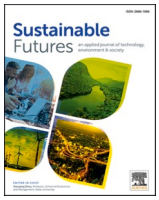
Sustainable Futures 10 (2025) 101110

Contents lists available at ScienceDirect

Sustainable Futures

journal homepage: www.sciencedirect.com/journal/sustainable-futures



Toward a sustainable future: ESG as a mediator of innovation and performance under institutional contingencies

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ARTICLE INFO

Keywords:
Technological innovation
ESG engagement
Conditional moderated mediation
Sustainability
Institutional quality

ABSTRACT

This study examines how technological innovation influences firm performance through the mediating role of Environmental, Social, and Governance (ESG) engagement, and how this relationship is conditioned by institutional quality and firm nature in China. Using panel data from 3,300 listed firms (2010–2023), we apply a moderated mediation framework with subnational institutional indicators and a binary ownership classification.

Quantitative results show that innovation enhances ESG engagement, which in turn improves firm performance when measured by ROA, but not by Tobin's Q. Specifically, innovation increases Huazheng ESG scores by 2.80–2.90 units and Wind scores by 3.60–3.70 units. A one-unit rise in Huazheng scores raises ROA by 2.1%, and Wind scores by 1.5%. Mediation analysis confirms a significant indirect effect of innovation on ROA via ESG (0.052–0.114), though the effect is negative for Tobin's Q (−0.122 to −0.319). The ESG-mediated pathway is further moderated by institutional conditions. The positive moderating effect of non-state sector development on the innovation–ESG link is stronger for SOEs, especially in regions with more developed private sectors. In contrast, factor market development and improvements in the legal-institutional environment strengthen the innovation–ESG relationship more for non-SOEs. Where property rights are better protected and resources more efficiently allocated, non-SOEs gain legitimacy and utilize resources more effectively.

These findings highlight ESG as a strategic channel for converting innovation into value, shaped by institutional and organizational contexts, and contribute to sustainability strategy literature by unpacking how institutional heterogeneity and ownership identity influence ESG-aligned innovation in emerging economies.

1. Introduction

Environmental, Social, and Governance (ESG) principles have become central to corporate strategy, reshaping how firms innovate, compete, and create long-term value. As sustainability considerations gain global momentum, the intersection of technological innovation and ESG engagement has emerged as a strategic frontier in responsible business practice. Firms increasingly integrate ESG and innovation goals, embedding sustainability into technological transformation to meet both performance expectations and broader societal objectives.

This study contributes to this growing dialogue by examining how firms in emerging markets align innovation with ESG engagement to enhance sustainable performance. Specifically, it addresses the practical and theoretical challenge of operationalizing ESG in complex institutional environments. It supports the United Nations Sustainable Development Goals (SDGs)—notably SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 16 (Peace, Justice and Strong Institutions)—by proposing a novel framework in which ESG engagement operates as a strategic mechanism shaped by both institutional quality and firm ownership nature.

Recent studies have highlighted the synergistic relationship between innovation and ESG performance. Firms with strong research and development (R&D) capabilities often achieve superior ESG outcomes, suggesting that innovation enhances a firm's capacity to implement sustainability initiatives effectively [9,30]. Beyond improving disclosures through AI-enabled systems and data infrastructures [33,40], technological advances also enable cleaner production, environmental monitoring, and inclusive governance practices [4,10,49]. These

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https://doi.org/10.1016/j.sftr.2025.101110
Received 28 May 2025; Received in revised form 28 July 2025; Accepted 2 August 2025
Available online 7 August 2025

developments enhance firm transparency, attract talent, and strengthen long-term resilience.

However, the performance outcomes of ESG-oriented innovation vary significantly across institutional contexts—particularly in China, where subnational differences are pronounced. The Marketization Index for China's Provinces captures five dimensions of institutional quality: the government–market relationship (GMR), development of the non-state sector (DNS), product market development (PMD), factor market development (FMD), and the legal and institutional environment (LIE). These dimensions shape how regional institutions support ESG innovation and govern firm behavior.

China's decentralized institutional environment and centralized policy agenda—such as the 14th Five-Year Plan's emphasis on green transformation—make it a salient case for studying ESG-innovation dynamics. In this context, ESG engagement can help firms enhance legitimacy, efficiency, and capital access. Yet, the impact of ESG on firm performance is conditional on regional institutional features: a balanced GMR fosters competition, a mature DNS encourages entrepreneurship, and a robust LIE supports enforcement and investor trust [49,51].

Despite growing research on ESG and innovation, important gaps remain. Few studies conceptualize ESG as a mediator in the innovation–performance relationship, especially in emerging markets. Moreover, the moderating role of subnational institutional quality—and how firm ownership influences this moderation—remains underexplored. These gaps hinder our understanding of how firms transform innovation capacity into sustainable value across diverse institutional and organizational settings.

To address these gaps, this study develops and empirically tests a conditional moderated mediation model, in which ESG engagement mediates the relationship between innovation and firm performance; institutional quality moderates this mediation; and firm ownership (state vs. non-state) serves as a second-order moderator. The core research problem centers on understanding how firms operating in institutionally diverse environments—such as China—can convert innovation capacity into sustainable performance through ESG engagement. The objective of the study is to clarify when, how, and for whom ESG engagement functions as a transmission channel between innovation and performance. The novelty of this work lies in three areas: (1) conceptualizing ESG not merely as a performance driver but as a strategic mediator; (2) operationalizing institutional heterogeneity at the subnational level using China's Marketization Index; and (3) introducing firm ownership nature as a second-order moderator that shapes the institutional effect on ESG–performance dynamics. This integrated framework provides new insight into how innovation and sustainability strategies interact under varied institutional and organizational conditions.

This study contributes to ESG–innovation research by integrating ESG engagement as a strategic mechanism through which firms convert innovation into performance outcomes. It also brings institutional theory into sharper focus by examining how subnational institutional quality and firm ownership interact to shape this relationship. By situating the analysis in China—a context marked by centralized governance and decentralized institutional variation—the study offers insights relevant to other emerging economies pursuing innovation-led sustainability transitions. A detailed discussion of the study's theoretical and empirical contributions is presented in Section 4.6.

The remainder of the paper is structured as follows. Section 2 presents the literature review and develops the theoretical foundation and research hypotheses. Section 3 outlines the research design, including data, variables, and empirical methodology. Section 4 presents the empirical results and provides discussion and implications. Section 5 concludes the study, highlighting key contributions and outlining directions for future research.

2. Theoretical background and hypothesis development

2.1. Literature foundations

The relationship between ESG engagement and firm performance has gained substantial attention in both developed and emerging markets. A growing body of research supports the idea that ESG strategies contribute positively to firm-level outcomes such as profitability, valuation, and stakeholder trust [7,11,47]. ESG engagement has been shown to reinforce operational efficiency, reduce reputational and regulatory risks, and promote long-term strategic resilience [6,16]. In China's capital market context, Jia et al. [21] confirm that institutional ownership enhances ESG outcomes and firm performance.

A more recent strand of research emphasizes ESG's role in reducing information asymmetry and agency costs, which in turn mitigates firm risk and increases investor confidence. For example, Sharma et al. [34] demonstrate that firms adopting SDGs experience lower firm-specific risk, driven by improved ESG performance and stakeholder alignment. This risk-mitigation function not only strengthens the strategic rationale for ESG integration but also reinforces its value-enhancing potential in capital markets. In a related study, Sharma et al. [35] show that ESG-oriented firms in India experience greater share price synchronicity, suggesting that ESG improves transparency and strengthens market-based valuation through incentive-compatible governance mechanisms. These findings are particularly relevant to our study's use of Tobin's Q as a performance metric.

Technological innovation has long been considered a key engine of firm competitiveness and value creation. Innovations in products, processes, and digital technologies enable firms to achieve efficiency gains, develop new markets, and adapt to changing stakeholder expectations. Empirical studies consistently find a positive relationship between innovation and firm performance across industries and institutional contexts. In China, innovation-driven strategies are often supported by industrial policy and capital markets, reinforcing their role in enhancing firm outcomes [5,52].

An emerging literature stream explores the mutual reinforcement between ESG and innovation. Firms that engage in R&D and digital transformation often exhibit stronger ESG performance, while those with ESG-oriented strategies tend to develop more sustainable, socially responsive innovations [5,26,52]. ESG practices are increasingly seen not just as outcomes of innovation but also as strategic mechanisms that enhance the performance impact of innovation efforts. For example, ESG adoption facilitates green innovation, stakeholder legitimacy, and reputational benefits, which help firms capture more value from innovation [34,37].

Recent studies further conceptualize ESG as a mediating mechanism that transforms innovation into performance outcomes. ESG capabilities—such as environmental stewardship, transparency, and social responsibility—serve as intangible assets that align with the resource-based view (RBV), offering firms competitive advantages that are valuable, rare, inimitable, and non-substitutable [3]. These ESG capabilities can bridge the gap between technological innovation and market valuation by enhancing legitimacy, stakeholder trust, and external resource access [34,47].

Ownership characteristics also play a crucial role in shaping ESG strategies and innovation behavior. Studies highlight that different forms of ownership—such as institutional investors, foreign shareholding, and ownership concentration—can significantly influence firms' ESG outcomes. For instance, Wang et al. [45] show that heterogeneity in institutional ownership affects ESG outcomes in Chinese firms. Wei and Chengshu [46] find that institutional investors increasingly prioritize ESG factors, influencing firm trajectories. Wang et al. [44] demonstrate the role of Qualified Foreign Institutional Investors (QFIIs) in driving ESG adoption and sustainability performance. Q. Li et al. [25] suggest that institutional ownership enhances ESG efficiency and facilitates innovation. Parallel to these findings, firm nature—whether

state-owned or non-state-owned—also shapes firms' responsiveness to ESG mandates. SOEs typically respond to top-down directives, while non-SOEs are more market-sensitive and agile in adapting to stakeholder demands [20,32,48,50].

Institutional context—particularly the strength of subnational institutions—moderates how effectively ESG and innovation strategies translate into firm performance. While much of the prior research relies on national-level institutional indicators, more recent studies highlight the importance of regional variation in institutional enforcement, market development, and fiscal capacity [2,18,23].

Within the Chinese policy context, regional enforcement of environmental mandates and institutional sustainability goals further condition how ESG practices are interpreted and rewarded [22]. Such findings lend strong support to our focus on institutional quality as a moderator, particularly given the subnational variation in regulatory implementation and fiscal support for green initiatives in China.

In addition, cross-national evidence from India suggests that ESG-oriented firms aligned with the "5Ps for Sustainability" (People, Planet, Prosperity, Peace, and Partnership) are better able to translate sustainability signalling into improved firm valuation, even in regional or institutional contexts with varied governance structures [36]. This provides external validation for our moderated mediation model, reinforcing the view that ESG's mediating role is sensitive to both institutional quality and ownership characteristics.

Despite increasing scholarly attention, existing research falls short in several key areas. First, ESG engagement is typically treated as an antecedent or consequence of firm performance, with limited studies conceptualizing it as a mediating mechanism linking innovation to performance. Second, the majority of ESG–institutional studies rely on national-level indicators, despite substantial subnational institutional heterogeneity in countries like China, where regional variation in governance, enforcement, and market development can critically influence outcomes. Third, while ownership structure is often examined in relation to ESG strategy, few studies explore it as a second-order moderator—shaping how institutional quality affects the ESG–performance relationship. These gaps limit our understanding of how context-specific dynamics influence ESG efficacy.

This study aims to address these gaps by proposing a conditional moderated mediation model that incorporates ESG as a channel linking innovation to performance, moderated by regional institutional quality and ownership type.

As illustrated in Fig. 1, this conceptual framework synthesizes the literature by depicting ESG engagement as both an outcome and enabler of innovation. The relationship between innovation, ESG, and firm performance is moderated by institutional quality and ownership configuration.

2.2. ESG as mediator in the innovation–performance relationship

Technological innovation is widely recognized as a critical driver of firm competitiveness, yet its effect on performance often depends on how firms channel innovation into broader strategic and reputational advantages. ESG engagement, in this context, operates as a mediating mechanism that enhances the value firms extract from their innovation efforts. Rather than acting independently, ESG and innovation are increasingly seen as synergistic—firms that strategically integrate ESG practices into their innovation processes tend to realize greater operational gains, stakeholder alignment, and market legitimacy [15,37,52].

Theoretically, this relationship is supported by the resource-based view, which positions ESG as a form of intangible asset that is valuable, rare, inimitable, and non-substitutable—characteristics that enable firms to build sustainable competitive advantages [3,11]. ESG-oriented firms often benefit from enhanced internal efficiencies, improved stakeholder trust, and reputational protection—all of which can amplify the outcomes of technological advancements [16,47]. Empirical studies further suggest that ESG engagement plays an instrumental role in bridging innovation with firm outcomes by reinforcing strategic coherence and improving access to resources [5,45].

In this view, ESG is not merely a peripheral reporting tool but a strategic pathway that transforms innovation into performance advantages. Firms that innovate without aligning those innovations with stakeholder and environmental expectations may fall short of realizing

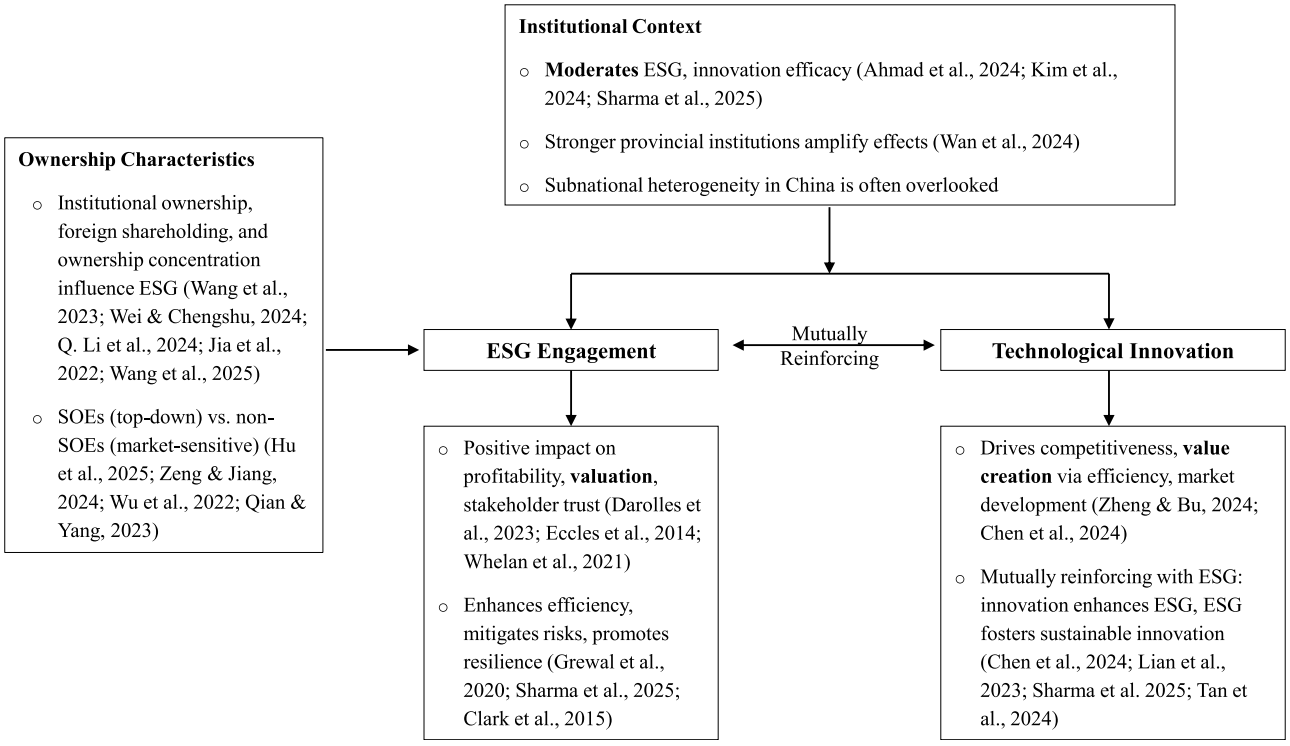

Fig. 1. Key literature streams supporting the conceptual framework.

their full performance potential. Conversely, firms that embed ESG considerations into their innovation strategies are more likely to secure market credibility, mitigate external risks, and capture sustainable value.

Accordingly, we propose the following hypothesis:

Hypothesis 1. (H1): *Technological innovation positively influences ESG engagement, which in turn enhances firm performance, thereby mediating the relationship between innovation and performance.*

2.3. The moderating role of the institutional quality in the technological innovation – firm performance relationship

While technological innovation and ESG engagement can jointly enhance firm performance, the extent of this effect is not uniform across contexts. According to institutional theory, firms are embedded in broader environments of formal rules, enforcement mechanisms, and governance norms that influence strategic behavior and performance outcomes [28]. In this study, we focus on how regional institutional quality moderates the strength of the ESG-mediated relationship between innovation and performance within the Chinese market.

China presents a uniquely diverse institutional landscape, where provinces differ widely in marketization, legal enforcement, government effectiveness, and environmental regulation. This subnational heterogeneity affects not only the adoption of ESG strategies but also their effectiveness in converting innovation into performance outcomes. For instance, provinces with more transparent regulatory systems and stronger market-supporting institutions are more likely to reward ESG engagement, particularly when aligned with innovation-driven activities [18,27].

Empirical studies in Asian markets support this logic. Ahmad et al. [2] show that firms operating in stronger institutional contexts capture more financial value from ESG activities. In South Korea, Kim et al. [23] find that regulatory stringency enhances ESG performance and its impact on firm value. Similarly, Pham et al. [29] observe that regional variation in ESG enforcement shapes the link between sustainability initiatives and financial performance across Southeast and East Asia. In the Chinese context, Wang et al. [43] and Donghui et al. [8] demonstrate that provincial-level institutional quality moderates the ESG–innovation and ESG–efficiency relationships, underscoring the importance of local governance dynamics.

These findings point to a conditional mechanism: ESG can only serve as an effective conduit for innovation-related performance when it is supported by an enabling institutional environment. Stronger provincial institutions—characterized by higher regulatory capacity, fiscal support, and market development—can amplify the reputational, financial, and operational benefits of ESG-aligned innovation. In contrast, weaker institutions may undermine ESG credibility or dilute its signalling power, thus weakening its mediating role.

We therefore hypothesize that the strength of the indirect effect between innovation and firm performance—through ESG engagement—is contingent on the regional institutional environment in which the firm operates.

Hypothesis 2. (H2): *The indirect relationship between technological innovation and firm performance—mediated by ESG engagement—is conditionally moderated by regional institutional quality in China.*

Specifically, the strength of this indirect effect is amplified in regions with higher regulatory enforcement, stronger government support, and more robust ESG-related institutional infrastructures.

