidence interval is treated as the primary inferential criterion. The conditional indirect effect is positive and significant at the mean and high levels of institutional quality (BC CIs excluding zero), but not at low institutional quality (BC CI includes zero), supporting the moderated mediation hypothesis: the indirect, ESG-mediated legitimacy benefit of green innovation strengthens as institutional quality increases. Robust standard errors in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

where Product Market Development (PMD) is the only significant moderator. The remaining institutional dimensions and the composite Marketization Index exhibit insignificant interaction effects. These findings indicate that the moderating role of institutional quality varies with the measurement of green innovation.

To address potential contemporaneous simultaneity, we further estimate a one-period-lagged specification, measuring green innovation, institutional quality and their interactions at *t*-1 relative to SOL at *t*. Table 9 shows that green innovation remains positively associated with SOL across six specifications ($\beta = 0.0218–0.0256$, $p < 0.05$ or better).

The lagged moderation results are broadly consistent with the baseline findings. PMD remains the only significant institutional moderator ($\beta = 0.00906$, $p < 0.01$), compared with its contemporaneous estimate ($\beta = 0.00387$, $p < 0.1$). The remaining institutional dimensions and the composite Marketization Index ($\beta = 0.00168$, n.s.) exhibit insignificant interaction effects. Thus, the lagged results provide further evidence that the moderating role of institutional quality is concentrated in Product Market Development rather than the aggregate institutional environment.

Lagging reduces the estimation sample from 9660 to 7549 firm-years (1303 firms). Although temporal separation strengthens the temporal ordering of the analysis, it does not eliminate reverse causality or time-varying omitted-variable bias.

4.4.3 | Robustness and Endogeneity Check for H3a

To assess the robustness of H3a, we re-estimate the two-step fixed panel mediation model using green patent citation (CSMAR) instead of patent application counts (CNRDS). Table 10 shows that citation-based green innovation has no significant effect on ESG engagement ($\beta = 0.000283$, $p > 0.1$), unlike the significant first-stage relationship obtained using patent counts (Table 4). Although ESG engagement remains positively associated with SOL ($\beta = 0.279$, $p < 0.05$), the bootstrapped indirect effect is statistically insignificant (bias-corrected 95% CI [−0.0003, 0.0008]). Thus, the mediation finding is sensitive to the measurement of green innovation.

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TABLE 6 | Robustness check: effect of Green Innovation citations on state-oriented legitimacy (SOL)—H1.

Variables	(1) Fixed Effect	(2) Quantile 10	(3) Quantile 25	(4) Quantile 50	(5) Quantile 75	(6) Quantile 90
Independent variable						
Green Innovation Citation (CSMAR)	0.0245*	0.0428**	0.0392***	0.0461***	0.0498***	0.0311**
	(0.0139)	(0.0198)	(0.0134)	(0.00976)	(0.0103)	(0.0132)
Control variable						
Firm Size	0.150***	−0.0592**	0.0261	0.103***	0.110***	0.111***
	(0.0502)	(0.0249)	(0.0169)	(0.0123)	(0.0130)	(0.0166)
Firm Age	0.000479	0.0695**	0.0494**	0.0321*	0.0486***	0.0783***
	(0.0640)	(0.0350)	(0.0237)	(0.0173)	(0.0182)	(0.0234)
Leverage Ratio	−0.301*	−0.0445	−0.0634	−0.0366	−0.144	0.00494
	(0.173)	(0.173)	(0.117)	(0.0855)	(0.0903)	(0.116)
Return on Asset	0.144	0.879*	0.531*	0.563**	0.644***	0.409
	(0.293)	(0.458)	(0.310)	(0.226)	(0.239)	(0.306)
Board Independence	0.247	−0.788**	−0.428**	−0.458***	−0.473***	−0.911***
	(0.194)	(0.312)	(0.211)	(0.154)	(0.163)	(0.208)
Institutional Ownership	−2.79e-05	0.00604***	0.00578***	0.00377***	0.00385***	0.00312***
	(0.00213)	(0.00123)	(0.000837)	(0.000610)	(0.000644)	(0.000825)
CEO-Chair Duality	−0.0176	−0.210***	−0.146***	−0.0861***	−0.104***	−0.0997**
	(0.0475)	(0.0615)	(0.0417)	(0.0304)	(0.0321)	(0.0411)
Regional DGP per Capita	−0.136	0.0742	0.0267	0.0966***	0.0905***	0.0899**
	(0.194)	(0.0622)	(0.0421)	(0.0307)	(0.0324)	(0.0415)
Industry Green Innovation Citation Average (CSMAR)	0.0343	0.0556	0.0298	0.00258	0.0157	0.0307
	(0.0333)	(0.0342)	(0.0232)	(0.0169)	(0.0178)	(0.0229)
Constant	−2.505	−1.152	−2.220***	−4.107***	−3.705***	−3.077***
	(2.233)	(0.819)	(0.555)	(0.405)	(0.427)	(0.548)
Observations	6663	6663	6663	6663	6663	6663
R-squared	0.157					
Number of firms	1307					

Note: This table tests the robustness of the Green Innovation–SOL relationship using the Green Patent Citations (CSMAR) proxy (Section 3.1). Column (1) presents the baseline fixed-effects regression; Columns (2)–(6) report quantile regressions at the 10th, 25th, 50th, 75th, and 90th percentiles of SOL. Controls and year fixed effects follow Section 3.1. Robust standard errors are reported in parentheses. Robust standard errors in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

To examine whether this result reflects the distribution of patent citations, we distinguish between the extensive margin (whether firms receive any citations) and the intensive margin (citation volume conditional on receiving citations). Neither exhibits a significant association with ESG engagement (has citation: $p = 0.122$; log citations: $p = 0.661$). These findings suggest that the ESG mediation pathway is more consistently associated with green innovation volume than with its citation-based influence, identifying a measurement-related boundary condition for H3a.

We further examine temporal robustness using a specification in which green innovation is measured at *t*-2, ESG engagement at *t*-1, and SOL at *t*. Table 11 shows that the first-stage relationship remains positive but marginally significant ($\beta = 0.0026$, $p = 0.053$), whereas the ESG-to-SOL relationship becomes statistically insignificant ($\beta = 0.154$, $p = 0.225$). Nevertheless, the bootstrapped indirect effect remains significant under the bias-corrected criterion (95% CI [0.0001, 0.0022]), although the normal-based test is insignificant ($p = 0.198$). The direct effect of green innovation on SOL also remains positive and significant ($\beta = 0.0235$, $p < 0.01$).

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TABLE 7 | Robustness check: effect of lagged Green Innovation on state-oriented legitimacy (SOL)—H1.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Full Fixed Effect**	**Quantile 10**	**Quantile 25**	**Quantile 50**	**Quantile 75**	**Quantile 90**
Independent variable						
Green Innovation (GI), lagged	0.0445***	0.0287	0.0480***	0.0666***	0.0686***	0.0623***
	(0.0165)	(0.0201)	(0.0132)	(0.0101)	(0.0103)	(0.0124)
Control variable (all lagged)						
Firm Size	0.0773*	−0.0121	0.0454***	0.105***	0.119***	0.114***
	(0.0428)	(0.0236)	(0.0155)	(0.0119)	(0.0121)	(0.0146)
Firm Age	−0.0477	0.0839**	0.0358*	0.0153	0.0658***	0.0692***
	(0.0591)	(0.0327)	(0.0214)	(0.0164)	(0.0168)	(0.0202)
Leverage	−0.343**	−0.225	−0.118	−0.0383	−0.0996	0.0686
	(0.147)	(0.159)	(0.104)	(0.0801)	(0.0817)	(0.0982)
Return on Asset	0.644**	1.233***	0.778***	0.718***	1.045***	0.963***
	(0.253)	(0.413)	(0.271)	(0.208)	(0.212)	(0.255)
Board Independence	0.162	−0.386	−0.375*	−0.601***	−0.382**	−0.781***
	(0.164)	(0.301)	(0.197)	(0.151)	(0.154)	(0.186)
Institutional Ownership	−0.000935	0.00365***	0.00401***	0.00308***	0.00312***	0.00283***
	(0.00167)	(0.00114)	(0.000745)	(0.000572)	(0.000583)	(0.000702)
CEO-Chair Duality	−0.294*	0.154***	0.0301	0.102***	0.0854***	0.107***
	(0.174)	(0.0570)	(0.0374)	(0.0287)	(0.0293)	(0.0352)
Regional GDP per Capita	−0.0168	0.0792***	0.0418***	0.00291	0.00482	0.0297*
	(0.0304)	(0.0247)	(0.0162)	(0.0124)	(0.0127)	(0.0152)
Industry Green Innovation Average (CNRDs)	−0.0272	−0.244***	−0.120***	−0.122***	−0.158***	−0.154***
	(0.0417)	(0.0579)	(0.0379)	(0.0291)	(0.0297)	(0.0357)
Constant	1.027	−3.170***	−2.609***	−4.139***	−3.969***	−3.672***
	(2.021)	(0.746)	(0.489)	(0.376)	(0.383)	(0.461)
Observations	8305	8305	8305	8305	8305	8305
R-squared	0.160					
Number of firms	1400					

Note: This table presents fixed-effects and quantile regression results for one-period-lagged Green Innovation on SOL, addressing reverse causality and simultaneity concerns. Green innovation and all controls (Section 3.1) are lagged one period; SOL remains contemporaneous. Column (1) reports the baseline fixed-effects regression; Columns (2)–(6) report quantile regressions at the 10th, 25th, 50th, 75th, and 90th percentiles of SOL. All models include year fixed effects. Robust standard errors are reported in parentheses. Robust standard errors in parentheses.

***$p < 0.01$.

**$p < 0.05$.

*$p < 0.1$.

Overall, the temporally separated specification provides qualified support for the mediation finding, whereas the citation-based specification does not. The attenuation of the ESG-to-SOL relationship may reflect the timing of legitimacy formation or reduced estimation precision. Although temporal separation strengthens the ordering of the hypothesized pathway, it does not establish causal mediation.

