



Greenwashing as an Unconventional Resource Channel for Corporate R&D Investment in China

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Abstract. Using a sample of A-share firms listed in Shanghai, Shenzhen, and Beijing from 2014 to 2024, this study investigates the impact mechanism of corporate greenwashing on innovation investment. The degree of greenwashing is measured and its relationship with research and development (R&D) intensity is examined, with environmental, social, and governance (ESG) performance and financing constraints incorporated as moderator variables. Empirical results indicate that greenwashing exerts a significant positive effect on R&D investment, a resource crowding-in effect concentrated among non-state-owned enterprises. Financing constraints significantly attenuate this main effect, whereas actual ESG performance does not display a significant moderating role. These findings reveal a mechanism by which spurious green signals can be converted into innovation resources through capital market channels in transitional economies. The analysis further clarifies the heterogeneous logic of the greenwashing effect from an ownership perspective and provides empirical evidence concerning the governance effectiveness of the ESG rating system. The conclusions offer practical implications for optimizing the allocation of green financial resources and strengthening supervision of environmental information disclosure.

Keywords: Greenwashing, R&D Investment, ESG Performance, Financing Constraints.

1 Introduction

Driven by the global trajectory toward sustainable development, corporate environmental information disclosure has become an important reference for resource allocation in capital markets. Concurrently, the rapid expansion of environmental, social, and governance (ESG) investment has increased the prevalence of corporate greenwashing, defined as selective disclosure or exaggeration of environmental performance that creates a false green image [1]. High-profile sanctions for greenwashing, exemplified by the *DWS Group* episode that coincided with a greater than 12% single-day share price decline, suggest that greenwashing not only undermines investor trust but also distorts capital allocation and impedes substantive green transformation [2]. In this context, a

rigorous understanding of the economic consequences and limits of greenwashing behavior is both theoretically valuable and practically urgent for refining green governance frameworks and directing resources toward genuinely environmentally beneficial innovation.

The extant literature has established a foundation for assessing the economic effects of greenwashing. For example, Shi (2025) documented that greenwashing would weaken the positive effect of firms' environmental performance on green innovation output [3], whereas Zhou (2024) reported that greenwashing could promote firms' outward investment decisions and facilitate access to government subsidies that support outward foreign direct investment [4]. Nevertheless, gaps remain. First, empirical evidence is scarce on the relationship between greenwashing and corporate research and development (R&D) investment, particularly in large-sample studies situated within the Chinese institutional context. Second, prior studies typically treat greenwashing as a homogeneous opportunistic behavior and pay insufficient attention to how contextual factors such as ownership structure and resource endowments condition its effects. These lacunae motivate the present investigation.

The paper employs a panel of Chinese A-share listed firms from 2014 to 2024 to examine the relationship between corporate greenwashing and R&D intensity, and to test the moderating roles of ESG performance and external financing constraints. The marginal contributions are threefold. First, at the level of research question, the analysis shows that under China's evolving green finance policies, greenwashing signals may be temporarily rewarded by the market and converted into resource advantages that support R&D investment, thereby extending signaling theory within the domain of environmental disclosure. Second, at the level of boundary conditions, the study introduces dual moderators, ESG performance and financing constraints, offering new empirical evidence on the heterogeneous consequences of greenwashing. Third, with respect to policy relevance, the findings indicate an institutional vulnerability in the current allocation of green financial resources whereby symbolic green claims capture policy benefits; they further highlight limitations of the ESG rating system in distinguishing substantive environmental performance from greenwashing, thereby providing empirical justification for regulatory efforts to tighten green finance eligibility criteria and enhance transparency in ESG evaluations.

2 Theoretical Basis and Research Hypotheses

2.1 The Relationship between Greenwashing and R&D Investment

Signaling theory provides the principal theoretical foundation for understanding the relationship between greenwashing and R&D investment [5]. Under conditions of information asymmetry, firms have incentives to transmit signals about their quality or capabilities to external stakeholders in order to reduce information search costs and secure resource support. Greenwashing constitutes a strategic environmental signal, involving selective disclosure or exaggeration of environmental performance to convey a green image to investors, consumers, and regulators and thereby obtain reputation advantages, policy subsidies, or financing benefits [1]. A divergence may arise, however,

between the veracity of such signals and actual firm behavior, producing a decoupling phenomenon.