2.4. Firm nature (SOE or non-SOE) as a second-order moderator

Firm nature—whether a firm is state-owned (SOE) or non-state-owned (non-SOE)—is a key contextual factor that influences how firms engage with environmental, social, and governance (ESG) practices and respond to institutional environments. SOEs, given their close alignment with government policy objectives, often operate under stronger regulatory oversight and benefit from preferential access to resources and political support. In contrast, non-SOEs tend to be more market-driven, agile, and responsive to competitive pressures but may face greater constraints in financing and legitimacy [32,48].

This nature distinction has implications for how firms leverage institutional quality to support ESG engagement. In regions with strong institutional environments—characterized by effective regulation, robust legal systems, and policy incentives—SOEs are especially well-positioned to enhance their ESG performance, as their strategic goals are typically embedded in broader state agendas. Institutional support reinforces ESG compliance and facilitates resource mobilization for sustainability initiatives [32,50]. Conversely, non-SOEs, while more sensitive to market forces, may be less equipped to translate institutional improvements into ESG gains due to limited access to public mechanisms or weaker connections to state-driven policy [8,24,25].

Despite the relevance of these dynamics, existing research has largely treated institutional quality and firm nature as separate moderators. Few studies have explored how they interact, particularly in the context of moderated mediation models where ESG serves as a bridge between innovation and performance. While Wan et al. [42] consider regional market development as a moderator, and Tian et al. [39] highlight ESG divergence across ownership types, no prior work systematically examines whether firm nature alters the influence of institutional quality on ESG engagement.

To address this gap, we propose that firm nature functions as a second-order moderator, shaping how regional institutional quality moderates the effect of technological innovation on ESG engagement. We argue that the conditional influence of institutional quality may vary by firm nature type, with SOEs potentially benefiting more from politically driven institutions, while non-SOEs may respond more strongly to market-oriented and legal institutional developments. These differences reflect each group's distinct institutional embeddedness, access to resources, and strategic priorities. Accordingly, we propose the following hypothesis:

Hypothesis 3. (H3): *Firm nature (SOE vs. non-SOE) moderates the moderating effect of institutional quality on the relationship between technological innovation and ESG engagement.*

The strength and direction of this conditional effect vary depending on the firm's nature status and the specific dimension of institutional quality.

2.5. Conceptual framework and hypothesized model

Having developed the theoretical rationale for each hypothesized relationship, we now integrate these elements into a unified conceptual framework. This model synthesizes the direct, mediating, and moderating mechanisms through which technological innovation, ESG engagement, institutional quality, and firm ownership nature interact to influence firm performance in China. It reflects the logic of the proposed hypotheses and structures the empirical analysis that follows.

The framework specifies four key analytical pathways—Paths 1 through 4—each corresponding to a core hypothesis.

Path 1 captures the direct effect of technological innovation on firm performance. Innovation inputs—operationalized through measures such as R&D intensity and authorized patent counts—are theorized to enhance firm performance by improving operational efficiency, enabling product differentiation, and fostering long-term competitiveness. This direct path reflects well-established findings in the literature linking innovation to firm value creation.

Paths 2a and 2b introduce ESG engagement as a mediating mechanism. Path 2a represents the effect of technological innovation on ESG engagement, while Path 2b captures the subsequent impact of ESG engagement on firm performance. Together, these paths operationalize Hypothesis 1, positing that ESG functions as a strategic conduit through which innovation translates into improved performance outcomes. This

mediating role highlights the enabling function of ESG in aligning innovation with stakeholder expectations, regulatory demands, and reputational benefits.

Path 3 incorporates institutional quality as a moderator of the innovation–ESG relationship (Path 2a). In line with Hypothesis 2, this path theorizes that the strength of the innovation-induced ESG effect is conditional on the quality of the regional institutional environment. Specifically, regions with stronger regulatory enforcement, policy support, and institutional infrastructure are expected to facilitate more effective translation of innovation into ESG engagement. The five dimensions of the Marketization Index for China's Provinces—government–market relationship, non-state sector development, product market development, factor market development, and legal-institutional environment—are used to operationalize this moderator.

Path 4 introduces firm nature as a second-order moderator of the institutional effect described in Path 3. Drawing on Hypothesis 3, this path suggests that the moderating role of institutional quality is further conditioned by whether a firm is state-owned or non-state-owned. Non-state-owned enterprises (non-SOEs) are expected to be more responsive to institutional variation due to their greater exposure to market forces and external legitimacy pressures. In contrast, state-owned enterprises (SOEs) may be more insulated from local institutional dynamics, as their ESG engagement is often driven by top-down compliance imperatives. As SOEs are required to meet environmental regulation or political targets, they are expected to have a greater influence on the relationship. Further, SOEs exhibit greater competitiveness due to their access to more abundant resources.

Taken together, the framework articulates a multi-path, context-sensitive model that explains how innovation and ESG engagement interact—within varying institutional and ownership environments—to shape firm performance. It reflects the layered complexity of sustainability-oriented strategy in emerging market contexts and guides the empirical strategy that follows.

Fig. 2 presents the conceptual framework, summarizing the hypothesized relationships among technological innovation, ESG engagement, institutional quality, firm nature (state-owned or otherwise), and firm performance.

3. Empirical research design

3.1. Data and variable construction

This study empirically investigates the interrelationships among technological innovation, ESG engagement, institutional quality, and firm performance within the Chinese context. The analysis is based on a comprehensive panel dataset comprising firm-level financial, corporate governance, and innovation indicators, matched with province-level institutional data spanning from 2010 to 2023.

3.1.1. Dependent variables

Firm performance is operationalized using two widely adopted indicators. *Tobin's Q* serves as a proxy for market valuation, reflecting investor expectations of future profitability and growth. *Return on Assets (ROA)* captures operational efficiency and profitability from an accounting perspective. Together, these measures provide a robust and multidimensional assessment of firm performance outcomes.

3.1.2. Independent variables (X)

Technological innovation is measured using both input and output proxies. *R&D intensity*, calculated as the ratio of R&D expenditure to total sales, captures the input dimension of innovation activity. Innovation output is represented by the number of *authorized invention patents*, reflecting the firm's capacity to generate and formalize technological knowledge with legal protection. This dual-dimensional approach captures both the effort devoted to innovation and its tangible outcomes.

3.1.3. Mediating variable (M)

ESG engagement is modeled as a mediating variable and measured using two widely recognized Chinese ESG scoring systems: the *Huazheng ESG Score* and the *Wind ESG Combined Score*.

The *Huazheng ESG Score* provides a composite rating based on 44 indicators across environmental, social, and governance dimensions, rated on a nine-grade scale from AAA (highest) to C (lowest). It reflects firm-level ESG practices using both qualitative and quantitative data, updated quarterly or monthly.

The *Wind ESG Combined Score* is a continuous numerical index ranging from 0 to 10, with higher scores indicating stronger ESG performance. It incorporates over 500 indicators and is dynamically updated to reflect new ESG disclosures. Its quantitative structure is well-suited for regression-based analysis.

These two ESG metrics jointly capture the breadth and variation of sustainability performance among Chinese firms and support the study's examination of ESG as a mediating mechanism.

3.1.4 Moderating variables: institutional quality (W)

To capture the influence of regional institutional environments, this study employs the National Economic Research Institute (NERI) Marketization Index for China's Provinces [13,14].

This index offers a province-level measure of institutional

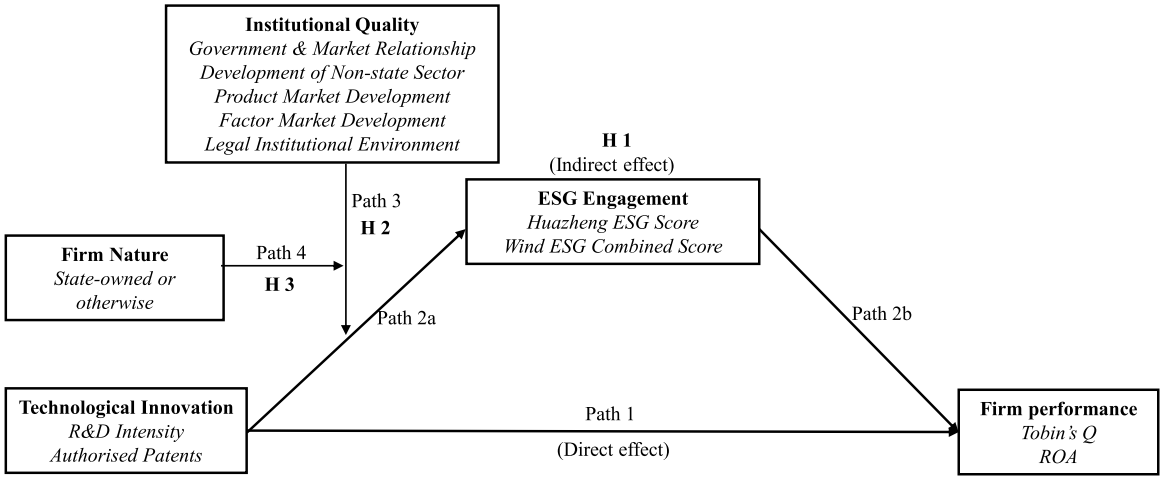

Fig. 2. Conceptual framework linking technological innovations, esg engagement, institutional quality, firm nature (State-owned or otherwise), and firm performance.

development and market orientation. It comprises five equally weighted sub-indices:

1. ***Government–Market Relationship (GMR):*** Assesses the extent of government intervention in resource allocation.
2. ***Development of the Non-State Sector (DNS):*** Reflects the scale and vitality of private enterprises.
3. ***Product Market Development (PMD):*** Measures price liberalization and competitive market dynamics.
4. ***Factor Market Development (FMD):*** Captures the efficiency of labor, capital, and land markets.
5. ***Legal and Institutional Environment (LIE):*** Evaluates contract enforcement, property rights protection, and institutional infrastructure.

Higher scores on the NERI marketization index indicate more advanced and market-oriented institutional settings. Interaction terms between ESG engagement and each of these institutional variables are constructed to test for conditional moderation effects, as hypothesized in the conceptual model.

3.1.5. Second-order moderating variable: firm nature (Z)

Firm Nature is operationalized as a binary variable distinguishing *state-owned enterprises (SOEs)* from *non-state-owned enterprises (non-SOEs)*. This variable is used to test for second-order moderation effects, specifically whether the institutional moderation of ESG–performance relationships vary by firm ownership nature.

3.1.6. Control variables

To account for confounding firm-specific characteristics, several control variables are included: *firm size* (log of total assets), *firm age, financial constraints, ownership concentration* (percentage of shares held by the largest shareholder), *board independence* (proportion of independent directors), and *CEO–chairman duality*. In addition, industry, year, and firm fixed effects are included in all regression models to control for unobserved heterogeneity and mitigate omitted variable bias.

Financial constraints are measured using the *Hadlock–Pierce (HP) Index* [17], calculated as:

$$HP\ Index = (-0.737\ \times Size) + \left(0.043\ \times Size^2\right) - (0.040\ \times Age)$$

Where:

- Size is the natural logarithm of total assets
- Age is the number of years the firm has been listed on the China stock exchanges.

A higher index indicates greater financial constraints.

Detailed definitions for all variables are provided in Appendix 1.

3.2. Data collection

This study analyses data from 3300 Chinese A-share listed firms (*ST or ST companies and financial institutions are excluded) from 2010-2023, forming an unbalanced panel of 17,534 firm-year observations.

All institutional variables are sourced from the *Report on China's Provincial Marketization Index*, which provides longitudinal data on the quality of institutional environments across Chinese provinces. Interaction terms between ESG engagement and each of the institutional variables are included in the model to test for moderating effects.

Accounting, financial, and innovation data for non-financial listed Chinese firms were obtained from the CSMAR (China Stock Market & Accounting Research Database) database and Wind Information. ESG engagement metrics were sourced from Chinese rating agencies (Huazheng ESG and Wind ESG via WIND Information Co.).

3.3. Methodology

To empirically examine the relationships outlined in the conceptual framework (Fig. 2), we adopt a multi-step conditional process analysis, integrating mediation and moderated mediation techniques based on Preacher and Hayes [31] and Hayes [19]. This approach enables the identification of both direct and indirect effects of technological innovation on firm performance, while simultaneously assessing how these effects are conditioned by institutional quality and firm ownership nature.

Step 1: Estimating the direct effect (Path 1) As a baseline, we first estimate the direct effect of technological innovation on firm performance:

$$Tobin's\ Q_{i,t} = \beta_0 + \beta_1 Tech_{i,t-1} + \beta_2 X_{i,t-1} + \ \epsilon_{1i,t}$$

Where:

Tobin's Q_i is the market-based firm performance for firm i at time t

Tech is the level of technological innovation, such as R&D intensity, and authorised patents.

X_i is a vector of control variables

$\epsilon_{1i,t}$ is the error term

Step 2: Testing the mediation pathway (Paths 2a and 2b)

We next assess whether ESG engagement mediates the relationship between innovation and performance. This involves estimating two equations:

- Path 2a: Effect of innovation on ESG engagement

$$ESG_{i,t} = \alpha_0 + \alpha_1 Tech_{i,t} + \alpha_2 X_{i,t} + \epsilon_{2i,t}$$

- Path 2b: Effect of ESG engagement on firm performance, controlling for technological innovation

$$Tobin's\ Q_{i,t} = \gamma_0 + \gamma_1 ESG_{i,t-1} + \gamma_2 Tech_{i,t-1} + \gamma_3 X_{i,t-1} + \epsilon_{3i,t-1}$$

The indirect effect of innovation on firm performance via ESG engagement is calculated as $\alpha_1 \times \gamma_1$. We use bootstrapped confidence intervals (5,000 replications) to assess the statistical significance of the indirect effect. A positive and significant estimate supports Hypothesis 1, indicating that ESG serves as a mechanism through which innovation enhances performance.

Step 3: Conditional mediation—moderating role of institutional quality (Path 3)

To evaluate whether institutional quality moderate the innovation → ESG engagement relationship (Path 2a), we include an interaction term between innovation and institutional quality:

$$ESG_{i,t} = \delta_0 + \delta_1 Tech_{i,t} + \delta_2 Institutional\ Quality_t + \delta_3\left(Tech_{i,t} \times Institutional\ Quality_t\right) + \delta_4 X_{i,t} + \epsilon_{4i,t}$$

A significant δ_3 provides support for Hypothesis 2, indicating that regional institutional environments condition the degree to which innovation contributes to ESG engagement.

Step 4: Second-order moderation—role of firm nature (Path 4)

To assess whether firm nature moderates the moderating effect of institutional quality—i.e., a second-order moderation—we extend the previous model with a three-way interaction term:

$$ESG_{i,t} = \theta_0 + \theta_1 Tech_{i,t} + \theta_2 Institutional\ Quality_t + \theta_3 Firm\ Nature_{i,t} + \theta_4\left(Tech_{i,t} \times Institutional\ Quality_t\right) + \theta_5\left(Tech_{i,t} \times Institutional\ Quality_t \times Firm\ Nature_{i,t}\right) + \theta_6 X_{i,t} + \epsilon_{5i,t}$$

Here, firm nature is a binary indicator differentiating SOEs from non-

SOEs. A significant θ_5 supports Hypothesis 3, indicating the strength and direction of this conditional effect vary depending on the firm's nature and the specific dimension of institutional quality.

In aid clarity and transparency, Fig. 3 provides the statistical diagram based on SPSS Process Model 11. Fig. 3A illustrates the direct effect of technological innovation on firm performance, as well as the indirect effect via the mediator ESG engagement (H1). Fig. 3B shows the moderating role of institutional quality on this indirect relationship, reflected in the interaction between technological innovation and institutional quality (H2). Lastly, Fig. 3C depicts the second-order moderating role of firm nature (SOE vs. non-SOE) on the moderation by institutional quality, captured through the three-way interaction among technological innovation, institutional quality, and firm nature.

3.3.1. Additional estimation considerations

All continuous independent variables, including ESG scores and institutional quality indicators, are lagged by one year to mitigate endogeneity concerns. Wind ESG Combined scores and financial variables are winsorized at the 1st and 99th percentiles, and log transformations are applied where appropriate to reduce skewness.

Control variables, including firm size, age, ownership concentration, board independence, CEO–chairman duality, and financial constraints (HP Index), are included throughout. All models also control for firm, industry, and year fixed effects to absorb unobserved heterogeneity.

Robustness checks using an alternative measure of innovation—authorized patents—were conducted to validate the main findings, while ESG and institutional quality dimensions remained consistent across specifications.

4. Empirical results, interpretation, theoretical contributions, and policy implications

4.1. Descriptive statistics and correlation matrix

Table 1 presents the descriptive statistics for the key variables used in this study. The dependent variables, *Return on Assets* (ROA) and *Tobin's Q*, show mean values of 0.026 and 0.432, respectively, indicating relatively low profitability and moderate market valuation across the sample of firms. The standard deviations suggest substantial variation, particularly for ROA (S.D. = 0.078), which ranges from -0.340 to 0.216.

Regarding the independent variables, the first proxy for technological innovation, *R&D intensity* (R&D/sales), has a mean of 0.048 and a right-skewed distribution (max = 0.344), while the second proxy, the natural log of *authorized patents*, averages 3.400, reflecting firm-level heterogeneity in innovation output.

Two ESG engagement metrics are included as mediators: the *Wind ESG Combined Score* and the *Huazheng ESG Score*, with means of 6.008 and 4.109, respectively. Both variables exhibit relatively tight distributions, suggesting limited dispersion in ESG performance across firms.

Institutional environment variables, operationalized as moderators, show considerable cross-provisional variation. For instance, the *Government-Market Relationship* (GMR) has a mean of 7.469, while *Development of Non-State Sector* (DNS), *Product Market Development* (PMD), *Factor Market Development* (FMD), and *Legal and Institutional Environment* (LIE) display broader ranges, particularly FMD (Min = 1.55, Max = 20.28).

Firm nature (binary-coded) has a mean of 0.299, indicating that approximately 30% of the firms are state-owned. Among control variables, *firm size* (log of total assets) and *age* (log-transformed) show moderate dispersion, while indicators such as CEO-chairman duality and board independence reflect governance variations. Notably, all continuous independent, and control variables have been winsorized at the 1st and 99th percentiles to mitigate the influence of extreme values.

Table 2 reports the pairwise Pearson correlation coefficients among the variables used in the analysis. Several notable patterns emerge. First, among the dependent variables, *ROA* is negatively correlated with *Tobin's Q* ($r = -0.352$, $p < 0.01$), suggesting that firms with higher accounting-based performance may not necessarily exhibit stronger market-based valuation, which may reflect differing informational content or investor expectations.