4.4.4 | Robustness and Endogeneity Check for H3b

To assess the robustness of H3b, we re-estimate the two-step fixed-effects panel moderated mediation model using green patent citations (CSMAR) instead of patent application counts (CNRDS), retaining the composite Marketization index as the measure of institutional quality. Table 12 shows that neither

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TABLE 8 | Robustness check: moderating effects of institutional quality on Green Innovation and SOL (using green innovation citation)—H2.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**SOL**	**SOL**	**SOL**	**SOL**	**SOL**	**SOL**
Independent variable						
Green Innovation (GI Citation)	0.00446	0.00113	0.00371	0.00596	0.00492	0.00279
	(0.00718)	(0.00732)	(0.00742)	(0.00724)	(0.00709)	(0.00720)
Moderator						
Government-Market Relationship (GMR)	−0.0302***					
	(0.0116)					
Non-State Sector Development (NSD)		0.00269				
		(0.00699)				
Product Market Development (PMD)			−0.00789			
			(0.00661)			
Factor Market Development (FMD)				0.0135**		
				(0.00605)		
Legal and Institutional Environment (LIE)					0.0123**	
					(0.00514)	
Marketization Index						0.0169
						(0.0177)
Interaction term						
Green Innovation × GMR	0.00924**					
	(0.00384)					
Green Innovation × NSD		−0.00167				
		(0.00305)				
Green Innovation × PMD			0.00264			
			(0.00215)			
Green Innovation × FMD				−0.00113		
				(0.00170)		
Green Innovation × LIE					−0.00112	
					(0.00152)	
Green Innovation × Marketization Index						0.000285
						(0.00341)
Control variable						
Firm Size	0.114***	0.115***	0.117***	0.107***	0.109***	0.112***
	(0.0265)	(0.0269)	(0.0267)	(0.0266)	(0.0269)	(0.0268)
Firm Age	0.0757**	0.0749**	0.0744**	0.0599*	0.0615*	0.0713**
	(0.0329)	(0.0333)	(0.0333)	(0.0336)	(0.0340)	(0.0339)
Leverage Ratio	−0.189**	−0.193**	−0.186**	−0.181*	−0.185**	−0.192**
	(0.0926)	(0.0929)	(0.0925)	(0.0934)	(0.0938)	(0.0934)

(Continues)

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TABLE 8 | (Continued)

Variables	(1) SOL	(2) SOL	(3) SOL	(4) SOL	(5) SOL	(6) SOL
Return on Asset	0.129	0.120	0.108	0.131	0.110	0.121
	(0.156)	(0.157)	(0.156)	(0.156)	(0.156)	(0.156)
Board Independence	0.0965	0.0879	0.0846	0.0827	0.0796	0.0848
	(0.103)	(0.104)	(0.104)	(0.103)	(0.103)	(0.103)
Institutional Ownership	8.33e-05	8.86e-05	8.68e-05	2.88e-05	−5.53e-05	6.87e-05
	(0.00114)	(0.00114)	(0.00114)	(0.00114)	(0.00114)	(0.00114)
CEO-Chair Duality	−0.00505	−0.00571	−0.00639	−0.00524	−0.00646	−0.00546
	(0.0253)	(0.0253)	(0.0254)	(0.0254)	(0.0252)	(0.0253)
Regional DGP per Capita	0.338***	0.351***	0.334***	0.293***	0.271***	0.323***
	(0.0545)	(0.0569)	(0.0565)	(0.0618)	(0.0634)	(0.0625)
Industry Green Innovation Average	0.00383	0.0134	0.0102	0.0191	0.0220	0.0141
	(0.0131)	(0.0131)	(0.0133)	(0.0135)	(0.0138)	(0.0135)
Constant	−6.593***	−6.781***	−6.641***	−5.950***	−5.741***	−6.406***
	(0.609)	(0.613)	(0.622)	(0.696)	(0.729)	(0.709)
Observations	6603	6603	6603	6603	6603	6603
R-squared	0.131	0.129	0.130	0.131	0.131	0.129
Number of firms	1289	1289	1289	1289	1289	1289

Note: This table tests the robustness of Hypothesis 2 using the Green Patent Citations (CSMAR) proxy (Section 3.1) in place of patent counts. Each column introduces a different moderator—GMR, NSD, PMD, FMD, LIE, or the composite Marketization Index—and the GI × moderator interaction captures its conditional effect. Controls, fixed effects, and clustering follow the specification in Section 3.2. Robust standard errors in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

citation-based green innovation ($\beta = 0.0003$, $p = 0.679$) nor its interaction with institutional quality ($\beta = 0.0002$, $p = 0.720$) significantly predicts ESG engagement. Although ESG engagement remains positively associated with SOL ($\beta = 0.278$, $p < 0.05$), its interaction with institutional quality is insignificant ($\beta = 0.018$, $p = 0.774$). Consequently, the conditional indirect effects are statistically insignificant across all three levels of institutional quality. These findings indicate that the contemporaneous moderated mediation results are sensitive to the measurement of green innovation.

An additional temporally separated citation-based specification yields significant first-stage effects for green innovation ($\beta = 0.0032$, $p < 0.01$) and its interaction with institutional quality ($\beta = 0.0014$, $p < 0.05$). However, the ESG-to-SOL relationship remains insignificant, and none of the conditional indirect effects reaches statistical significance. This suggests that the first-stage relationship may be sensitive to temporal specification, although the conditional indirect effect remains unsupported.

To address potential endogeneity, we further estimate the patent-count-based moderated mediation model using green innovation and institutional quality at *t*-2, ESG engagement and its interaction with institutional quality at *t*-1, and SOL at *t*. Table 13 shows that the first-stage interaction between green innovation and institutional quality remains positive and significant ($\beta = 0.0020$, $p < 0.01$), consistent with the contemporaneous findings in Table 5. However, the ESG-to-SOL relationship becomes insignificant ($\beta = 0.109$, $p = 0.409$), and none of the conditional indirect effects is statistically significant under the bias-corrected bootstrap criterion, unlike the contemporaneous results.

Overall, the findings indicate that first-stage institutional moderation persists under temporal separation when green innovation is measured using patent counts. However, the conditional indirect effects are sensitive to both measurement and temporal specification. The attenuation of ESG-to-SOL relationship may reflect the timing of legitimacy formation or reduced estimation precision. Although temporal separation strengthens the ordering of the proposed mechanism, it does not establish causality.

4.4.5 | Robustness and Validation of the SOL Measure

To assess the validity of the SOL measure and address potential overlap with conventional ESG indicators, we conduct dimension-level decomposition, alternative index construction, weighting sensitivity analysis, and external validation.

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TABLE 9 | Endogeneity check: effect of lagged Green Innovation and institutional quality interaction on state-oriented legitimacy (SOL)—H2.

Variables	(1) SOL	(2) SOL	(3) SOL	(4) SOL	(5) SOL	(6) SOL
Independent variable						
Green Innovation (GI)	0.0218**	0.0231**	0.0256***	0.0224**	0.0228**	0.0228**
	(0.00889)	(0.00899)	(0.00893)	(0.00889)	(0.00895)	(0.00898)
Moderator						
Government-Market Relationship (GMR)	−0.0348***					
	(0.00866)					
Non-State Sector Development (NSD)		0.00696				
		(0.00837)				
Product Market Development (PMD)			−0.0303***			
			(0.00599)			
Factor Market Development (FMD)				0.0168***		
				(0.00541)		
Legal and Institutional Environment (LIE)					0.0153***	
					(0.00459)	
Marketization Index						0.0261*
						(0.0156)
Interaction term						
Green Innovation × GMR	−0.00120					
	(0.00436)					
Green Innovation × NSD		0.00232				
		(0.00362)				
Green Innovation × PMD			0.00906***			
			(0.00269)			
Green Innovation × FMD				−0.00238		
				(0.00190)		
Green Innovation × LIE					−0.00135	
					(0.00179)	
Green Innovation × Marketization Index						0.00168
						(0.00441)
Control variable						
Firm Size	0.0689***	0.0812***	0.0788***	0.0731***	0.0768***	0.0774***
	(0.0243)	(0.0244)	(0.0242)	(0.0243)	(0.0241)	(0.0241)
Firm Age	0.0628**	0.0658**	0.0481	0.0473	0.0465	0.0598*
	(0.0317)	(0.0322)	(0.0322)	(0.0325)	(0.0328)	(0.0325)
Leverage Ratio	−0.271***	−0.294***	−0.262***	−0.272***	−0.286***	−0.292***
	(0.0830)	(0.0836)	(0.0822)	(0.0830)	(0.0835)	(0.0839)

(Continues)

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TABLE 9 | (Continued)

Variables	(1) SOL	(2) SOL	(3) SOL	(4) SOL	(5) SOL	(6) SOL
Return on Asset	0.228	0.177	0.184	0.191	0.177	0.181
	(0.150)	(0.150)	(0.150)	(0.149)	(0.149)	(0.149)
Board Independence	0.0577	0.0372	0.0255	0.0300	0.0279	0.0347
	(0.0935)	(0.0931)	(0.0926)	(0.0930)	(0.0929)	(0.0929)
Institutional Ownership	−0.000658	−0.000741	−0.000825	−0.000789	−0.000879	−0.000796
	(0.000954)	(0.000959)	(0.000960)	(0.000954)	(0.000954)	(0.000958)
CEO-Chair Duality	−0.0171	−0.0186	−0.0187	−0.0181	−0.0181	−0.0188
	(0.0245)	(0.0245)	(0.0244)	(0.0243)	(0.0242)	(0.0244)
Regional GDP per Capita	0.347***	0.356***	0.307***	0.289***	0.265***	0.322***
	(0.0512)	(0.0539)	(0.0527)	(0.0563)	(0.0582)	(0.0573)
Industry Green Innovation Average	−0.0115	−0.00230	−0.00860	0.00266	0.00378	−0.000807
	(0.0141)	(0.0141)	(0.0138)	(0.0138)	(0.0137)	(0.0140)
Constant	−5.446***	−5.842***	−5.187***	−4.887***	−4.685***	−5.353***
	(0.586)	(0.575)	(0.584)	(0.649)	(0.649)	(0.645)
Observations	7549	7549	7549	7549	7549	7549
R-squared	0.128	0.125	0.132	0.127	0.127	0.125
Number of firms	1303	1303	1303	1303	1303	1303

Note: This table tests the robustness of Hypothesis 2 to reverse causality and simultaneity, using a one-period-lagged specification consistent with the baseline model (Table 3). Each column introduces a different lagged moderator—GMR, NSD, PMD, FMD, LIE, or the composite Marketization Index—with green innovation, the moderator, and their interaction all dated at *t*-1. Controls, fixed effects, and clustering follow the specification in Section 3.2. Robust standard errors in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

First, Table 14 decomposes the relationship between green innovation and SOL across its six dimensions. All 12 coefficients are positive across the contemporaneous and lagged specifications. Community acceptance is significant contemporaneously ($p < 0.05$), alongside environmental and political legitimacy ($p < 0.1$). Under the lagged specification, trust, community acceptance and environmental legitimacy are significant ($p < 0.05$). The environmental dimension accounts for 28.9% and 37.1% of the contemporaneous and lagged aggregate effects, respectively. The findings indicate that the association extends beyond environmental indicators, particularly to stakeholder-facing dimensions.

Second, we examine alternative index constructions (Table 15). Excluding the environmental dimension yields positive and significant coefficients in both contemporaneous ($\beta = 0.0364$) and lagged ($\beta = 0.0361$) specifications. Further excluding the procedural dimension produces a coefficient of 0.0361. Restricting the index to the two state-facing dimensions yields a significant contemporaneous coefficient ($\beta = 0.0309$), although significance is not retained under the lagged specification. Equal weighting also produces a positive and significant association ($\beta = 0.0359$, $p < 0.01$).

Third, weighting sensitivity analysis using 200 randomly generated weight vectors produces positive coefficients in every specification, with 86% significant at the 5% level. The median coefficient is 0.0320, indicating that the findings are not dependent on the theoretically assigned weights.

Finally, we use government subsidy intensity, measured as government grants relative to total assets, as an external proxy for state-conferred legitimacy. Green innovation is positively associated with subsidy intensity ($\beta = 0.000209$, $p < 0.05$; $N = 9181$), providing additional evidence that the baseline relationship is not specific to the constructed SOL index.

Collectively, these analyses demonstrate that the positive association between green innovation and SOL is not solely attributable to environmental indicators, the selected weighting scheme or the particular construction of the composite index.

4.5 | Summary of Empirical Findings

Table 16 summarizes the empirical findings for the four hypotheses. H1 is supported; green innovation is positively associated with state-oriented legitimacy (SOL), although the strength of this relationship varies across the legitimacy distribution. H2 receives partial support; Product Market Development (PMD)

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TABLE 10 | Robustness check: two-step fixed-effects panel mediation analysis of the effect of Green Innovation (citation-based) on state-oriented legitimacy via ESG engagement—H3a.

