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Environmental Disclosure as an Information-Transparency Mechanism in the Government Subsidy–Green Innovation Link: Evidence from China's Heavily Polluting Industries

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Abstract. Government environmental subsidies are widely used to stimulate corporate green innovation, yet the information-transmission mechanisms through which such support influences innovation outcomes remain insufficiently explained. This study examines whether environmental information disclosure functions as the key mediating mechanism linking perceived government environmental subsidy support (GESS) to green innovation performance in China's heavily polluting industries. Drawing on institutional theory and agency theory, we distinguish two disclosure dimensions—environmental information disclosure breadth (EID-B) and environmental information disclosure quality (EID-Q)—and two innovation outcomes: strategic green innovation performance (EGIP-S) and substantive green innovation performance (EGIP-M). Using survey data from 588 senior managers of A-share listed firms and analysing the model with PLS-SEM, we test a dual-path mediation framework. The results show that GESS has a significant direct effect on strategic green innovation but no significant direct effect on substantive green innovation. Both disclosure breadth and disclosure quality significantly mediate the relationship between subsidies and the two innovation outcomes, with disclosure quality consistently exhibiting the stronger mediating role. The mediation is partial for strategic green innovation and fully indirect for substantive green innovation, indicating that the subsidy-to-substantive-innovation effect operates entirely through strengthened environmental disclosure. These findings suggest that subsidies alone are insufficient to drive substantive green transformation unless supported by effective transparency mechanisms. The study contributes to the literature by identifying environmental disclosure as an information-based transmission channel and offers implications for integrating disclosure requirements into subsidy design and industrial green-transition governance.

Keywords: Government environmental subsidy support; Environmental information disclosure; Substantive green innovation; Strategic green innovation; Mediation; PLS-SEM; Heavily polluting industries

1. Introduction

As the world's largest carbon emitter, contributing approximately 32% of global emissions (International Energy Agency, 2024), China has committed to peaking carbon emissions by 2030 and achieving carbon neutrality by 2060. Heavily polluting industries, characterized by high pollution, high energy consumption, and high resource dependency (Lin et al., 2021), occupy a paradoxical position in this transition: they remain indispensable engines of economic growth yet constitute the primary sources of environmental degradation. Government environmental subsidies have emerged as a central policy instrument for nudging these enterprises toward green innovation by reducing financial barriers and sharing technological risks (Montmartin & Herrera, 2015; Bai et al., 2019).

Yet a fundamental question persists: through what mechanisms do subsidies, as policy inputs, translate into innovation outputs at the organizational level? A growing body of research demonstrates that government subsidies can promote green innovation by encouraging R&D investment and reducing financial constraints (Huang et al., 2019; Du et al., 2023), while a contrasting stream warns that subsidies may lead to resource misallocation, rent-seeking, or dependency, potentially suppressing autonomous innovation (Chen et al., 2020; Liu et al., 2022). Recent bibliometric evidence synthesizing global research patterns confirms this complexity, revealing that subsidy effectiveness is contingent upon multiple mediating mechanisms including environmental information disclosure, environmental regulation intensity, and managerial environmental concern, rather than operating through simple direct effects (Chen & Masukujjaman, 2025). This inconclusive evidence suggests that the subsidy–innovation relationship is neither direct nor uniform; rather, critical information-transmission mechanisms condition whether policy resources are effectively converted into meaningful innovation outcomes.

From an information-governance perspective, the effectiveness of subsidy programs depends not only on the magnitude of financial resources transferred but also on the quality and flow of information within the policy–firm–stakeholder system. Heavily polluting industries do not operate in isolation; they are embedded in broader industrial service systems that encompass regulators, investors, supply-chain partners, and internal management functions (DiMaggio & Powell, 1983). Within such systems, environmental information disclosure serves as a key coordination mechanism: it enables regulators to monitor subsidy utilization, provides investors with decision-relevant signals, facilitates supply-chain partners' assessment of environmental risks, and equips internal managers with performance benchmarks for innovation planning. When this information-transparency mechanism functions effectively, the conversion efficiency from policy inputs to organizational innovation outputs is enhanced. When it is absent or weak, subsidies risk being absorbed without generating substantive environmental improvement.

Three critical gaps in the existing literature motivate this study, each centering on the information-transmission process that connects policy resources to innovation outcomes. First, most studies assume a direct linear link between subsidies and innovation, leaving the transmission mechanisms largely unexamined. Environmental information disclosure (EID), the practice of publicly reporting environmental management and performance data, represents a theoretically compelling yet empirically underexplored mediator in this relationship. While disclosure has been linked independently to both policy compliance and innovation outcomes (Li et al., 2022; Ding et al., 2022), its role as an information bridge connecting subsidy inputs to innovation outputs has received scant attention. Second, existing studies that do examine EID treat it as a unidimensional construct, overlooking the distinct information functions of disclosure breadth (the scope and coverage of reporting) and disclosure quality (the rigor, verifiability, and quantitative precision of reporting). These two dimensions operate through theoretically distinct mechanisms, breadth serving a visibility function and quality serving an accountability function, and conflating them obscures important nuances in the information-transmission process. Third, the literature has predominantly failed to

distinguish between strategic green innovation (compliance-oriented, image-driven activities) and substantive green innovation (technology-oriented, transformative activities), making it difficult to assess whether subsidies stimulate genuine environmental improvement or merely symbolic positioning (Wang et al., 2022; Lian et al., 2022).

This study addresses these gaps by constructing and testing a dual-pathway mediation model grounded in institutional theory and agency theory. Specifically, we examine how perceived government environmental subsidy support (GESS) influences both strategic and substantive green innovation performance through two distinct mediating channels: environmental information disclosure breadth (EID-B) and environmental information disclosure quality (EID-Q). Using primary data from 588 senior managers across China's heavily polluting industries and Partial Least Squares Structural Equation Modeling (PLS-SEM), this research makes three contributions. First, it opens the "black box" of the subsidy–innovation relationship by identifying environmental information disclosure as the essential information-transmission mechanism, demonstrating that the effect on substantive innovation is fully mediated through disclosure while the effect on strategic innovation is only partially mediated. This finding reframes the subsidy–innovation question from "how much funding drives how much innovation" to "how effectively does information transparency convert policy resources into organizational innovation outcomes." Second, it unpacks the differential mediating roles of disclosure breadth versus disclosure quality, revealing that the quality dimension—which creates stronger accountability pressure through verifiable performance benchmarks—consistently exerts a stronger mediating influence. Third, it provides a motivation-based differentiation of green innovation outcomes, showing that the same policy instrument operates through qualitatively different information pathways depending on whether the innovation is strategic or substantive in nature. These findings offer practical implications for designing subsidy programs that integrate disclosure requirements as an information-governance mechanism to improve the conversion efficiency of policy inputs into substantive green transformation within industrial service systems.