The two innovation proxies reveal divergent relationships with firm performance. *R&D intensity* is negatively correlated with both *ROA* ($r = -0.109$, $p < 0.01$) and *Tobin's Q* ($r = -0.276$, $p < 0.01$), indicating that higher R&D expenditure relative to sales does not immediately translate to better financial outcomes, possibly due to lag effects or riskiness of R&D investments. In contrast, the *log of authorized patents* shows a positive correlation with Tobin's Q ($r = 0.302$, $p < 0.01$), suggesting that more advanced or protectable innovations may be more highly valued by investors.

The ESG engagement metrics present positive associations with *ROA*—especially the *Huazheng ESG score* ($r = 0.225$, $p < 0.01$)—and negative or weakly negative correlations with *Tobin's Q*, implying that while ESG performance might be positively aligned with operational efficiency, its impact on market valuation may be more nuanced.

Institutional quality variables, such as *GMR, DNS*, and *LIE*, are generally weakly correlated with performance measures, though several are significantly associated with innovation inputs. For instance, *Factor Market Development* (FMD) and *Legal and Institutional Environment* (LIE) correlate positively with the *authorized patent* measure ($r = 0.209$ and $r = 0.207$, respectively), suggesting that more developed institutional environments may support innovation output.

Notably, *firm nature* correlates positively with Tobin's Q ($r = 0.217$, $p < 0.01$) and negatively with *R&D intensity* ($r = -0.203$, $p < 0.01$), suggesting differences in strategic orientation between state and non-state owned firms.

Most control variables, such as *firm size, HP index*, and *board independence*, show statistically significant correlations with performance and innovation variables, but the magnitudes remain moderate, indicating a low risk of multicollinearity. This supports the robustness of including these controls in regression specifications.

4.2. Empirical results for hypothesis 1: mediation analysis of ESG engagement

Tables 3.1 through 4.2 report the mediation analysis for Hypothesis 1, which posits that ESG engagement mediates the relationship between technological innovation and firm performance. The analysis follows a two-path structure: Path 1 shows that technological innovation alone has a negative direct impact on firm performance (ROA and Tobin's Q). Path 2a examines the impact of technological innovation (measured by R&D intensity) on ESG engagement, while Path 2b estimates the impact of ESG engagement on firm performance, controlling for innovation. Tables 3.1 and 3.2 use Return on Assets (ROA) as the dependent variable, whereas Tables 4.1 and 4.2 use Tobin's Q. Each specification is estimated separately using Huazheng and Wind ESG scores as alternative mediators.

In Table 3.1, ESG engagement—proxied by the Huazheng score—exhibits a significant mediating role. R&D intensity positively affects ESG engagement at the 1% significance level (Path 2a), and ESG engagement, in turn, is positively associated with ROA (Path 2b). The indirect effect is statistically significant, indicating that innovation not only mediations innovation-performance relationship but also improves firm performance through enhanced ESG engagement, despite the negative direct effect of innovation on ROA observed in Path 1—likely reflecting short-term cost burdens associated with innovation investment.

Table 3.2 confirms this result using the Wind Combined ESG score. Both Path 2a and 2b are positive and highly significant, and the bootstrapped indirect effect remains statistically robust. Together, the evidence from Tables 3.1 and 3.2 supports the mediating role of ESG engagement in the innovation–performance linkage when performance is measured by ROA.

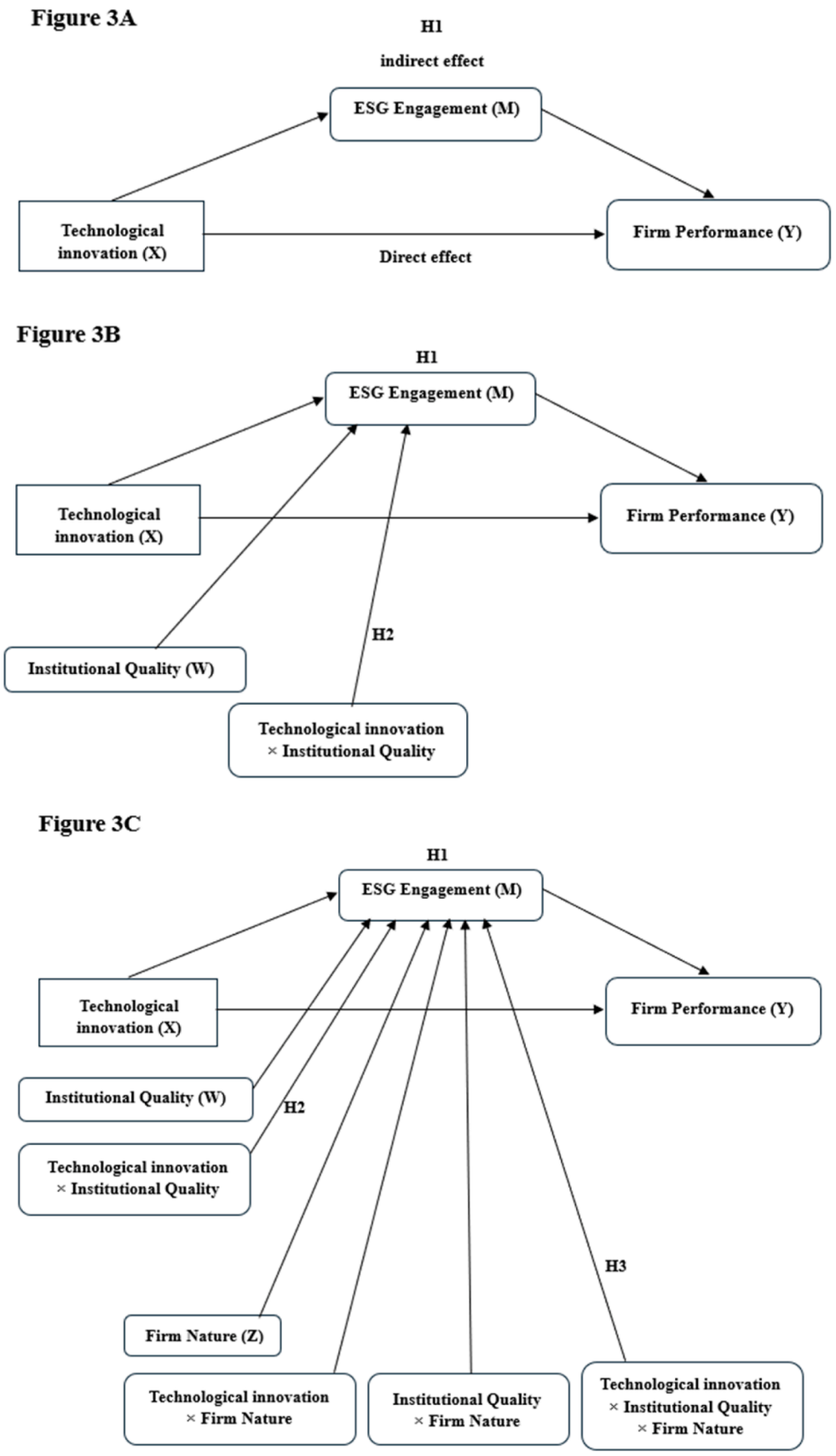

Fig. 3. Statistical diagram of the methodology.

In contrast, Tables 4.1 and 4.2 reveal a consistently negative indirect effect when Tobin's Q is used as the outcome. While R&D intensity continues to positively influence ESG engagement (Path 2a), the effect of ESG engagement on Tobin's Q (Path 2b) is negative and statistically significant across both ESG measures. The bootstrapped indirect effects confirm that ESG engagement mediates the innovation–performance link negatively under a market-based performance lens.

This finding suggests a potential disconnect between operational ESG performance and capital market perceptions. Market participants may interpret ESG engagement—particularly when linked to innovation—as costly or uncertain in its payoff, leading to penalization in market valuation. This aligns with earlier evidence (e.g., [12]), which shows that capital markets may discount ESG efforts due to short-term cost implications or sectoral expectations, especially in industries with high transition risks.

In summary, the results provide partial support for Hypothesis 1. ESG engagement mediates the relationship between innovation and firm performance when accounting-based outcomes (ROA) are considered, but not when market-based performance (Tobin's Q) is used. This divergence underscores the importance of performance metric selection and the potentially contrasting views of internal efficiency and external investor perception.

4.3. Empirical results for hypothesis 2: moderated mediation by institutional quality (W)

Hypothesis 2 posits that the indirect effect of technological innovation on firm performance—mediated by ESG engagement—is conditioned by regional institutional quality. This hypothesis is tested by including interaction terms between R&D intensity and institutional quality indicators (Path 3) and by examining conditional indirect effects at low, average, and high levels of the moderator W.

In Table 3.1, where ROA is the outcome variable and ESG is proxied by Huazheng score, the interaction term between R&D intensity and institutional quality (X × W) is statistically significant in *FMD* and *LIE* models, indicating that the innovation–ESG relationship is moderated by factor market development and the legal and institutional environment. In Table 3.2, when we replace Huazheng with the Wind score, the interaction term between R&D intensity and institutional quality is no longer statistically significant across models, indicating the absence of a strong first-stage moderation effect. We further examine the conditional indirect effects, which are found to be statistically significant at all levels of the moderator W. Specifically:

- In Table 3.1 (Huazheng ESG), the indirect effects through ESG engagement at low, average, and high levels of the government–market relationship are 0.055, 0.059, and 0.062, respectively (holding firm ownership nature (Z) constant and zero). A similar pattern holds for development of the non-state sector (0.060 to 0.062), product market development (0.060–0.063), factor market development (0.046 – 0.063) and legal and institutional environment (0.043 – 0.068), respectively.
- In Table 3.2 (Wind ESG), the indirect effects are likewise positive and significant, though more stable across moderator (W) levels. For instance, the effect through the government–market relationship ranges from 0.052 to 0.057, 0.055 to 0.057 through development of the non-state sector, 0.054 to 0.057 through product market development. 0.053 to 0.055 for factor market development and 0.050 to 0.058 for legal and institutional environment, respectively.

In all cases, 95% bootstrapped confidence intervals exclude zero, confirming statistical significance of the indirect effects. While the slopes of change across moderator levels are small, the pattern suggests that institutional quality modestly impacts the strength of ESG-mediated innovation effects on ROA.

In contrast, Tables 4.1 and 4.2, which use Tobin's Q as the performance metric, present a different picture. The indirect effects of R&D intensity on Tobin's Q via ESG engagement are negative and statistically significant across all models and levels of institutional quality. Again, the X × W interaction terms are significant only for factor market development and legal and institutional environment in Huazheng-based analyses but become insignificant in Wind-based analyses. These findings partially support Hypothesis 2, suggesting that institutional conditions have moderating impacts on the ESG-mediated relationship between innovation and firm performance, but the results are influenced by the choice of ESG engagement measurement.

4.4. Empirical results for hypothesis 3: second-order moderated mediation by firm nature (Z)

Hypothesis 3 proposes that the moderating effect of institutional quality on the ESG-mediated innovation–performance relationship is contingent upon the firm's nature. For instance, state-owned enterprises (SOEs) benefit from greater resources and government connections and are expected to fulfil environmental regulation and/or political targets, such that the indirect effect of innovation on performance via ESG engagement—moderated by institutional quality—is further amplified in SOEs. This hypothesis is tested via a three-way interaction term (X × W × Z), capturing the conditional moderated mediation structure.

In Table 3.1 (ROA, Huazheng ESG), the three-way interaction term between R&D intensity, development of the non-state sector, and firm nature (when it equals 1, indicating that the firm nature is SOE) is positive and statistically significant at the 1% level. This suggests that the moderating effect of non-state sector development on the innovation–ESG link is significantly stronger for SOEs. In other words, private sector development positively moderates the technological innovation on ESG engagement, and this positive effect is further amplified for SOEs operating in regions with higher levels of private sector development. Although this may seem counterintuitive, faster private sector development typically leads to an increased proportion of private enterprises and greater market competition. However, in such environments, due to greater access to resources and stronger political connections, SOE can leverage their advantages more effectively. As discussed by ([38], p.10): "the state's principal objective of encouraging the development of non-state economy is to improve economic efficiency of socialist institutions through market-oriented mechanisms, not fully liberalize the institutional power of market capitalism." Thus, this result is consistent with Hypothesis 3. By contrast, when government–market relationship, product market development, factor market development or legal and institutional environment are used as the institutional moderators, the corresponding three-way interaction terms are statistically insignificant.

Further support is provided by the "index of moderated moderated mediation" (i.e. 0.016), which is statistically significant only for the non-state sector development moderator, as indicated by 95% bootstrap confidence intervals that exclude zero. Additionally, since the three-way interaction is calculated based on SOE status (when firm nature = 1), we further assess the second-order moderating impact at different firm nature levels (i.e. non-SOE and SOE levels) by analyzing the "indices of conditional moderated mediation". We find that when firm nature equals 1 (i.e. firms are SOEs), the index is statistically significant at the 5% level, which is consistent with our previous findings. Furthermore, we observe that the moderating effects of factor market development and the legal and institutional environment on the innovation-ESG link is further amplified in non-SOEs (i.e. firm nature equals 0). When there are property rights are better protected and resources are allocated more efficiently, non-SOEs could gain greater legitimacy and utilise resources more effectively.

The results in Table 3.2 (ROA, Wind ESG) offer similar but weaker support. The three-way interaction term involving R&D intensity, non-state sector development, and firm nature remains positive but is only marginally significant at the 10% level. This reduced effect may reflect differences in sensitivity between the two ESG measures or sample

characteristics. We also observe a significant three-way interaction effect between R&D intensity, product market development and firm nature, as shown in Model 3 of Table 3.2. This implies that the second-order moderating effects vary across different ESG and institutional quality measures.

In the Tobin's Q models (Tables 4.1 and 4.2), the pattern largely holds. In Table 4.1 (Huazheng ESG), the three-way interaction involving non-state sector development and SOE firm nature is again statistically significant at the 1% level, even though the direction of the ESG → performance effect remains negative. Additionally, non-SOE firm nature further amplifies the moderating effects of factor market development, and the legal and institutional environment based on the "indices of conditional moderated mediation". However, in Table 4.2 (Wind ESG), the three-way interaction effect between R&D intensity, non-state sector development and SOE firm nature loses statistical significance, whereas the interaction between R&D intensity, product market development and SOE firm nature remains significant at the 10% level. This indicates that the results are not consistently replicated across all specifications.

Overall, the findings offer partial but targeted support for Hypothesis 3. The three-way interaction is mainly statistically significant and robust when development of the non-state sector is used as the institutional moderator, and particularly when ESG engagement is measured using the Huazheng score. Using the Wind score, we find that SOEs also enhance the moderating effect of product market development on the relationship between innovation and ESG performance. These results indicate that firm nature conditions the institutional effect on ESG engagement and SOEs benefit more from a supportive institutional environment due to their greater resources such as financial and political support. Lastly, we find that the moderating effects of factor market development and the legal and institutional environment are stronger for non-SOEs.

To facilitate interpretation of the empirical results and enhance consistency with our theoretical framing, we present a consolidated summary in Table 5 and a graphical illustration in Fig. 4, which closely mirrors the structure of the conceptual framework shown in Fig. 2.

4.5. Robustness check: authorized patent as an alternative innovation measure

To ensure the robustness of the main findings, we re-estimate the proposed models using authorized patents as an alternative proxy for firm-level technological innovation. The results are reported in Tables 6.1 through 7.2. These robustness checks complement the primary analyses based on R&D intensity by providing an output-oriented indicator of innovation.

For Hypothesis 1, we find partial support for the mediation effect. Specifically, using the Huazheng ESG score as the mediator, technological innovation measured by authorized patents positively influences ESG engagement (Path 2a), and ESG engagement, in turn, is significantly associated with firm performance (Path 2b). This holds for both ROA (Table 6.1) and Tobin's Q (Table 7.1), although effect sizes are relatively modest. However, when ESG engagement is measured by the Wind ESG score (Tables 6.2 and 7.2), the mediation pathway is weaker, and the link from authorized patents to ESG engagement becomes statistically insignificant, suggesting sensitivity to the choice of ESG measurement.

Regarding Hypothesis 2, we find that the interaction terms between authorized patents and factor market development or the legal and institutional environment are statistically significant in the Huazheng-based analyses, but largely insignificant across other institutional quality measures and in the Wind-based analyses. These results are consistent with our previous findings.

As for Hypothesis 3, we observe partial support. In Table 6.1, the three-way interaction involving government–market relationship and firm nature (SOE) is marginally significant at the 10% level in the Huazheng model for ROA. Moreover, in the Wind ESG specification, Tables 6.2 and 7.2 report statistically significant three-way interactions involving development of the non-state sector and firm nature (SOE), again at the 10% level, across both performance metrics. These findings reinforce the earlier conclusion that firm nature meaningfully conditions the influence of institutional quality—particularly the vitality of the non-state sector—on the ESG–performance relationship. Additionally, the "indices of conditional moderation mediation" shows that the moderating effect of factor market development is stronger for SOEs in Tobin's Q analyses (i.e. firm nature = 1).

In sum, the robustness analyses confirm that the mediated relationship proposed in H1 as well as the moderating effects of factor market development and the legal and institutional environment in H2 are generally supported under the Huazheng ESG specification. H3 gains conditional support, particularly when the non-state sector dimension of institutional quality interacts with firm nature status.

4.6. Integrated discussion, theoretical contribution, and policy implications

This study investigates a central research question: how can firms in institutionally diverse environments—such as China—translate technological innovation into improved performance through ESG engagement? Prior research has often treated ESG and innovation as separate factors. By contrast, this study develops and tests a moderated mediation model in which ESG serves as a conduit through which innovation

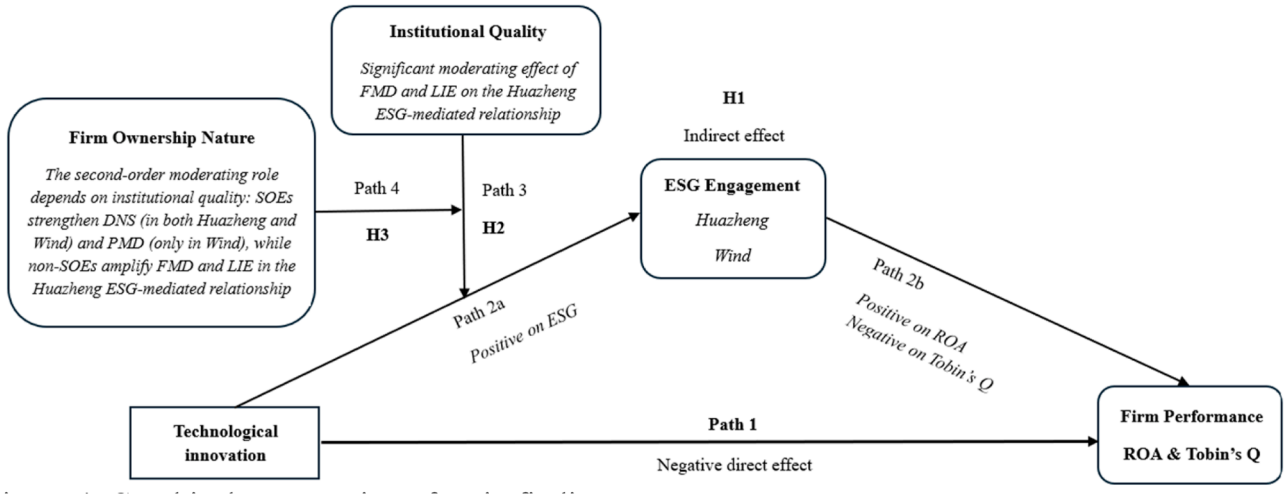

Fig. 4. Graphical presentation of main findings.

enhances firm performance, conditional on institutional quality and firm ownership nature.