Panel A: Regression results

	(1)	(2)
Variables	**ESG Score**	**SOL**
Independent variable		
Green Innovation	0.000283	0.0132
	(0.000971)	(0.00829)
ESG Engagement		0.279***
		(0.140)
Control variables		
Firm Size	0.0269***	0.0699**
	(0.00366)	(0.0301)
Firm Age	0.0149***	0.00309
	(0.00559)	(0.0390)
Leverage	−0.0814***	−0.131
	(0.0156)	(0.102)
Return on Asset	0.0122	0.0450
	(0.0276)	(0.173)
Board Independence	0.0314**	0.127
	(0.0136)	(0.116)
Institutional Ownership	−3.74e-05	2.67e-05
	(0.000173)	(0.00126)
CEO-Chair Duality	0.000178	−0.00785
	(0.00438)	(0.0282)
Regional GDP per Capita	−0.00946	−0.0653
	(0.0151)	(0.115)
Industry Green Innovation Average (Citation)	−0.000589	0.0186
	(0.00244)	(0.0199)
Constant	3.796***	−2.406*
	(0.175)	(1.398)
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
R-squared	0.515	0.561
Observations	6603	6603
Number of firms	1289	1289

Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)

Path	Coefficient	Bootstrap SE	*z*	*p*	95% CI (normal)	95% CI (percentile)	95% CI (bias-corrected)
a: GI (Citation) → ESG	0.0003	0.00087	0.32	0.746	[−0.0014, 0.0020]	[−0.0014, 0.0020]	[−0.0014, 0.0020]
b: ESG → SOL	0.2788	0.12325	2.26	0.024	[0.0372, 0.5203]	[0.0373, 0.5206]	[0.0402, 0.5275]

(Continues)

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TABLE 10 | (Continued)

Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)

Path	Coefficient	Bootstrap SE	*z*	*p*	95% CI (normal)	95% CI (percentile)	95% CI (bias-corrected)
Indirect effect (a × b)	**0.0001**	**0.00027**	**0.29**	**0.773**	**[−0.0005, 0.0006]**	**[−0.0004, 0.0007]**	**[−0.0003, 0.0008]**
Direct effect (GI → SOL)	0.0132	0.00762	1.73	0.083	[−0.0017, 0.0281]	[−0.0023, 0.0284]	[−0.0020, 0.0286]
Total effect (Direct + Indirect)	0.0133	0.00763	1.74	0.081	[−0.0017, 0.0282]	[−0.0022, 0.0284]	[−0.0022, 0.0286]

Note: This table tests whether the mediation results in Table 4 hold when green innovation is measured using citations (CSMAR) rather than patent counts. Fixed effects and clustering follow Section 3.2. The indirect effect is evaluated via a firm-cluster bootstrap with 5000 replications (Panel B). Bootstrap based on 5000 replications clustered on 1289 firms (stockcode). Consistent with the reporting convention established in Table 4, the bias-corrected (BC) confidence interval is treated as the primary inferential criterion. The BC 95% CI for the indirect effect [−0.0003, 0.0008] includes zero, indicating no significant mediation effect when green innovation is measured using citations rather than patent application counts. Robust standard errors in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

positively moderates the relationship between green innovation and SOL in the baseline and lagged specifications, whereas the other institutional dimensions and the composite Marketization Index exhibit insignificant moderation effects.

H3a is supported in the baseline analysis, demonstrating that ESG engagement mediates the relationship between green innovation and SOL. However, this mediation is sensitive to the measurement of green innovation: the indirect effect is insignificant when green patent citations replace patent counts. The temporally separated specification provides qualified evidence of mediation, with significance depending on the bootstrap criterion.

For H3b, the baseline results reveal significant first-stage moderation by the Marketization Index, but no significant second-stage moderation. The conditional indirect effect is significant at mean and high levels of institutional quality in the contemporaneous specification. However, these indirect effects become statistically insignificant under temporal separation, despite the persistence of significant first-stage moderation.

Supplementary analyses of the five institutional sub-dimensions (Appendices C–G) reveal heterogeneous first-stage moderation effects. Specifically, PMD exhibits a negative interaction, whereas NSD, FMD, and LIE exhibit positive interactions; GMR shows no significant moderating effect.

5 | Discussion

Empirically, our findings demonstrate that green innovation enhances state-oriented legitimacy both directly and indirectly through ESG engagement, and that this relationship is conditioned by institutional quality. These results indicate that the translation of environmental strategy into legitimacy depends not only on firms' substantive actions but also on their communicative strategies and the institutional environment that governs interpretation. These findings suggest that the relationship between green innovation and legitimacy depends partly on ESG engagement and the institutional environment under which firms operate.

5.1 | Theoretical Implications: Rethinking Legitimacy Under State Capitalism

This study contributes to the environmental strategy literature by examining how green innovation translates into institutional recognition through ESG engagement under state-capitalist conditions. It also extends the discussion of legitimacy beyond the conventional Social License to Operate (SLO) within the institutional logic of state capitalism, where legitimacy is not filtered through deliberative community consent but through symbolic alignment with national policy agendas and performance within state-mediated reputation systems (Kostka 2016; Marquis and Raynard 2015). While conventional SOL frameworks emphasize grassroots approval (Boutilier and Thomson 2011; Gehman et al. 2017), we introduce state-oriented legitimacy (SOL), an informal endorsement conferred primarily by state actors and political intermediaries in developmental authoritarian regimes.

Our results further reveal heterogeneity in this relationship, showing that the legitimacy returns to green innovation are stronger among firms with higher baseline legitimacy. This pattern reflects a Matthew effect in legitimacy accrual (Merton 1968), echoing research showing that organizations with pre-existing legitimacy convert new actions into reputational gains more efficiently (Barich et al. 2021; Delmas and Toffel 2008). In this sense, environmental strategy is not equally effective across firms but depends on prior reputational positioning and institutional embeddedness.

Beyond statistical significance, it is worth situating these effects in economic terms. Because green innovation enters the model as ln (patent count +1), the baseline coefficient of 0.0397 implies that a firm doubling its green patent output—a substantial but achievable 1-year strategic shift—is associated with an increase in SOL of only about $0.0397 \times \ln(2) \approx 0.027$ standard deviations. Green innovation's legitimacy returns are therefore statistically significant in the main specifications but economically incremental: legitimacy under state capitalism appears to accrue gradually through sustained innovation activity rather than through any single strategic action, consistent with the Matthew effect pattern described above. The institutional-quality moderation is smaller still in absolute terms: the significant Product

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TABLE 11 | Robustness check: effect of Green Innovation on state-oriented legitimacy via ESG engagement, temporally separated specification—H3a.

Panel A: Regression results

Variables	(1) ESG(t-1)	(2) SOL
Independent variable		
Green Innovation (GI), *t*-2	0.00255**	
	(0.00132)	
Green Innovation (GI), *t*-1		0.0235***
		(0.00877)
ESG Score, *t*-1		0.154
		(0.125)
Control variables (t-2 for Col. 1, t-1 for Col. 2)		
Firm Size	0.0164***	0.0353
	(0.00352)	(0.0232)
Firm Age	−0.00356	−0.0330
	(0.00411)	(0.0328)
Leverage	−0.0423***	−0.148*
	(0.0119)	(0.0784)
Return on Asset	0.200***	0.306**
	(0.0211)	(0.134)
Board Independence	0.0179	0.0773
	(0.0130)	(0.0879)
Institutional Ownership	0.000126	−0.000555
	(0.000143)	(0.000889)
CEO-Chair Duality	0.00130	−0.0139
	(0.00374)	(0.0222)
Regional GDP per Capita	−0.0160	−0.141
	(0.0115)	(0.0928)
Industry Green Innovation Average	0.00190	−0.0103
	(0.00248)	(0.0162)
Constant	4.120***	−0.130
	(0.139)	(1.155)
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	6983	8202
Number of firms	1233	1379
R-squared	0.092	0.163

Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)

Path	Coefficient	Bootstrap SE	z	*p*	95% CI (normal)	95% CI (percentile)	95% CI (bias-corrected)
a: GI(*t*-2) → ESG(*t*-1)	0.0026	0.00132	1.94	0.053	[−0.0000, 0.0051]	[−0.0001, 0.0038]	[0.0001, 0.0064]

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TABLE 11 | (Continued)

Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)

Path	Coefficient	Bootstrap SE	z	*p*	95% CI (normal)	95% CI (percentile)	95% CI (bias-corrected)
b: ESG(*t*-1) → SOL(*t*)	0.1539	0.12681	1.21	0.225	[−0.0946, 0.4025]	[−0.0930, 0.4013]	[−0.0855, 0.4079]
Indirect effect ($a \times b$)	**0.0004**	**0.00031**	**1.29**	**0.198**	**[−0.0002, 0.0010]**	**[−0.0003, 0.0010]**	**[0.0001, 0.0022]**
Direct effect (GI → SOL)	0.0235	0.00876	2.69	0.007	[0.0064, 0.0407]	[0.0065, 0.0408]	[0.0067, 0.0412]
Total effect (Direct + Indirect)	0.0239	0.00879	2.72	0.006	[0.0067, 0.0412]	[0.0065, 0.0411]	[0.0072, 0.0417]

Note: This table tests Hypothesis 3(a) against reverse causality, with green innovation at *t*-2, ESG at *t*-1, and SOL at t so the mediation chain reflects a genuine temporal sequence. Column (1) presents the first-stage regression (ESG at *t*-1 on GI and controls at *t*-2); Column (2) presents the second-stage regression (SOL at t on ESG and GI at *t*-1, controls at *t*-1). Fixed effects and clustering follow Section 3.2. The indirect effect is evaluated via a firm-cluster bootstrap with 5000 replications (Panel B). Bootstrap based on 5000 replications clustered on firms (stockcode); cluster count varies slightly by resample due to the two-period lag structure. Consistent with Tables 4 and 10, the bias-corrected (BC) confidence interval is treated as the primary inferential criterion given the known skewness in the sampling distribution of the indirect effect. The BC 95% CI [0.0001, 0.0022] excludes zero, supporting a statistically significant indirect effect despite a nonsignificant normal-based test ($p = 0.198$). Robust standard errors in parentheses.

***$p < 0.01$.

**$p < 0.05$.

*$p < 0.1$.

Market Development interaction ($\beta = 0.00387$) implies that the legitimacy return to green innovation rises by only 0.00387 SD for each one-unit increase in the PMD index, a modest amplification relative to the direct effect. This is consistent with the finding that ESG-mediated legitimacy accounts for only about 5% of green innovation's total effect (Section 4.3.1). Overall, the results indicate a modest legitimacy return to environmental strategy operating through multiple channels rather than through a single dominant mechanism.

Consistent with our mediation results, ESG engagement serves as the key mechanism through which green innovation is translated into legitimacy. The mediating role of ESG engagement reinforces legitimacy as socially constructed, communicatively performed, and symbolically mediated (Bitektine 2011; Suchman 1995). ESG engagement translates internal innovation into externally legible signals that resonate with institutional audiences—regulators, affiliated media, and political gatekeepers, particularly in contexts of opacity and information asymmetry. This aligns with emerging research highlighting ESG's performative and communicative dimensions in legitimacy construction (Abdullah et al. 2024; Ioannou and Serafeim 2015). Recent evidence from Zhang and Wang (2024) reinforces this signaling perspective, showing that China's mandatory ESG disclosure policy significantly strengthened the transmission of green innovation into visible reputational gains by facilitating both policy recognition and improved access to financing.

