Available on: https://jmrr.ep-journals.org/ E-ISSN: 3051-3588, P-ISSN: 3051-357X

Journal of Management Research and Review

Volume: 02 Issue: 09 September-2026

Corporate Governance, Market Structure, And Greenwashing: Evidence from A Two-Part Model in an Emerging Market

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Published Date: September 08, 2026 **Article DOI: 10.65150/EP-jmrr/V2E9/2026-03**

ABSTRACT: Objective: To examine whether corporate governance and product-market structure are associated with greenwashing among Brazilian firms and whether climate policy uncertainty conditions these relationships, distinguishing the occurrence of disclosure-performance misalignment from its conditional intensity. Methodology: We use a canonical panel of 970 firm-year observations from 105 firms over 2010–2023. Greenwashing is measured as the relative gap between Bloomberg® ESG Disclosure and LSEG Data & Analytics® environmental performance. The common sample includes 942 observations for the extensive margin and 516 observations with GW > 0 for the intensive margin. Fully controlled main specifications use Logit and OLS with firm-level controls, NAICS-3 fixed effects, and NAICS-3 clustered standard errors; year fixed effects are added in M5 as a robustness specification. Findings: In M4, corporate governance is not significant in the extensive margin ($\beta = 0.026$; $p = 0.929$) or intensive margin ($\beta = -0.039$; $p = 0.750$). HHI is likewise not significant ($\beta = -1.419$; $p = 0.398$; and $\beta = -0.255$; $p = 0.550$, respectively). Interactions with CCPU are non-significant in the separate fully controlled models, and M5 and the additional sensitivity analyses preserve the core inference. Significance: The findings show that inferences about governance, competition, and greenwashing depend critically on simultaneous observability of disclosure and performance, sample comparability, and separation of occurrence from intensity.

KEYWORDS: Greenwashing, Corporate Governance, Market Structure, ESG Disclosure, Climate Policy Uncertainty, Emerging Markets

INTRODUCTION

Corporate greenwashing has become central to the ESG disclosure agenda as regulatory, comparability, and assurance requirements increase pressure for verifiable environmental information (Christensen et al., 2021; García-Sánchez et al., 2019). A substantial stream of research assumes that corporate governance constrains such behavior. Recent evidence, however, suggests a more ambiguous picture: more sophisticated governance structures may improve monitoring while simultaneously expanding the organizational capacity to produce and manage complex ESG information (Lyon et al., 2023; Ghitti et al., 2024; Ma & Ahmad, 2024; Lee et al., 2025).

From an agency-theory perspective, the separation of ownership and control under information asymmetry and contractual incompleteness gives managers discretion over the production and disclosure of corporate information (Jensen & Meckling, 1976; Holmström, 1979). The disclosure literature shows that this discretion may be exercised strategically in response to proprietary costs, verification risk, and reputational incentives (Darrough & Stoughton, 1990; Verrecchia, 1983; Healy & Palepu, 2001). In the ESG domain, these frictions may materialize as a misalignment between environmental disclosure and underlying performance (Delmas & Burbano, 2011; Lyon & Montgomery, 2015).

Analyzing this phenomenon requires integrating internal and external disciplinary mechanisms. Corporate governance influences the credibility of disclosures, whereas product-market structure changes informational incentives and competitive pressure (Karuna, 2007; Giroud & Mueller, 2010). Climate policy uncertainty adds a contextual dimension because it can simultaneously alter disclosure incentives and the costs of verifying environmental information (Zhang & Ge, 2024).

This study asks: how are corporate governance and product-market concentration, separately and jointly, associated with the probability and intensity of greenwashing, and do these associations vary with climate policy uncertainty? To answer this question, greenwashing is treated as two economically distinct margins: the occurrence of a positive disclosure-performance gap and, conditional on that occurrence, the magnitude of the misalignment.

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The contribution is threefold. First, the study treats observability as a measurement requirement: only firm-year observations for which disclosure and environmental performance are simultaneously observable enter the greenwashing gap, thereby avoiding the classification of missing information as the absence of greenwashing. Second, it applies a two-part model on a common sample to separate occurrence from intensity and to compare governance and concentration without mechanical changes in sample composition. Third, it shows that associations apparently attributable to governance or competition are not robust once these restrictions are imposed, establishing a boundary condition for the use of aggregate proxies in identifying greenwashing risk.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 Greenwashing as informational misalignment

Greenwashing can be conceptualized as a manifestation of managerial discretion in the production and disclosure of corporate information, characterized by misalignment between reported ESG content and underlying environmental performance. Empirically, the measure used in this study identifies a relative disclosure-performance misalignment consistent with greenwashing, but it neither observes nor proves managerial intent to deceive (Lyon & Maxwell, 2011). In low-verifiability environments, signals may be imperfect or biased, allowing communication to become decoupled from operational reality (Spence, 1973; Connelly et al., 2011).