The findings provide three key insights. First, ESG engagement mediates the innovation–performance link, but its effect varies with the performance measure. When using ROA, ESG supports internal value creation. When using Tobin's Q, however, the mediation effect is negative—possibly due to market skepticism toward ESG initiatives in settings with uneven enforcement and transparency. This divergence highlights the importance of considering both internal and external performance metrics in evaluating ESG effectiveness.

Second, institutional quality—particularly the development of the non-state sector—plays a critical moderating role. Firms located in regions with more advanced private sector development experience stronger positive indirect effects of innovation on performance through ESG. This suggests that institutions that promote competition, resource accessibility, and entrepreneurial activity create a more fertile ground for ESG-aligned innovation. Interestingly, the positive effect of private sector development is even more pronounced for SOEs, which, despite facing greater competition, can more effectively leverage their resource advantages and political ties in such environments. This finding reflects China's institutional design, where market-enhancing reforms coexist with state coordination, aiming to improve the efficiency of public-sector-led development [38].

Third, firm ownership further shapes how institutional environments influence ESG outcomes. While SOEs benefit more from non-state sector development, non-SOEs respond more strongly to improvements in factor markets and legal institutions. These environments enhance legitimacy, resource access, and protection of property rights, which are especially vital for private firms without state backing. These results indicate that no one-size-fits-all approach exists; rather, firms' responsiveness to institutional quality depends on their ownership and the institutional levers at play.

Taken together, these findings support a context-sensitive view of ESG as a strategic asset. From a theoretical perspective, the study makes three contributions. First, it reframes ESG from a symbolic or compliance-based practice to a capability that mediates innovation-driven value creation, aligning with the resource-based view. Second, it advances institutional theory by showing that subnational institutional heterogeneity—captured through China's Marketization Index—meaningfully conditions ESG–innovation dynamics. Third, it deepens our understanding of ownership effects by showing that SOEs and non-SOEs derive ESG benefits from different institutional configurations.

These insights also carry broader societal relevance, particularly in relation to the Sustainable Development Goals (SDGs). Our results indicate that institutional features such as rule enforcement, transparency, and private sector development do not merely benefit firms—they also shape whether technological innovation translates into sustainable and inclusive growth. In particular, the findings underscore the role of institutional integrity and legal infrastructure—pillars of SDG 16 (Peace, Justice and Strong Institutions)—in supporting ESG-aligned strategies across different types of firms.

This aligns with recent work highlighting the role of institutions in enabling sustainable outcomes. Ullah et al. [41] demonstrate that institutional development—through improved legal structures, trade openness, and R&D support—enhances productivity and reduces rural poverty. Their findings show that institutional design fosters equitable resource access and innovation outcomes. Likewise, Agarwal et al. [1] emphasize the need for trust, regulatory clarity, and coordination in public–private partnerships, particularly in emerging sectors like sustainable agriculture. Their study highlights that partnerships can be powerful vehicles for innovation, but only if institutional environments are designed to mitigate risks such as governance failures and contract incompleteness.

Our findings offer parallel implications. The enabling role of public–private complementarities—particularly under varying institutional structures—can unlock ESG value, but only when firms and institutions are aligned. For SOEs, access to political capital can amplify ESG outcomes in competitive regions. For non-SOEs, transparent legal institutions and efficient markets are more critical. These dynamics suggest that both types of firms play essential roles in China's innovation–sustainability transition, but require differentiated institutional support.

Policy implications follow. Policymakers should not assume that innovation or ESG alone generate sustainable outcomes. Instead, institutional reforms must be tailored. Strengthening property rights, expanding private sector capacity, and improving legal transparency can catalyze ESG engagement among non-SOEs. Meanwhile, reforms that deepen competition and market-based coordination can enhance the strategic integration of ESG among SOEs. Ultimately, supporting diverse institutional pathways is necessary to realize ESG-aligned innovation across China's complex ownership and governance landscape.

5. Conclusion

This study explores how technological innovation affects firm performance through ESG engagement and how this relationship is conditioned by regional institutional quality and firm nature in China. Using a moderated mediation framework and panel data from A-share listed firms, we find that ESG engagement can act as a strategic channel through which innovation contributes to performance—but only under specific institutional and organizational conditions.

Our analysis yields three core findings. First, ESG engagement positively mediates the innovation–performance link when internal performance (ROA) is considered, but not when market-based performance (Tobin's Q) is used—highlighting a gap between ESG-driven operational value and external market perception. Second, regional institutional quality—especially the development of factor markets, the non-state sector, and legal institutions—conditions the strength of this ESG-mediated effect. Third, firm nature matters: while SOEs benefit more from private-sector development, non-SOEs respond more positively to improvements in legal and resource market institutions.

Beyond firm-level dynamics, these findings carry broader societal relevance. They highlight how enabling institutional environments—marked by legal clarity, fair competition, and support for private enterprise—facilitate inclusive and responsible innovation. These insights contribute to the achievement of global sustainability goals, particularly SDGs 9, 12, and 16.

From a practical standpoint, the study offers several implications. For managers, it underscores the need to tailor ESG and innovation strategies to the local institutional environment and firm ownership nature. Firms operating in regions with strong legal institutions and efficient factor markets are better positioned to realize ESG-related innovation benefits. For policymakers, the results highlight the importance of dimension-specific institutional reforms. Strengthening legal protections, improving market efficiency, and fostering private-sector development can create institutional ecosystems that empower responsible business conduct and sustainability-led innovation.

We acknowledge several limitations. First, while our data focus on Chinese listed firms, the generalizability of the findings to other emerging markets should be approached with caution due to institutional and ownership structure differences. Second, although we incorporate subnational institutional quality, firm-level ESG data may still be influenced by reporting variability. Future research could expand this work by examining cross-country comparisons or incorporating additional governance dimensions, such as civic engagement, media freedom, or stakeholder activism, which may further shape the ESG–innovation relationship.

Overall, this study provides a context-sensitive framework for understanding how firms integrate innovation and ESG under varying institutional and organizational configurations. It offers actionable insights for firms and policymakers, while contributing to broader discussions on how to align corporate strategy with sustainable

development goals in emerging economies.

CRediT authorship contribution statement

Li Xian Liu: Writing – original draft, Supervision, Project administration, Methodology, Formal analysis, Conceptualization. **Zhiyue Sun:** Writing – review & editing, Validation, Software, Methodology, Formal analysis. **Keren He:** Validation, Software, Resources, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix 1. Descriptions of the variables

Variables Names	Description
Dependent Variables	
Tobin's Q	Following Doidge et al. (2004), Tobin's Q is calculated as: $\text{Tobin's q} = \frac{\text{Total Asset} - -\text{Book Value of Equity} + \text{Market Value of Equity}}{\text{Total Asset}}$ This variable reflects the market's valuation of a firm relative to its assets, serving as an indicator of growth opportunities and market performance.
Return on Assets	Measured as net income divided by total assets, this variable captures a firm's efficiency in generating profits from its asset base.
Independent Variables (X)	
R&D Intensity	Measured as the ratio of a firm's research and development (R&D) expenses to its sales, this variable reflects the intensity of R&D activities relative to firm performance.
Authorized Patent	Log of the number of firm's patents authorized.
Mediators (M)	
Huazheng ESG Score	The Hua Zheng ESG Combined Score is derived from a hierarchical indicator system developed by Sino-Securities Index Information Service Co., Ltd. The evaluation framework includes 3 primary indicators, 14 secondary indicators, and 26 tertiary categories, based on over 130 underlying data points. Firms are assigned ratings on a nine-tier scale ranging from AAA (highest) to C (lowest). For quantitative analysis, these ratings are converted into a numerical scale from 1 (C/CCC) to 9 (AAA), where higher values indicate stronger ESG performance. This score provides a standardized and structured assessment of a firm's sustainability practices within the Chinese capital market.
Wind ESG Combined Score	The Wind ESG Combined Score is developed by Wind Information Co., Ltd. and reflects a firm's overall ESG performance on a continuous scale from 0 to 10, with higher values indicating stronger ESG engagement. It aggregates Environmental, Social, and Governance components into a single metric and is constructed using a comprehensive set of over 500 indicators. The score is dynamically updated to incorporate the most recent ESG disclosures, making it suitable for quantitative assessments of ESG impact on firm-level outcomes.
Moderators (W)	
Government-Market Relationship	Assesses the extent of government intervention in economic activities. Indicators include the share of government budgetary expenditures in GDP, reflecting the balance between administrative control and market mechanisms.
Development of the Non-state sector	Measures the growth and significance of private enterprises within the economy. This includes metrics such as the proportion of non-state-owned enterprises in total industrial output and employment, indicating the vitality of the private sector.
Product Market Development	Evaluates the degree of competition and openness in goods markets. Factors considered encompass price liberalization, the prevalence of competitive market structures, and the reduction of barriers to entry for new firms.
Factor Market Development	Assesses the efficiency and openness of markets for production factors such as labor and capital. This includes the mobility of labor, the development of financial markets, and the allocation mechanisms for capital and land resources.
Legal and Institutional Environment	Measures the establishment and effectiveness of institutions that support market operations, including legal frameworks, regulatory bodies, and financial intermediaries. Indicators cover aspects like contract enforcement, protection of property rights, and the presence of professional services that facilitate market transactions.
Second-order Moderator (Z)	
Firm Nature	This binary variable captures the ownership type of the firm, classified based on the official registration codes provided in the firm database. Firms are grouped into two categories: State-owned enterprises (SOEs), coded as 1, include firms designated under P0301: State-owned or State Holding Enterprise. Non-state-owned enterprises (non-SOEs), coded as 0, encompass all other ownership types, including foreign-invested enterprises (P0302–P0304), collectively-owned (P0305), private firms (P0306), public institutions (P0307), government agencies (P0308), and others (P0309).
Control Variables	
Size	Firm size is measured as the natural logarithm of total assets, a standard proxy for firm scale. Larger firms typically have greater resource access, market power, and investor visibility, which may influence both innovation and ESG performance.
Age	This variable is calculated as the number of years since the firm's listing on China stock exchanges, reflecting its operational experience and maturity.
Financial Constraints (HP)	Based on the methodology of Hadlock and Pierce [17], the financial constraints index (HP Index) is calculated as: $HP\ Index = (-0.737 \times Size) + (0.043 \times Size^2) - (0.040 \times Age)$ where Size is the natural logarithm of total assets, and Age is the number of years the firm has been listed on China stock exchanges. A higher index indicates greater financial constraints.
CEO & Chairman Duality	This binary variable equals 1 if the CEO concurrently serves as the board chairperson, and 0 otherwise. CEO duality reflects concentrated decision-making power and may influence governance quality, strategic orientation, and responsiveness to ESG norms.
Board Independence	This variable measures the proportion of independent directors on the board of directors. A higher ratio is generally associated with stronger internal governance and more effective oversight of ESG and innovation decisions.
Ownership Concentration	This variable reflects the percentage of shares held by the largest shareholder. It captures the degree of ownership concentration, which can affect strategic alignment, monitoring incentives, and agency costs.

Table 1
Descriptive statistics of the variables used in the analysis.

	Observations	Mean	S.D.	P25	Median	P75	Min	Max
Dependent Variables								
ROA	17,534	0.026	0.078	0.009	0.033	0.063	-0.340	0.216
Tobin's Q	17,474	0.432	0.203	0.273	0.425	0.576	0.055	0.965
Independent Variables (X)								
Technological Innovation proxy 1 (R & D / sales)	15,300	0.048	0.052	0.015	0.036	0.057	0.0002	0.344
Technological Innovation proxy 2 Ln (Authorized patent)	4,794	3.400	1.365	2.485	3.401	4.277	0	7.200
Mediator Variables (M)								
Wind ESG Combined Score	15,107	6.008	0.796	5.46	5.93	6.48	4.22	8.27
Huazheng ESG Score	17,515	4.109	0.885	4	4	5	1	8
Moderator Variables (W)								
Government-Market Relationship (GMR)	17,530	7.469	1.236	7.073	7.377	7.98	-0.288	12.15
Development of Non-state sector (DNS)	17,530	11.84	1.802	11.16	12.14	12.96	0.47	23.75
Product Market Development (PMD)	17,530	6.944	2.421	5.808	7.431	8.566	-1.336	10.46
Factor Market Development (FMD)	17,530	14.02	3.488	11.59	14.33	16.70	1.55	20.28
Legal and Institutional Environment (LIE)	17,530	13.26	3.470	11.20	13.67	15.87	-0.22	19.76
Second Moderator Variables (Z)								
Firm Nature (State vs Non-state)	17,474	0.299	0.458	0	0	1	0	1
Control Variables								
HP index	17,534	4.721	1.563	3.651	4.474	5.510	1.417	10.07
Age	17,534	2.974	0.325	2.773	2.996	3.219	0.693	3.497
Size	17,534	22.40	1.292	21.49	22.23	23.14	18.96	26.17
CEO & Chairman Duality	17,534	1.700	0.458	1	2	2	1	2
Board Independence	17,534	0.384	0.075	0.333	0.375	0.429	0.25	0.6
Ownership Concentration	17,534	33.40	14.83	21.79	31.07	43.14	8.36	74.88

*All dependent, independent, and control variables have been winsorised at 1% and 99% percentiles.

Table 2
Pairwise pearson correlation coefficients among the variables used in the analysis.

ROA	(1)	1																
Tobin's Q	(2)	-0.352***	1															
R&D Intensity	(3)	-0.109***	-0.276***	1														
Authorised Patent	(4)	-0.022	0.302***	0.042**	1													
Wind ESG	(5)	0.179***	-0.125***	0.179***	0.163***	1												
Huazheng ESG	(6)	0.225***	-0.188***	0.141***	0.150***	0.438***	1											
GMR	(7)	0.051***	-0.076***	0.116***	-0.060***	0.075***	0.093***	1										
DNS	(8)	0.007	-0.045***	0.073***	0.065***	0.044***	0.064***	0.415***	1									
PMD	(9)	0.064***	-0.049***	0.003	-0.135***	-0.011	0.043***	0.573***	0.359***	1								
FMD	(10)	-0.047***	-0.027***	0.187***	0.209***	0.118***	0.116***	0.491***	0.448***	0.060***	1							
LIE	(11)	-0.029***	-0.006	0.143***	0.207***	0.115***	0.089***	0.397***	0.587***	0.083***	0.828***	1						
Ownership Concentration	(12)	0.021***	0.217***	-0.203***	0.175***	0.067***	0.029***	-0.168***	-0.203***	-0.178***	-0.177***	-0.183***	1					
HP	(13)	0.029***	0.083***	-0.121***	0.056***	0.031***	0.009	-0.024***	-0.043***	-0.031***	-0.034***	-0.047***	0.177***	1				
Age	(14)	-0.079***	0.154***	-0.154***	0.108***	-0.024***	-0.058***	-0.132***	0.149***	-0.156***	0.192***	0.026***	0.176***	0.108***	1			
Size	(15)	0.093***	0.437***	-0.255***	0.554***	0.192***	0.200***	-0.096***	-0.048***	-0.133***	0.023***	0.032***	0.345***	0.175***	0.176***	1		
CEO & Chairman Duality	(16)	0.007	0.113***	-0.137***	0.079***	0.037***	-0.023***	-0.103***	-0.086***	-0.077***	-0.099***	-0.089***	0.276***	0.091***	0.111***	0.167***	1	
Board Independence	(17)	0.016**	-0.060***	0.065***	0.057***	0.024***	0.080***	0.042***	0.050***	0.035***	0.061***	0.063***	-0.145***	-0.052***	-0.051***	-0.074***	-0.120***	1
Firm Nature (State vs Non-state)	(18)	0.026***	0.001	-0.028***	0.007	0.018**	0.013*	-0.009	-0.0002	-0.007	0.011	0.018**	0.027***	0.184***	0.026***	0.032***	0.01	-0.005	1

Table 3.1
Moderated mediation results for technological innovation, ESG engagement/huazheng ESG, and ROA using R&D Intensity as Innovation Measure.