However, symbolic signaling also introduces the risk of decoupling, where formal ESG commitments diverge from substantive sustainability outcomes. In politically supervised environments, disclosure regimes may incentivize ritualized or ceremonial compliance, enabling firms to construct legitimacy facades (Heugens and Lander 2009). This resonates with Fornasari (2020), who finds that state-driven ESG systems—such as those operated by stock exchanges—prioritize transparency metrics over accountability. Similarly, Ansari et al. (2013) argue that symbolic and cognitive logics often dominate ESG adoption, while Bartley (2018) describes such systems as "rules without rights," offering the veneer of compliance without institutionalized reform. Henisz and Zelner (2005) likewise show that in politically mediated governance systems, symbolic structures are strategically maintained to preserve legitimacy. These dynamics underscore the importance of distinguishing ESG as signal from ESG as substance, especially in state-centered ESG regimes that may privilege symbolic legitimacy more than genuine performance (Christensen et al. 2017).

Our findings also highlight the conditioning role of institutional context. The sub-dimension analysis reveals two further nuances that qualify this conditioning logic. First, the moderating effect of institutional quality is not uniform across all facets of regional marketization. While Non-State Sector Development, Factor Market Development, and Legal and Institutional Environment each strengthen the conversion of green innovation into ESG engagement—consistent with the composite Marketization Index—Product Market Development shows the opposite pattern: green innovation converts into ESG engagement *less* readily in provinces with more developed product markets. One plausible explanation is that product market competition offers firms an alternative channel for establishing legitimacy that substitutes for, rather than complements, ESG signaling. In highly competitive product markets, firms may gain reputational standing through price competitiveness, market share, and consumer-facing performance metrics that are directly observable to stakeholders, reducing their reliance on ESG disclosure as a signaling mechanism specifically. This stands in contrast to Government–Market Relationship, which shows no significant moderating effect at either stage, suggesting that the state–market balance in a given province—as distinct from the openness of its product markets—does not systematically affect how firms translate environmental innovation into visible sustainability engagement.

Second, the results reveal an asymmetry in the moderated mediation pathway: institutional quality significantly moderates

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TABLE 12 | Robustness check: Moderated mediation analysis for Hypothesis 3b, alternative measure of Green Innovation (citation-based).

Panel A: Regression results		
Variables	**(1) ESG Engagement**	**(2) SOL**
Independent variable		
Green Innovation (Citation)	0.000347	0.0157*
	(0.000941)	(0.00822)
Mediator		
ESG		0.278**
		(0.139)
Moderator		
Marketization Index	−0.0000406	−0.0280
	(0.00319)	(0.0244)
Interaction term		
Green Innovation (Citation) × Marketization Index	0.000167	
	(0.000514)	
ESG × Marketization Index		0.0178
		(0.0685)
Control variables		
Firm Size	0.0270***	0.0701**
	(0.00368)	(0.0299)
Firm Age	0.0151***	0.00348
	(0.00560)	(0.0391)
Leverage	−0.0814***	−0.127
	(0.0157)	(0.101)
Return on Asset	0.0121	0.0486
	(0.0277)	(0.173)
Board Independence	0.0315**	0.128
	(0.0136)	(0.116)
Institutional Ownership	−3.14e-05	0.000122
	(0.000174)	(0.00125)
CEO-Chair Duality	0.000253	−0.00737
	(0.00438)	(0.0283)
Regional GDP per Capita	−0.00985	−0.0520
	(0.0153)	(0.117)
Industry Green Innovation Average	−0.00192	−0.0116
	(0.00344)	(0.0218)
Constant	−0.484***	−1.269
	(0.177)	(1.369)
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes

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TABLE 12 | (Continued)

Panel A: Regression results		
Variables	**(1) ESG Engagement**	**(2) SOL**
Observations	6603	6603
Number of firms	1289	1289
R-squared	0.515	0.561

Panel B: mediation path estimates (firm-cluster bootstrap, 5000 replications)					
-Path	**Coefficient**	**Bootstrap SE**	***z***	***p***	**95% CI (normal)**
a1: GI (Citation) → ESG	0.0003	0.00084	0.41	0.679	[−0.0013, 0.0020]
a3: GI (Citation) × IQ → ESG	0.0002	0.00047	0.36	0.720	[−0.0007, 0.0011]
b1: ESG → SOL	0.2776	0.12453	2.23	0.026	[0.0336, 0.5217]
b3: ESG × IQ → SOL	0.0178	0.06201	0.29	0.774	[−0.1037, 0.1394]
Direct effect (GI → SOL)	0.0157	0.00741	2.11	0.035	[0.0011, 0.0302]

Panel C: Conditional indirect effects at levels of the Marketization Index				
Moderator level	**Indirect effect**	**Bootstrap SE**	**95% CI (normal)**	**95% CI (bias-corrected)**
Low (−1 SD)	0.0000	0.00034	[−0.0007, 0.0007]	[−0.0007, 0.0008]
Mean	0.0001	0.00027	[−0.0004, 0.0006]	[−0.0003, 0.0009]
High (+1 SD)	0.0002	0.00045	[−0.0007, 0.0011]	[−0.0004, 0.0016]

Note: This table re-estimates the moderated mediation model in Table 5 using Green Patent Citations (CSMAR) in place of patent counts. Column (1) models ESG as a function of citation-based GI, IQ, and their interaction (Equation 5); Column (2) models SOL as a function of ESG, citation-based GI, IQ, and the ESG × IQ interaction (Equation 6). Fixed effects and clustering follow Section 3.2. Panel C reports conditional indirect effects at low (−1 SD), mean, and high (+1 SD) levels of the Marketization Index via a firm-cluster bootstrap (5000 replications). Bootstrap based on 5000 replications clustered on 1289 firms (stockcode). Consistent with prior tables, the bias-corrected (BC) confidence interval is treated as the primary inferential criterion. None of the three conditional indirect effects (low, mean, high) reach statistical significance under this criterion, consistent with the nonsignificant first-stage moderation (a3) reported in Panel B, and in contrast to the contemporaneous patent-count specification (Table 5), where the indirect effect was significant at mean and high levels of institutional quality. Robust standard errors in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

the first-stage relationship between green innovation and ESG engagement in five of the six specifications, although the direction of moderation varies across institutional dimensions. No significant second-stage moderation is observed. This asymmetry suggests that once a firm's sustainability efforts are rendered visible through ESG engagement, the state's recognition of that signal operates relatively uniformly across regions, regardless of local market institutional quality. This is consistent with the top-down, centrally administered character of state-oriented legitimacy conferral described in Section 2.1: while the *production* of credible ESG signals is shaped by local institutional conditions—market competition, legal infrastructure, ownership structure—the *evaluation* of those signals by state and quasi-state actors may follow more standardized criteria that are less sensitive to subnational variation. Future research could usefully examine whether this asymmetry reflects genuine uniformity in state evaluation processes, or whether it instead reflects limitations in the institutional-quality proxies used here to capture variation in how legitimacy is conferred once signals are sent.

5.2 | Managerial and Policy Implications

The findings have implications for managers and policymakers operating within state-capitalist environments. ESG engagement may function either as a substantive transformation mechanism or a symbolic compliance tool, depending on firms' strategic intent, capability, and institutional context. Because these implications are derived from China's specific institutional architecture—a province-level marketization index, a centralized CSR/ESG disclosure infrastructure (CNRDS, Wind), and the post-2020 CSRC disclosure mandate—we frame them as illustrative of legitimacy dynamics under state capitalism rather than as claims that travel uniformly across all state-led or authoritarian economies. Countries vary substantially in bureaucratic capacity, the formality of state–firm linkages, and the availability of standardized disclosure infrastructure; the mechanisms described below presuppose institutional features that are not universal even among nominally similar regimes (see Section 5.3 for further discussion of this boundary condition).

For managers, particularly in politically embedded or state-dominated economies, our findings suggest that securing legitimacy requires a dual strategy: engaging in substantive green innovation while symbolically aligning with state priorities through ESG disclosure. Importantly, the results indicate that environmental strategy alone is insufficient; firms must actively translate innovation into ESG signals that are legible within institutional evaluation systems. Where bottom-up stakeholder pressures are muted, ESG serves as both a legitimacy shield and

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TABLE 13 | Endogeneity check: moderated mediation analysis for Hypothesis 3b, temporally separated specification (Marketization Index).

Panel A: Regression results		
Variables	**(1) ESG engagement(*t*-1)**	**(2) SOL**
Independent variable		
Green Innovation (GI), *t*-2	0.00183	
	(0.00144)	
Green Innovation (GI), *t*-1		0.0208**
		(0.00884)
Mediator		
ESG Engagement, *t*-1		0.109
		(0.133)
Moderator		
Marketization Index, *t*-2	−0.00201	
	(0.00269)	
Marketization Index, *t*-1		−0.0276
		(0.0186)
Interaction term		
Green Innovation × Marketization Index, *t*-2	0.00198***	
	(0.000530)	
ESG × Marketization Index, *t*-1		0.0656
		(0.0574)
Control Variables (t-2 for Col. 1, t-1 for Col. 2)		
Firm Size	0.0175***	0.0316
	(0.00390)	(0.0241)
Firm Age	−0.00367	−0.0316
	(0.00469)	(0.0339)
Leverage	−0.0377***	−0.143*
	(0.0135)	(0.0810)
Return on Asset	0.189***	0.242
	(0.0235)	(0.149)
Board Independence	0.0211	0.0812
	(0.0131)	(0.0942)
Institutional Ownership	1.57e-05	−0.000905
	(0.000146)	(0.000924)
CEO-Chair Duality	0.000306	−0.0183
	(0.00396)	(0.0243)
Regional GDP per Capita	−0.0155	−0.107
	(0.0121)	(0.0955)
Industry Green Innovation Average	0.00460*	−0.0151
	(0.00259)	(0.0179)

(Continues)

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TABLE 13 | (Continued)

Panel A: Regression results		
Variables	**(1) ESG engagement(*t*-1)**	**(2) SOL**
Constant	−0.197	0.327
	(0.152)	(1.113)
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	6006	7549
Number of firms	1089	1303
R-squared	0.089	0.161

Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)					
Path	**Coefficient**	**Bootstrap SE**	***z***	***p***	**95% CI (normal)**
a1: GI(t-2) → ESG(*t*-1)	0.0018	0.00144	1.28	0.202	[−0.0010, 0.0046]
a3: GI × IQ(t-2) → ESG(*t*-1)	0.0020***	0.00054	3.71	< 0.001	[0.0009, 0.0030]
b1: ESG(t-1) → SOL(t)	0.1092	0.13229	0.83	0.409	[−0.1500, 0.3685]
b3: ESG × IQ(t-1) → SOL(t)	0.0656	0.05866	1.12	0.263	[−0.0493, 0.1806]
Direct effect (GI → SOL)	0.0208**	0.00897	2.32	0.021	[0.0032, 0.0384]

Panel C: Conditional indirect effects of GI on SOL via ESG, at levels of Marketization Index				
Moderator level	**Indirect effect**	**Bootstrap SE**	**95% CI (normal)**	**95% CI (bias-corrected)**
Low (−1 SD)	0.0000	0.00033	[−0.0006, 0.0007]	[−0.0006, 0.0008]
Mean	0.0002	0.00035	[−0.0005, 0.0009]	[−0.0001, 0.0015]
High (+1 SD)	0.0012	0.00121	[−0.0011, 0.0036]	[−0.0005, 0.0046]

Note: This table tests Hypothesis 3b against reverse causality, with green innovation and institutional quality at t-2, ESG and its interaction with institutional quality at t-1, and SOL at t. Column (1) presents the first-stage regression (ESG at t-1 on GI, IQ, and their interaction at t-2); Column (2) presents the second-stage regression (SOL at t on ESG, GI, IQ, and the ESG × IQ interaction, all at t-1). Fixed effects and clustering follow Section 3.2. The conditional indirect effects are evaluated via a firm-cluster bootstrap (5000 replications, Panel C). Bootstrap based on 5000 replications clustered on firms (firmid); cluster count varies by equation due to the two-period lag structure (1089 for Step 1, 1303 for Step 2). Consistent with prior tables, the bias-corrected (BC) confidence interval is treated as the primary inferential criterion. None of the three conditional indirect effects (low, mean, high) reach statistical significance under this criterion, in contrast to the contemporaneous specification (Table 5), where the indirect effect was significant at mean and high levels of institutional quality. The first-stage moderation (a3) remains significant, indicating the moderating role of institutional quality in the conversion of green innovation into ESG engagement is not an artifact of contemporaneous simultaneity, though the compounded conditional indirect effect is more sensitive to the temporal separation imposed by this specification. Robust standard errors in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

a policy-alignment signal (Alonso-Almeida et al. 2024). This highlights the need for strategic sequencing, where firms first build substantive capabilities and then communicate them effectively within institutional frameworks.