From the perspective of signaling theory, two distinct transmission mechanisms can account for the effect of greenwashing on R&D investment. The first mechanism is a resource diversion logic, i.e., greenwashing requires the allocation of managerial attention and financial resources to constructing and disseminating environmental claims that might otherwise be devoted to substantive R&D activities [6]. Facing external legitimacy pressures, firms may prioritize lower-cost symbolic environmental actions over substantive green innovation, thereby constraining R&D investment. The second mechanism is a resource crowding-in logic [7]. If the green image produced by greenwashing is accepted by the market, firms may attract additional resources such as green credit, policy subsidies, and reputational capital. When these inflows are not directed solely to environmental compliance, they can be reallocated to finance R&D activities. In the context of China's ongoing promotion of green finance, green signals constitute an important channel for firms to access credit, and spurious green signals may therefore be temporarily transformed into financing advantages. The net effect of greenwashing on R&D investment is theoretically ambiguous, as it depends on institutional conditions and firm resource endowments. Accordingly, the following Hypothesis 1 is proposed.

H1: Corporate greenwashing behavior has a significant effect on R&D investment.

2.2 The Moderating Effect of ESG Performance

Signaling theory also informs the moderating role of actual ESG performance. Both greenwashing and genuine ESG outcomes constitute environmental signals intended to convey positive information about corporate environmental responsibility. When two congruent signals coexist, receivers' assessments of firm greenness depend on their interaction rather than on the isolated effect of either signal.

Specifically, actual ESG performance alters the market recognition environment and the conditions for resource conversion associated with signals generated by greenwashing. First, firms with strong ESG performance have established substantive green reputations, which may affect the credibility and marginal value of greenwashing in the perceptions of investors and thus influence whether greenwashing yields R&D-supporting resources. Second, limitations in information transparency and inconsistencies in ESG evaluation standards may cause actual ESG performance and greenwashing to be conflated in the eyes of signal receivers, altering market responses to corporate green signals [8]. Consequently, ESG performance, as a contextual factor shaping signal interpretation and resource allocation, may moderate the relationship between greenwashing and R&D investment. Hence, a Hypothesis 2 is advanced.

H2: Corporate ESG performance moderates the relationship between greenwashing and R&D investment.

2.3 The Moderating Effect of Financing Constraints

Resource dependence theory highlights firms' reliance on external resources for survival and growth [9], and financing constraints capture the difficulty of obtaining such external funds [10]. Financing constraints constitute a key boundary condition for resource allocation decisions. Under severe financing constraints, liquidity pressures elevate short-term survival considerations above longer-term development priorities, thereby influencing whether resources obtained through green signals can be redirected to R&D. Moreover, prospect theory suggests that resource scarcity can induce firms to adopt higher-risk strategies to pursue potential gains [11], which may affect both the intensity of greenwashing and subsequent allocation of obtained resources. Therefore, financing constraints, as a critical contextual determinant of signal conversion and resource distribution, may moderate the relationship between greenwashing and R&D investment. The following hypothesis is proposed.

H3: Corporate financing constraints moderate the relationship between greenwashing and R&D investment.

3 Data and Methodology

3.1 Sample Selection and Data Sources

The study employs annual data for Chinese A-share firms listed on the Shanghai, Shenzhen, and Beijing exchanges from 2014 to 2024, a period that captures China's transition from high-speed growth to high-quality development. The sample is thus representative of the institutional context under investigation. Data sources include the *Choice* financial database, *Sino-Securities Index Information Service (Shanghai) Co., Ltd.*, and *Bloomberg*. To ensure reliability and comparability and following prevailing practice, the initial sample is screened as follows. First, observations with missing values for key variables would be excluded; second, financial firms are excluded; third, observations for firms designated as ST or *ST during the sample period are removed; finally, to mitigate the influence of outliers on regression results, all continuous variables are winsorized at the 1st and 99th percentiles. After these procedures, the final sample comprises 6,409 firm-year observations.