2. Literature Review and Hypothesis Development

This section reviews the literature along three focused dimensions that correspond to the gaps identified above: the subsidy–innovation mechanism gap (Section 2.1), the disclosure dimensionality gap (Section 2.2), and the information-transmission gap (Section 2.3). Each subsection develops the theoretical logic and specific hypotheses that together constitute the dual-pathway mediation framework.

2.1 Government Environmental Subsidy Support and Green Innovation Performance

Government subsidies represent a form of institutional incentive designed to correct market failures in green innovation, where positive externalities, high costs, and long payback periods lead to systematic underinvestment (Ghisetti & Pontoni, 2015). From the perspective of institutional theory, subsidies create both coercive pressure (through compliance requirements attached to funding) and mimetic incentive (through legitimacy signals that encourage firms to align with policy objectives) (DiMaggio & Powell, 1983). Firms receiving subsidies are expected to demonstrate visible responses to government policy signals, engaging in innovation activities that reinforce their legitimacy as responsible recipients of public funds.

This institutional logic suggests that subsidies will promote strategic green innovation, the type of innovation oriented toward meeting government requirements and enhancing the firm's public environmental image. Strategic green innovation typically involves incremental process adjustments or product modifications that are visible and countable, such as patent filings, without necessarily entailing deep technological transformation (Boeing, 2016; Dechezleprêtre et al., 2016). The signaling and compliance dynamics embedded in subsidy programs align closely with this form of innovation.

Simultaneously, agency theory highlights the potential for information asymmetry between the government (principal) and firms (agents) to influence how subsidies are deployed. When monitoring is imperfect, managers may channel subsidy resources toward activities that maximize private benefit rather than environmental outcomes, favoring visible but superficial innovation over costly but transformative technological change (Jensen & Meckling, 1976). Nevertheless, subsidies also provide genuine financial resources and risk mitigation that can empower firms to pursue substantive green innovation, the kind of transformative technological investment that reduces pollution at the source (Montmartin & Herrera, 2015). Government backing further serves as a positive market signal, attracting complementary resources from investors and partners (Bai et al., 2019).

Drawing on this dual theoretical logic, we hypothesize:

H1a: Perceived government environmental subsidy support is positively associated with strategic green innovation performance.

H1b: Perceived government environmental subsidy support is positively associated with substantive green innovation performance.

2.2 Environmental Information Disclosure: Breadth and Quality as Distinct Dimensions

Environmental information disclosure refers to the practice of publicly reporting a firm's environmental management activities and performance to external stakeholders (Clarkson et al., 2008). While prior studies have examined EID primarily as a unitary concept, recent scholarship recognizes that disclosure encompasses qualitatively different dimensions with distinct antecedents and consequences (Helfaya & Moussa, 2017; Giannarakis et al., 2020). Furthermore, evidence across different asset classes shows that the scale and scope of corporate disclosures are significantly shaped by industry characteristics and the nature of property rights (Luo et al., 2025).

Disclosure breadth (EID-B) captures the scope, coverage, and proactiveness of a firm's environmental reporting. It encompasses the range of environmental topics addressed, the variety of reporting channels utilized, the extent of lifecycle coverage, and the voluntary provision of information beyond regulatory mandates (Jenkins & Yakovleva, 2006; Kuo et al., 2012). Firms with high disclosure breadth communicate across more environmental domains, through more channels, and to a wider range of stakeholder groups.

Disclosure quality (EID-Q) captures the clarity, quantitative rigor, verifiability, and substantive effectiveness of disclosed information. It encompasses the transparency of reported policies, the inclusion of measurable performance indicators, the establishment of third-party verification mechanisms, and active stakeholder engagement for continuous improvement (Clarkson et al., 2008; Meng et al., 2014). Firms with high disclosure quality produce information that external parties can independently verify and use for resource allocation decisions.

The theoretical distinction between these dimensions is critical because they operate through different influence mechanisms. Disclosure breadth functions primarily through a *visibility mechanism*: by expanding the scope and reach of environmental reporting, firms construct a comprehensive public narrative of environmental commitment that is visible to diverse stakeholders (Suchman, 1995). This enhanced visibility generates external expectations and reputational incentives that can motivate both image-oriented (strategic) and pressure-driven (substantive) innovation. Disclosure quality functions primarily through an *accountability mechanism*: by committing to quantitative, verifiable reporting, firms establish self-imposed performance benchmarks against which their future conduct will be evaluated (Clarkson et al., 2008). This accountability pressure is particularly consequential for substantive innovation, as firms must demonstrate genuine, measurable environmental improvements to maintain the credibility of their high-quality disclosures.

2.3 The Mediating Logic: From Subsidies Through Disclosure to Innovation

We propose that environmental information disclosure serves as the critical information-transmission channel linking government subsidies to green innovation outcomes. This mediation logic proceeds in two steps.

Step 1: GESS enhances environmental information disclosure. Firms receiving government environmental subsidies face heightened scrutiny from regulators, investors, and the public to demonstrate responsible and effective use of public resources (Tang et al., 2020). In this context, comprehensive and high-quality environmental disclosure becomes a strategic response that signals accountability and upholds legitimacy. Subsidized firms have strong incentives to expand the scope of their environmental reporting (enhancing breadth) and to improve the rigor and verifiability of the information they provide (enhancing quality) in order to maintain favorable regulatory relationships and secure ongoing support (Cailou et al., 2021). Additionally, the financial resources embedded in subsidies equip firms with the capacity to invest in more sophisticated disclosure systems, third-party audits, and stakeholder engagement processes.

Step 2: Enhanced disclosure drives green innovation. Once disclosure is enhanced, two distinct pathways translate transparency into innovation outcomes.