For multinational firms and global investors, these findings highlight the importance of interpreting ESG disclosures in light of the institutional context in which they are produced, particularly in China and in other state-capitalist systems with centralized disclosure infrastructures and policy-linked evaluation mechanisms. In such settings, ESG scores may reflect compliance with domestic legitimacy norms more than adherence to global sustainability frameworks such as Global Reporting initiative, Task Force on Climate-related Financial Disclosures, or Sustainability Accounting Standards Board. This may create a signaling mismatch, as international audiences may interpret ESG according to different institutional expectations and overlook their role in demonstrating alignment with state priorities. However, we do not assume that this argument extends to all state-capitalist systems. Countries with less developed or less standardized ESG reporting infrastructures than China may exhibit different signalling dynamics. Within the settings to which these implications apply, ESG disclosure should be interpreted cautiously, as reporting practices may not always reflect substantive sustainability performance (Ştefănescu and Suciu 2026).

From a policy perspective, our findings highlight the importance of institutional mechanisms that reward substantive ESG engagement—including standardized impact auditing and transparent disclosure systems—rather than symbolic compliance alone. Civil society plays a limited role in authoritarian ESG ecosystems, but expanding channels for stakeholder input, grievance mechanisms, and whistleblower protection could improve the balance between symbolic and substantive legitimacy without undermining the institutional logic of state-centered evaluation.

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TABLE 14 | Effect of green innovation on individual legitimacy dimensions.

Panel A. Contemporaneous specification (N = 9788; 1600 firms)			
Legitimacy dimension	**Coefficient**	**Std. error**	**Contribution to composite effect**
Trust and reputation	0.0100	(0.0148)	4.7%
Community acceptance	0.0277**	(0.0125)	6.6%
Procedural fairness	0.0145	(0.0125)	10.3%
Environmental legitimacy	0.0244*	(0.0141)	28.9%
Social conflict	0.0259	(0.0158)	36.8%
Political legitimacy	0.0178*	(0.0106)	12.7%
Panel B. One-period lagged specification (N = 8305; 1400 firms)			
Legitimacy dimension	**Coefficient**	**Std. error**	**Contribution to composite effect**
Trust and reputation	0.0354**	(0.0168)	14.9%
Community acceptance	0.0348**	(0.0135)	7.3%
Procedural fairness	0.0177	(0.0142)	11.2%
Environmental legitimacy	0.0352**	(0.0154)	37.1%
Social conflict	0.0180	(0.0196)	22.8%
Political legitimacy	0.0104	(0.0112)	6.6%

Note: Each row is a separate firm and year fixed-effects regression with the standardised dimension score as the dependent variable and the full baseline control set. Standard errors are clustered by firm. Contribution is the dimension's weighted coefficient expressed as a share of the summed weighted coefficients. All 12 coefficients are positive.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

TABLE 15 | Green innovation and SOL under alternative index constructions.

Dependent variable	**ESG-overlapping weight removed**	**Contemporaneous**	**Lagged**
SOL, theory-weighted (baseline)	—	0.0397*** (0.0137)	—
SOL excluding environmental dimension	25%	0.0364** (0.0143)	0.0361** (0.0174)
SOL excluding environmental and procedural	40%	0.0361** (0.0152)	—
SOL, state-facing dimensions only	55%	0.0309** (0.0149)	0.0206 (0.0182)
SOL, equally weighted	—	0.0359*** (0.0124)	—
Random weightings (200 Dirichlet draws)	—	Positive in 100%; significant in 86%	—

Note: All specifications include firm and year fixed effects, the full baseline control set, and standard errors clustered by firm. Correlations of the alternative indices with the baseline index are 0.890, 0.772, 0.592 and 0.926 respectively.
***$p < 0.01$.
**$p < 0.05$.

5.3 | Limitations and Future Research

Several limitations provide avenues for future research. First, although our SOL index incorporates a Social Conflict/Opposition dimension, it relies on observable and state-sanctioned proxies (e.g., CSR disclosures, media reports, penalties). In authoritarian contexts, protest activity and reputational crises may be suppressed or selectively disclosed, rendering conflict indicators incomplete. Future studies could incorporate unstructured data (social media, leaked documents, web-scraped protest logs) or alternative legitimacy metrics beyond official channels.

Second, while we account for provincial-level variation using the China Marketization Index, more granular institutional heterogeneity may influence legitimacy strategies. Future work could integrate city-level governance indicators, industry-specific regulatory fragmentation, or sectoral ESG enforcement variation to examine differences within provinces.

Third, although China is a prototypical state-capitalist regime, future research should explore whether SOL generalizes to other state-led or authoritarian-capitalist contexts such as Vietnam, the UAE, Saudi Arabia, or Russia. Comparative studies could

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TABLE 16 | Summary of empirical tests for Hypotheses 1–3.

Hypothesis	Description	Key path(s)	Significance	Supported?	Key findings
H1	Green innovation positively influences state-oriented legitimacy	GI → SOL	$\beta = 0.0397$, $p < 0.01$	Partial ✓	Robust across quantile regression, citation-based measure (Table 6), and lagged specification (Table 7)
H2	Institutional quality moderates the GI → SOL relationship	GI × IQ → SOL	Significant only for Product Market Development ($\beta = 0.00387$, $p < 0.1$, strengthening to $p < 0.01$ under the lagged specification, Table 9)	Partial ✓	The composite Marketization Index interaction is not significant (corrected from the original manuscript text); only PMD shows robust moderation (Tables 2, 7, and 8)
H3a	ESG engagement mediates the relationship between GI and SOL	GI → ESG → SOL	Indirect effect significant via BC CI ($\beta = 0.0011$, BC CI [0.0002, 0.0025])	Partial ✓	Partial mediation: direct effect dominates (~95% of total effect). Mediation holds for patent-count GI (Table 4) and under temporal separation (Table 10), but not for citation-based GI (Table 9)
H3b	Indirect effect of GI on SOL via ESG is conditional on institutional quality	First stage: GI × IQ → ESG; Second stage: ESG × IQ → SOL	First stage significant ($\beta = 0.0014$, $p < 0.01$); second stage not significant ($\beta = 0.031$, $p = 0.526$)	Partial ✓	Moderation confirmed only at the first stage; conditional indirect effect strengthens with IQ but weakens under temporal separation (Table 11)
H3b–GMR	Sub-dimension: Government–Market Relationship	GI × GMR → ESG; ESG × GMR → SOL	Neither stage significant	×	No moderating role detected for GMR (Appendix C)
H3b–NSD	Sub-dimension: Non-State Sector Development	GI × NSD → ESG; ESG × NSD → SOL	First stage significant, positive ($p < 0.05$); second stage not significant	Partial ✓	Same pattern as composite index (Appendix D)
H3b–PMD	Sub-dimension: Product Market Development	GI × PMD → ESG; ESG × PMD → SOL	First stage significant, negative ($p < 0.01$); second stage not significant	Reversed	Conversion of GI into ESG is weaker, not stronger, in provinces with more developed product markets—opposite direction from the composite index (Appendix E)
H3b–FMD	Sub-dimension: Factor Market Development	GI × FMD → ESG; ESG × FMD → SOL	First stage significant, positive ($p < 0.01$); second stage not significant	Partial ✓	Same pattern as composite index (Appendix F)
H3b–LIE	Sub-dimension: Legal and Institutional Environment	GI × LIE → ESG; ESG × LIE → SOL	First stage significant, positive ($p < 0.01$); second stage not significant	Partial ✓	Same pattern as composite index (Appendix G)

Note: This table summarizes the empirical results across all tested hypotheses, including main effects, mediation, and moderated mediation pathways, based on the two-step fixed-effects panel framework used throughout this study (Sections 3.2, 4.1–4.4). For H3b, both the composite Marketization Index and its five institutional sub-dimensions are analyzed. Significance levels for indirect and conditional indirect effects are based on bias-corrected (BC) bootstrap confidence intervals, consistent with the reporting convention established in Table 4.

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develop a typological theory of legitimacy across governance structures.

Fourth, our modeling framework treats legitimacy as relatively stable. Yet legitimacy in authoritarian systems is often episodic and shock-driven. Future research could employ event-study designs, dynamic panel methods (e.g., Arellano–Bond), or hazard models to analyze legitimacy erosion and recovery following policy shocks, scandals, or leadership changes.

Fifth, ESG may also function as a greenwashing mechanism, especially in low-transparency settings. Future research could examine ESG–performance decoupling using textual analysis, disclosure audits, or discrepancy indices, and further explore how different ESG rating providers influence the measurement and interpretation of legitimacy outcomes.

Finally, a further boundary condition concerns the temporal stability of the mediating mechanism. Re-estimating the first-stage path separately across sub-periods yields a significant coefficient before 2018 ($\beta = 0.0516$, $p < 0.01$) and a smaller, non-significant coefficient thereafter ($\beta = 0.0131$), although a formal test does not reject equality of the two estimates ($p = 0.157$). This pattern is consistent with the compression of ESG ratings that followed the expansion of mandatory disclosure requirements in China, which may reduce the extent to which green innovation differentiates firms on rating-based measures. This pattern suggests a possible temporal boundary condition that warrants further investigation, although the difference between the two periods is not statistically significant.

6 | Conclusion

Using panel data from Chinese listed firms, this study examines how green innovation relates to state-oriented legitimacy (SOL) in a state-capitalist context. The findings reveal a positive association between green innovation and SOL, partly mediated by ESG engagement. Institutional quality strengthens the relationship between green innovation and ESG engagement, although its moderating role varies across institutional dimensions, and no significant second-stage moderation is observed.

By examining state-oriented legitimacy (SOL) as an outcome of firms' environmental strategies, this study extends legitimacy and sustainability research beyond conventional market- and community-oriented perspectives. It highlights how legitimacy in state-capitalist contexts is shaped by alignment with policy priorities, ESG signalling, and institutional conditions.

The study further contributes to environmental strategy research by clarifying ESG engagement as a mechanism linking green innovation to state-oriented legitimacy. It also demonstrates that institutional conditions shape this relationship, particularly by moderating how green innovation translates into ESG engagement.