The low convergence of ratings across ESG data providers reinforces the need for caution when greenwashing metrics combine distinct sources (Berg et al., 2022). Part of the observed gap may arise from methodological differences across providers rather than exclusively from strategic corporate behavior. Accordingly, the empirical interpretation explicitly recognizes potential measurement noise.

The relative-gap approach is useful because it does not equate a high level of disclosure with good environmental performance. Instead, it asks whether a firm's disclosure position is unusually favorable relative to its performance position among firms observed in the same year. Standardizing both components within year removes common shifts in the level and dispersion of provider scores and makes the construct explicitly comparative. A positive gap therefore indicates that the firm ranks more favorably on disclosure than on environmental performance in that year; a non-positive gap indicates that disclosure does not exceed performance on this relative scale. This interpretation is deliberately narrower than an allegation of deception. The construct captures observable inconsistency between two information dimensions and should be read as a risk signal consistent with greenwashing rather than direct evidence of managerial intent (Delmas & Burbano, 2011; Lyon & Montgomery, 2015).

Legitimacy theory further suggests that disclosure may perform a symbolic function of institutional alignment and external-pressure mitigation even when it is not accompanied by substantive performance changes (Suchman, 1995; Deegan, 2002; Meyer & Rowan, 1977; Cho et al., 2015). The degree of external scrutiny may also alter incentives for selective disclosure (Marquis et al., 2016).

This distinction also motivates the study's emphasis on observability. If either disclosure or performance is missing, the relative gap is not identified: coding such cases as zero would confound absence of evidence with evidence of alignment. Requiring both components to be observed sacrifices sample size but protects the meaning of the dependent variable. It also creates a clearer basis for comparing internal governance and external market mechanisms because both are evaluated against the same measurable outcome rather than against a mixture of observed gaps and unobserved cases.

2.2 Corporate governance and informational capacity

Corporate governance is traditionally viewed as an arrangement designed to mitigate inefficiencies arising from the separation of ownership and control (Fama & Jensen, 1983). Mechanisms such as board independence, CEO-chair separation, diversity, and the presence of non-executive directors can constrain managerial discretion and enhance the credibility of disclosed information (Adams et al., 2010).

At the same time, sophisticated governance structures can expand an organization's capacity to produce, integrate, and communicate ESG information. Two theoretically competing mechanisms therefore coexist. The monitoring channel predicts less misalignment because governance restricts discretion and increases verifiability; the informational-capacity channel allows more sophisticated structures to increase the ability to produce complex ESG narratives when underlying performance is difficult to verify. Recent evidence on boards, sustainability committees, and executive-power asymmetries yields heterogeneous signs across institutional settings (Ghitti et al., 2024; Ma & Ahmad, 2024; Zhao et al., 2024; Lee et al., 2025). The net direction of the association is therefore treated as an empirical question rather than imposed ex ante.

The two channels need not be mutually exclusive. Monitoring mechanisms can improve the accuracy of internal information and constrain opportunistic disclosure, while the same organizational infrastructure can increase the volume, sophistication, and strategic tailoring of ESG communication. Whether improved information-processing capacity produces greater alignment or merely more persuasive disclosure depends on the board's incentives, the verifiability of environmental claims, and the extent of external scrutiny. This helps explain why individual board attributes may exhibit heterogeneous associations even when an aggregate governance index has little net effect: aggregation can combine dimensions that operate through different mechanisms or in opposite directions. The empirical question is therefore not whether governance is intrinsically 'good' or 'bad' for environmental communication, but whether its monitoring role dominates its informational-capacity role in the observed setting (Adams et al., 2010; Ghitti et al., 2024; Ma & Ahmad, 2024). Accordingly, H1 is formulated as a non-directional hypothesis derived from competing theoretical mechanisms.

H1: Corporate governance is associated with greenwashing; the net direction depends on the balance between the competing monitoring and informational-capacity mechanisms.

2.3 Market structure and informational incentives

Product-market structure affects firms' economic and informational incentives. The Herfindahl-Hirschman Index (HHI) summarizes industry concentration: higher values indicate greater concentration and lower competitive intensity. Competing channels again coexist. Stronger competition may discipline managers and raise the reputational cost of informational inconsistency, but it may also intensify incentives to differentiate through favorable environmental narratives. More concentrated markets, in turn, reduce competitive pressure but may facilitate scrutiny of dominant firms (Karuna, 2007; Giroud & Mueller, 2010; El Diri et al., 2020).