Model 1															
	Mediator variable model (Huazheng)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	0.545***	0.174	3.134	0.002	0.205; 0.886	-0.123***	0.016	-7.596	0.000	-0.154; -0.091	Low	Low (0)	0.055	0.007	0.042; 0.070
Technology innovation R&D intensity (X)	2.800***	0.178	15.71	0.000	2.451; 3.150	-0.128***	0.016	-8.044	0.000	-0.159; -0.097	Low	High (1)	0.069	0.014	0.043; 0.097
Huazheng (M)						0.021***	0.001	24.12	0.000	0.019; 0.023	Average	Low (0)	0.059	0.005	0.049; 0.069
Government-market relationship (W)	0.047***	0.008	5.577	0.000	0.030; 0.063						Average	High (1)	0.073	0.010	0.055; 0.095
Firm nature (Z)	0.070***	0.019	3.622	0.000	0.032; 0.107						High	Low (0)	0.062	0.006	0.051; 0.074
X × W	0.152	0.178	0.854	0.393	-0.197; 0.500						High	High (1)	0.077	0.019	0.043; 0.117
X × Z	0.686	0.427	1.607	0.108	-0.151; 1.523						**Index of moderated moderated mediation:**		**0.0003**	**0.012**	**-0.023; 0.026**
W × Z	0.071***	0.018	3.875	0.000	0.035; 0.107						**Indices of conditional moderated mediation**				
X × W × Z	0.013	0.514	0.025	0.980	-0.996; 1.021						Firm nature = 0		0.003	0.004	-0.005; 0.011
Model R-sq	R-sq = 0.111, F(21, 12323) = 73.08, p=0.000					R-sq = 0.077, F(16, 12328) = 63.97, p=0.000					Firm nature = 1		0.004	0.012	-0.019; 0.027
Model 2															
	Mediator variable model (Huazheng)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Development of non-state sector (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	0.477***	0.174	2.741	0.006	0.136; 0.817	-0.123***	0.016	-7.596	0.000	-0.154; -0.091	Low	Low (0)	0.060	0.007	0.047; 0.075
Technology innovation R&D intensity (X)	2.906***	0.177	16.43	0.000	2.559; 3.252	-0.128***	0.016	-8.044	0.000	-0.159; -0.097	Low	High (1)	0.058	0.011	0.037; 0.080
Huazheng (M)						0.021***	0.001	24.12	0.000	0.019; 0.023	Average	Low (0)	0.061	0.005	0.052; 0.072
Development of non-state sector (W)	0.029***	0.007	4.455	0.000	0.016; 0.042						Average	High (1)	0.086	0.011	0.066; 0.109
Firm nature (Z)	0.052***	0.019	2.706	0.007	0.014; 0.090						High	Low (0)	0.062	0.006	0.050; 0.075
X × W	0.031	0.125	0.251	0.802	-0.214; 0.276						High	High (1)	0.114	0.017	0.082; 0.150
X × Z	1.188***	0.430	2.762	0.006	0.345; 2.031						**Index of moderated moderated mediation:**		**0.016**	**0.006**	**0.004; 0.029**
W × Z	0.019*	0.011	1.785	0.074	-0.002; 0.040						**Indices of conditional moderated mediation**				
X × W × Z	**0.773*** **	**0.264**	**2.931**	**0.003**	**0.256; 1.290**						Firm nature = 0		0.001	0.003	-0.005; 0.006
Model R-sq	R-sq = 0.105, F(21, 12323) = 68.99, p=0.000					R-sq = 0.077, F(16, 12328) = 63.97, p=0.000					**Firm nature = 1**		**0.017**	**0.006**	**0.006; 0.028**
Model 3															
	Mediator variable model (Huazheng)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Product market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	0.433***	0.174	2.486	0.013	0.092; 0.774	-0.123***	0.016	-7.596	0.000	-0.154; -0.091	Low	Low (0)	0.063	0.006	0.052; 0.075
Technology innovation R&D intensity (X)	2.917***	0.177	16.46	0.000	2.569; 3.624	-0.128***	0.016	-8.044	0.000	-0.159; -0.097	Low	High (1)	0.080	0.009	0.063; 0.099
Huazheng (M)						0.021***	0.001	24.12	0.000	0.019; 0.023	Average	Low (0)	0.061	0.005	0.052; 0.072
Product market development (W)	0.016***	0.004	3.916	0.000	0.008; 0.024						Average	High (1)	0.079	0.011	0.058; 0.104
Firm nature (Z)	0.055***	0.019	2.838	0.005	0.017; 0.093						High	Low (0)	0.060	0.007	0.048; 0.073
X × W	-0.025	0.065	-0.381	0.703	-0.153; 0.103						High	High (1)	0.077	0.018	0.045; 0.116
X × Z	0.833*	0.442	1.885	0.059	-0.033; -1.698						**Index of moderated moderated mediation:**		**0.000**	**0.004**	**-0.008; 0.008**

(*continued on next page*)

Table 3.1 (*continued*)

Model 1														
	Mediator variable model (Huazheng)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**			
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
W × Z	0.012*	0.007	1.727	0.084	-0.002; 0.026						**Indices of conditional moderated mediation**				
X × W × Z	-0.0004	0.157	-0.003	0.998	-0.308; 0.307						Firm nature = 0		-0.001	0.002	-0.004; 0.003
Model R-sq	R-sq = 0.105, F(21, 12323) = 68.74, p=0.000					R-sq = 0.077, F(16, 12328) = 63.97, p=0.000					Firm nature = 1		-0.001	0.004	-0.008; 0.007
Model 4														
	Mediator variable model (Huazheng)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**			
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Factor market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	0.607***	0.174	3.497	0.001	0.267; 0.947	-0.123***	0.016	-7.596	0.000	-0.154; -0.091	Low	Low (0)	0.046	0.008	0.031; 0.063
Technology innovation R&D intensity (X)	2.597***	0.188	13.82	0.000	2.228; 2.966	-0.128***	0.016	-8.044	0.000	-0.159; -0.097	Low	High (1)	0.072	0.014	0.044; 0.101
Huazheng (M)						0.021***	0.001	24.12	0.000	0.019; 0.023	Average	Low (0)	0.055	0.006	0.044; 0.066
Factor market development (W)	0.026***	0.003	7.769	0.000	0.020; 0.033						Average	High (1)	0.068	0.010	0.050; 0.087
Firm nature (Z)	0.066***	0.019	3.466	0.001	0.029; 0.104						High	Low (0)	0.063	0.005	0.054; 0.073
X × W	**0.131****	**0.056**	**2.319**	**0.020**	**0.020; 0.241**						High	High (1)	0.063	0.012	0.041; 0.087
X × Z	0.625	0.426	1.466	0.143	-0.211; 1.460						**Index of moderated moderated mediation:**		**-0.004**	**0.003**	**-0.010; 0.002**
W × Z	0.017***	0.006	2.896	0.004	0.005; 0.028						**Indices of conditional moderated mediation**				
X × W × Z	-0.199	0.141	-1.411	0.158	-0.476; 0.078						**Firm nature = 0**		**0.003**	**0.001**	**0.000; 0.005**
Model R-sq	R-sq = 0.113, F(21, 12323) = 74.79, p=0.000					R-sq = 0.077, F(16, 12328) = 63.97, p=0.000					Firm nature = 1		-0.001	0.003	-0.007; 0.004
Model 5														
	Mediator variable model (Huazheng)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**			
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Legal and institutional environment (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	0.625***	0.174	3.602	0.000	0.285; 0.966	-0.123***	0.016	-7.596	0.000	-0.154; -0.091	Low	Low (0)	0.043	0.008	0.028; 0.061
Technology innovation R&D intensity (X)	2.648***	0.183	14.47	0.000	2.289; 3.007	-0.128***	0.016	-8.044	0.000	-0.159; -0.097	Low	High (1)	0.056	0.015	0.029; 0.086
Huazheng (M)						0.021***	0.001	24.12	0.000	0.019; 0.023	Average	Low (0)	0.056	0.005	0.047; 0.067
Legal and institutional environment (W)	0.041***	0.004	10.18	0.000	0.033; 0.049						Average	High (1)	0.075	0.010	0.058; 0.096
Firm nature (Z)	0.067***	0.019	3.510	0.000	0.030; 0.105						High	Low (0)	0.068	0.006	0.057; 0.079
X × W	**0.198*****	**0.066**	**2.992**	**0.003**	**0.068; 0.327**						High	High (1)	0.095	0.015	0.067; 0.126
X × Z	0.946***	0.423	2.234	0.026	0.116; 1.776						**Index of moderated moderated mediation:**		**0.002**	**0.004**	**-0.006; 0.011**
W × Z	0.010	0.006	1.543	0.123	-0.003; 0.022						**Indices of conditional moderated mediation**				
X × W × Z	0.115	0.164	0.704	0.482	-0.206; 0.437						**Firm nature = 0**		**0.004**	**0.002**	**0.001; 0.007**
Model R-sq	R-sq = 0.113, F(21, 12323) = 74.56, p=0.000					R-sq = 0.077, F(16, 12328) = 63.97, p=0.000					Firm nature = 1		0.007	0.004	-0.001; 0.014

Table 3.2
Moderated Mediation Results for Technological Innovation, ESG Engagement/Wind ESG, and ROA Using R&D Intensity as Innovation Measure.

Model 1															
	Mediator variable model (Wind Combined)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	2.528***	0.159	15.90	0.000	2.217; 2.840	-0.157***	0.017	-9.381	0.000	-0.190; -0.124	Low	Low (0)	0.052	0.005	0.042; 0.062
Technology innovation R&D intensity (X)	3.566***	0.163	21.95	0.000	3.248; 3.885	-0.121***	0.017	-7.292	0.000	-0.153; -0.088	Low	High (1)	0.064	0.010	0.046; 0.085
Wind Combined (M)						0.015***	0.001	15.45	0.000	0.013; 0.017	Average	Low (0)	0.054	0.004	0.046; 0.064
Government-market relationship (W)	0.029***	0.008	3.811	0.000	0.014; 0.044						Average	High (1)	0.075	0.008	0.061; 0.091
Firm nature (Z)	0.123***	0.017	7.091	0.000	0.089; 0.158						High	Low (0)	0.057	0.005	0.047; 0.068
X × W	0.165	0.161	1.021	0.307	-0.151; 0.481						High	High (1)	0.086	0.012	0.064; 0.110
X × Z	1.354***	0.390	3.477	0.001	0.591; 2.118						**Index of moderated moderated mediation:**		**0.007**	**0.007**	**-0.007; 0.021**
W × Z	0.088***	0.017	5.318	0.000	0.056; 0.120						**Indices of conditional moderated mediation**				
X × W × Z	0.475	0.467	1.017	0.309	-0.441; 1.391						Firm nature = 0		0.003	0.003	-0.002; 0.008
Model R-sq	R-sq = 0.136, F(21, 12147) = 90.94, p=0.000					R-sq = 0.052, F(16, 12152) = 41.28, p=0.000					Firm nature = 1		0.010	0.007	-0.004; 0.024
Model 2															
	Mediator variable model (Wind Combined)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Development of non-state sector (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	2.459***	0.159	15.44	0.000	2.147; 2.771	-0.157***	0.017	-9.381	0.000	-0.190; -0.124	Low	Low (0)	0.057	0.006	0.046; 0.069
Technology innovation R&D intensity (X)	3.656***	0.161	22.66	0.000	3.340; 3.972	-0.121***	0.017	-7.292	0.000	-0.153; -0.088	Low	High (1)	0.070	0.009	0.055; 0.088
Wind Combined (M)						0.015***	0.001	15.45	0.000	0.013; 0.017	Average	Low (0)	0.056	0.005	0.047; 0.066
Development of non-state sector (W)	-0.005	0.006	-0.773	0.439	-0.016; 0.007						Average	High (1)	0.079	0.008	0.065; 0.097
Firm nature (Z)	0.010***	0.017	5.718	0.000	0.066; 0.134						High	Low (0)	0.055	0.005	0.045; 0.066
X × W	-0.039	0.114	-0.338	0.735	-0.262;0.185						High	High (1)	0.088	0.011	0.070; 0.112
X × Z	1.556***	0.392	3.971	0.000	0.788; 2.324						**Index of moderated moderated mediation:**		**0.006**	**0.004**	**-0.001; 0.013**
W × Z	0.036***	0.010	3.730	0.000	0.017; 0.055						**Indices of conditional moderated mediation**				
X × W × Z	**0.397***	**0.239**	**1.660**	**0.097**	**-0.072; 0.865**						Firm nature = 0		-0.001	0.002	-0.004; 0.003
Model R-sq	R-sq = 0.129, F(21, 12147) = 85.95, p=0.000					R-sq = 0.052, F(16, 12152) = 41.28, p=0.000					**Firm nature = 1**		**0.006**	**0.003**	**-0.001; 0.012**
Model 3															
	Mediator variable model (Wind Combined)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Product market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	2.449***	0.159	15.36	0.000	2.137; 2.762	-0.157***	0.017	-9.381	0.000	-0.190; -0.124	Low	Low (0)	0.054	0.005	0.045; 0.064
Technology innovation R&D intensity (X)	3.653***	0.162	22.59	0.000	3.336; 3.970	-0.121***	0.017	-7.292	0.000	-0.153; -0.088	Low	High (1)	0.072	0.008	0.057; 0.088
Wind Combined (M)						0.015***	0.001	15.45	0.000	0.013; 0.017	Average	Low (0)	0.056	0.005	0.047; 0.065
Product market development (W)	0.001	0.004	0.314	0.753	-0.006; 0.008						Average	High (1)	0.082	0.009	0.066; 0.100
Firm nature (Z)	0.108***	0.018	6.131	0.000	0.074; 0.143						High	Low (0)	0.057	0.005	0.047; 0.068
X × W	0.042	0.059	0.702	0.483	-0.074; 0.158						High	High (1)	0.093	0.011	0.072; 0.118
X × Z	1.761***	0.404	4.363	0.000	0.970; 2.553						**Index of moderated moderated mediation:**		**0.004**	**0.002**	**-0.001; 0.009**

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Table 3.2 (*continued*)

Model 1															
	Mediator variable model (Wind Combined)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
W × Z	0.024***	0.006	3.763	0.000	0.011; 0.036						**Indices of conditional moderated mediation**				
X × W × Z	**0.253***	**0.143**	**1.775**	**0.076**	**-0.026; 0.532**						Firm nature = 0		0.001	0.001	-0.001; 0.003
Model R-sq	R-sq = 0.130, F(21, 12147) = 86.27, p=0.000					R-sq = 0.052, F(16, 12152) = 41.28, p=0.000					**Firm nature = 1**		**0.005**	**0.002**	**0.001; 0.009**
Model 4															
	Mediator variable model (Wind Combined)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Factor market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	2.562***	0.159	16.11	0.000	2.250; 2.874	-0.157***	0.017	-9.381	0.000	-0.190; -0.124	Low	Low (0)	0.053	0.006	0.042; 0.065
Technology innovation R&D intensity (X)	3.529***	0.171	20.62	0.000	3.193; 3.865	-0.121***	0.017	-7.292	0.000	-0.153; -0.088	Low	High (1)	0.070	0.010	0.051; 0.091
Wind Combined (M)						0.015***	0.001	15.45	0.000	0.013; 0.017	Average	Low (0)	0.054	0.005	0.045; 0.063
Factor market development (W)	0.017***	0.003	5.464	0.000	0.011;0.023						Average	High (1)	0.070	0.008	0.056; 0.086
Firm nature (Z)	0.115***	0.017	6.593	0.000	0.081; 0.149						High	Low (0)	0.055	0.005	0.045; 0.065
X × W	0.017	0.051	0.324	0.746	-0.084; 0.117						High	High (1)	0.071	0.009	0.054; 0.090
X × Z	1.088***	0.389	2.798	0.005	0.326; 1.850						**Index of moderated moderated mediation:**		**-0.0001**	**0.002**	**-0.004; 0.004**
W × Z	0.021***	0.005	3.880	0.000	0.010; 0.031						**Indices of conditional moderated mediation**				
X × W × Z	-0.006	0.128	-0.050	0.960	-0.258; 0.245						Firm nature = 0		0.0003	0.001	-0.002; 0.002
Model R-sq	R-sq = 0.136, F(21, 12147) = 90.98, p=0.000					R-sq = 0.052, F(16, 12152) = 41.28, p=0.000					Firm nature = 1		0.0002	0.002	-0.003; 0.004
Model 5															
	Mediator variable model (Wind Combined)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Legal and institutional environment (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	2.565***	0.159	16.11	0.000	2.253; 2.877	-0.157***	0.017	-9.381	0.000	-0.190; -0.124	Low	Low (0)	0.050	0.006	0.040; 0.062
Technology innovation R&D intensity (X)	3.524***	0.167	21.13	0.000	3.197; 3.851	-0.121***	0.017	-7.292	0.000	-0.153; -0.088	Low	High (1)	0.080	0.010	0.061; 0.101
Wind Combined (M)						0.015***	0.001	15.45	0.000	0.013; 0.017	Average	Low (0)	0.054	0.005	0.046; 0.063
Legal and institutional environment (W)	0.025***	0.004	6.874	0.000	0.018; 0.032						Average	High (1)	0.073	0.008	0.059; 0.089
Firm nature (Z)	0.118***	0.017	6.808	0.000	0.084; 0.152						High	Low (0)	0.058	0.005	0.048; 0.068
X × W	0.086	0.061	1.422	0.155	-0.033; 0.205						High	High (1)	0.066	0.010	0.049; 0.088
X × Z	1.265***	0.386	3.275	0.001	0.508; 2.022						**Index of moderated moderated mediation:**		**-0.004**	**0.002**	**-0.008; 0.001**
W × Z	0.010*	0.006	1.726	0.084	-0.001; 0.021						**Indices of conditional moderated mediation**				
X × W × Z	-0.235	0.149	-1.576	0.115	-0.527; 0.057						Firm nature = 0		0.001	0.001	-0.001; 0.003
Model R-sq	R-sq = 0.135, F(21, 12147) = 90.41, p=0.000					R-sq = 0.052, F(16, 12152) = 41.28, p=0.000					Firm nature = 1		-0.002	0.002	-0.007; 0.002

Table 4.1
Moderated Mediation Results for Technological Innovation, ESG Engagement/Huazheng ESG, and Tobin's Q Using R&D Intensity as Innovation Measure.