Environmental strategies do not automatically generate legitimacy. Their legitimacy implications depend on substantive environmental innovation, ESG engagement, and the institutional context in which these activities are evaluated.

Author Contributions

Li Xian Liu: conceptualization, methodology, investigation, validation, formal analysis, software, funding acquisition, writing – original draft, project administration, writing – review and editing, visualization, data curation. **Fuming Jiang:** writing – review and editing, conceptualization, methodology. **Xiaosong Zheng:** writing – review and editing, resources, data curation. **Breda McCarthy:** funding acquisition, writing – review and editing.

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Appendix A: Variable Descriptions

Variable	Description/construction	Unit/transformation	Data source
Dependent variable			
SOL (State-Oriented Legitimacy)	Firm-year average sentiment score from CNRDs binary database, including 46 items under 6 main themes.	Standardized index	CNRD database
Independent Variable			
Green Patent (CNRDS)	Measured by the number of green patents filed (solely or jointly) by firm *i* in year *t*. This proxy captures the firm's annual engagement in environmental technology development and innovation activities.	ln (1 + # of patents)	CNRDS
Green Patent Citation (CSMAR)	Measured by the number of citations received by green patents, both from domestic and international sources within China. This indicator reflects the influence, technological relevance, and diffusion impact of green innovations, with higher citation counts indicating greater recognition of environmentally related technologies.	ln (1 + # of citations)	CSMAR
Mediator			
ESG Performance	Composite ESG score based on third-party assessments of firm's environmental, social, and governance practices.	Continuous	WIND
Moderator			
Institutional Quality (Marketization Index)	Provincial-level marketization index measuring legal transparency, market openness, financial system maturity, and governance capacity.	*Mean-centered* to construct interaction terms.	Wang and Fan (2023); China Marketization Index
Government-Market Relationship (GMR)	Assesses the extent of government intervention versus market autonomy, including fiscal dominance, administrative control, and nontax burdens imposed on enterprises.	*Mean-centered* to construct interaction terms.	
Non-State Sector Development (NDS)	Measures the expansion and vitality of private and non-state-owned enterprises in production, investment, and employment, reflecting progress in ownership reform.	*Mean-centered* to construct interaction terms.	
Product Market Development (PMD)	Captures the degree of price liberalization, market competition, and reduction of regional trade barriers, highlighting the efficiency of goods allocation through market forces	*Mean-centered* to construct interaction terms.	
Factor Market Development (FMD)	Evaluates how freely and efficiently production factors such as labour, capital, and technology circulate across regions and sectors, emphasizing the depth of financial and labour market reforms.	*Mean-centered* to construct interaction terms.	
Legal and Institutional Environment (LIE)	Reflects the maturity of supporting institutions, including legal frameworks, market intermediaries (lawyers, accountants, credit agencies), and the protection of property and contractual rights.	*Mean-centered* to construct interaction terms.	
Control Variables			
Firm Size	Proxied by the book value of total assets. To address skewness, we used the natural logarithm of total assets (ln_total_assets); when total assets were nonpositive, the transformation ln(1 + total assets) was applied.	ln (total assets)	CSMAR

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Variable	Description/construction	Unit/transformation	Data source
Firm Age	Measured as the number of years since a firm's initial public listing, calculated as the difference between the financial year and the listing year. Negative values (pre-listing years) were recoded to zero. The natural logarithm of firm age (ln_firm_age_listing) was used to reduce skewness.	Years	CSMAR
ROA	Return on Assets (ROA) is calculated as net income divided by the average of total assets over the reporting period. This measure reflects how efficiently a firm uses its asset base to generate profits. Unlike point-in-time ROA measures, using average total assets provides a more stable and representative measure of asset utilization over time.	ROA = Net Income/average total assets	CSMAR
Leverage	Calculated as total liabilities divided by total assets. It reflects the proportion of a firm's assets financed by debt.	Ratio	CSMAR
Institutional Ownership	Calculated as the percentage of total share capital held by institutional investors. Reflects the ownership stake of institutions in the firm.	Percentage	CSMAR
Board Independence	Calculated as the number of independent directors divided by the total number of board directors. Measures the proportion of independent oversight within the board structure.	Percentage	CSMAR
Industry Green Innovation	Industry-level average values were constructed for key innovation and R&D-related firm-level variables to account for industry-specific trends and heterogeneity. The industry classification is based on the CSMAR 67-industry category system, using the variable Nindnme as the industry identifier. For each year and industry, we calculated the average of the following firm-level variables.	ln (1 + avg. industry green patents)	CSMAR, Constructed
Regional GDP per capita	Gross Domestic Product per capita for the region where the firm is registered, serving as a proxy for regional economic development, income level, and overall regional development. The variable is log-transformed to reduce skewness and allow for interpretation in percentage terms.	RMB (log-transformed)	NBS/Provincial Yearbooks

Appendix B: Construction of the SOL Index.

B.1 | Overview

This appendix details the construction of the state-oriented legitimacy (SOL) Index, developed using binary CSR indicators from the CNRDS database (2006–2023). Informed by Suchman (1995), Freeman (2010), DiMaggio and Powell (1983), and the SLO Pyramid Model (Boutilier and Thomson 2011), the index captures multiple dimensions of legitimacy within the context of China's state capitalism. Drawing on stakeholder, institutional, and legitimacy theories, we identify six legitimacy-related dimensions. Each consists of firm-year binary indicators classified as either advantage-type or concern-type; the latter are inverted prior to scoring for consistency.

B.2 | Variable Mapping and Inversion Logic

Table A1 maps each CNRDS variable to a SOL theme and indicates whether it represents a legitimacy-enhancing signal (advantage-type) or a potential threat (concern-type). Concern-type variables are inverted to ensure consistency in scoring direction.

Variable classification logic:

- *Advantage-type*: positive legitimacy signals (e.g., CSR Vision, Environmental Certification)
- *Concern-type*: negative signals (e.g., Accounting Violation, Mass Layoffs)

Eight concern-type indicators are inverted prior to scoring. Within Procedural Fairness these are Accounting Violation, No Female Executives and Employee Safety Dispute; within Environmental Legitimacy, Environmental Penalty and Pollutant Emissions; and within Social Conflict, all three indicators, namely Product Dispute, Financing Dispute and Mass Layoffs. Because all three Social Conflict indicators are inverted, higher scores on that dimension denote the absence of stakeholder opposition, and the dimension therefore enters the composite index with a positive weight.

B.3 | Worked Example: Theme Scoring for Firm XYZ

Each theme is measured using binary indicators coded as 1 (present) or 0 (absent). For firm i in year t and theme j, the theme score is:

$$ThemeScore_{it} = \frac{A_{ijt} - C_{ijt}}{N_{ijt}}$$

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TABLE A1 | CNRDS variables by SOL theme and type.

Theme and legitimacy type	Binary variables (from CNRDS)	Theoretical basis and justification
1. Trust and reputation (*cognitive legitimacy*)	- Product Quality Awards—CSR Vision—Inclusive HR—Vocational Training—Employee Shareholding—Employee Benefits	Reflects internal consistency, stakeholder trust, and perceptions of credibility and values (Deephouse & Carter, 2005).
2. Community acceptance (*pragmatic legitimacy*)	- Product Quality System—After-sales Service—Customer Satisfaction Survey—Support for Education—Charity Support—Volunteer Activities—International Aid—Employment Promotion—Local Economic Development	Indicates practical value to external stakeholders and alignment with social welfare priorities (Freeman 2010).
3. Procedural fairness (*moral legitimacy*)	- CSR Report Coverage—CSR Column—CSR Leadership—CSR Training—CSR Report Reliability—Anti-corruption Measures—Integrity & Fair Competition—Accounting Violation—Female Executives—Women on Board—No Female Executives—Safety Management System—Workplace Safety Training—Occupational Safety Certification—Employee Communication Channels—Employee Safety Dispute	Captures ethical governance, transparency, diversity, and workplace safety—key moral legitimacy components (DiMaggio and Powell 1983; Suchman 1995).
4. Environmental legitimacy (*normative legitimacy*)	- Environmentally Friendly Product—Three-Waste Reduction—Circular Economy—Energy Conservation—Green Office—Environmental Certification—Environmental Recognition—Environmental Penalty—Pollutant Emissions	Reflects adherence to environmental norms and regulatory expectations (Christmann and Taylor 2001).
5. Social conflict/opposition (*stakeholder resistance/institutional pressure*)	- Product Dispute—Financing Dispute—Mass Layoffs	Signals legitimacy withdrawal due to stakeholder backlash or regulatory scrutiny (Kostova and Zaheer 1999).
6. Political legitimacy (*authoritative/regulatory legitimacy*)	- Party Member in Leadership—SOE or State Shareholding—Government Subsidy	Indicates political alignment and reduced nonmarket risk in state-capitalist systems (Li et al. 2008; Nee and Opper 2012).

where:

A_{ijt}: Count of "advantage" binary variables = 1

C_{ijt}: Count of "concern" binary variables, each entering as one minus its raw value

N_{it}: Total number of nonmissing binary variables for this theme

This yields scores from −1 (all concerns) to +1 (all advantages); 0 indicates neutral legitimacy.

- Total advantages = 3
- Total concerns (after inversion) = 1
- Total nonmissing variables = 7

$$S_{xyz,Fairness,2021} = \frac{3-1}{7} \approx 0.286$$

Raw scores are then z-standardized:

$$Z_{Theme} = \frac{ThemeScore_{it} - \mu_{theme}}{\sigma_{Theme}}$$

where:

- μ_{theme}: Mean of theme across all firms and years
- σ_{Theme}: Standard deviation of theme

B.4 | Composite SOL Index: Weighting Scheme

We construct the composite index using two approaches:

- Equal weighting:

$$SOL_{it}^{equal} = \frac{1}{6}\sum_{1}^{6} Z_{i,jt}$$

- Context-sensitive weighting:

$$SOL_{it}^{weighted} = \sum_{j=1}^{6} w_j Z_{i,jt}$$

The relative weights assigned to the six dimensions (Table A3) are theoretically derived rather than statistically estimated, consistent with the formative specification of the index (Section 3.2). They operationalize the distinctions developed in Section 2.1 between the substantive and symbolic bases of legitimacy and between state-facing and stakeholder-facing audiences under state capitalism (Suchman 1995; Musacchio and Lazzarini 2014).

Two dimensions carry the largest weights because they most directly index state-facing, authoritative legitimacy—the form that most sharply distinguishes SOL from the community-based SLO construct. Social Conflict/Opposition (30%) is weighted highest because visible unrest constitutes the most immediate signal of legitimacy withdrawal to state authorities responsible for social stability (Suchman 1995). Political Legitimacy (15%) captures direct institutional embeddedness—party presence in leadership and state ownership—and is retained despite its low variance (Section 3.2) because it is the dimension most proximate to the authoritative legitimacy theorized in Section 2.1 (Musacchio and Lazzarini 2014; Marquis and Qian 2014).

Environmental Legitimacy (25%) is weighted second-highest because it is the primary channel of substantive legitimacy under state capitalism and the dimension through which green innovation is theorized to operate

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TABLE A2 | Example (procedural fairness for firm XYZ in 2021).

Indicator	Type	Raw value	Inversion applied	Score contribution
Csr_report	Advantage	1	No	+1
CSR_training	Advantage	1	No	+1
CSR_report_reliable	Advantage	0	No	0
Accounting_violation	Concern	1	Yes	−1
Employee_safety_dispute	Concern	0	Yes	0
Safety_mgmt_system	Advantage	1	No	+1
Female_execs	Advantage	0	No	0

TABLE A3 | Context-sensitive weighting of legitimacy dimensions for the composite state-oriented legitimacy (SOL) index.