3.2 Variable Definition and Measurement

Explained Variable – R&D Investment (*RD*). Consistent with prior studies, R&D investment is measured by R&D intensity, defined as the ratio of total R&D expenditure to operating revenue [12]. This indicator captures the extent of resource commitment to innovation activities; higher values indicate greater emphasis on research and development.

Explanatory Variable – Greenwashing Score (*GWS*). Following Hu (2023), the degree of greenwashing is measured as the deviation between the quality of corporate

environmental disclosure and substantive green behavior [1]. Concretely, greenwashing is operationalized as the difference between an environmental disclosure score and an environmental performance score. The formula is presented in equation (1). The first term represents the standardized relative position of a firm in the distribution of disclosure scores, proxied by Bloomberg's environmental disclosure rating (ER_{dis}). The second term denotes the standardized relative position of the firm in the distribution of actual environmental performance, proxied by *Huazheng*'s environmental performance rating (ER_{per}). A larger positive *GWS* value indicates a greater propensity for greenwashing, whereas a negative value suggests relative underreporting of green behavior. The one-period lag of *GWS* is used in regression analyses.

$$GWS_i = \left(\frac{ER_i - \overline{ER_{dis}}}{\sigma_{dis}} \right) - \left(\frac{ER_i - \overline{ER_{per}}}{\sigma_{per}} \right) \quad (1)$$

Moderator Variables. ① ESG score (*ESG*): Corporate actual ESG performance reflects a firm's substantive outcomes across environmental, social, and governance dimensions. This study proxies ESG actual performance using *Huazheng* ESG ratings. Higher ratings indicate stronger ESG practices and superior actual performance. This rating system integrates international ESG frameworks with the regulatory orientation, institutional environment, and business characteristics of the Chinese A-share market, balancing international comparability and local adaptability [13]. Since it covers all A-share listed firms, the dataset is highly representative and mitigates selection bias. Ratings employ a nine-level scale from C to AAA (C, CC, CCC, B, BB, BBB, A, AA, AAA). Consistent with prevailing practice in Chinese ESG research, these categories are coded numerically from 1 to 9 (C=1 through AAA=9), with higher values indicating better overall ESG performance. ② Financing constraints (*SA*): Financing constraints are measured by the *SA* index proposed by Hadlock and Pierce [10]. The *SA* index is computed with the following equation (2).

$$SA = -0.737 \times \ln(A) + 0.043 \times \ln(A)^2 - 0.040 \times AGE \quad (2)$$

Here, *A* represents the firm's total assets, and *AGE* denotes firm age. The absolute value of the *SA* is used in analysis, with larger values denoting more severe financing constraints.

Control Variables. Following prior studies, the following control variables are included to mitigate omitted variable bias, including return on assets (*ROA*), firm size (*SIZE*, natural logarithm of *A*), leverage ratio (*LEV*), net cash flow (*CF*, net cash flow from operating activities divided by total assets), *GROWTH* (growth rate of operating revenue), and *AGE*.

3.3 Empirical Models

To test hypotheses H1, H2 and H3, the following multiple regression specifications are estimated. All models include industry and year fixed effects and report standard errors

clustered at the firm level. The baseline model assesses the effect of greenwashing on R&D intensity, as shown in equation (3).

$$RD_{i,t} = \alpha_0 + \alpha_1 GWS_{i,t-1} + \alpha_2 \mathbf{Controls}'_{i,t-1} + \sum IND + \sum YEAR + \varepsilon_{i,t} \quad (3)$$

Here, $RD_{i,t}$ denotes R&D investment of firm i in year t ; **Controls** includes the control variables described in 3.2.4 and the moderators in 3.2.3. $\varepsilon_{i,t}$ is the error term. A statistically significant coefficient α_1 provides support for H1.