Because these channels imply different directions, the analysis distinguishes the engagement decision from the conditional intensity of the behavior.

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Competition can affect both the expected benefit and the expected cost of selective environmental communication. In more competitive industries, firms face stronger pressure to differentiate products, brands, and reputations, potentially increasing the payoff to favorable ESG narratives. At the same time, competitive discipline can make reputational mistakes more costly and reduce managerial slack. In concentrated industries, weaker rivalry may reduce the need for symbolic differentiation, yet dominant firms may attract greater visibility from investors, regulators, civil society, and the media. HHI therefore captures a market environment in which disciplinary and reputational forces can move in opposing directions. Separating occurrence from intensity allows these forces to affect the decision to exhibit a positive gap differently from the magnitude of that gap once it occurs (Karuna, 2007; Giroud & Mueller, 2010). Accordingly, H2 is formulated as a non-directional hypothesis derived from competing theoretical mechanisms.

H2: Product-market concentration is associated with greenwashing; the net direction depends on the balance among competitive discipline, informational differentiation, and scrutiny of dominant firms.

2.4 Climate policy uncertainty as a moderator

Climate policy uncertainty may alter both disclosure incentives and the costs of verifying environmental information. Recent evidence indicates that greater climate uncertainty may intensify greenwashing in some settings, particularly when verifiability is limited (Zhang & Ge, 2024; Wang et al., 2026). CCPU is therefore treated as a contextual moderator rather than a direct measure of enforcement.

Interaction terms require greater statistical power than direct effects. Accordingly, marginal results or findings that are sensitive to control saturation are interpreted as exploratory.

Conceptually, climate-policy uncertainty may change the relative strength of these channels rather than exerting a uniform direct effect. Uncertainty can increase the value of flexible corporate narratives because future regulatory requirements are less predictable, but it can also raise stakeholder attention to environmental claims and increase the expected cost of inconsistency. For governance, this means that monitoring and informational capacity may become more consequential when the external information environment is unstable. For market structure, uncertainty may amplify either competitive differentiation or scrutiny of dominant firms. The moderation hypothesis is therefore intentionally contextual: it tests whether the association of each focal mechanism with the disclosure-performance gap changes as policy uncertainty varies, without interpreting CCPU itself as enforcement or regulatory stringency (Zhang & Ge, 2024; Wang et al., 2026).

H3: The associations of corporate governance and market structure with greenwashing are conditioned by climate policy uncertainty.

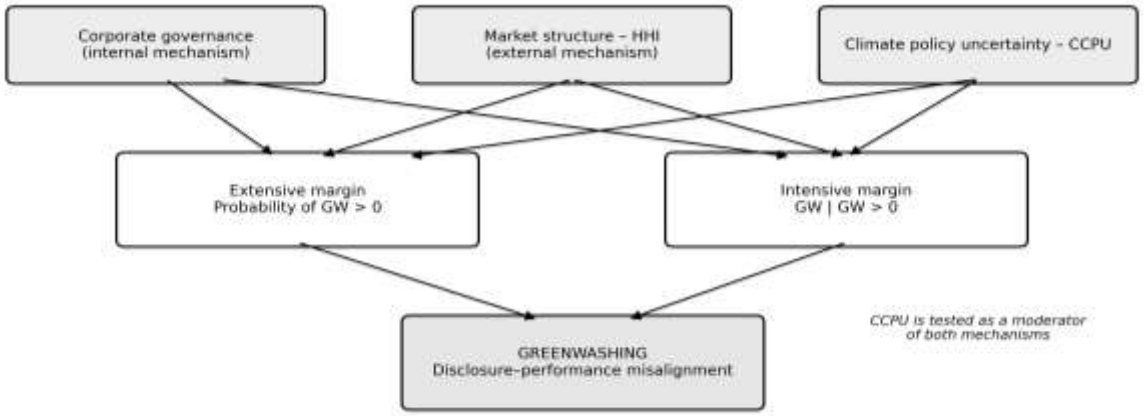


Figure 1. Conceptual framework of the study
Source: Prepared for this study.

MATERIALS AND METHODS

3.1 Data and sample construction

The sample comprises Brazilian firms listed on B3 between 2010 and 2023 and integrates: (i) Bloomberg® for ESG Disclosure; (ii) LSEG Data & Analytics® for environmental performance, governance attributes, market structure, and financial variables; and (iii) the climate policy uncertainty index developed by Gavriilidis (2021), constructed from newspaper coverage and inspired by the approach of Baker et al. (2016).