Through the breadth pathway, expanded disclosure creates a broad platform of visible environmental commitments. This visibility motivates firms to pursue green innovation that reinforces their public environmental image (strategic innovation) while simultaneously generating stakeholder scrutiny that can pressure firms toward more genuine improvements (substantive innovation). Through the *quality pathway*, high-quality, quantitative disclosure establishes verifiable performance benchmarks that create accountability pressure. Firms must increase R&D investment, adopt cleaner technologies, and develop eco-friendly products to support the claims made in verified reports (Li et al., 2022; Ding et al., 2022). This self-binding mechanism is especially powerful for driving substantive innovation, as genuine technological progress is needed to satisfy quantified commitments.

Synthesizing these arguments, we propose four specific mediation pathways. By testing these pathways separately, we can identify whether the transmission mechanism operates through the visibility channel (breadth), the accountability channel (quality), or both, and whether the mediating strength differs across strategic versus substantive innovation outcomes.

H2a: Environmental information disclosure breadth (EID-B) mediates the positive relationship between GESS and strategic green innovation performance.

H2b: Environmental information disclosure quality (EID-Q) mediates the positive relationship between GESS and strategic green innovation performance.

H2c: Environmental information disclosure breadth (EID-B) mediates the positive relationship between GESS and substantive green innovation performance.

H2d: Environmental information disclosure quality (EID-Q) mediates the positive relationship between GESS and substantive green innovation performance.

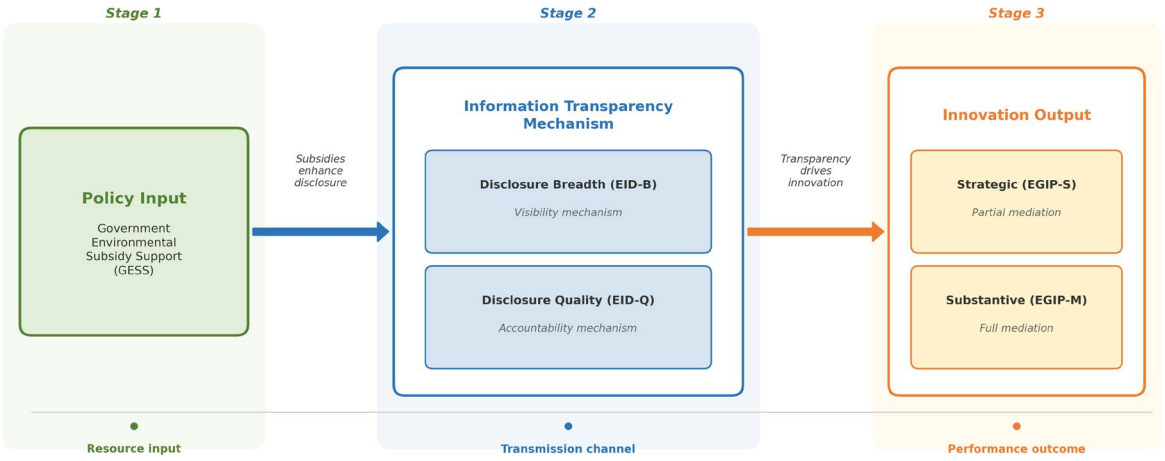

Fig.1. High-Level Information-Mechanism Framework

This study conceptualizes the subsidy, innovation relationship as a three-stage information-transmission process: government environmental subsidies serve as the policy input (Stage 1), environmental information disclosure functions as the information-transparency mechanism (Stage 2), and green innovation performance represents the organizational output (Stage 3). The transparency mechanism operates through two distinct channels, disclosure breadth (visibility mechanism) and disclosure quality (accountability mechanism), that differentially transmit subsidy effects to strategic and substantive innovation outcomes. The detailed hypothesized paths are presented in Figure 2.

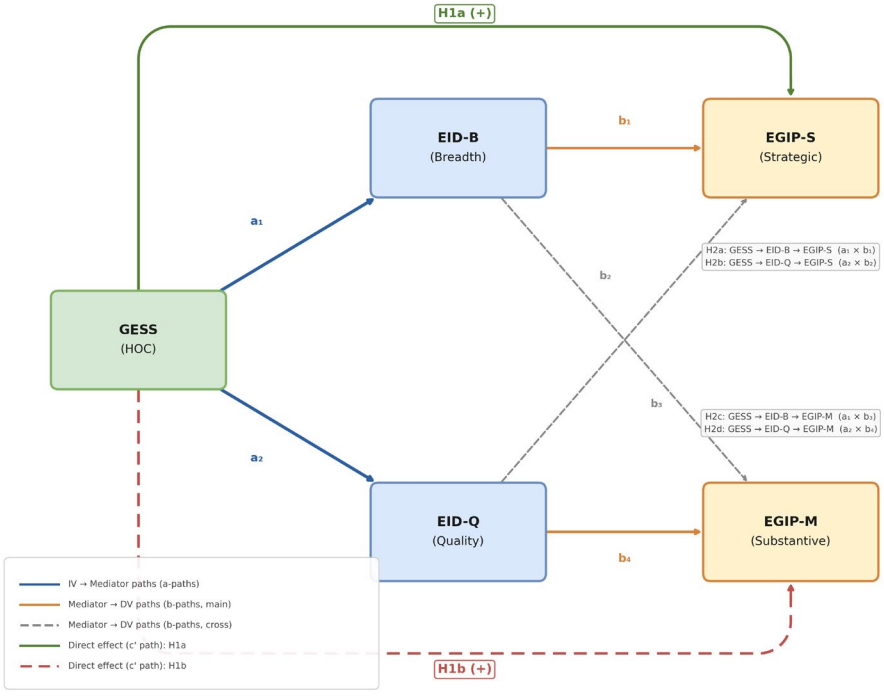

Fig.2: Conceptual Framework

The proposed dual-pathway mediation model showing the hypothesized relationships among Government Environmental Subsidy Support (GESS), Environmental Information Disclosure Breadth

(EID-B), Environmental Information Disclosure Quality (EID-Q), Strategic Green Innovation Performance (EGIP-S), and Substantive Green Innovation Performance (EGIP-M). Solid arrows represent the hypothesized direct effects (H1a, H1b); dashed arrows represent the hypothesized mediation pathways (H2a–H2d).