To examine whether actual ESG performance moderates the relationship between greenwashing and R&D (H2), an interaction term between greenwashing and ESG is added in equation (4).

$$RD_{i,t} = \beta_0 + \beta_1 GWS_{i,t-1} + \beta_2 ESG_{i,t-1} + \beta_3 (GWS_{i,t-1} \times ESG_{i,t-1}) + \beta_4 \mathbf{Controls}'_{i,t-1} + \sum IND + \sum YEAR + \varepsilon_{i,t} \quad (4)$$

Here, **Controls** contains the control variables in 3.2.4, and also the *SA*. A statistically significant β_3 indicates that ESG performance moderates the effect of greenwashing on R&D, supporting H2.

To test the moderating role of financing constraints (H3), an interaction between greenwashing and the *SA* index is included. The model is shown as equation (5).

$$RD_{i,t} = \theta_0 + \theta_1 GWS_{i,t-1} + \theta_2 SA_{i,t-1} + \theta_3 (GWS_{i,t-1} \times SA_{i,t-1}) + \theta_4 \mathbf{Controls}'_{i,t-1} + \sum IND + \sum YEAR + \varepsilon_{i,t} \quad (5)$$

In this model, **Controls** contains all the control variables in 3.2.4, and *GWS*. A statistically significant θ_3 indicates that financing constraints moderate the relationship between greenwashing and R&D, supporting H3.

4 Research Results and Analysis

4.1 Descriptive Analysis

Table 1 presents descriptive statistics for the principal variables. Over the sample period, the mean greenwashing measure (*GWS*) is -0.0118 with a standard deviation of 1.1302, indicating substantial cross-sectional variation in greenwashing behavior. Some firms exhibit pronounced greenwashing tendencies, whereas others disclose environmental information relatively faithfully. The mean R&D intensity (*RD*) is 0.0447, with a standard deviation of 0.0536 and a median of 0.0325, suggesting generally low R&D intensity and considerable heterogeneity across firms; the maximum and minimum values are 0.3170 and 0.0002, respectively. The mean *ESG* score is 4.5059, the standard deviation is 1.0368, and the median equals 5, indicating that overall ESG performance is above the midpoint but varies across firms. *SA* ranges from 2.6391 to 10.8435, reflecting heterogeneous degrees of financing constraint among sample firms. Distributions of the remaining variables lie within acceptable ranges.

Table 1. Descriptive statistical results.

Variable	Count	Mean	Standard deviation	Minimum	Median	Maximum
<i>GWS</i>	6409	-0.0118	1.1302	-2.5911	0.0414	3.0428
<i>RD</i>	6409	0.0447	0.0536	0.0002	0.0325	0.3170
<i>ESG</i>	6409	4.5059	1.0368	2.0000	5.0000	7.0000
<i>SA</i>	6409	5.7209	1.6295	2.6391	5.5363	10.8435
<i>ROA</i>	6409	0.0666	0.0703	-0.1576	0.0560	0.3035
<i>SIZE</i>	6409	0.2358	0.0123	0.2109	0.2349	0.2709
<i>LEV</i>	6409	0.4714	0.1873	0.0825	0.4838	0.8690
<i>CF</i>	6409	0.1362	0.1883	-0.2028	0.0922	1.1735
<i>GROWTH</i>	6409	0.1301	0.2729	-0.4698	0.0951	1.3656
<i>AGE</i>	6409	21.7095	5.5534	9	22	37

4.2 Correlation Analysis

A correlation analysis is conducted to assess potential multicollinearity among explanatory variables. Except for a high correlation between *SA* and *SIZE*, the absolute values of pairwise correlation coefficients are below 0.7, suggesting no severe multicollinearity. The elevated correlation between *SA* and *SIZE* is attributable to the construction of the *SA* index, which mechanically incorporates *SIZE* and *AGE*; this mechanical correlation does not compromise the reliability of subsequent regression estimates. Accordingly, all variables are retained for analysis.