The canonical dataset contains 970 firm-year observations from 105 firms for which the greenwashing gap is genuinely observable; 531 observations have GW > 0. To compare governance and HHI under the same conditions, complete cases are required for all variables used in the models, producing 942 observations from 103 firms in the extensive margin. Conditioning this common sample on GW > 0 yields 516 observations from 94 firms in the intensive margin. This design fixes the sample before comparing mechanisms.

Table 1. Construction of the analytical sample

Stage	Firm-year N	Firms	GW > 0	Analytical role
Clean canonical dataset	970	105	531	Starting point
Common complete sample	942	103	516	Extensive margin / horse race
Intensive sample	516	94	516	GW > 0

Note. Greenwashing is not recoded as zero when either disclosure or environmental performance is unobserved.

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3.2 Dependent variable: Greenwashing

Greenwashing is operationalized as the misalignment between ESG disclosure and environmental performance: GW_it = Z_t(Disclosure_it) - Z_t(Performance_it), where Z_t(·) denotes cross-sectional standardization by year. Disclosure comes from Bloomberg® and environmental performance from LSEG Data & Analytics®. Positive values indicate disclosure that is relatively higher than observed performance. The extensive margin uses GW_bin = 1 when GW > 0 and 0 when GW ≤ 0; the intensive margin uses continuous GW only among observations with GW > 0. This two-part (hurdle-style) decomposition treats zero as a substantive classification threshold rather than as censoring. The gap is interpreted as relative disclosure-performance misalignment consistent with greenwashing and does not establish deceptive managerial intent. Combining different data providers may introduce measurement noise arising from methodological divergence (Berg et al., 2022).

Year-specific standardization is important for two reasons. First, ESG scoring practices, disclosure expectations, and the cross-sectional distribution of environmental scores can evolve over a long panel. Comparing standardized positions within the same year limits the influence of such common shifts on the gap. Second, subtraction places disclosure and performance on a common scale before their difference is calculated. The resulting measure is thus a relative, contemporaneous discrepancy rather than a difference between raw provider scores with potentially different units. The zero threshold has a direct interpretation on this standardized scale: it separates observations in which disclosure exceeds performance from those in which it does not. Alternative thresholds are nevertheless examined because small positive values may reflect measurement noise rather than economically meaningful misalignment.

3.3 Explanatory variables and controls

Corporate governance is captured by a synthetic index based on eight board attributes: board composition/size, affiliation, experience, independence, gender diversity, sustainability committee, CEO-chair separation, and the share of non-executive members. Each component is standardized before the Gov_index is computed as the simple mean of the eight indicators. In the analytical dataset, the sustainability-committee and CEO-chair-separation indicators are empirically identical; for transparency, a sensitivity analysis reconstructs the index using seven empirically unique dimensions. Market structure is measured by the HHI, calculated as the sum of squared sales-based market shares within each NAICS-3 industry-year using LSEG data at the construction stage, before restriction to the final matched greenwashing sample. Market share is defined analogously as firm sales divided by total industry-year sales. Climate policy uncertainty follows Gavriilidis (2021). The original CPU measure is news-based and constructed from major U.S. newspapers; in this study it is therefore interpreted as an external climate-policy uncertainty signal rather than as a Brazil-specific domestic-policy index. The direct CCPU term enters in its original scale, whereas CCPU_c is mean-centered and used only in interaction terms. The control vector includes leverage, ROA, market-to-book (MTB), cash/assets, PPE/assets, market share, and firm size measured as ln(total assets).

Table 2. Variable definitions

Variable	Definition	Source
GW	Z(ESG Disclosure) - Z(environmental performance), by year	Bloomberg; LSEG; Authors' calculations
GW_bin	1 if GW > 0; 0 if GW ≤ 0	Authors' calculations
Gov_index	Standardized mean of eight board attributes	LSEG; Authors' calculations
HHI	Sum of squared sales-based market shares within NAICS-3 industry-year, constructed before final matched-sample restriction	LSEG; Authors' calculations
CCPU	News-based U.S. climate policy uncertainty index; direct effect entered in original scale	Gavriilidis (2021)
CCPU_c	Mean-centered CCPU, used exclusively in interaction terms	Authors' calculations
Leverage	Total debt / total assets	LSEG; Authors' calculations
ROA	Net income / total assets	LSEG; Authors' calculations
MTB	Market value / book equity	LSEG; Authors' calculations
Cash/Assets	Cash and equivalents / total assets	LSEG; Authors' calculations
PPE/Assets	Property, plant and equipment / total assets	LSEG; Authors' calculations
Market share	Firm sales / industry-year sales	LSEG; Authors' calculations
Size	Ln(total assets)	LSEG; Authors' calculations

Note. NAICS-3 is used for fixed effects and clustering of standard errors. HHI is constructed at the NAICS-3 industry-year level from LSEG sales-based market shares before restriction to the final matched GW sample. The Gavriilidis (2021) CCPU measure is U.S. news-based and is interpreted here as an external climate-policy uncertainty signal, not as a Brazil-specific policy index.