3. Research Methods

3.1 Research Design and Sample

This study employs a quantitative, cross-sectional research design, collecting primary data through a structured questionnaire survey administered to senior managers in China's heavily polluting industries. The target population comprises middle-to-senior managers (CEOs, CTOs, environmental officers, R&D directors, and production managers) of companies listed on China's A-share market that operate within 18 designated heavily polluting industry categories, including coal mining, chemical manufacturing, steel smelting, power generation, cement production, and petroleum processing.

A stratified sampling approach was adopted to ensure proportional representation across industry types and company sizes. The questionnaire was distributed through both online survey platforms and offline professional networks. Following rigorous data screening for missing data, straight-lining patterns, abnormal response times, and logical inconsistencies, 588 valid responses were retained from 653 total responses, yielding an effective response rate of 90.05%.

3.2 Measurement Instruments

All core constructs were measured using multi-item Likert scales (1 = "strongly disagree" to 5 = "strongly agree") developed through a systematic process of literature review, expert panel consultation, and pilot testing (N = 70). The pilot study confirmed satisfactory reliability (Cronbach's $\alpha > 0.70$) and construct validity (AVE > 0.80) for all scales.

Government Environmental Subsidy Support (GESS) is operationalized as a Type II Reflective-Formative higher-order construct comprising three first-order dimensions: Subsidy Acquisition and Funding (SAF, 3 items), Subsidy Effectiveness (SE, 4 items), and Awareness and Policy Cognition (APC, 3 items). This specification follows guidelines for formative higher-order constructs (Hair et al., 2019; Becker et al., 2012), reflecting the theoretical rationale that these dimensions represent distinct facets that jointly compose the meaning of GESS rather than interchangeable reflections of a single latent factor.

Environmental Information Disclosure Breadth (EID-B) was measured with items capturing the scope and coverage of environmental reporting, the variety of disclosure channels, lifecycle reporting extent, and voluntary disclosure beyond regulatory requirements.

Environmental Information Disclosure Quality (EID-Q) was measured with items assessing the transparency and clarity of environmental policies, the inclusion of quantitative performance indicators, third-party verification mechanisms, stakeholder engagement, and the perceived contribution of disclosure to reputation and compliance.

Strategic Green Innovation Performance (EGIP-S) was measured with items assessing the firm's green innovation activities motivated by compliance with government requirements, public image enhancement, and market demand response.

Substantive Green Innovation Performance (EGIP-M) was measured with items assessing the firm's actual performance in developing green products/technologies that reduce pollution, adopting clean energy or energy-saving technologies, and improving environmental performance.

Control variables included enterprise establishment time, enterprise scale, property nature, enterprise growth, historical performance, market power, financial leverage, management stockholding, and CEO's political connection.

3.3 Analytical Approach

Data analysis was conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS 4. PLS-SEM was chosen for three reasons: (a) the presence of a formative higher-order construct (GESS) precludes the use of covariance-based SEM; (b) the study's prediction-oriented objectives align with the composite-based estimation logic of PLS; and (c) the method handles complex mediation models with multiple parallel mediators efficiently (Hair et al., 2019).

Path coefficient significance was assessed through bootstrapping with 5,000 subsamples and bias-corrected and accelerated (BCa) confidence intervals. Mediation analysis followed Zhao et al. (2010), testing specific indirect effects and classifying mediation types based on the significance patterns of direct and indirect effects. Variance Accounted For (VAF) was calculated to assess the proportion of the total effect transmitted through each mediating pathway. Common method variance (CMV) was assessed using Harman's single-factor test (Podsakoff et al., 2003). Predictive performance was evaluated using PLSpredict (Shmueli et al., 2019) and the Cross-Validated Predictive Ability Test (CVPAT) (Sharma et al., 2023).

4. Results

4.1 Common Method Variance

Harman's single-factor test was conducted across all 53 observed indicators. The first unrotated factor accounted for less than 50% of the total variance, and full collinearity VIF values in the structural model ranged from 1.033 to 1.652 (all below the 3.3 threshold), indicating that common method variance does not pose a substantive concern.

4.2 Measurement Model Assessment

Table 1 summarizes the construct reliability and convergent validity results for all reflective constructs.

Table 1: Construct Reliability and Convergent Validity

Construct	Items	Outer Loadings	Cronbach's α	Composite Reliability (CR)	AVE
SAF	3	0.845–0.854	0.808	0.887	0.723
SE	4	0.801–0.846	0.840	0.893	0.676
APC	3	0.823–0.846	0.777	0.871	0.692
EID-B	6	0.822–0.856	0.915	0.934	0.703
EID-Q	6	0.826–0.856	0.916	0.935	0.704
EGIP-S	7	0.845–0.863	0.938	0.949	0.729
EGIP-M	7	0.823–0.848	0.927	0.941	0.695

Note: All outer loadings exceeded the 0.708 threshold (Hair et al., 2019). Cronbach's α values ranged from 0.777 (APC) to 0.938 (EGIP-S), all exceeding 0.70. Composite reliability (rho_c) values ranged from 0.871 (APC) to 0.949 (EGIP-S), confirming strong internal consistency. AVE values ranged from 0.676 (SE) to 0.729 (EGIP-S), all exceeding the 0.50 cutoff, indicating adequate convergent validity for all constructs.

Discriminant validity was established through both the Fornell-Larcker criterion and the HTMT ratio. All HTMT values between conceptually independent construct pairs fell below the conservative threshold of 0.85 (Henseler et al., 2015). The HTMT value between EID-B and EID-Q was 0.350, demonstrating that these two disclosure dimensions capture empirically distinct phenomena despite both addressing environmental information disclosure.

For the formative higher-order GESS construct, VIF values for the three first-order dimensions ranged from 3.410 to 4.377 (all below 5.0), confirming the absence of problematic multicollinearity. The outer weights of SAF and SE were significant. Although APC's outer weight was non-significant, it was retained based on its significant outer loading and theoretical necessity, consistent with guidelines for formative measurement (Hair et al., 2019). Redundancy analysis confirmed convergent validity with a path coefficient exceeding 0.70.

4.3 Structural Model Assessment

Inner model VIF values ranged from 1.033 to 1.652, confirming that collinearity does not bias the structural estimates. Table 2 presents the coefficient of determination for all endogenous constructs.