Model 1															
	Mediator variable model (Huazheng)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	0.544**	0.174	3.133	0.002	0.204; 0.885	-0.586***	0.035	-16.56	0.000	-0.655; -0.516	Low	Low (0)	-0.154	0.019	-0.193; -0.118
Technology innovation R&D intensity (X)	2.801***	0.178	15.72	0.000	2.451; 3.150	-0.447***	0.035	-12.82	0.000	-0.516; -0.379	Low	High (1)	-0.193	0.038	-0.271; -0.122
Huazheng (M)						-0.059***	0.002	-30.80	0.000	-0.062; -0.055	Average	Low (0)	-0.164	0.013	-0.191; -0.140
Government-market relationship (W)	0.047***	0.008	5.577	0.000	0.030; 0.063						Average	High (1)	-0.205	0.027	-0.261; -0.155
Firm nature (Z)	0.070***	0.019	3.623	0.000	0.032; 0.107						High	Low (0)	-0.174	0.016	-0.205; -0.144
X × W	0.152	0.178	0.854	0.393	-0.197; 0.500						High	High (1)	-0.216	0.050	-0.320; -0.120
X × Z	0.685	0.427	1.604	0.109	-0.152; 1.523						**Index of moderated moderated mediation:**		**-0.001**	**0.034**	**-0.069; 0.066**
W × Z	0.071***	0.018	3.867	0.000	0.035; 0.107						**Indices of conditional moderated mediation**				
X × W × Z	0.023	0.515	0.044	0.965	-0.986; 1.031						Firm nature = 0		-0.009	0.01	-0.029; 0.013
Model R-sq	R-sq = 0.111, F(21, 12322) = 73.03, p=0.000					R-sq = 0.272, F(16, 12327) = 287.31, p=0.000					Firm nature = 1		-0.010	0.032	-0.074; 0.054
Model 2															
	Mediator variable model (Huazheng)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Development of non-state sector (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	0.475***	0.174	2.734	0.006	0.135; 0.816	-0.586***	0.035	-16.56	0.000	-0.655; -0.516	Low	Low (0)	-0.168	0.019	-0.206; -0.132
Technology innovation R&D intensity (X)	2.906***	0.177	16.43	0.000	2.559; 3.253	-0.447***	0.035	-12.82	0.000	-0.516; -0.379	Low	High (1)	-0.162	0.030	-0.221; -0.104
Huazheng (M)						-0.059***	0.002	-30.80	0.000	-0.062; -0.055	Average	Low (0)	-0.171	0.013	-0.196; -0.146
Development of non-state sector (W)	0.029***	0.007	4.456	0.000	0.016; 0.042						Average	High (1)	-0.240	0.029	-0.303; -0.186
Firm nature (Z)	0.052***	0.019	2.707	0.007	0.014; 0.090						High	Low (0)	-0.174	0.017	-0.208; -0.140
X × W	0.031	0.125	0.252	0.802	-0.214; 0.277						High	High (1)	-0.319	0.046	-0.414; -0.231
X × Z	1.187***	0.430	2.759	0.006	0.344; 2.030						**Index of moderated moderated mediation:**		**-0.046**	**0.017**	**-0.081; -0.013**
W × Z	0.019*	0.011	1.768	0.077	-0.002; 0.040						**Indices of conditional moderated mediation**				
X × W × Z	**0.779*** **	**0.264**	**2.951**	**0.003**	**0.262; 1.296**						Firm nature = 0		-0.002	0.008	-0.017; 0.014
Model R-sq	R-sq = 0.105, F(21, 12322) = 68.97, p=0.000					R-sq = 0.272, F(16, 12327) = 287.31, p=0.000					**Firm nature = 1**		**-0.048**	**0.016**	**-0.079; -0.017**
Model 3															
	Mediator variable model (Huazheng)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Product market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	0.432**	0.174	2.480	0.013	0.091; 0.773	-0.586***	0.035	-16.56	0.000	-0.655; -0.516	Low	Low (0)	-0.175	0.016	-0.208; -0.146
Technology innovation R&D intensity (X)	2.917***	0.177	16.46	0.000	2.570; 3.265	-0.447***	0.035	-12.82	0.000	-0.516; -0.379	Low	High (1)	-0.223	0.026	-0.278; -0.178
Huazheng (M)						-0.059***	0.002	-30.80	0.000	-0.062; -0.055	Average	Low (0)	-0.171	0.013	-0.198; -0.147
Product market development (W)	0.016***	0.004	3.916	0.000	0.008; 0.024						Average	High (1)	-0.220	0.030	-0.281; -0.164
Firm nature (Z)	0.055***	0.019	2.838	0.005	0.017; 0.093						High	Low (0)	-0.168	0.018	-0.202; -0.134
X × W	-0.025	0.065	-0.382	0.703	-0.153; 0.103						High	High (1)	-0.217	0.047	-0.313; -0.127
X × Z	0.832*	0.442	1.883	0.060	-0.034; 1.698						**Index of moderated moderated mediation:**		**-0.0002**	**0.011**	**-0.021; 0.021**

(*continued on next page*)

Table 4.1 (*continued*)

Model 1

	Mediator variable model (Huazheng)					Dependent variable model (Tobin's Q)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
W × Z	0.012*	0.007	1.705	0.088	-0.002; 0.026						**Indices of conditional moderated mediation**				
X × W × Z	0.003	0.157	0.018	0.986	-0.305; 0.310						Firm nature = 0		0.002	0.004	-0.007; 0.010
Model R-sq	R-sq = 0.105, F(21, 12322) =68.70, p=0.000					R-sq = 0.272, F(16, 12327) = 287.31, p=0.000					Firm nature = 1		0.001	0.010	-0.017; 0.020

Model 4

	Mediator variable model (Huazheng)					Dependent variable model (Tobin's Q)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Factor market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	0.606***	0.174	3.491	0.001	0.266; 0.946	-0.586***	0.035	-16.56	0.000	-0.655; -0.516	Low	Low (0)	-0.129	0.023	-0.173; -0.085
Technology innovation R&D intensity (X)	2.598***	0.188	13.83	0.000	2.229; 2.966	-0.447***	0.035	-12.82	0.000	-0.516; -0.379	Low	High (1)	-0.201	0.039	-0.281; -0.128
Huazheng (M)						-0.059***	0.002	-30.80	0.000	-0.062; -0.055	Average	Low (0)	-0.152	0.014	-0.181; -0.126
Factor market development (W)	0.026***	0.003	7.768	0.000	0.020; 0.033						Average	High (1)	-0.189	0.025	-0.240; -0.141
Firm nature (Z)	0.066***	0.019	3.465	0.001	0.029; 0.104						High	Low (0)	-0.176	0.013	-0.202; -0.152
X × W	**0.131****	**0.056**	**2.319**	**0.020**	**0.020; 0.241**						High	High (1)	-0.177	0.032	-0.242; -0.118
X × Z	0.622	0.426	1.461	0.144	-0.213; 1.458						**Index of moderated moderated mediation:**		**0.012**	**0.009**	**-0.006;0.029**
W × Z	0.017***	0.006	2.882	0.004	0.005; 0.028						**Indices of conditional moderated mediation**				
X × W × Z	-0.197	0.141	-1.393	0.164	-0.474; 0.080						**Firm nature = 0**		**-0.008**	**0.004**	**-0.015; -0.0002**
Model R-sq	R-sq = 0.113, F(21, 12322) = 74.74, p=0.000					R-sq = 0.272, F(16, 12327) = 287.31, p=0.000					Firm nature = 1		0.004	0.008	-0.012; 0.020

Model 5

	Mediator variable model (Huazheng)					Dependent variable model (Tobin's Q)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Legal and institutional environment (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	0.624***	0.174	3.595	0.000	0.284; 0.964	-0.586***	0.035	-16.56	0.000	-0.655; -0.516	Low	Low (0)	-0.121	0.023	-0.168; -0.078
Technology innovation R&D intensity (X)	2.648***	0.183	14.47	0.000	2.290; 3.007	-0.447***	0.035	-12.82	0.000	-0.516; -0.379	Low	High (1)	-0.156	0.041	-0.237; -0.077
Huazheng (M)						-0.059***	0.002	-30.80	0.000	-0.062; -0.055	Average	Low (0)	-0.155	0.014	-0.184; -0.130
Legal and institutional environment (W)	0.041***	0.004	10.18	0.000	0.033; 0.049						Average	High (1)	-0.211	0.026	-0.264; -0.162
Firm nature (Z)	0.067***	0.019	3.511	0.000	0.030; 0.105						High	Low (0)	-0.190	0.014	-0.219; -0.162
X × W	**0.198*****	**0.066**	**2.992**	**0.003**	**0.068; 0.327**						High	High (1)	-0.265	0.041	-0.349; -0.189
X × Z	0.944**	0.423	2.228	0.026	0.114; 1.774						**Index of moderated moderated mediation:**		**-0.007**	**0.012**	**-0.031; 0.016**
W × Z	0.010	0.006	1.533	0.125	-0.003; 0.022						**Indices of conditional moderated mediation**				
X × W × Z	0.118	0.164	0.719	0.472	-0.204; 0.439						**Firm nature = 0**		**-0.012**	**0.005**	**-0.021; -0.003**
Model R-sq	R-sq = 0.113, F(21, 12322) = 74.53, p=0.000					R-sq = 0.272, F(16, 12327) = 287.31, p=0.000					Firm nature = 1		-0.019	0.011	-0.040; 0.002

Table 4.2
Moderated Mediation Results for Technological Innovation, ESG Engagement/Wind ESG, and Tobin's Q Using R&D Intensity as Innovation Measure.

Model 1															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	2.530***	0.159	15.906	0.000	2.218; 2.841	-0.503***	0.037	-13.55	0.000	-0.576; -0.430	Low	Low (0)	-0.122	0.012	-0.146; -0.099
Technology innovation R&D intensity (X)	3.566***	0.163	21.964	0.000	3.247; 3.884	-0.489***	0.037	-13.35	0.000	-0.561; -0.417	Low	High (1)	-0.152	0.022	-0.198; -0.111
Wind Combined (M)						-0.036***	0.002	-16.50	0.000	-0.040; -0.032	Average	Low (0)	-0.128	0.010	-0.149; -0.110
Government-market relationship (W)	0.029***	0.008	3.811	0.000	0.014; 0.044						Average	High (1)	-0.177	0.018	-0.213; -0.145
Firm nature (Z)	0.123***	0.017	7.091	0.000	0.089; 0.158						High	Low (0)	-0.135	0.012	-0.160; -0.113
X × W	0.165	0.161	1.021	0.307	-0.151; 0.481						High	High (1)	-0.202	0.028	-0.260; -0.151
X × Z	1.356***	0.390	3.481	0.001	0.592, 2.119						**Index of moderated moderated mediation:**		**-0.017**	**0.017**	**-0.051; 0.018**
W × Z	0.088***	0.017	5.327	0.000	0.056; 0.120						**Indices of conditional moderated mediation**				
X × W × Z	0.463	0.467	0.990	0.322	-0.453; 1.379						Firm nature = 0		-0.006	0.006	-0.019; 0.005
Model R-sq	R-sq = 0.136, F(21, 12146) = 90.97, p=0.000					R-sq = 0.230, F(16, 12151) = 226.30, p=0.000					Firm nature = 1		-0.023	0.016	-0.055; 0.009
Model 2															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Development of non-state sector (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	2.460***	0.159	15.45	0.000	2.148; 2.772	-0.503***	0.037	-13.55	0.000	-0.576; -0.430	Low	Low (0)	-0.134	0.013	-0.161; -0.110
Technology innovation R&D intensity (X)	3.656***	0.161	22.66	0.000	3.340; 3.972	-0.489***	0.037	-13.35	0.000	-0.561; -0.417	Low	High (1)	-0.167	0.019	-0.205; -0.131
Wind Combined (M)						-0.036***	0.002	-16.50	0.000	-0.040; -0.032	Average	Low (0)	-0.132	0.010	-0.152; -0.113
Development of non-state sector (W)	-0.005	0.006	-0.774	0.439	-0.016; 0.007						Average	High (1)	-0.188	0.018	-0.225; -0.155
Firm nature (Z)	0.010***	0.017	5.718	0.000	0.066; 0.134						High	Low (0)	-0.129	0.012	-0.153; -0.108
X × W	-0.039	0.114	-0.338	0.735	-0.262;0.185						High	High (1)	-0.209	0.024	-0.261; -0.165
X × Z	1.557***	0.392	3.974	0.000	0.789; 2.326						**Index of moderated moderated mediation:**		**-0.014**	**0.009**	**-0.032; 0.002**
W × Z	0.036***	0.010	3.744	0.000	0.017; 0.055						**Indices of conditional moderated mediation**				
X × W × Z	0.392	0.239	1.641	0.101	-0.076; 0.861						Firm nature = 0		0.001	0.004	-0.007; 0.010
Model R-sq	R-sq = 0.129, F(21, 12146) =85.95, p=0.000					R-sq = 0.230, F(16, 12151) = 226.30, p=0.000					Firm nature = 1		-0.013	0.007	-0.028; 0.001
Model 3															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Product market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	2.450***	0.159	15.368	0.000	2.138; 2.763	-0.503***	0.037	-13.55	0.000	-0.576; -0.430	Low	Low (0)	-0.128	0.012	-0.153; -0.107
Technology innovation R&D intensity (X)	3.652***	0.162	22.59	0.000	3.335; 3.969	-0.489***	0.037	-13.35	0.000	-0.561; -0.417	Low	High (1)	-0.170	0.018	-0.206; -0.137
Wind Combined (M)						-0.036***	0.002	-16.50	0.000	-0.040; -0.032	Average	Low (0)	-0.131	0.010	-0.153; -0.113
Product market development (W)	0.001	0.004	0.315	0.753	-0.006; 0.008						Average	High (1)	-0.195	0.019	-0.235; -0.160
Firm nature (Z)	0.108***	0.018	6.131	0.000	0.074; 0.143						High	Low (0)	-0.135	0.012	-0.159; -0.113
X × W	0.042	0.059	0.703	0.482	-0.074; 0.158						High	High (1)	-0.220	0.026	-0.275; -0.173
X × Z	1.762***	0.404	4.365	0.000	0.971; 2.554						**Index of moderated moderated mediation:**		**-0.009**	**0.006**	**-0.021; 0.001**

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Table 4.2 (*continued*)

Model 1	**Mediator variable model (Wind Combined)**					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
W × Z	0.024***	0.006	3.783	0.000	0.012; 0.037						**Indices of conditional moderated mediation**				
X × W × Z	**0.250***	**0.143**	**1.755**	**0.079**	**-0.029; 0.530**						Firm nature = 0		-0.002	0.002	-0.006; 0.003
Model R-sq	R-sq = 0.130, F(21, 12146) =86.27, p=0.000					R-sq = 0.230, F(16, 12151) = 226.30, p=0.000					**Firm nature = 1**		**-0.011**	**0.005**	**-0.021; -0.001**
Model 4															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Factor market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	2.563***	0.159	16.12	0.000	2.252; 2.875	-0.503***	0.037	-13.55	0.000	-0.576; -0.430	Low	Low (0)	-0.125	0.013	-0.153; -0.101
Technology innovation R&D intensity (X)	3.529***	0.171	20.62	0.000	3.193; 3.864	-0.489***	0.037	-13.35	0.000	-0.561; -0.417	Low	High (1)	-0.166	0.022	-0.209; -0.125
Wind Combined (M)						-0.036***	0.002	-16.50	0.000	-0.040; -0.032	Average	Low (0)	-0.127	0.010	-0.149; -0.108
Factor market development (W)	0.017***	0.003	5.467	0.000	0.011; 0.023						Average	High (1)	-0.166	0.017	-0.201; -0.135
Firm nature (Z)	0.115***	0.017	6.597	0.000	0.081; 0.149						High	Low (0)	-0.129	0.011	-0.152; -0.109
X × W	0.017	0.051	0.325	0.745	-0.084; 0.117						High	High (1)	-0.167	0.021	-0.212; -0.129
X × Z	1.091***	0.389	2.806	0.005	0.329; 1.853						**Index of moderated moderated mediation:**		**0.0004**	**0.005**	**-0.009; 0.009**
W × Z	0.021***	0.005	3.900	0.000	0.010; 0.031						**Indices of conditional moderated mediation**				
X × W × Z	-0.010	0.128	-0.077	0.939	-0.261; 0.241						Firm nature = 0		-0.001	0.002	-0.005; 0.003
Model R-sq	R-sq = 0.136, F(21, 12146) =91.01, p=0.000					R-sq = 0.230, F(16, 12151) = 226.30, p=0.000					Firm nature = 1		-0.0002	0.004	-0.009; 0.008
Model 5															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Legal and institutional environment (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	2.566***	0.159	16.12	0.000	2.254; 2.878	-0.503***	0.037	-13.55	0.000	-0.576; -0.430	Low	Low (0)	-0.118	0.013	-0.145; -0.093
Technology innovation R&D intensity (X)	3.524***	0.167	21.13	0.000	3.197; 3.851	-0.489***	0.037	-13.35	0.000	-0.561; -0.417	Low	High (1)	-0.189	0.023	-0.237; -0.144
Wind Combined (M)						-0.036***	0.002	-16.50	0.000	-0.040; -0.032	Average	Low (0)	-0.127	0.010	-0.147; -0.108
Legal and institutional environment (W)	0.025***	0.004	6.878	0.000	0.018; 0.033						Average	High (1)	-0.172	0.017	-0.208; -0.140
Firm nature (Z)	0.118***	0.017	6.807	0.000	0.084; 0.152						High	Low (0)	-0.136	0.012	-0.161; -0.114
X × W	0.086	0.061	1.422	0.155	-0.033; 0.205						High	High (1)	-0.156	0.023	-0.205; -0.115
X × Z	1.267***	0.386	3.282	0.001	0.510; 2.025						**Index of moderated moderated mediation:**		**0.009**	**0.006**	**-0.003; 0.020**
W × Z	0.010*	0.006	1.737	0.082	-0.001; 0.021						**Indices of conditional moderated mediation**				
X × W × Z	-0.237	0.149	-1.592	0.111	-0.529; 0.055						Firm nature = 0		-0.003	0.003	-0.008; 0.002
Model R-sq	R-sq = 0.135, F(21, 12146) =90.43, p=0.000					R-sq = 0.230, F(16, 12151) = 226.30, p=0.000					Firm nature = 1		0.005	0.005	-0.005; 0.016

Table 5
Summary of Main Findings Based on Tables 3.1, 3.2, 4.1 and 4.2.

Hypothesis	Description	Main results
H1:	Mediation analysis of ESG engagement	Accepted
Path 2a	Impact of technological innovation on ESG engagement	Positive and significant impact observed
Path 2b	Impact of ESG engagement on firm performance	Positive and significant impact if performance is measured by ROA Negative and significant impact if performance is measured by Tobin's Q.
H2 & Path 3	To evaluate whether institutional quality moderates the innovation → ESG engagement relationship	Accepted, but the results are influenced by the choice of ESG engagement measurement. We observe significant moderating effects of factor market development and the legal and institutional environment (i.e. X × W) on the Huazheng ESG-mediated relationship.
H3 & Path 4	To assess whether firm nature moderates the moderating effect of institutional quality on innovation → ESG engagement relationship —i.e., a second-order moderation. *Firm nature (SOE vs. non-SOE) moderates the moderating effect of institutional quality on the relationship between technological innovation and ESG engagement. The strength and direction of this conditional effect vary depending on the firm's nature status and the specific dimension of institutional quality.*	Accepted. When non-state sector development and product market development are used as the institutional quality moderators, we observe significant interactions between innovation, non-state sector development/product market development and SOE firm nature (i.e. X × W × Z). We also find that the moderating effects of factor market development and the legal and institutional environment are amplified in non-SOEs. Such results support H3 as the second-order moderator role of firm nature (SOE or non-SOE) is contingent upon the types of institutional quality.

Table 6.1
Robustness Check: Moderated Mediation Results for ESG Engagement/Huazheng ESG and ROA Using Authorized Patents as Innovation Measure.