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3.4 Empirical strategy

The empirical strategy uses a two-part model, appropriate when occurrence and conditional intensity are distinct processes (Cragg, 1971; Greene, 2018; Wooldridge, 2010). M1 includes the focal mechanism and NAICS-3 fixed effects; M2 adds the direct effect of CCPU; M3 adds the interaction between the focal mechanism and CCPU_c; and M4 adds the full firm-level control set and is treated as the fully controlled main specification. M5 adds year fixed effects as a robustness specification. Because CCPU varies over time, its direct effect is absorbed by year dummies in M5, while the interaction terms remain identified through cross-sectional variation in the focal mechanism. Standard errors are clustered by NAICS-3 (Cameron et al., 2011).

The two-part structure is not only a distributional convenience; it corresponds to two economically different questions. The extensive margin asks whether a firm-year displays a positive disclosure-performance discrepancy at all. The intensive margin asks, conditional on a positive discrepancy being observed, how large that discrepancy is. A single linear specification applied to all observations would impose the same data-generating process on the crossing of the zero threshold and on variation among positive gaps. Conversely, estimating intensity only among positive observations without modeling occurrence would omit an important part of the phenomenon. Treating the margins separately therefore permits governance, market concentration, and their interactions with climate-policy uncertainty to have different associations with the emergence and the magnitude of observable misalignment (Cragg, 1971; Wooldridge, 2010).

$$Pr(GW_it > 0) = \Lambda[\alpha + \beta 1\ Z_it + \beta 2\ CCPU_t + \beta 3(Z_it \times CCPU_c,t) + \gamma' X_it + \mu_s]$$

$$GW_it \mid GW_it > 0 = \alpha + \beta 1\ Z_it + \beta 2\ CCPU_t + \beta 3(Z_it \times CCPU_c,t) + \gamma' X_it + \mu_s + \varepsilon_it$$

where $Z_it \in \{Gov_index, HHI\}$, X_it is the vector of firm-level controls, μ_s denotes NAICS-3 fixed effects, and $CCPU_c,t$ denotes mean-centered CCPU used only in the interaction term. In the M5 robustness specification, year fixed effects λ_t are added; the direct CCPU effect is then absorbed by the year indicators.

The horse-race specification includes governance and HHI simultaneously, together with CCPU, both interactions with CCPU_c, the same firm-level controls, and NAICS-3 fixed effects, always using the common sample. The main horse-race comparison follows the M4 architecture; a complementary M5 version adds year fixed effects as a robustness specification. The comparison emphasizes coefficient stability and inferential precision.

3.5 Robustness and limitations

Robustness checks include: (i) adding year fixed effects to M4 (M5); (ii) alternative clustering by firm; (iii) a linear probability model with firm and year fixed effects; (iv) sensitivity to GW_bin classification thresholds (-0.5σ, 0, +0.5σ); (v) 1%/99% winsorization of financial variables; (vi) an HHI model excluding market share; (vii) a governance index with seven empirically unique dimensions; (viii) index decomposition; (ix) VIF diagnostics; and (x) coefficient-stability analysis inspired by Oster (2019). These procedures are sensitivity analyses rather than definitive causal-identification strategies. ESG data coverage restricts the sample to firms with greater informational density, and governance may be endogenous to disclosure choices (Hermalin & Weisbach, 2003).

RESULTS

4.1 Descriptive statistics

Table 3A. Descriptive statistics: intensive-margin sample (N = 516)

Variable	N	Mean	SD	Median	P25	P75	Minimum	Maximum	Skewness	Kurtosis
GW_intensity	516	0.757	0.645	0.544	0.268	1.085	0.000	2.595	1.159	0.664
Gov_index	516	-0.037	0.475	-0.023	-0.361	0.304	-1.258	1.189	-0.106	-0.442
HHI	516	0.218	0.189	0.173	0.120	0.240	0.052	1.000	2.510	6.426
CCPU	516	1.361	0.750	1.185	0.703	1.876	0.357	2.945	0.464	-0.756
Market share	516	0.127	0.203	0.038	0.010	0.168	0.000	1.000	2.440	6.185
Leverage	516	0.595	0.333	0.582	0.448	0.705	0.004	5.087	6.643	77.450
ROA	516	0.041	0.116	0.045	0.014	0.079	-1.141	1.070	-2.374	46.450
MTB	516	2.637	7.046	1.542	0.980	2.763	-10.082	132.790	14.733	251.592
Cash/Assets	516	0.146	0.106	0.124	0.075	0.190	0.001	0.900	2.157	8.198
PPE/Assets	516	0.236	0.230	0.166	0.022	0.383	0.000	0.816	0.797	-0.565
Size (ln assets)	516	16.725	1.336	16.644	15.818	17.488	13.204	21.247	0.678	1.143

Note. The intensive sample is conditional on GW > 0. Size is the natural logarithm of total assets. Extreme values in leverage, ROA, and MTB motivate the 1%/99% winsorization sensitivity analysis.