Theme	Weight	Rationale
Social conflict/opposition	30%	Most visible form of legitimacy withdrawal, e.g., protests, crises
Environmental legitimacy	25%	Central to state mandates and public expectations
Procedural fairness	15%	Reflects moral legitimacy and transparency
Political legitimacy	15%	Captures alignment with CCP/state structures crucial to market access
Trust and reputation	10%	Indirect result of strong governance and ESG alignment
Community acceptance	5%	Hard to observe directly due to media censorship; outcome of other factors

Note: This structure balances the dual imperatives of state approval and stakeholder trust in China's censored information environment.

(H1; Clarkson et al. 2008; Patten 1992). Procedural Fairness (15%) reflects moral legitimacy (Suchman 1995) and is weighted equally to Political Legitimacy as a distinct but comparably important institutional signal.

The two remaining dimensions receive the lowest weights because they are the most stakeholder-facing and least observable to state evaluators in a censored information environment (Section 3.2). Trust & Reputation (10%) is treated as a downstream consequence of sustained ESG and governance conduct rather than an independent channel. Community Acceptance (5%) receives the lowest weight because public sentiment is the most heavily censored and least observable of the six bases, limiting its informativeness even though it remains conceptually part of the construct.

We note that these weights reflect a defensible theoretical judgment rather than a statistically estimated or formally elicited quantity—a limitation inherent to any formative index for which no single correct empirical weighting exists (Bollen and Lennox 1991; Diamantopoulos and Winklhofer 2001; Nardo, Saisana, Saltelli, Tarantola, Hoffmann, & Giovannini, 2008). We therefore do not rely on the precision of the specific percentages for the credibility of our results; Section 4.4.10 shows the effect of green innovation on SOL is positive and, in the large majority of specifications, significant across an unweighted average, two data-driven weightings, and 200 randomly drawn weight vectors.

B.5 | Composite SOL Indices and Validation Strategy

To capture the multidimensional nature of SOL, we construct four alternative versions of the composite SOL index. These variants reflect both theory-driven and data-driven aggregation strategies, each applied to the six standardized legitimacy dimensions introduced earlier. This approach ensures that our findings are not dependent on a single index construction method and allows for robustness checks across different operationalizations of the latent construct.

Table A4 summarizes the construction logic of each index. The first two indices rely on theoretical considerations: a weighted index, which applies context-sensitive weights derived from legitimacy theory and China's institutional context, and an unweighted average, which assumes equal importance across all six dimensions. The latter two indices are empirically derived: one based on Principal Component Analysis (PCA) and the other on Exploratory Factor Analysis (EFA), capturing the dominant latent structure in the underlying legitimacy indicators.

TABLE A4 | Overview of composite state-oriented legitimacy (SOL) index construction methods.

Index name	Description
SOL_index_weighted	Weighted sum of z-standardized theme scores using theory-driven weights
SOL_index_avg	Unweighted average of the six standardized theme scores
SOL_index_pca	First principal component extracted via Principal Component Analysis (PCA)
SOL_index_factor	Factor scores derived from Exploratory Factor Analysis (EFA)

All final indices are standardized post hoc for comparability. The weighted index serves as the main dependent variable in our empirical analysis, while the other variants are used for robustness checks.

We conduct Principal Component Analysis (PCA) on the six standardized theme scores. The first principal component explains 39.6% of the total variance (Refer to Table A5). The component loads most heavily on procedural fairness (0.53), community acceptance (0.52), trust and reputation (0.48), and environmental legitimacy (0.44). Conflict (−0.11) and political legitimacy (0.08) exhibit weak or negative loadings, suggesting that the first component captures a generalized stakeholder-oriented legitimacy dimension rather than direct alignment with state or political authority.

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TABLE A5 | Principal component loadings of SOL themes on the first component.

Theme	Loading
Procedural fairness	0.5304
Community acceptance	0.5227
Trust and reputation	0.4839
Environmental legitimacy	0.4407
Political legitimacy	0.0751
Social conflict	−0.1071

TABLE A6 | Factor loadings of SOL themes on the first extracted factor.

Theme	Factor1 loading
Procedural fairness	0.8179
Community acceptance	0.8061
Trust and reputation	0.7461
Environmental legitimacy	0.6797
Political legitimacy	0.1158
Social conflict	−0.1652

To validate the underlying structure further, we apply Exploratory Factor Analysis (EFA) using principal component factoring. Consistent with the PCA results, the first factor also explains 39.6% of the total variance. The loading pattern mirrors the PCA findings, with strong coefficients on procedural fairness (0.82), community acceptance (0.81), trust and reputation (0.75), and environmental legitimacy (0.68), and weaker contributions from political legitimacy (0.12) and conflict (−0.17) Table A6.

B.6 | Convergence of Index Variants

We compute pairwise correlations among the four standardized indices. Table A7 shows strong convergence across methods, particularly between the PCA and factor-based indices ($r = 0.996$), and between the average and PCA/factor indices ($r \approx 0.90$). The theory-weighted index is moderately correlated with the data-driven indices ($r \approx 0.70$), reflecting some normative divergence but supporting convergent validity.

TABLE A7 | Pairwise correlations among standardized SOSL indices.

	Weighted	Average	PCA	Factor
Weighted	1.000	0.926	0.706	0.704
Average		1.000	0.895	0.895
PCA			1.000	0.996
Factor				1.000

B.7 | Conclusion

CSR indicators have long been employed in legitimacy research as externally visible signals of responsible corporate behavior. Actions such as environmental initiatives, transparency efforts, employee protections, and stakeholder engagement are often interpreted as strategic performances of legitimacy rather than mere compliance (Bitektine 2011; Suchman 1995). Prior studies have used CSR disclosures to assess organizational legitimacy (Deephouse and Carter 2005), stakeholder relationships (Wang et al. 2016), and political legitimacy in Chinese regulatory contexts (Li et al. 2021; Parsa et al. 2021). In the Chinese setting, where surveys or protest data are unreliable due to censorship, codified firm behaviours provide a context-sensitive and observable basis for inferring legitimacy. Our approach aligns with this logic.

In the Chinese context—where direct indicators such as protest or survey data are unreliable due to censorship—codified corporate behaviors provide a more consistent, observable, and context-sensitive basis for legitimacy assessment. Building on this premise, we develop a novel, multidimensional state-oriented legitimacy (SOL) Index grounded in firm-level CSR indicators from the CNRDS database.

The SOL Index captures diverse facets of legitimacy relevant to China's hybrid institutional setting, incorporating six theoretically informed dimensions. The theory-driven weighted index introduces normative components—particularly political legitimacy and stakeholder conflict—that are often underrepresented in purely data-driven approaches. Validation through Principal Component Analysis and Exploratory Factor Analysis confirms the empirical coherence of the underlying structure.

By combining normative theory with empirical validation, the SOL Index offers a robust and contextually grounded measure of corporate legitimacy. It enables systematic investigation of how firms in state-capitalist systems seek to secure both stakeholder trust and political endorsement—especially in environments where traditional legitimacy metrics are absent or obscured.

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Appendix C: Moderated Mediation Analysis for Hypothesis 3b: Indirect Effect of Green Innovation on State-Oriented Legitimacy via ESG, Conditional on Government-Market Relationship (GMR)

Estimated identically to Table 5, using GMR in place of the composite Marketization Index. Column (1) models ESG as a function of GI, GMR, and their interaction; Column (2) models SOL as a function of ESG, GI, GMR, and the ESG×GMR interaction. Fixed effects and clustering follow Section 3.2. Panel C reports conditional indirect effects at low (−1 SD), mean, and high (+1 SD) levels of GMR via a firm-cluster bootstrap (5000 replications).

Panel A: Regression results		
Variables	**(1) ESG**	**(2) SOL**
Independent variable		
Green Innovation (GI)	0.00216*	0.0194**
	(0.00118)	(0.00796)
Mediator		
ESG		0.473***
		(0.110)
Moderator		
Government-Market Relationship (GMR)	−0.00238	−0.0140
	(0.00146)	(0.0109)
Interaction term		
Green Innovation × GMR	−0.000381	
	(0.000516)	
ESG×GMR		0.0179
		(0.0672)
Control variables		
Firm Size	0.0252***	0.0584**
	(0.00324)	(0.0235)
Firm Age	0.00715*	0.00633
	(0.00409)	(0.0297)
Leverage	−0.0697***	−0.159**
	(0.0119)	(0.0746)
Return on Asset	0.0311	0.0256
	(0.0208)	(0.131)
Board Independence	0.0443***	0.0312
	(0.0117)	(0.0897)
Institutional Ownership	2.50e-05	0.000817
	(0.000135)	(0.000897)
CEO-Chair Duality	−0.000380	0.0124
	(0.00347)	(0.0212)
Regional GDP per Capita	−0.00319	−0.0772
	(0.0118)	(0.0924)
Industry Green Innovation Average	−0.00184	−0.0174
	(0.00252)	(0.0148)
Constant	−0.500***	−0.684
	(0.143)	(1.086)
Firm fixed effects	Yes	Yes

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Panel A: Regression results					
Variables			**(1) ESG**		**(2) SOL**
Year fixed effects			Yes		Yes
Observations			9660		9660
Number of firms			1572		1572
R-squared			0.500		0.564
Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)					
Path	**Coefficient**	**Bootstrap SE**	***z***	***p***	**95% CI (normal)**
a1: GI → ESG	0.0022	0.00108	2.01	0.045	[0.0000, 0.0043]
a3: GI × GMR → ESG	−0.0004	0.00047	−0.82	0.414	[−0.0013, 0.0005]
b1: ESG → SOL	0.4727	0.10092	4.68	< 0.001	[0.2749, 0.6705]
b3: ESG × GMR → SOL	0.0179	0.06272	0.28	0.776	[−0.1051, 0.1408]
Direct effect (GI → SOL)	0.0194	0.00718	2.70	0.007	[0.0053, 0.0334]
Panel C: Conditional indirect effects at levels of GMR					
Moderator level		**Indirect effect**	**Bootstrap SE**		**95% CI (bias-corrected)**
Low (−1 SD)		0.0012	0.00067		[0.0002, 0.0029]
Mean		0.0010	0.00058		[0.0000, 0.0024]
High (+1 SD)		0.0008	0.00074		[−0.0007, 0.0025]

Note: Bootstrap based on 5000 replications clustered on 1572 firms. Neither interaction term is significant; GMR does not significantly moderate either stage of the mediation pathway. Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Appendix D: Moderated Mediation Analysis for Hypothesis 3b: Indirect Effect of Green Innovation on State-Oriented Legitimacy via ESG, Conditional on Non-State Sector Development (NSD)

Panel A: Regression results		
Variables	**(1) ESG**	**(2) SOL**
Independent variable		
Green Innovation (GI)	0.00232**	0.0190**
	(0.00115)	(0.00793)
Mediator		
ESG		0.476***
		(0.107)
Moderator		
Non-State Sector Development (NSD)	0.00104	−0.0123*
	(0.00105)	(0.00632)
Interaction term		
Green Innovation × NSD	0.000760*	
	(0.000399)	
ESG × NSD		0.0670
		(0.0487)
Control variables		