Model 1

	Mediator variable model (Huazheng)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	1.261***	0.352	3.584	0.000	0.571; 1.951	-0.004	0.023	-0.182	0.856	-0.050; 0.041	Low	Low (0)	0.0004	0.0002	-0.0001; 0.001
Technology innovation - authorized patent (X)	0.024*	0.015	1.663	0.096	-0.004; 0.052	-0.0002	0.001	-0.288	0.773	-0.002; 0.001	Low	High (1)	0.0004	0.0002	0.000; 0.001
Huazheng (M)						0.010***	0.001	9.232	0.000	0.008; 0.012	Average	Low (0)	0.0002	0.0001	0.000; 0.001
Government-market relationship (W)	-0.014	0.013	-1.086	0.277	-0.04; 0.012						Average	High (1)	0.001	0.0002	0.0003; 0.001
Firm nature (Z)	-0.056*	0.033	-1.688	0.092	-0.120; 0.009						High	Low (0)	0.0001	0.0002	-0.0003; 0.001
X × W	-0.009	0.010	-0.885	0.376	-0.028; 0.011						High	High (1)	0.001	0.0003	0.0003; 0.002
X × Z	0.041*	0.021	1.938	0.053	-0.001; 0.082						**Index of moderated moderated mediation:**		**0.0003**	**0.0002**	**0.000; 0.001**
W × Z	0.058***	0.019	3.074	0.002	0.021; 0.096						**Indices of conditional moderated mediation**				
X × W × Z	**0.026***	**0.015**	**1.734**	**0.083**	**-0.003; 0.055**						Firm nature = 0		-0.0001	0.0001	-0.0003; 0.0001
Model R-sq	R-sq = 0.067, F(29, 4183) = 10.43, p=0.000					R-sq = 0.044, F(24, 4188) = 7.992, p=0.000					Firm nature = 1		0.0002	0.0001	0.000; 0.0004

Model 2

	Mediator variable model (Huazheng)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Development of non-state sector (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	1.151***	0.351	3.281	0.001	0.463; 1.838	-0.004	0.023	-0.182	0.856	-0.050; 0.041	Low	Low (0)	0.0002	0.0002	-0.0003; 0.001
Technology innovation - authorized patent (X)	0.024*	0.015	1.649	0.099	-0.005; 0.053	-0.0002	0.001	-0.288	0.773	-0.002; 0.001	Low	High (1)	0.0004	0.0002	0.000; 0.001
Huazheng (M)						0.010***	0.001	9.232	0.000	0.008; 0.012	Average	Low (0)	0.0002	0.0001	-0.0001; 0.001
Development of non-state sector (W)	0.002	0.013	0.189	0.850	-0.023; 0.027						Average	High (1)	0.001	0.0002	0.0003; 0.001
Firm nature (Z)	-0.061*	0.033	-1.833	0.067	-0.126; 0.004						High	Low (0)	0.0003	0.0002	-0.0001; 0.001
X × W	0.001	0.009	0.113	0.910	-0.017; 0.019						High	High (1)	0.001	0.0003	0.0004; 0.001

(*continued on next page*)

Table 6.1 (*continued*)

Model 1

	Mediator variable model (Huazheng)					Dependent variable model (ROA)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
X × Z	0.039*	0.022	1.820	0.069	-0.003; 0.082						**Index of moderated moderated mediation:**		**0.0001**	**0.0001**	**-0.0001; 0.0004**
W × Z	0.031*	0.017	1.844	0.065	-0.002; 0.063						**Indices of conditional moderated mediation**				
X × W × Z	0.013	0.012	1.075	0.282	-0.011; 0.037						Firm nature = 0		0.0000	0.0001	-0.0001; 0.0002
Model R-sq	R-sq = 0.067, F(29, 4183) = 10.32, p=0.000					R-sq = 0.044, F(24, 4188) = 7.992, p=0.000					Firm nature = 1		0.0001	0.0001	0.000; 0.0003

Model 3

	Mediator variable model (Huazheng)					Dependent variable model (ROA)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Product market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	1.251***	0.351	3.561	0.000	0.563; 1.940	-0.004	0.023	-0.182	0.856	-0.050; 0.041	**Low**	**Low (0)**	**0.0004**	**0.0002**	**0.0001; 0.001**
Technology innovation - authorized patent (X)	0.026*	0.015	1.755	0.079	-0.003; 0.054	-0.0002	0.001	-0.288	0.773	-0.002; 0.001	Low	High (1)	0.001	0.0002	0.0002; 0.001
Huazheng (M)						0.010***	0.001	9.232	0.000	0.008; 0.012	Average	Low (0)	0.0003	0.0001	0.000; 0.001
Product market development (W)	0.001	0.009	0.065	0.949	-0.018; 0.019						Average	High (1)	0.001	0.0002	0.0002; 0.001
Firm nature (Z)	-0.060*	0.033	-1.838	0.066	-0.125; 0.004						High	Low (0)	0.0001	0.0002	-0.0003; 0.0004
X × W	-0.009	0.007	-1.297	0.195	-0.022; 0.005						High	High (1)	0.001	0.0003	0.0001; 0.001
X × Z	0.039*	0.021	1.799	0.072	-0.004; 0.080						**Index of moderated moderated mediation:**		**0.0001**	**0.0001**	**-0.0001; 0.0003**
W × Z	0.017	0.013	1.324	0.186	-0.008; 0.043						**Indices of conditional moderated mediation**				
X × W × Z	0.010	0.009	1.058	0.290	-0.008; 0.028						Firm nature = 0		-0.0001	0.0001	-0.0002; 0.000
Model R-sq	R-sq = 0.066, F(29, 4183) = 10.12, p=0.000					R-sq = 0.044, F(24, 4188) = 7.992, p=0.000					Firm nature = 1		0.0000	0.0001	-0.0001; 0.0001

Model 4

	Mediator variable model (Huazheng)					Dependent variable model (ROA)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Factor market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	1.239***	0.348	3.559	0.000	0.556; 1.921	-0.004	0.023	-0.182	0.856	-0.050; 0.041	Low	Low (0)	0.000	0.0002	-0.001; 0.0004
Technology innovation - authorized patent (X)	0.023	0.015	1.618	0.106	-0.005; 0.052	-0.0002	0.001	-0.288	0.773	-0.002; 0.001	Low	High (1)	0.0004	0.0002	-0.0001; 0.001
Huazheng (M)						0.010***	0.001	9.232	0.000	0.008; 0.012	Average	Low (0)	0.0002	0.0001	0.000; 0.001
Factor market development (W)	0.006	0.007	0.940	0.347	-0.007; 0.019						Average	High (1)	0.001	0.0002	0.0001; 0.001
Firm nature (Z)	-0.058*	0.033	-1.747	0.081	-0.123; 0.007						High	Low (0)	0.001	0.0002	0.0002; 0.001
X × W	**0.008***	**0.004**	**1.928**	**0.054**	**-0.0001; 0.016**						High	High (1)	0.001	0.0002	0.0002; 0.001
X × Z	0.028	0.021	1.337	0.181	-0.013; 0.070						**Index of moderated moderated mediation:**		**0.0000**	**0.0001**	**-0.0001; 0.0001**
W × Z	0.012	0.008	1.387	0.166	-0.005; 0.028						**Indices of conditional moderated mediation**				
X × W × Z	-0.004	0.006	-0.616	0.538	-0.015; 0.008						**Firm nature = 0**		**0.0001**	**0.0000**	**0.000; 0.0002**
Model R-sq	R-sq = 0.067, F(29, 4183) = 10.36, p=0.000					R-sq = 0.044, F(24, 4188) = 7.992, p=0.000					Firm nature = 1		0.0000	0.0000	0.000; 0.0001

Model 5

	Mediator variable model (Huazheng)					Dependent variable model (ROA)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Legal and institutional environment (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	1.236***	0.348	3.551	0.000	0.554; 1.919	-0.004	0.023	-0.182	0.856	-0.050; 0.041	Low	Low (0)	-0.0001	0.0002	-0.001; 0.0004
Technology innovation -	0.023	0.015	1.558	0.119	-0.006; 0.051	-0.0002	0.001	-0.288	0.773	-0.002; 0.001	Low	High (1)	0.001	0.0002	0.000; 0.001

(*continued on next page*)

Table 6.1 (*continued*)

Model 1	Mediator variable model (Huazheng)					Dependent variable model (ROA)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
authorized patent (X)															
Huazheng (M)						0.010***	0.001	9.232	0.000	0.008; 0.012	Average	Low (0)	0.0002	0.0001	-0.0001; 0.001
Legal and institutional environment (W)	0.003	0.007	0.384	0.701	-0.011; 0.016						Average	High (1)	0.001	0.0002	0.0002; 0.001
Firm nature (Z)	-0.059*	0.033	-1.777	0.076	-0.125; 0.006						High	Low (0)	0.001	0.0002	0.0002; 0.001
X × W	**0.008****	**0.004**	**1.966**	**0.049**	**0.000; 0.016**						High	High (1)	0.001	0.0003	0.0002; 0.001
X × Z	0.034	0.021	1.587	0.113	-0.008; 0.075						**Index of moderated moderated mediation:**		**-0.0001**	**0.0001**	**-0.0002; 0.0001**
W × Z	0.007	0.008	0.901	0.368	-0.008; 0.023						**Indices of conditional moderated mediation**				
X × W × Z	-0.006	0.006	-0.956	0.339	-0.017; 0.006						**Firm nature = 0**		**0.0001**	**0.0000**	**0.000; 0.0002**
Model R-sq	R-sq = 0.066, F(29, 4183) = 10.15, p=0.000					^{R}-sq = 0.044, F(24, 4188) = 7.992, p=0.000					Firm nature = 1		0.0000	0.0000	-0.0001; 0.0001

Table 6.2
Robustness Check: Moderated Mediation Results for ESG Engagement/Wind ESG and ROA Using Authorized Patents as Innovation Measure.

Model 1	Mediator variable model (Wind Combined)					Dependent variable model (ROA)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	3.951***	0.450	8.779	0.000	3.068; 4.834	-0.126***	0.039	-3.249	0.001	-0.203; -0.050	Low	Low (0)	0.000	0.0002	-0.0004; 0.001
Technology innovation - authorized patent (X)	0.010	0.018	0.568	0.570	-0.025; 0.045	0.0002	0.001	0.167	0.868	-0.002; 0.003	Low	High (1)	0.001	0.0003	0.0001; 0.001
Wind Combined (M)						0.008***	0.002	4.154	0.000	0.004; 0.012	Average	Low (0)	0.0001	0.0001	-0.0002; 0.0004
Government-market relationship (W)	0.023	0.020	1.148	0.251	-0.016; 0.063						Average	High (1)	0.001	0.0003	0.0002; 0.001
Firm nature (Z)	0.099**	0.040	2.477	0.013	0.021; 0.177						High	Low (0)	0.0001	0.0002	-0.0003; 0.001
X × W	0.004	0.018	0.228	0.820	-0.030; 0.038						High	High (1)	0.001	0.0004	0.0001; 0.002
X × Z	0.067**	0.027	2.486	0.014	0.014; 0.120						**Index of moderated moderated mediation:**		**0.0000**	**0.0002**	**-0.0004; 0.001**
W × Z	0.121***	0.034	3.595	0.000	0.055; 0.187						**Indices of conditional moderated mediation**				
X × W × Z	0.004	0.026	0.135	0.892	-0.047; 0.054						Firm nature = 0		0.0000	0.0001	-0.0003; 0.0003
Model R-sq	R-sq = 0.093, F(21, 1982) = 9.642, p=0.000					R-sq = 0.055, F(16, 1987) =7.225, p=0.000					Firm nature = 1		0.0001	0.0002	-0.0002; 0.0004
Model 2															
	Mediator variable model (Wind Combined)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Development of non-state sector (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	3.868***	0.452	8.563	0.000	2.982; 4.754	-0.126***	0.039	-3.249	0.001	-0.203; -0.050	Low	Low (0)	0.0003	0.0002	-0.0001; 0.001
Technology innovation - authorized patent (X)	0.014	0.018	0.797	0.426	-0.021; 0.050	0.0002	0.001	0.167	0.868	-0.002; 0.003	Low	High (1)	0.001	0.0003	0.0002; 0.001
Wind Combined (M)						0.008***	0.002	4.154	0.000	0.004; 0.012	Average	Low (0)	0.0001	0.0001	-0.0002; 0.0004

(*continued on next page*)

Table 6.2 (*continued*)

Model 1

	Mediator variable model (Wind Combined)					Dependent variable model (ROA)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Development of non-state sector (W)	0.008	0.017	0.447	0.655	-0.026; 0.041						Average	High (1)	0.001	0.0003	0.0003; 0.001
Firm nature (Z)	0.066*	0.040	1.651	0.099	-0.012; 0.144						High	Low (0)	-0.0001	0.0002	-0.001; 0.003
X × W	-0.015	0.011	-1.309	0.191	-0.037; 0.007						High	High (1)	0.001	0.0003	0.0003; 0.002
X × Z	0.079***	0.027	2.891	0.004	0.025; 0.133						**Index of moderated moderated mediation:**		**0.0002**	**0.0001**	**0.000; 0.001**
W × Z	0.023	0.022	1.059	0.290	-0.020; 0.067						**Indices of conditional moderated mediation**				
X × W × Z	**0.027***	**0.016**	**1.716**	**0.086**	**-0.004; 0.057**						Firm nature = 0		-0.0001	0.0001	-0.0003; 0.0000
Model R-sq	R-sq = 0.081, F(21, 1982) = 8.363, p=0.000					R-sq = 0.055, F(16, 1987) =7.225, p=0.000					Firm nature = 1		0.0001	0.0001	-0.0001; 0.0003

Model 3

	Mediator variable model (Wind Combined)					Dependent variable model (ROA)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Product market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	3.951***	0.452	8.743	0.000	3.065; 4.838	-0.126***	0.039	-3.249	0.001	-0.203; -0.050	Low	Low (0)	0.0003	0.0002	-0.0001; 0.001
Technology innovation - authorized patent (X)	0.015	0.018	0.819	0.413	-0.021; 0.050	0.0002	0.001	0.167	0.868	-0.002; 0.003	Low	High (1)	0.001	0.0003	0.0003; 0.002
Wind Combined (M)						0.008***	0.002	4.154	0.000	0.004; 0.012	Average	Low (0)	0.0001	0.0001	-0.0002; 0.0004
Product market development (W)	0.0004	0.001	0.036	0.971	-0.019; 0.020						Average	High (1)	0.001	0.0003	0.0002; 0.001
Firm nature (Z)	0.081**	0.040	2.020	0.044	0.002; 0.159						High	Low (0)	0.000	0.0002	-0.001; 0.0003
X × W	-0.009	0.008	-1.119	0.263	-0.024; 0.007						High	High (1)	0.001	0.0003	0.000; 0.001
X × Z	0.068**	0.028	2.571	0.014	0.014; 0.122						**Index of moderated moderated mediation:**		**0.0000**	**0.0001**	**-0.0002; 0.0002**
W × Z	0.038**	0.015	2.571	0.010	0.009; 0.067						**Indices of conditional moderated mediation**				
X × W × Z	0.0004	0.011	0.034	0.973	-0.021; 0.022						Firm nature = 0		-0.0001	0.0001	-0.0002; 0.0000
Model R-sq	R-sq = 0.084, F(21, 1982) = 8.668, p=0.000					R-sq = 0.055, F(16, 1987) =7.225, p=0.000					Firm nature = 1		-0.0001	0.0001	-0.0002; 0.0001

Model 4

	Mediator variable model (Wind Combined)					Dependent variable model (ROA)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Factor market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	3.790***	0.449	8.451	0.000	2.911; 4.670	-0.126***	0.039	-3.249	0.001	-0.203; -0.050	Low	Low (0)	-0.0001	0.0002	-0.001; 0.0003
Technology innovation - authorized patent (X)	0.008	0.018	0.429	0.671	-0.028; 0.043	0.0002	0.001	0.167	0.868	-0.002; 0.003	Low	High (1)	0.0003	0.0003	-0.0002; 0.001
Wind Combined (M)						0.008***	0.002	4.154	0.000	0.004; 0.012	Average	Low (0)	0.0001	0.000	-0.0002; 0.0004
Factor market development (W)	0.027***	0.008	3.204	0.001	0.010; 0.043						Average	High (1)	0.001	0.0003	0.0002; 0.001
Firm nature (Z)	0.069*	0.040	1.733	0.083	-0.009; 0.146						High	Low (0)	0.0002	0.0002	-0.0002; 0.001
X × W	0.007	0.006	1.148	0.251	-0.005; 0.018						High	High (1)	0.001	0.0004	0.0003; 0.002
X × Z	0.070***	0.027	2.599	0.009	0.017; 0.122						**Index of moderated moderated mediation:**		**0.0001**	**0.0001**	**-0.0001; 0.0002**
W × Z	0.005	0.012	0.389	0.698	-0.018; 0.027						**Indices of conditional moderated mediation**				
X × W × Z	0.008	0.009	0.883	0.378	-0.009; 0.024						Firm nature = 0		0.0001	0.0000	0.0000; 0.0002

(*continued on next page*)

Table 6.2 (*continued*)

Model 1															
	Mediator variable model (Wind Combined)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Model R-sq	R-sq = 0.091, F(21, 1982) = 9.440, p=0.000					R-sq = 0.055, F(16, 1987) =7.225, p=0.000					Firm nature = 1		0.0001	0.0001	0.0000; 0.0003
Model 5															
	Mediator variable model (Wind Combined)					**Dependent variable model (ROA)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Legal and institutional environment (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	3.831***	0.450	8.513	0.000	2.948; 4.714	-0.126***	0.039	-3.249	0.001	-0.203; -0.050	Low	Low (0)	0.000	0.0002	-0.0004; 0.0004
Technology innovation - authorized patent (X)	0.008	0.018	0.425	0.671	-0.028; 0.043	0.0002	0.001	0.167	0.868	-0.002; 0.003	Low	High (1)	0.001	0.0003	0.0001; 0.001
Wind Combined (M)						0.008***	0.002	4.154	0.000	0.004; 0.012	Average	Low (0)	0.0001	0.0001	-0.0002; 0.0004
Legal and institutional environment (W)	0.023**	0.010	2.438	0.015	0.005; 0.042						Average	High (1)	0.001	0.0003	0.0003; 0.001
Firm nature (Z)	0.064	0.040	1.595	0.111	-0.015; 0.142						High	Low (0)	0.0001	0.0002	-0.0003; 0.001
X × W	0.003	0.006	0.490	0.624	-0.009; 0.014						High	High (1)	0.001	0.0004	0.0002; 0.002
X × Z	0.080***	0.027	2.973	0.003	0.027; 0.133						**Index of moderated moderated mediation:**		**0.0000**	**0.0001**	**-0.0001; 0.0002**
W × Z	-0.010	0.012	-0.833	0.405	-0.033; 0.013						**Indices of conditional moderated mediation**				
X × W × Z	0.002	0.009	0.251	0.802	-0.016; 0.020						Firm nature = 0		0.0000	0.0000	-0.0001; 0.0001
Model R-sq	R-sq = 0.082, F(21, 1982) = 8.377, p=0.000					R-sq = 0.055, F(16, 1987) =7.225, p=0.000					Firm nature = 1		0.0000	0.0001	-0.0001; 0.0002

Table 7.1
Robustness Check: Moderated Mediation Results for ESG Engagement/Huazheng ESG and Tobin's Q Using Authorized Patents as Innovation Measure.