Table 3B. Correlation matrix of focal variables and controls (N = 516)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) GW	1.00										
(2) GOV	0.08	1.00									
(3) HHI	-0.19	-0.17	1.00								

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Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(4) CCPU	-0.03	0.02	0.00	1.00							
(5) MShare	-0.04	0.02	0.60	-0.02	1.00						
(6) LEV	0.03	-0.04	0.04	-0.03	0.03	1.00					
(7) ROA	0.05	0.00	-0.06	-0.15	0.04	-0.36	1.00				
(8) MTB	-0.07	0.08	0.01	0.08	-0.02	0.06	-0.02	1.00			
(9) CASH	-0.08	-0.07	0.18	0.01	-0.12	-0.09	0.02	0.08	1.00		
(10) PPE	0.07	0.22	-0.03	-0.02	0.14	0.01	0.03	-0.02	-0.06	1.00	
(11) SIZE	0.16	0.38	-0.16	-0.08	0.23	0.02	0.02	-0.08	-0.23	0.31	1.00

Note. Pearson correlations. GOV = Gov_index; MShare = market share; LEV = leverage; CASH = cash/assets; PPE = PPE/assets; SIZE = ln(total assets).

In the intensive-margin sample, mean GW is 0.757 and the median is 0.544. The simple correlation between governance and greenwashing intensity is low (0.080), whereas HHI and market share are correlated at 0.600. The remaining bivariate correlations are moderate. The mechanical association between concentration and market share is addressed explicitly in an HHI specification that excludes market share.

4.2 Probability of greenwashing: extensive margin

Table 4. Logit: corporate governance (extensive margin)

Variable	M1	M2	M3	M4	M5 – Robustness
	Focal	*+ CCPU*	*+ Interaction*	*+ Firm controls*	*+ Year FE*
Gov_index	-0.038 (0.322)	-0.039 (0.324)	-0.027 (0.329)	0.026 (0.288)	0.007 (0.279)
CCPU	—	-0.013 (0.101)	-0.009 (0.103)	-0.030 (0.118)	absorbed (year FE)
Gov_index × CCPU_c	—	—	0.144 (0.187)	0.167 (0.175)	0.210 (0.190)
Leverage	—	—	—	-0.191 (0.285)	-0.265 (0.283)
ROA	—	—	—	-0.481 (1.017)	-0.760 (1.087)
MTB	—	—	—	0.003 (0.012)	0.002 (0.011)
Cash/Assets	—	—	—	-1.766 (1.175)	-1.858 (1.156)
PPE/Assets	—	—	—	-0.722 (0.953)	-0.497 (1.040)
Market share	—	—	—	-0.128 (0.930)	0.359 (0.819)
Size (ln assets)	—	—	—	-0.139 (0.160)	-0.242 (0.191)
Observations	942	942	942	942	942
Firms	103	103	103	103	103
NAICS-3 clusters	43	43	43	43	43
Firm-level controls	No	No	No	Yes	Yes
NAICS-3 FE	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes
Model role	Main sequence	Main sequence	Main sequence	Main sequence	Year-FE robustness
Pseudo R^2 (McFadden)	0.143	0.143	0.143	0.149	0.158
Log-likelihood	-556.111	-556.102	-555.901	-552.141	—
AIC	1200.222	1202.204	1203.802	1210.283	1223.700
BIC	1413.534	1420.365	1426.810	1467.227	—

Note. Coefficients with NAICS-3 clustered standard errors in parentheses. * p < 0.10; ** p < 0.05; *** p < 0.01. M4 is the fully controlled main specification and includes the full firm-level control set, size as ln(total assets), and NAICS-3 fixed effects. M5 adds year fixed effects as a robustness specification. The direct CCPU effect is absorbed in M5.