4.3 Panel Regression Analysis

Results of Hypothesis 1. Based on the hypotheses above, regressions are estimated for the full sample and for subsamples of state-owned and non-state-owned firms. Table 2 reports the principal results. In the full-sample regressions, the coefficient on greenwashing (*GWS*) is 0.0023 and is positive and significant at the 1% level, indicating a positive association between corporate greenwashing and R&D intensity. This finding is consistent with a resource crowding-in mechanism, whereby strategic green signaling enables firms to reallocate compliance-cost savings or policy-derived resources to R&D activities. Additional analysis shows a positive correlation between *GWS* and *CF*, with a coefficient of 0.0037 significant at the 10% level. By overstating environmental performance, firms may obtain a green reputation premium in capital markets, lower equity financing costs, or increase the likelihood of green bond issuance, thereby mobilizing additional funds for R&D. Under stakeholder pressure, a greenwashed image can also enhance consumer recognition and investor confidence, reinforcing brand value and expanding firms’ resource base for innovation investment. Consequently, although greenwashing distorts environmental information, it can nonetheless generate resource inflows that support R&D.

Subsample results (columns 2 and 3) reveal heterogeneity by ownership. In the state-owned enterprise subsample, the *GWS* coefficient is 0.0007 and statistically insignificant, indicating no detectable effect of greenwashing on R&D investment for state-owned firms. Possible explanations include greater policy burdens and social responsibilities that make R&D decisions more responsive to government directives than to market reputation [14]; stronger external supervision and administrative constraints that limit opportunities for converting green signals into R&D resources; and ESG practices that are more compliance-driven than strategically motivated, yielding weaker marginal innovation effects.

In the non-state-owned firm subsample, the *GWS* coefficient is 0.0027 and positive and significant at the 1% level, indicating that the positive relationship between greenwashing and R&D investment is primarily driven by non-state-owned enterprises. Compared with state-owned firms, non-state firms exhibit greater managerial flexibility, fewer administrative constraints on R&D allocation, and a higher propensity for market participants to reward green signals with financing advantages. Weaker regulatory intensity for non-state firms also increases scope for greenwashing and amplifies the reputation premiums and resource crowding-in effects associated with strategic environmental disclosure.

Table 2. Regression results for Hypothesis 1.

	Full sample	State-owned firms	Non-state-owned firms
<i>GWS</i>	0.0023***	0.0007	0.0027**
<i>ESG</i>	0.0033***	-0.0001	0.0043***
<i>SA</i>	0.0024	-0.0184	0.0032
<i>ROA</i>	-0.1054***	-0.0939**	-0.1124***
<i>SIZE</i>	-0.6141	2.3432	-0.7092
<i>LEV</i>	-0.0467***	-0.0226*	-0.0596***
<i>CF</i>	0.0184***	0.0118	0.0146**
<i>GROWTH</i>	0.0076***	0.0085	0.0067*
<i>AGE</i>	-0.0008	-0.0007	-0.0009
<i>Year FE</i>	Yes	Yes	Yes
<i>Industry FE</i>	Yes	Yes	Yes
<i>R-squared</i>	0.3202	0.1694	0.3492
<i>F</i>	90.979	12.113	75.491
<i>N</i>	6409	1873	4536

Note: The data in the table are regression coefficients of each variable, and ***, **, and * are significant at the significance level of 1%, 5% and 10% respectively.

Results of Hypothesis 2 & 3. Hypothesis 2 examines whether ESG performance moderates the relationship between greenwashing and R&D. An interaction term between greenwashing and ESG ($GWS \times ESG$) is included in the baseline specification. In Table 3, the estimated coefficient on the interaction term is 0.0001 and is not statistically

significant, indicating that ESG performance does not materially moderate the effect of greenwashing on R&D investment. In other words, the marginal effect of greenwashing on R&D does not differ significantly across firms with different ESG performance levels. Potential explanations include the partial mechanistic overlap between ESG performance and greenwashing as concurrent green signals, which may attenuate the incremental explanatory power of the *GWS* term when both are included; limitations of the ESG rating system in China, including inconsistent standards and limited transparency, which may impair investors' ability to distinguish substantive environmental performance from symbolic disclosure; and possible path dependence in greenwashing strategies, whereby established greenwashing practices are not readily altered by short-term improvements in ESG ratings.