Table 2: Coefficient of Determination (R^2)

Endogenous Construct	R^2	Adjusted R^2
EGIP-M (Substantive Innovation)	0.269	0.260
EGIP-S (Strategic Innovation)	0.236	0.227
EID-B (Disclosure Breadth)	0.224	0.223
EID-Q (Disclosure Quality)	0.222	0.221

The model explains 26.9% of the variance in substantive green innovation performance and 23.6% in strategic green innovation performance, both at or near the moderate level for behavioral research (Cohen, 1988). GESS explains approximately 22% of the variance in each disclosure construct.

Table 3 presents the structural path coefficients estimated through bootstrapping (5,000 subsamples, BCa confidence intervals).

Table 3: Structural Path Coefficients (Direct Effects)

Path	β	t-value	p-value	95% BCa CI	Sig.
GESS → EGIP-S	0.180	3.313	0.001	[0.070, 0.280]	Yes
GESS → EGIP-M	0.010	0.179	0.858	[−0.107, 0.110]	No
GESS → EID-B	0.474	11.086	< 0.001	[0.378, 0.548]	Yes
GESS → EID-Q	0.471	10.906	< 0.001	[0.378, 0.549]	Yes
EID-B → EGIP-S	0.168	3.169	0.002	[0.066, 0.273]	Yes
EID-B → EGIP-M	0.156	2.806	0.005	[0.050, 0.266]	Yes
EID-Q → EGIP-S	0.185	3.759	< 0.001	[0.088, 0.280]	Yes
EID-Q → EGIP-M	0.223	4.264	< 0.001	[0.117, 0.322]	Yes

H1a is supported: GESS exerts a significant positive direct effect on strategic green innovation ($\beta = 0.180$, $p = 0.001$). H1b is not supported: the direct effect of GESS on substantive green innovation is not statistically significant ($\beta = 0.010$, $p = 0.858$). However, the total effect of GESS on EGIP-M is significant ($\beta = 0.191$, $t = 4.219$, $p < 0.001$), indicating that the influence operates entirely through intermediate mechanisms. GESS strongly predicts both EID-B ($\beta = 0.474$) and EID-Q ($\beta = 0.471$), and both mediators significantly predict both outcome variables, with EID-Q exhibiting consistently stronger effects than EID-B (EGIP-S: 0.185 vs. 0.168; EGIP-M: 0.223 vs. 0.156).

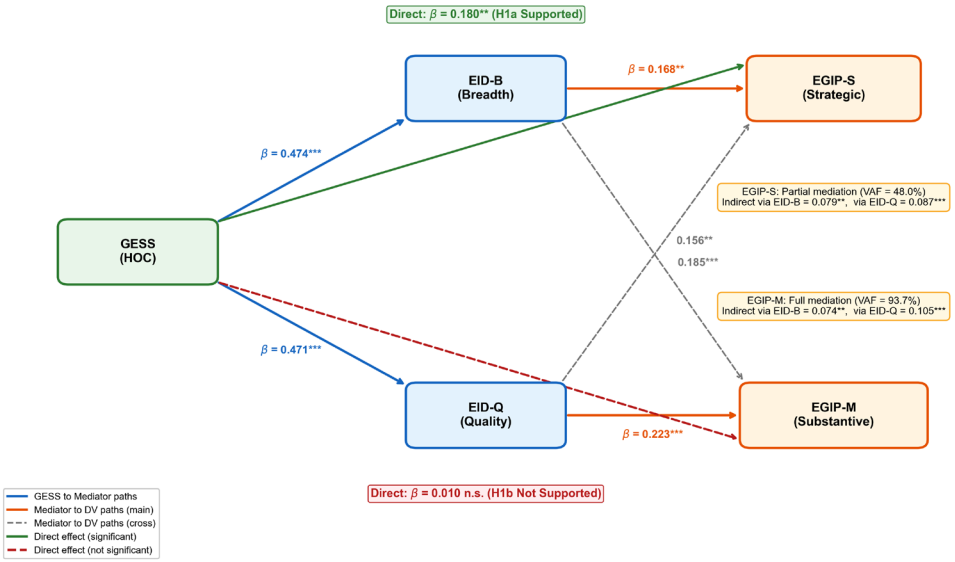

Fig.3: Structural Model Results with Mediation Pathways

Path coefficients are standardized estimates from PLS-SEM bootstrapping (5,000 subsamples). Solid lines indicate significant paths; dashed lines indicate non-significant paths. GESS = Government Environmental Subsidy Support (Type II Reflective-Formative HOC); EID-B = Environmental Information Disclosure Breadth; EID-Q = Environmental Information Disclosure Quality; EGIP-S = Strategic Green Innovation Performance; EGIP-M = Substantive Green Innovation Performance. VAF values and mediation types are annotated: EGIP-S partial complementary mediation (VAF = 48.0%); EGIP-M full indirect-only mediation (VAF = 93.7%). **p < 0.01,** *p < 0.001, n.s. = not significant.

4.4 Mediation Analysis

Table 4 presents the specific indirect effects for the four mediation hypotheses.

Table 4: Specific Indirect Effects and Mediation Type Assessment

Hypothesis	Indirect Path	β (a × b)	t-value	p-value	95% BCa CI	Result
H2a	GESS → EID-B → EGIP-S	0.079	2.957	0.003	[0.031, 0.138]	Supported
H2b	GESS → EID-Q → EGIP-S	0.087	3.590	< 0.001	[0.043, 0.138]	Supported
H2c	GESS → EID-B → EGIP-M	0.074	2.644	0.008	[0.023, 0.130]	Supported
H2d	GESS → EID-Q → EGIP-M	0.105	4.127	< 0.001	[0.056, 0.155]	Supported

All four indirect effects are statistically significant with BCa confidence intervals excluding zero. Table 5 summarizes the mediation type classification following Zhao et al. (2010).

Table 5: Mediation Type Classification

Outcome	Direct Effect (c')	Indirect via EID-B	Indirect via EID-Q	Total Indirect	Total Effect	VAF	Mediation Type
EGIP-S	0.180**	0.079**	0.087**	0.166	0.346	48.0%	Partial Complementary
EGIP-M	0.010 (n.s.)	0.074**	0.105**	0.179	0.191	93.7%	Full Indirect-Only

Note: ** $p < 0.01$. VAF = Variance Accounted For (total indirect effect / total effect × 100%). Mediation type follows Zhao et al. (2010): complementary = direct and indirect effects share the same sign; indirect-only = indirect effect significant while direct effect is not.