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Table 5. Logit: HHI (extensive margin)

Variable	M1	M2	M3	M4	M5 – Robustness
	Focal	*+ CCPU*	*+ Interaction*	*+ Firm controls*	*+ Year FE*
HHI	-0.622 (1.513)	-0.610 (1.541)	-0.559 (1.576)	-1.419 (1.679)	-0.350 (1.712)
CCPU	—	-0.008 (0.101)	0.136 (0.137)	0.119 (0.153)	absorbed (year FE)
HHI × CCPU_c	—	—	-0.705 (0.541)	-0.758 (0.648)	-0.957 (0.705)
Leverage	—	—	—	-0.168 (0.289)	-0.246 (0.297)
ROA	—	—	—	-0.628 (1.189)	-0.925 (1.322)
MTB	—	—	—	0.003 (0.012)	0.002 (0.011)
Cash/Assets	—	—	—	-1.770 (1.181)	-1.840 (1.149)
PPE/Assets	—	—	—	-0.725 (0.958)	-0.478 (1.064)
Market share	—	—	—	0.313 (0.919)	0.627 (0.914)
Size (ln assets)	—	—	—	-0.174 (0.173)	-0.263 (0.199)
Observations	942	942	942	942	942
Firms	103	103	103	103	103
NAICS-3 clusters	43	43	43	43	43
Firm-level controls	No	No	No	Yes	Yes
NAICS-3 FE	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes
Model role	Main sequence	Main sequence	Main sequence	Main sequence	Year-FE robustness
Pseudo R^2 (McFadden)	0.143	0.143	0.144	0.150	0.160
Log-likelihood	-556.051	-556.048	-555.249	-551.235	—
AIC	1200.102	1202.096	1202.498	1208.470	—
BIC	1413.415	1420.256	1425.507	1465.414	—

Note. Coefficients with NAICS-3 clustered standard errors in parentheses. * p < 0.10; ** p < 0.05; *** p < 0.01. M4 is the fully controlled main specification and includes the full firm-level control set, size as ln(total assets), and NAICS-3 fixed effects. M5 adds year fixed effects as a robustness specification. The direct CCPU effect is absorbed in M5.

In the fully controlled M4 specification, corporate governance is not statistically significant in the extensive margin (β = 0.026; SE = 0.288; p = 0.929), nor is Gov_index × CCPU_c (β = 0.167; p = 0.341). HHI is also non-significant (β = -1.419; SE = 1.679; p = 0.398), as is HHI × CCPU_c (β = -0.758; p = 0.242). Adding year fixed effects in M5 leaves the focal main effects and interactions non-significant.

4.3 Greenwashing intensity: intensive margin

Table 6. OLS: corporate governance (intensive margin)

Variable	M1	M2	M3	M4	M5 – Robustness
	Focal	*+ CCPU*	*+ Interaction*	*+ Firm controls*	*+ Year FE*
Gov_index	-0.030 (0.113)	-0.030 (0.114)	-0.036 (0.114)	-0.039 (0.123)	-0.053 (0.130)
CCPU	—	-0.018 (0.045)	-0.020 (0.046)	0.001 (0.049)	absorbed (year FE)
Gov_index × CCPU_c	—	—	-0.084 (0.086)	-0.071 (0.086)	-0.070 (0.090)
Leverage	—	—	—	0.103 (0.070)	0.098 (0.107)
ROA	—	—	—	0.228 (0.209)	0.223 (0.169)
MTB	—	—	—	-0.009*** (0.003)	-0.010*** (0.003)

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Variable	M1	M2	M3	M4	M5 – Robustness
	Focal	*+ CCPU*	*+ Interaction*	*+ Firm controls*	*+ Year FE*
Cash/Assets	—	—	—	0.125 (0.305)	0.147 (0.311)
PPE/Assets	—	—	—	0.091 (0.251)	0.075 (0.229)
Market share	—	—	—	0.178 (0.329)	0.172 (0.253)
Size (ln assets)	—	—	—	0.045 (0.068)	0.058 (0.084)
Observations	516	516	516	516	516
Firms	94	94	94	94	94
NAICS-3 clusters	41	41	41	41	41
Firm-level controls	No	No	No	Yes	Yes
NAICS-3 FE	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes
Model role	Main sequence	Main sequence	Main sequence	Main sequence	Year-FE robustness
R^2	0.141	0.142	0.144	0.157	0.178
Adjusted R^2	0.067	0.066	0.066	0.067	0.066
AIC	1016.200	1017.937	1018.763	1024.589	1035.480
BIC	1194.536	1200.520	1205.591	1241.141	1302.985

Note. Coefficients with NAICS-3 clustered standard errors in parentheses. * p < 0.10; ** p < 0.05; *** p < 0.01. M4 is the fully controlled main specification and includes the full firm-level control set, size as ln(total assets), and NAICS-3 fixed effects. M5 adds year fixed effects as a robustness specification. The direct CCPU effect is absorbed in M5.