Model 1															
	Mediator variable model (Huazheng)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	1.275***	0.355	3.591	0.000	0.579; 1.971	-1.058***	0.061	-17.30	0.000	-1.178; -0.938	Low	Low (0)	-0.001	0.001	-0.003; 0.0004
Technology innovation - authorized patent (X)	0.025*	0.015	1.702	0.089	-0.004; 0.054	0.005**	0.002	2.084	0.037	0.0003; 0.009	Low	High (1)	-0.001	0.001	-0.003; 0.0001
Huazheng (M)						-0.033***	0.003	-11.79	0.000	-0.039; -0.028	Average	Low (0)	-0.001	0.001	-0.002; 0.0001
Government-market relationship (W)	-0.014	0.013	-1.027	0.305	-0.040; 0.013						Average	High (1)	-0.002	0.001	-0.004; -0.001
Firm nature (Z)	-0.054	0.033	-1.632	0.103	-0.119; 0.011						High	Low (0)	-0.001	0.001	-0.002; 0.001
X × W	-0.006	0.010	-0.617	0.537	-0.026; 0.014						High	High (1)	-0.003	0.001	-0.005; -0.001
X × Z	0.040*	0.021	1.880	0.060	-0.002, 0.081						**Index of moderated moderated mediation:**		**-0.001**	**0.001**	**-0.002; 0.0003**
W × Z	0.058***	0.019	3.017	0.003	0.020; 0.096						**Indices of conditional moderated mediation**				
X × W × Z	0.022	0.015	1.462	0.144	-0.007; 0.051						Firm nature = 0		0.0002	0.0004	-0.001; 0.001
Model R-sq	R-sq = 0.067, F(29, 4127) = 10.14, p=0.000					R-sq = 0.361, F(24, 4132) = 97.41, p=0.000					Firm nature = 1		-0.001	0.0004	-0.001; 0.0003
Model 2															
	Mediator variable model (Huazheng)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				

(*continued on next page*)

Table 7.1 (*continued*)

Model 1

	Mediator variable model (Huazheng)					Dependent variable model (Tobin's Q)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Development of non-state sector (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	1.171***	0.354	3.311	0.000	0.477; 1.864	-1.058***	0.061	-17.30	0.000	-1.178; -0.938	Low	Low (0)	-0.001	0.001	-0.002; 0.001
Technology innovation - authorized patent (X)	0.025*	0.015	1.703	0.089	-0.004; 0.054	0.005**	0.002	2.084	0.037	0.0003; 0.009	Low	High (1)	-0.001	0.001	-0.003; 0.000
Huazheng (M)						-0.033***	0.003	-11.79	0.000	-0.039; -0.028	Average	Low (0)	-0.001	0.001	-0.002; 0.0001
Development of non-state sector (W)	0.001	0.013	0.081	0.935	-0.024; 0.026						Average	High (1)	-0.002	0.001	-0.004; -0.001
Firm nature (Z)	-0.059*	0.033	-1.762	0.078	-0.124; 0.007						High	Low (0)	-0.001	0.001	-0.002; 0.0002
X × W	0.003	0.009	0.284	0.776	-0.015; 0.021						High	High (1)	-0.003	0.001	-0.005; -0.001
X × Z	0.038*	0.022	1.741	0.082	-0.005; 0.081						**Index of moderated moderated mediation:**		**-0.0003**	**0.0004**	**-0.001; 0.001**
W × Z	0.031*	0.017	1.879	0.060	-0.001; 0.035						**Indices of conditional moderated mediation**				
X × W × Z	0.010	0.012	0.826	0.409	-0.014; 0.035						Firm nature = 0		-0.0001	0.0003	-0.001; 0.0004
Model R-sq	R-sq = 0.066, F(29, 4127) = 10.04, p=0.000					R-sq = 0.361, F(24, 4132) = 97.41, p=0.000					Firm nature = 1		-0.0004	0.0003	-0.001; 0.0001

Model 3

	Mediator variable model (Huazheng)					Dependent variable model (Tobin's Q)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Product market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	1.273***	0.354	3.592	0.000	0.578; 1.967	-1.058***	0.061	-17.30	0.000	-1.178; -0.938	**Low**	**Low (0)**	**-0.001**	**0.001**	**-0.003; -0.0001**
Technology innovation - authorized patent (X)	0.026*	0.015	1.791	0.073	-0.003; 0.055	0.005**	0.002	2.084	0.037	0.0003; 0.009	Low	High (1)	-0.002	0.001	-0.004; -0.001
Huazheng (M)						-0.033***	0.003	-11.79	0.000	-0.039; -0.028	Average	Low (0)	-0.001	0.001	-0.002; 0.000
Product market development (W)	-0.0002	0.009	-0.019	0.985	-0.019; 0.018						Average	High (1)	-0.002	0.001	-0.004; -0.001
Firm nature (Z)	-0.059*	0.033	-1.780	0.075	-0.124; 0.006						High	Low (0)	-0.0004	0.001	-0.002; 0.001
X × W	-0.007	0.007	-1.033	0.302	-0.020; 0.006						High	High (1)	-0.002	0.001	-0.004; -0.0002
X × Z	0.038*	0.022	1.741	0.082	-0.005; 0.080						**Index of moderated moderated mediation:**		**-0.0002**	**0.0003**	**-0.001; 0.0004**
W × Z	0.020	0.013	1.482	0.138	-0.006; 0.046						**Indices of conditional moderated mediation**				
X × W × Z	0.007	0.009	0.743	0.457	-0.011; 0.025						Firm nature = 0		0.0002	0.0002	-0.0002; 0.001
Model R-sq	R-sq = 0.065, F(29, 4127) = 9.847, p=0.000					R-sq = 0.361, F(24, 4132) = 97.41, p=0.000					Firm nature = 1		0.0000	0.0002	-0.0004; 0.0004

Model 4

	Mediator variable model (Huazheng)					Dependent variable model (Tobin's Q)					Conditional effect of X on Y through M				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Factor market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	1.254***	0.351	3.573	0.000	0.566; 1.943	-1.058***	0.061	-17.30	0.000	-1.178; -0.938	Low	Low (0)	0.0001	0.001	-0.001; 0.002
Technology innovation - authorized patent (X)	0.025*	0.015	1.693	0.091	-0.004; 0.053	0.005**	0.002	2.084	0.037	0.0003; 0.009	Low	High (1)	-0.001	0.001	-0.003; 0.0003
Huazheng (M)						-0.033***	0.003	-11.79	0.000	-0.039; -0.028	Average	Low (0)	-0.001	0.001	-0.002; 0.0002
Factor market development (W)	0.005	0.007	0.826	0.409	-0.007; 0.018						Average	High (1)	-0.002	0.001	-0.003; -0.001
Firm nature (Z)	-0.056*	0.033	-1.688	0.092	-0.122; 0.009						High	Low (0)	-0.002	0.001	-0.003; -0.001

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Table 7.1 (*continued*)

Model 1															
	Mediator variable model (Huazheng)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
X × W	**0.009****	**0.004**	**2.055**	**0.040**	**0.0004; 0.017**						High	High (1)	-0.002	0.001	-0.004; -0.001
X × Z	0.028	0.021	1.309	0.191	-0.014; 0.070						**Index of moderated moderated mediation:**		**0.0001**	**0.0002**	**-0.0002; 0.001**
W × Z	0.011	0.009	1.309	0.191	-0.006; 0.028						**Indices of conditional moderated mediation**				
X × W × Z	-0.004	0.006	-0.714	0.475	-0.016; 0.007						**Firm nature = 0**		**-0.0003**	**0.0001**	**-0.001; 0.000**
Model R-sq	R-sq = 0.066, F(29, 4127) = 10.09, p=0.000					R-sq = 0.361, F(24, 4132) = 97.41, p=0.000					Firm nature = 1		-0.0001	0.0001	-0.0004; 0.0002
Model 5															
	Mediator variable model (Huazheng)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Legal and institutional environment (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	1.251***	0.351	3.564	0.000	0.563; 1.940	-1.058***	0.061	-17.30	0.000	-1.178; -0.938	Low	Low (0)	0.0002	0.001	-0.001; 0.002
Technology innovation - authorized patent (X)	0.024	0.015	1.626	0.104	-0.005; 0.053	0.005**	0.002	2.084	0.037	0.0003; 0.009	Low	High (1)	-0.002	0.001	-0.003; -0.0001
Huazheng (M)						-0.033***	0.003	-11.79	0.000	-0.039; -0.028	Average	Low (0)	-0.001	0.001	-0.002; 0.0002
Legal and institutional environment (W)	0.003	0.007	0.376	0.707	-0.011; 0.016						Average	High (1)	-0.002	0.001	-0.003; -0.001
Firm nature (Z)	-0.057*	0.034	-1.697	0.090	-0.123; 0.009						High	Low (0)	-0.002	0.001	-0.003; -0.001
X × W	**0.008****	**0.004**	**2.056**	**0.040**	**0.0004; 0.016**						High	High (1)	-0.002	0.001	-0.004; -0.001
X × Z	0.033	0.021	1.542	0.123	-0.009; 0.075						**Index of moderated moderated mediation:**		**0.0002**	**0.0002**	**-0.0002; 0.001**
W × Z	0.007	0.008	0.831	0.406	-0.009; 0.022						**Indices of conditional moderated mediation**				
X × W × Z	-0.006	0.006	-1.069	0.285	-0.018; 0.005						**Firm nature = 0**		**-0.0003**	**0.0001**	**-0.001; 0.000**
Model R-sq	R-sq = 0.065, F(29, 4127) = 9.898, p=0.000					R-sq = 0.361, F(24, 4132) = 97.41, p=0.000					Firm nature = 1		-0.0001	0.0001	-0.0003; 0.0002

Table 7.2
Robustness check: moderated mediation results for ESG engagement/wind ESG and Tobin's Q using authorized patents as innovation measure.

Model 1															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	3.955***	0.450	8.789	0.000	3.073; 4.838	-0.651***	0.096	-6.780	0.000	-0.840; -0.463	Low	Low (0)	-0.0002	0.001	-0.002; 0.002
Technology innovation - authorized patent (X)	0.010	0.018	0.568	0.571	-0.025; 0.045	0.009***	0.003	2.689	0.007	0.002; 0.015	Low	High (1)	-0.002	0.001	-0.004; -0.001
Wind Combined (M)						-0.034***	0.005	-6.886	0.000	-0.043; -0.024	Average	Low (0)	-0.0003	0.001	-0.002; 0.001
Government-market relationship (W)	0.023	0.020	1.150	0.250	-0.016; 0.063						Average	High (1)	-0.003	0.001	-0.005; -0.001
Firm nature (Z)	0.099**	0.040	2.476	0.013	0.021; 0.177						High	Low (0)	-0.001	0.001	-0.002; 0.001
X × W	0.004	0.018	0.227	0.820	-0.030; 0.038						High	High (1)	-0.003	0.001	-0.006; -0.001
X × Z	0.067**	0.027	2.473	0.014	0.014; 0.120						**Index of moderated moderated mediation:**		**-0.0002**	**0.001**	**-0.002; 0.002**
W × Z	0.124***	0.034	3.663	0.000	0.057; 0.190						**Indices of conditional moderated mediation**				

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Table 7.2 (*continued*)

Model 1															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
X × W × Z	0.005	0.026	0.184	0.854	-0.046; 0.055						Firm nature = 0		-0.0001	0.001	-0.001; 0.001
Model R-sq	R-sq = 0.093, F(21, 1981) = 9.677, p=0.000					R-sq = 0.297, F(16, 1986) =52.46, p=0.000					Firm nature = 1		-0.0003	0.001	-0.002; 0.001
Model 2															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Development of non-state sector (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	3.870***	0.452	8.566	0.000	2.984; 4.756	-0.651***	0.096	-6.780	0.000	-0.840; -0.463	Low	Low (0)	-0.001	0.001	-0.003, 0.0003
Technology innovation - authorized patent (X)	0.014	0.018	0.794	0.427	-0.021; 0.050	0.009***	0.003	2.689	0.007	0.002; 0.015	Low	High (1)	-0.003	0.001	-0.005; -0.001
Wind Combined (M)						-0.034***	0.005	-6.886	0.000	-0.043; -0.024	Average	Low (0)	-0.001	0.001	-0.002; 0.001
Development of non-state sector (W)	0.008	0.017	0.448	0.654	-0.026; 0.041						Average	High (1)	-0.003	0.001	-0.005; -0.001
Firm nature (Z)	0.066*	0.040	1.649	0.099	-0.013; 0.144						High	Low (0)	0.0003	0.001	-0.001; 0.002
X × W	-0.015	0.011	-1.310	0.190	-0.037; 0.007						High	High (1)	-0.004	0.001	-0.006; -0.002
X × Z	0.079***	0.027	2.888	0.004	0.025; 0.132						**Index of moderated moderated mediation:**		**-0.001**	**0.001**	**-0.002; 0.000**
W × Z	0.025	0.022	1.117	0.264	-0.019; 0.068						**Indices of conditional moderated mediation**				
X × W × Z	**0.027***	**0.016**	**1.754**	**0.080**	**-0.003; 0.058**						Firm nature = 0		0.001	0.0003	-0.0002; 0.001
Model R-sq	R-sq = 0.082, F(21, 1981) = 8.369, p=0.000					R-sq = 0.297, F(16, 1986) =52.46, p=0.000					Firm nature = 1		-0.0004	0.0003	-0.001; 0.0002
Model 3															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Product market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	3.954***	0.452	8.749	0.000	3.067; 4.841	-0.651***	0.096	-6.780	0.000	-0.840; -0.463	Low	Low (0)	-0.001	0.001	-0.003; 0.0003
Technology innovation - authorized patent (X)	0.015	0.018	0.816	0.415	-0.021; 0.050	0.009***	0.003	2.689	0.007	0.002; 0.015	Low	High (1)	-0.003	0.001	-0.006; -0.002
Wind Combined (M)						-0.034***	0.005	-6.886	0.000	-0.043; -0.024	Average	Low (0)	-0.001	0.001	-0.002; 0.001
Product market development (W)	0.0004	0.001	0.038	0.970	-0.019; 0.020						Average	High (1)	-0.003	0.001	-0.005; -0.001
Firm nature (Z)	0.081**	0.040	2.021	0.043	0.002; 0.159						High	Low (0)	0.0002	0.001	-0.001; 0.002
X × W	-0.009	0.008	-1.119	0.263	-0.024; 0.007						High	High (1)	-0.002	0.001	-0.005; 0.0002
X × Z	0.068**	0.028	2.445	0.015	0.013; 0.122						**Index of moderated moderated mediation:**		**0.000**	**0.0003**	**-0.001; 0.001**
W × Z	0.039***	0.015	2.614	0.009	0.010; 0.068						**Indices of conditional moderated mediation**				
X × W × Z	0.001	0.011	0.055	0.956	-0.021; 0.022						Firm nature = 0		0.0003	0.0002	-0.0002; 0.001
Model R-sq	R-sq = 0.084, F(21, 1981) = 8.673, p=0.000					R-sq = 0.297, F(16, 1986) =52.46, p=0.000					Firm nature = 1		0.0003	0.0003	-0.0002; 0.001
Model 4															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Factor market development (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	3.795***	0.449	8.462	0.000	2.915; 4.674	-0.651***	0.096	-6.780	0.000	-0.840; -0.463	Low	Low (0)	0.0004	0.001	-0.001; 0.002

(*continued on next page*)

Table 7.2 (*continued*)

Model 1															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Government-market relationship (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Technology innovation - authorized patent (X)	0.008	0.018	0.429	0.668	-0.027; 0.043	0.009***	0.003	2.689	0.007	0.002; 0.015	Low	High (1)	-0.001	0.001	-0.003; 0.001
Wind Combined (M)						-0.034***	0.005	-6.886	0.000	-0.043; -0.024	Average	Low (0)	-0.0003	0.001	-0.002; 0.001
Factor market development (W)	0.027***	0.008	3.210	0.001	0.010; 0.043						Average	High (1)	-0.003	0.001	-0.005; -0.001
Firm nature (Z)	0.068*	0.040	1.723	0.085	-0.009; 0.146						High	Low (0)	-0.001	0.001	-0.003; 0.001
X × W	0.007	0.006	1.148	0.251	-0.005; 0.018						High	High (1)	-0.004	0.001	-0.007; -0.002
X × Z	0.069**	0.027	2.570	0.010	0.016; 0.121						**Index of moderated moderated mediation:**		**-0.0003**	**0.0003**	**-0.001; 0.0003**
W × Z	0.005	0.012	0.459	0.646	-0.018; 0.028						**Indices of conditional moderated mediation**				
X × W × Z	0.008	0.009	0.927	0.354	-0.009; 0.025						Firm nature = 0		-0.0002	0.0002	-0.001; 0.0002
Model R-sq	R-sq = 0.091, F(21, 1981) = 9.470, p=0.000					R-sq = 0.297, F(16, 1986) =52.46, p=0.000					**Firm nature = 1**		**-0.001**	**0.0002**	**-0.001; -0.0001**
Model 5															
	Mediator variable model (Wind Combined)					**Dependent variable model (Tobin's Q)**					**Conditional effect of X on Y through M**				
Lagged predictors	**B**	**SE**	**t**	**p**	**95% CI**	**B**	**SE**	**t**	**p**	**95% CI**	**Legal and institutional environment (W)**	**Firm nature (Z)**	**Indirect effect or index**	**BootSE**	**Boot 95% CI**
Constant	3.834***	0.450	8.518	0.000	2.951; 4.716	-0.651***	0.096	-6.780	0.000	-0.840; -0.463	Low	Low (0)	0.000	0.001	-0.002; 0.002
Technology innovation - authorized patent (X)	0.008	0.018	0.426	0.670	-0.028; 0.043	0.009***	0.003	2.689	0.007	0.002; 0.015	Low	High (1)	-0.002	0.001	-0.005; -0.001
Wind Combined (M)						-0.034***	0.005	-6.886	0.000	-0.043; -0.024	Average	Low (0)	-0.0003	0.001	-0.002; 0.001
Legal and institutional environment (W)	0.024**	0.010	2.447	0.015	0.005; 0.042						Average	High (1)	-0.003	0.001	-0.005; -0.001
Firm nature (Z)	0.063	0.040	1.586	0.113	-0.015; 0.142						High	Low (0)	-0.001	0.001	-0.002; 0.001
X × W	0.003	0.006	0.491	0.624	-0.009; 0.014						High	High (1)	-0.004	0.001	-0.006; -0.001
X × Z	0.080***	0.027	2.960	0.003	0.027; 0.133						**Index of moderated moderated mediation:**		**-0.0001**	**0.0003**	**-0.001; 0.001**
W × Z	-0.010	0.012	-0.800	0.424	-0.033; 0.014						**Indices of conditional moderated mediation**				
X × W × Z	0.003	0.009	0.276	0.783	-0.015; 0.020						Firm nature = 0		-0.0001	0.0002	-0.001; 0.0003
Model R-sq	R-sq = 0.082, F(21, 1981) =8.371, p=0.000					R-sq = 0.297, F(16, 1986) =52.46, p=0.000					Firm nature = 1		-0.0002	0.0002	-0.001; 0.0003

Data availability

Data will be made available on request.

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