For strategic green innovation (EGIP-S), both the direct effect and indirect effects are significant and share the same positive sign, constituting partial complementary mediation. The combined indirect effect through EID-B and EID-Q (0.166) accounts for 48.0% of the total effect (0.346), indicating that disclosure mechanisms transmit approximately half of the subsidy effect, while the remaining direct pathway likely reflects legitimacy signaling and direct resource allocation for image-oriented projects.

For substantive green innovation (EGIP-M), the direct effect is non-significant while both indirect effects are significant, constituting full indirect-only mediation. The total indirect effect (0.179) accounts for 93.7% of the total effect (0.191), demonstrating that the subsidy-to-substantive-innovation transmission operates entirely through enhanced environmental disclosure. Across both outcomes, the EID-Q pathway yields a consistently stronger indirect effect than the EID-B pathway (EGIP-S: 0.087 vs. 0.079; EGIP-M: 0.105 vs. 0.074), suggesting that the quality dimension plays a somewhat stronger mediating role.

4.5 Predictive Performance

PLSpredict Q^2predict values were positive for all endogenous constructs (EGIP-M: 0.174; EGIP-S: 0.154; EID-B: 0.212; EID-Q: 0.206), confirming out-of-sample predictive capability (Shmueli et al., 2019). The CVPAT results confirmed that the PLS-SEM model significantly outperforms both the indicator average and the linear model benchmarks for all endogenous constructs ($p < 0.05$ for all comparisons), supporting the conclusion that the proposed structural model possesses adequate predictive performance (Sharma et al., 2023).

5. Discussion

5.1 The Asymmetric Direct Effects of Subsidies on Green Innovation

A central finding of this study is the striking divergence between the direct effects of government subsidies on strategic versus substantive green innovation. GESS directly promotes strategic green innovation ($\beta = 0.180$, $p = 0.001$) but fails to produce a significant direct effect on substantive green innovation ($\beta = 0.010$, $p = 0.858$). This asymmetry carries meaningful theoretical implications.

The positive direct link to strategic innovation is consistent with institutional theory predictions. When firms receive government subsidies, they face institutional pressure to demonstrate responsiveness to policy signals through visible environmental actions (DiMaggio & Powell, 1983). Green patent filings, incremental process adjustments, and public environmental commitments represent the type of quantifiable, rapid-turnaround outcomes that satisfy compliance requirements and maintain legitimacy (Boeing, 2016; Dechezleprêtre et al., 2016). Our finding aligns with prior research demonstrating that government subsidies enhance the quantity of green innovation patents (Du et al., 2023; Zhu & Tan, 2022), while extending these findings by demonstrating that this direct effect is specific to strategic (compliance-oriented) innovation.

The absence of a direct effect on substantive innovation reflects the deeper challenge identified by agency theory. Subsidies alone cannot overcome the information asymmetry between government agencies and firm managers regarding the allocation of resources between superficial versus genuine innovation activities (Jensen & Meckling, 1976). Without additional mechanisms that create transparency and accountability, managers may rationally direct subsidy resources toward activities that maximize visible outputs (strategic innovation) rather than investing in the costlier, riskier, and longer-horizon projects that define substantive green innovation. This result challenges the common

assumption in policy discourse that increasing subsidy amounts will proportionally increase the quality of green innovation outcomes.

5.2 The Dual Disclosure Pathways: Visibility Versus Accountability

The finding that both EID-B and EID-Q serve as significant mediators, yet operate with different strengths, illuminates the distinct mechanisms through which transparency converts policy resources into innovation outcomes.

The breadth pathway (EID-B) functions through a visibility mechanism. When firms expand the scope and reach of their environmental reporting, they construct a broad public platform of environmental commitments visible to multiple stakeholder groups (Suchman, 1995). This expanded visibility generates reputational incentives that motivate strategic green innovation (maintaining the green image) and stakeholder scrutiny that can pressure firms toward substantive improvements. The indirect effects through EID-B are significant for both strategic innovation ($\beta = 0.079$, $p = 0.003$) and substantive innovation ($\beta = 0.074$, $p = 0.008$), confirming that broader disclosure creates both image-oriented incentives and externally-driven pressure for genuine environmental action.

The quality pathway (EID-Q) functions through an accountability mechanism. When firms commit to quantitative, independently verified environmental disclosures, they establish performance benchmarks against which their future conduct will be evaluated (Clarkson et al., 2008). This self-binding commitment creates accountability pressure that compels measurable environmental improvements, as firms must demonstrate genuine progress to maintain the credibility of their verified reports, a dynamic consistent with the empirical findings of Li et al. (2022) and Ding et al. (2022) on the innovation-driving effects of environmental transparency. The stronger mediating effect of EID-Q (compared to EID-B) across both outcomes, particularly for substantive innovation (0.105 vs. 0.074), is theoretically coherent: genuine technological change requires verifiable performance improvements that can only be sustained when disclosure quality creates meaningful accountability.

5.3 The Full Mediation Finding: Transparency as the Essential Catalyst

The most consequential finding emerges from the full indirect-only mediation of the GESS → EGIP-M relationship (VAF = 93.7%). Government subsidies do not directly motivate firms to undertake genuine, transformative green innovation. Instead, the subsidy effect on substantive innovation operates *entirely* through the intermediate step of enhanced environmental information disclosure. When subsidized firms expand the breadth and improve the quality of their environmental disclosures, the resulting transparency creates accountability pressures and stakeholder expectations that compel substantive innovation efforts.

This finding carries a fundamental implication: subsidies function as resource inputs, but transparency mechanisms serve as the "transmission channel" that converts those resources into substantive environmental outcomes. Without the mediating discipline of enhanced disclosure, subsidies may generate strategic positioning but will not catalyze the technological transformation required for genuine environmental improvement. The contrast between partial mediation for strategic innovation (48.0%) and full mediation for substantive innovation (93.7%) reinforces this interpretation. Strategic innovation can be triggered directly by subsidy-driven compliance incentives, but substantive innovation requires an additional accountability mechanism, namely, the transparency created by enhanced environmental disclosure.