Hypothesis 3 assesses whether financing constraints, as proxied by the *SA* index, moderate the effect of greenwashing on R&D. The interaction term *GWS* × *SA* is negative and significant at the 5% level, indicating that financing constraints significantly dampen the positive association between greenwashing and R&D investment. In other words, the positive relationship between greenwashing and R&D weakens as firms face tighter financing constraints. This result is consistent with a mechanism in which firms subject to greater financing constraints encounter more limited funding channels and tighter external scrutiny, reducing the ability of greenwashing signals to be converted into tangible R&D resources. Conversely, firms with lower financing constraints are more likely to translate green signals into external financing, thereby amplifying the resource crowding-in effect of greenwashing on R&D.

Table 3. Regression results for Hypothesis 2 & 3.

	Hypothesis 2	Hypothesis 3
<i>GWS</i>	0.0018	0.0052**
<i>GWS</i> × <i>ESG</i>	0.0001	/
<i>GWS</i> × <i>SA</i>	/	-0.0006**
<i>ESG</i>	0.0033***	0.0033***
<i>SA</i>	0.0023	0.0050
<i>ROA</i>	-0.1053***	-0.1013***
<i>SIZE</i>	-0.6097	-0.8544
<i>LEV</i>	-0.0467***	-0.0500***
<i>CF</i>	0.0183***	0.0182***
<i>GROWTH</i>	0.0076***	0.0073***
<i>AGE</i>	-0.0008***	-0.0007**
<i>Year FE</i>	Yes	Yes
<i>Industry FE</i>	Yes	Yes
<i>R-squared</i>	0.3202	0.3175
<i>F</i>	97.288	99.584
<i>N</i>	6409	6409

Note: The data in the table are regression coefficient of each variable, and ***, **, and * are significant at the significance level of 1%, 5% and 10% respectively.

5 Conclusion and Policy Implications

This article examines the effect of corporate greenwashing on R&D investment and the moderating roles of contextual factors using a panel of Chinese A-share listed firms in Shanghai, Shenzhen, and Beijing from 2014 to 2024. The analysis finds that greenwashing exerts a significant positive effect on R&D investment, a relationship that holds for non-state-owned enterprises but is not significant for state-owned enterprises. In addition, financing constraints attenuate the positive association between greenwashing and R&D, whereas actual ESG performance does not demonstrate a significant moderating effect.

Based on these findings, the following policy recommendations are offered. First, improve the allocation mechanism for green financial resources to channel funds toward substantive green innovation. Current approval procedures for instruments such as green loans and green bonds have limited capacity to distinguish the quality of environmental disclosures, allowing some firms to capture policy benefits through false green signals. Regulatory authorities should adopt a dual verification mechanism linking disclosure quality to hard indicators such as actual pollution emissions and green patent output, raise entry thresholds for green financing, and implement continuous monitoring requirements to ensure that scarce financial resources flow to firms with genuine innovation capacity and intent.

Second, strengthen the transparency and standardization of the ESG rating system to enhance its signal differentiation function. Given evidence of weak identification of greenwashing in existing ratings, domestic ESG agencies should disclose the weighting schemes and calculation logic for disclosure and performance components in the environmental dimension to reduce subjectivity and improve comparability. Independent audits and cross validation by third-party institutions should be encouraged to increase the credibility of ratings so that ESG scores become a reliable input for investor decision making.

Third, adopt differentiated regulatory strategies that target greenwashing risks among non-state-owned firms. Authorities could refine environmental information disclosure requirements for non-state firms, especially in pollution intensive industries, by increasing reporting frequency and granularity, introducing sanctions for disclosure violations, and reducing opportunities for institutional arbitrage that enable greenwashing.

Fourth, alleviate financing constraints faced by small and medium sized (SME) and technology-oriented enterprises to reduce their reliance on symbolic green strategies. Policy measures may include deepening inclusive finance reforms, expanding equity financing channels for technology-based SMEs, promoting innovative instruments such as intellectual property pledge financing, and lowering external financing costs and information frictions. These measures would diminish incentives to substitute symbolic environmental claims for substantive resource acquisition.

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