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Panel A: Regression results

Variables	(1) ESG	(2) SOL
Firm Size	0.0257***	0.0566**
	(0.00325)	(0.0235)
Firm Age	0.00730*	0.00618
	(0.00407)	(0.0297)
Leverage	−0.0700***	−0.159**
	(0.0118)	(0.0744)
Return on Asset	0.0291	0.0259
	(0.0209)	(0.131)
Board Independence	0.0437***	0.0283
	(0.0117)	(0.0899)
Institutional Ownership	2.29e-05	0.000789
	(0.000134)	(0.000894)
CEO-Chair Duality	−0.000511	0.0115
	(0.00347)	(0.0212)
Regional GDP per Capita	−0.00839	−0.0821
	(0.0121)	(0.0919)
Industry Green Innovation Average	−0.00163	−0.0157
	(0.00250)	(0.0147)
Constant	−0.456***	−0.618
	(0.146)	(1.077)
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	9660	9660
Number of firms	1572	1572
R-squared	0.500	0.565

Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)

Path	Coefficient	Bootstrap SE	z	*p*	95% CI (Normal)
a1: GI → ESG	0.0023	0.00106	2.19	0.029	[0.0002, 0.0044]
a3: GI × NSD → ESG	0.0008	0.00037	2.05	0.040	[0.0000, 0.0015]
b1: ESG → SOL	0.4761	0.09973	4.77	< 0.001	[0.2807, 0.6716]
b3: ESG × NSD → SOL	0.0670	0.04476	1.50	0.135	[−0.0208, 0.1547]
Direct effect (GI → SOL)	0.0190	0.00725	2.61	0.009	[0.0047, 0.0332]

Panel C: Conditional indirect effects at levels of NSD

Moderator level	Indirect effect	Bootstrap SE	95% CI (bias-corrected)
Low (−1 SD)	0.0003	0.00049	[−0.0005, 0.0014]
Mean	0.0011	0.00059	[0.0001, 0.0025]
High (+1 SD)	0.0023	0.00099	[0.0008, 0.0046]

Note: Estimated identically to Appendix C, using Non-State Sector Development (NSD) in place of GMR. Bootstrap based on 5000 replications clustered on 1572 firms. Both interaction terms show the same qualitative pattern as Table 5: significant first-stage moderation, non-significant second-stage moderation, and a conditional indirect effect that strengthens with institutional quality. Robust standard errors in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

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Appendix E: Moderated Mediation Analysis for Hypothesis 3b: Indirect Effect of Green Innovation on State-Oriented Legitimacy via ESG, Conditional on Product Market Development (PMD)

Panel A: Regression results		
Variables	**(1) ESG**	**(2) SOL**
Independent variable		
Green Innovation (GI)	0.00135	0.0195**
	(0.00117)	(0.00796)
Mediator		
ESG		0.468***
		(0.109)
Moderator		
Product Market Development (PMD)	−0.000139	0.00754
	(0.00111)	(0.00850)
Interaction term		
Green Innovation × PMD	−0.00122***	
	(0.000323)	
ESG × PMD		−0.00194
		(0.0426)
Control variables		
Firm Size	0.0255***	0.0597**
	(0.00322)	(0.0236)
Firm Age	0.00703*	0.00484
	(0.00405)	(0.0296)
Leverage	−0.0692***	−0.164**
	(0.0119)	(0.0748)
Return on Asset	0.0294	0.0213
	(0.0207)	(0.130)
Board Independence	0.0459***	0.0304
	(0.0116)	(0.0896)
Institutional Ownership	2.17e-05	0.000790
	(0.000134)	(0.000894)
CEO-Chair Duality	−0.000487	0.0126
	(0.00346)	(0.0212)
Regional GDP per Capita	−0.00787	−0.118
	(0.0125)	(0.0947)
Industry Green Innovation Average	−0.000974	−0.0169
	(0.00247)	(0.0147)
Constant	−0.463***	−0.294
	(0.152)	(1.117)
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	9660	9660
Number of firms	1572	1572

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Panel A: Regression results					
Variables			**(1) ESG**		**(2) SOL**
R-squared			0.502		0.564
Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)					
Path	**Coefficient**	**Bootstrap SE**	**z**	***p***	**95% CI (Normal)**
a1: GI → ESG	0.0014	0.00108	1.25	0.211	[−0.0008, 0.0035]
a3: GI × PMD → ESG	−0.0012	0.00030	−4.10	< 0.001	[−0.0018, −0.0006]
b1: ESG → SOL	0.4680	0.09942	4.71	< 0.001	[0.2732, 0.6629]
b3: ESG × PMD → SOL	−0.0019	0.03924	−0.05	0.961	[−0.0788, 0.0750]
Direct effect (GI → SOL)	0.0195	0.00723	2.69	0.007	[0.0053, 0.0337]
Panel C: Conditional indirect effects at levels of PMD					
Moderator level	**Indirect effect**	**Bootstrap SE**	**95% CI (Bias-Corrected)**		
Low (−1 SD)	0.0020	0.00083	[0.0006, 0.0041]		
Mean	0.0006	0.00055	[−0.0004, 0.0019]		
High (+1 SD)	−0.0007	0.00070	[−0.0025, 0.0003]		

Note: Estimated identically to Appendix C, using Product Market Development (PMD) in place of GMR. Bootstrap based on 5000 replications clustered on 1572 firms. The first-stage interaction is significant and **negative**, reversing the pattern observed in Table 5 and Appendix D: green innovation converts less readily into ESG engagement in provinces with more developed product markets, and the conditional indirect effect is significant at low, not high, levels of PMD. Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Appendix F: Moderated Mediation Analysis for Hypothesis 3b: Indirect Effect of Green Innovation on State-Oriented Legitimacy via ESG, Conditional on Factor Market Development (FMD)

Panel A: Regression results		
Variables	**(1) ESG**	**(2) SOL**
Independent variable		
Green Innovation (GI)	0.00170	0.0193**
	(0.00114)	(0.00793)
Mediator		
ESG		0.471***
		(0.106)
Moderator		
Factor Market Development (FMD)	0.00214**	−0.00937
	(0.00101)	(0.00713)
Interaction term		
Green Innovation × FMD	0.000795***	
	(0.000185)	
ESG × FMD		0.00479
		(0.0287)
Control variables		
Firm Size	0.0248***	0.0612***
	(0.00322)	(0.0235)

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Panel A: Regression results

Variables	(1) ESG	(2) SOL
Firm Age	0.00806**	0.00477
	(0.00401)	(0.0296)
Leverage	−0.0697***	−0.161**
	(0.0118)	(0.0745)
Return on Asset	0.0302	0.0164
	(0.0208)	(0.130)
Board Independence	0.0445***	0.0300
	(0.0115)	(0.0899)
Institutional Ownership	2.05e-05	0.000796
	(0.000133)	(0.000892)
CEO-Chair Duality	−0.000706	0.0121
	(0.00346)	(0.0212)
Regional GDP per Capita	−0.00235	−0.118
	(0.0121)	(0.0922)
Industry Green Innovation Average	−0.000692	−0.0166
	(0.00245)	(0.0147)
Constant	−0.503***	−0.358
	(0.145)	(1.085)
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	9660	9660
Number of firms	1572	1572
R-squared	0.502	0.564

Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)

Path	Coefficient	Bootstrap SE	*z*	*p*	95% CI (Normal)
a1: GI → ESG	0.0017	0.00107	1.59	0.111	[−0.0004, 0.0038]
a3: GI × FMD → ESG	0.0008	0.00017	4.70	< 0.001	[0.0005, 0.0011]
b1: ESG → SOL	0.4714	0.09723	4.85	< 0.001	[0.2809, 0.6620]
b3: ESG × FMD → SOL	0.0048	0.02622	0.18	0.855	[−0.0466, 0.0562]
Direct effect (GI → SOL)	0.0193	0.00712	2.71	0.007	[0.0053, 0.0333]

Panel C: Conditional indirect effects at levels of FMD

Moderator level	Indirect effect	Bootstrap SE	95% CI (bias-corrected)
Low (−1 SD)	−0.0006	0.00061	[−0.0021, 0.0004]
Mean	0.0008	0.00056	[−0.0001, 0.0021]
High (+1 SD)	0.0023	0.00097	[0.0009, 0.0049]

Note: Estimated identically to Appendix C, using Factor Market Development (FMD) in place of GMR. Bootstrap based on 5000 replications clustered on 1572 firms. Same qualitative pattern as Table 5 and Appendix D: significant, positive first-stage moderation; nonsignificant second-stage moderation; indirect effect strengthens with institutional quality. Robust standard errors in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

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Appendix G: Moderated Mediation Analysis for Hypothesis 3b: Indirect Effect of Green Innovation on State-Oriented Legitimacy via ESG, Conditional on Legal and Institutional Environment (LIE)

Panel A: Regression results		
Variables	**(1) ESG**	**(2) SOL**
Independent variable		
Green Innovation (GI)	0.00172	0.0191**
	(0.00114)	(0.00792)
Mediator		
ESG		0.459***
		(0.106)
Moderator		
Legal and Institutional Environment (LIE)	−0.00151*	0.00549
	(0.000776)	(0.00615)
Interaction term		
Green Innovation × LIE	0.000681***	
	(0.000179)	
ESG × LIE		0.0202
		(0.0286)
Control variables		
Firm Size	0.0246***	0.0603**
	(0.00321)	(0.0234)
Firm Age	0.00781*	0.00624
	(0.00401)	(0.0296)
Leverage	−0.0686***	−0.161**
	(0.0119)	(0.0747)
Return on Asset	0.0315	0.0127
	(0.0208)	(0.131)
Board Independence	0.0440***	0.0291
	(0.0116)	(0.0897)
Institutional Ownership	2.96e-05	0.000762
	(0.000132)	(0.000897)
CEO-Chair Duality	−0.000724	0.0116
	(0.00344)	(0.0212)
Regional GDP per Capita	−0.00434	−0.108
	(0.0118)	(0.0927)
Industry Green Innovation Average	−0.000559	−0.0162
	(0.00245)	(0.0147)
Constant	−0.489***	−0.385
	(0.143)	(1.091)
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes

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Panel A: Regression results					
Variables		**(1) ESG**			**(2) SOL**
Observations		9660			9660
Number of firms		1572			1572
R-squared		0.502			0.564
Panel B: Mediation path estimates (firm-cluster bootstrap, 5000 replications)					
Path	**Coefficient**	**Bootstrap SE**	***z***	***p***	**95% CI (normal)**
a1: GI → ESG	0.0017	0.00107	1.60	0.109	[−0.0004, 0.0038]
a3: GI × LIE → ESG	0.0007	0.00016	4.18	< 0.001	[0.0004, 0.0010]
b1: ESG → SOL	0.4588	0.09777	4.69	< 0.001	[0.2672, 0.6504]
b3: ESG × LIE → SOL	0.0202	0.02612	0.77	0.440	[−0.0310, 0.0713]
Direct effect (GI → SOL)	0.0191	0.00720	2.65	0.008	[0.0050, 0.0332]
Panel C: Conditional indirect effects at levels of LIE					
Moderator level	**Indirect effect**	**Bootstrap SE**			**95% CI (bias-corrected)**
Low (−1 SD)	−0.0004	0.00054			[−0.0018, 0.0004]
Mean	0.0008	0.00056			[−0.0001, 0.0021]
High (+1 SD)	0.0024	0.00097			[0.0009, 0.0047]

Note: Estimated identically to Appendix C, using Legal and Institutional Environment (LIE) in place of GMR. Bootstrap based on 5000 replications clustered on 1572 firms. Same qualitative pattern as Table 5, Appendix D, and Appendix F. Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

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