This finding extends institutional theory by demonstrating that the pathway from institutional incentive (subsidy) to organizational behavioral change (substantive innovation) requires an information mechanism as a bridging structure. The finding also speaks to agency theory by showing that disclosure practices can partially resolve the principal-agent problem between government

funders and firm managers: when firms publicly commit to transparent environmental reporting, the scope for managers to redirect subsidy resources toward non-environmental purposes is reduced.

5.4 Theoretical Contributions

This study makes three contributions to the literature on government subsidies, environmental governance, and corporate green innovation.

First, this research opens the "black box" of the subsidy–green innovation relationship by providing the first systematic evidence that environmental information disclosure constitutes an essential, rather than peripheral, transmission mechanism. The discovery of full indirect-only mediation for substantive innovation demonstrates that the relationship between subsidies and genuine green technological transformation is not direct but is entirely contingent on intermediate transparency mechanisms. This challenges prevailing theoretical models that conceptualize subsidies as direct drivers of innovation and suggests that future research should routinely incorporate disclosure as a mediating variable.

Second, this study advances the environmental disclosure literature by decomposing EID into breadth and quality dimensions and demonstrating their differential mediating roles. The consistent finding that disclosure quality exerts a stronger mediating effect than disclosure breadth provides empirical evidence for the theoretical distinction between visibility mechanisms (breadth) and accountability mechanisms (quality) in driving corporate environmental behavior. This two-dimensional framework offers a more nuanced analytical tool than unidimensional conceptualizations that dominate the existing literature.

Third, by adopting a motivation-based classification of green innovation (strategic versus substantive), this study reveals that the same policy instrument can trigger qualitatively different innovation responses through distinct transmission pathways. The finding that subsidies directly drive strategic innovation but require disclosure mediation to influence substantive innovation demonstrates the analytical value of disaggregating innovation outcomes by underlying motivation, consistent with the classification framework proposed by Tong et al. (2014) and extended by Lian et al. (2022).

5.5 Practical and Policy Implications

For national policymakers, the finding that subsidies alone are insufficient to drive substantive green innovation suggests that subsidy program design should integrate mandatory disclosure requirements as a conditioning mechanism. Linking continued subsidy eligibility to verifiable improvements in environmental information quality would leverage the accountability mechanism identified in this study to channel subsidy resources toward genuine technological innovation.

For local government administrators, the asymmetric mediation findings imply that monitoring and evaluation systems should assess the quality rather than merely the quantity of subsidized firms' environmental activities. Prioritizing disclosure quality metrics, such as third-party verification rates and quantitative performance indicators, over breadth metrics (such as the number of disclosure topics covered) would more effectively promote substantive innovation outcomes.

For enterprise managers, these findings demonstrate that environmental transparency is not merely a compliance cost but a strategic catalyst for innovation. Firms that proactively invest in high-quality environmental disclosure position themselves to convert government subsidies more effectively into substantive technological advantages, enhancing both their environmental performance and long-term competitive position.

5.6 Limitations and Future Research

Several limitations should be acknowledged. First, the cross-sectional research design limits causal inferences; future research should employ longitudinal or panel data to trace the temporal dynamics of

the subsidy–disclosure–innovation pathway. Second, the study relies on perceptual data from single respondents within each firm, which, despite satisfactory CMV diagnostics, introduces potential measurement concerns that could be addressed through multi-informant designs or the integration of archival data. Third, the sample is drawn exclusively from Chinese heavily polluting enterprises, and the generalizability of these findings to other national contexts or less pollution-intensive industries requires further investigation. Fourth, this study focuses on the mediating role of disclosure; future research could examine moderated mediation models that incorporate moderating variables such as environmental regulation intensity and managerial environmental attention to provide a more comprehensive understanding of the boundary conditions under which disclosure mediates the subsidy–innovation relationship. For instance, recent research highlights that external environmental dynamism can significantly moderate the performance outcomes of green innovation strategies (Manurung et al., 2025).

6. Conclusion

This study investigated how perceived government environmental subsidy support influences green innovation in China's heavily polluting industries and whether this relationship is transmitted through environmental information disclosure. Using a dual-path PLS-SEM framework, the findings show that government subsidy support directly promotes strategic green innovation but does not directly stimulate substantive green innovation. Instead, the impact on substantive innovation is transmitted entirely through environmental information disclosure, while the effect on strategic innovation is only partially mediated. Across both outcomes, disclosure quality exerts a stronger mediating influence than disclosure breadth.

These results indicate that environmental disclosure is not merely a compliance outcome but an important information-transparency mechanism through which policy support is converted into innovation performance. In practical terms, the findings imply that subsidy programmes are more likely to generate substantive green transformation when they are coupled with stronger disclosure systems, especially those that improve the quality, verifiability, and usefulness of environmental information. This suggests that transparency requirements should be treated as part of the design logic of green industrial support rather than as a separate reporting obligation. This study contributes by showing how information disclosure functions as a managerial and governance mechanism that shapes the effectiveness of policy-driven innovation in industrial systems. Future research can strengthen this line of inquiry by incorporating archival disclosure data, longitudinal designs, and cross-industry comparisons, as well as by examining how digital reporting systems and data-driven monitoring platforms further influence the subsidy–innovation relationship.

References

Bai, X. & Lyu, C. (2023). Environmental information disclosure and corporate green innovation: The moderating effect of formal and informal institutions.*Sustainability, 15*, 6169.

Bai, Y., Song, S., Jiao, J. & Yang, R. (2019). The impacts of government R&D subsidies on green innovation: Evidence from Chinese energy-intensive firms.*Journal of Cleaner Production, 233*, 819-829.

Becker, J.-M., Klein, K. & Wetzels, M. (2012). Hierarchical latent variable models in PLS-SEM: Guidelines for using reflective-formative type models.*Long Range Planning, 45*, 359-394.

Boeing, P. (2016). The allocation and effectiveness of China's R&D subsidies: Evidence from listed firms.*Research Policy, 45*, 1774-1789.

Cailou, J., Fuyu, Z. & Chong, W. (2021). Environmental information disclosure, political connections and innovation in high-polluting enterprises.*Science of the Total Environment, 764*, 144248.

Chen, S., Fu, F., Xiang, T. & Zeng, J. (2020). Do government subsidies crowd out technological capabilities? Effects on Chinese high-tech firms' invention outcomes.*Chinese Management Studies, 14*, 895-913.

Chen, Y. & Masukujjaman, M. (2025). How do government subsidies empower corporate green innovation? A visual knowledge map analysis based on CiteSpace.*Journal of Logistics, Informatics and Service Science, 12*, 38-55.

Clarkson, P. M., Li, Y., Richardson, G. D. & Vasvari, F. P. (2008). Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis.*Accounting, Organizations and Society, 33*, 303-327.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Dechezleprêtre, A., Einiö, E., Martin, R., Nguyen, K. T. & Van Reenen, J. (2016). Do tax incentives for research increase firm innovation? An RD design for R&D (No. w22405).*National Bureau of Economic Research*.

DiMaggio, P. J. & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields.*American Sociological Review, 48*, 147-160.

Ding, J., Lu, Z. & Yu, C. H. (2022). Environmental information disclosure and firms' green innovation: Evidence from China.*International Review of Economics & Finance, 81*, 147-159.

Du, C., Zhang, Q. & Huang, D. (2023). Environmental protection subsidies, green technology innovation and environmental performance: Evidence from China's heavy-polluting listed firms.*PLoS ONE, 18*, e0278629.

Fornell, C. & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error.*Journal of Marketing Research, 18*, 39-50.

Ghisetti, C. & Pontoni, F. (2015). Investigating policy and R&D effects on environmental innovation: A meta-analysis.*Ecological Economics, 118*, 57-66.

Giannarakis, G., Andronikidis, A. & Sariannidis, N. (2020). Determinants of environmental disclosure: Investigating new and conventional corporate governance characteristics.*Annals of Operations Research, 294*, 87-105.

Hair, J. F., Risher, J. J., Sarstedt, M. & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM.*European Business Review, 31*, 2-24.

Helfaya, A. & Moussa, T. (2017). Do board's corporate social responsibility strategy and orientation influence environmental sustainability disclosure? UK evidence.*Business Strategy and the Environment, 26*, 1061-1077.

Henseler, J., Ringle, C. M. & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling.*Journal of the Academy of Marketing Science, 43*, 115-135.

Huang, Z., Liao, G. & Li, Z. (2019). Loaning scale and government subsidy for promoting green innovation.*Technological Forecasting and Social Change, 144*, 148-156.

International Energy Agency. (2024). *Carbon dioxide emissions in 2023*. IEA.

Jenkins, H. & Yakovleva, N. (2006). Corporate social responsibility in the mining industry: Exploring trends in social and environmental disclosure.*Journal of Cleaner Production, 14*, 271-284.

Jensen, M. C. & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure.*Journal of Financial Economics, 3*, 305-360.

Kuo, L., Yeh, C. C. & Yu, H. C. (2012). Disclosure of corporate social responsibility and environmental management: Evidence from China.*Corporate Social Responsibility and Environmental Management, 19*, 273-287.

Li, G., Xue, Q. & Qin, J. (2022). Environmental information disclosure and green technology innovation: Empirical evidence from China.*Technological Forecasting and Social Change, 176*, 121453.

Lian, G., Xu, A. & Zhu, Y. (2022). Substantive green innovation or symbolic green innovation? The impact of ER on enterprise green innovation based on the dual moderating effects.*Journal of Innovation & Knowledge, 7*, 100203.

Lin, Y., Huang, R. & Yao, X. (2021). Air pollution and environmental information disclosure: An empirical study based on heavy polluting industries.*Journal of Cleaner Production, 278*, 124313.

Liu, Y., Xu, H. & Wang, X. (2022). Government subsidy, asymmetric information and green innovation.*Kybernetes, 51*, 3681-3703.

Luo, Z., Cui, J. & Tian, Y. (2025). Research on the impact of industry type on data asset disclosure.*Journal of Service, Innovation and Sustainable Development, 6*, 74-86.

Manurung, L., Ningsi, E. H. & Imam, C. (2025). Digital marketing capability and green innovation effects on SME performance: Market orientation mediation and environmental dynamism moderation.*Journal of Logistics, Informatics and Service Science, 12*, 87-102.

Meng, X. H., Zeng, S. X., Shi, J. J., Qi, G. Y. & Zhang, Z. B. (2014). The relationship between corporate environmental performance and environmental disclosure: An empirical study in China.*Journal of Environmental Management, 145*, 357-367.

Montmartin, B. & Herrera, M. (2015). Internal and external effects of R&D subsidies and fiscal incentives: Empirical evidence using spatial dynamic panel models.*Research Policy, 44*, 1065-1079.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y. & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies.*Journal of Applied Psychology, 88*, 879-903.

Sharma, P. N., Sarstedt, M., Shmueli, G., Kim, K. H. & Thiele, K. O. (2023). PLS-based model selection: The role of alternative explanations in information systems research.*Journal of the Association for Information Systems, 20*, 346-397.

Shmueli, G., Sarstedt, M., Hair, J. F., Cheah, J. H., Ting, H., Vaithilingam, S. & Ringle, C. M. (2019). Predictive model assessment in PLS-SEM: Guidelines for using PLSpredict.*European Journal of Marketing, 53*, 2322-2347.

Suchman, M. C. (1995). Managing legitimacy: Strategic and institutional approaches.*Academy of Management Review, 20*, 571-610.

Tang, H., Liu, J. & Wu, J. (2020). The impact of command-and-control environmental regulation on enterprise total factor productivity: A quasi-natural experiment based on China's two-control zone policy.*Journal of Cleaner Production, 254*, 120011.

Tong, T. W., He, W., He, Z. L. & Lu, J. (2014). Patent regime shift and firm innovation: Evidence from the second amendment to China's patent law.*Academy of Management Proceedings, 2014*, 14174.

Wang, M., Li, Y., Li, J. & Wang, Z. (2022). Green process innovation, green product innovation and its economic performance improvement paths: A survey and structural model.*Journal of Environmental Management, 297*, 113282.

Zhao, X., Lynch, J. G., Jr. & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and truths about mediation analysis.*Journal of Consumer Research, 37*, 197-206.

Zhu, X. & Tan, K. Y. (2022). Green industrial policy and green innovation of heavily polluting enterprises: A dual perspective of government subsidies and bank loans.*Sustainability, 14*, 9451.