Table 7. OLS: HHI (intensive margin)

Variable	M1	M2	M3	M4	M5 – Robustness
	Focal	*+ CCPU*	*+ Interaction*	*+ Firm controls*	*+ Year FE*
HHI	-0.150 (0.391)	-0.124 (0.396)	-0.111 (0.403)	-0.255 (0.428)	-0.386 (0.417)
CCPU	—	-0.018 (0.045)	0.025 (0.061)	0.041 (0.060)	absorbed (year FE)
HHI × CCPU_c	—	—	-0.202* (0.122)	-0.192 (0.126)	-0.152 (0.158)
Leverage	—	—	—	0.099 (0.067)	0.100 (0.109)
ROA	—	—	—	0.159 (0.178)	0.170 (0.155)
MTB	—	—	—	-0.010*** (0.003)	-0.011*** (0.003)
Cash/Assets	—	—	—	0.114 (0.295)	0.137 (0.298)
PPE/Assets	—	—	—	0.074 (0.270)	0.050 (0.245)
Market share	—	—	—	0.290 (0.344)	0.305 (0.300)
Size (ln assets)	—	—	—	0.034 (0.068)	0.045 (0.084)
Observations	516	516	516	516	516
Firms	94	94	94	94	94
NAICS-3 clusters	41	41	41	41	41
Firm-level controls	No	No	No	Yes	Yes
NAICS-3 FE	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes
Model role	Main sequence	Main sequence	Main sequence	Main sequence	Year-FE robustness
R^2	0.141	0.142	0.143	0.157	0.178
Adjusted R^2	0.067	0.065	0.065	0.067	0.065
AIC	1016.324	1018.088	1019.006	1024.578	1035.869
BIC	1194.661	1200.671	1205.835	1241.130	1303.373

Note. Coefficients with NAICS-3 clustered standard errors in parentheses. * p < 0.10; ** p < 0.05; *** p < 0.01. M4 is the fully controlled main specification and includes the full firm-level control set, size as ln(total assets), and NAICS-3 fixed effects. M5 adds year fixed effects as a robustness specification. The direct CCPU effect is absorbed in M5.

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In the intensive margin, corporate governance is non-significant in M4 (β = -0.039; SE = 0.123; p = 0.750), as is Gov_index × CCPU_c (β = -0.071; p = 0.409). HHI is non-significant (β = -0.255; SE = 0.428; p = 0.550), and HHI × CCPU_c is also non-significant (β = -0.192; p = 0.128). MTB remains negatively associated with greenwashing intensity (p < 0.01). The M5 year-fixed-effects robustness specification preserves the same substantive inference.

4.4 Horse race: governance versus market concentration

Table 8. Joint horse race: corporate governance and HHI

Variable / statistic	Extensive – Main M4	Extensive – M5 robustness	Intensive – Main M4	Intensive – M5 robustness
	Logit	***Logit + Year FE***	***OLS***	***OLS + Year FE***
Gov_index	0.009 (0.289)	-0.002 (0.281)	-0.037 (0.121)	-0.056 (0.132)
HHI	-1.420 (1.693)	-0.384 (1.732)	-0.247 (0.417)	-0.389 (0.386)
CCPU	0.111 (0.158)	absorbed (year FE)	0.050 (0.063)	absorbed (year FE)
Gov_index × CCPU_c	0.124 (0.169)	0.149 (0.183)	-0.090 (0.087)	-0.087 (0.093)
HHI × CCPU_c	-0.702 (0.662)	-0.890 (0.715)	-0.240* (0.137)	-0.201 (0.176)
Leverage	-0.174 (0.291)	included	0.099 (0.070)	included
ROA	-0.645 (1.203)	included	0.164 (0.183)	included
MTB	0.002 (0.012)	included	-0.009*** (0.003)	included
Cash/Assets	-1.774 (1.175)	included	0.117 (0.305)	included
PPE/Assets	-0.735 (0.942)	included	0.089 (0.246)	included
Market share	0.325 (0.923)	included	0.279 (0.343)	included
Size (ln assets)	-0.176 (0.168)	included	0.035 (0.070)	included
Observations	942	942	516	516
Firms	103	103	94	94
NAICS-3 clusters	43	43	41	41
Firm-level controls	Yes	Yes	Yes	Yes
NAICS-3 FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Model role	Main M4	Robustness	Main M4	Robustness
Pseudo R^2 (McFadden)	0.150	—	—	—
R^2	—	—	0.160	0.178
Adjusted R^2	—	—	0.066	—
AIC	1212.187	1223.700	1027.014	1038.100

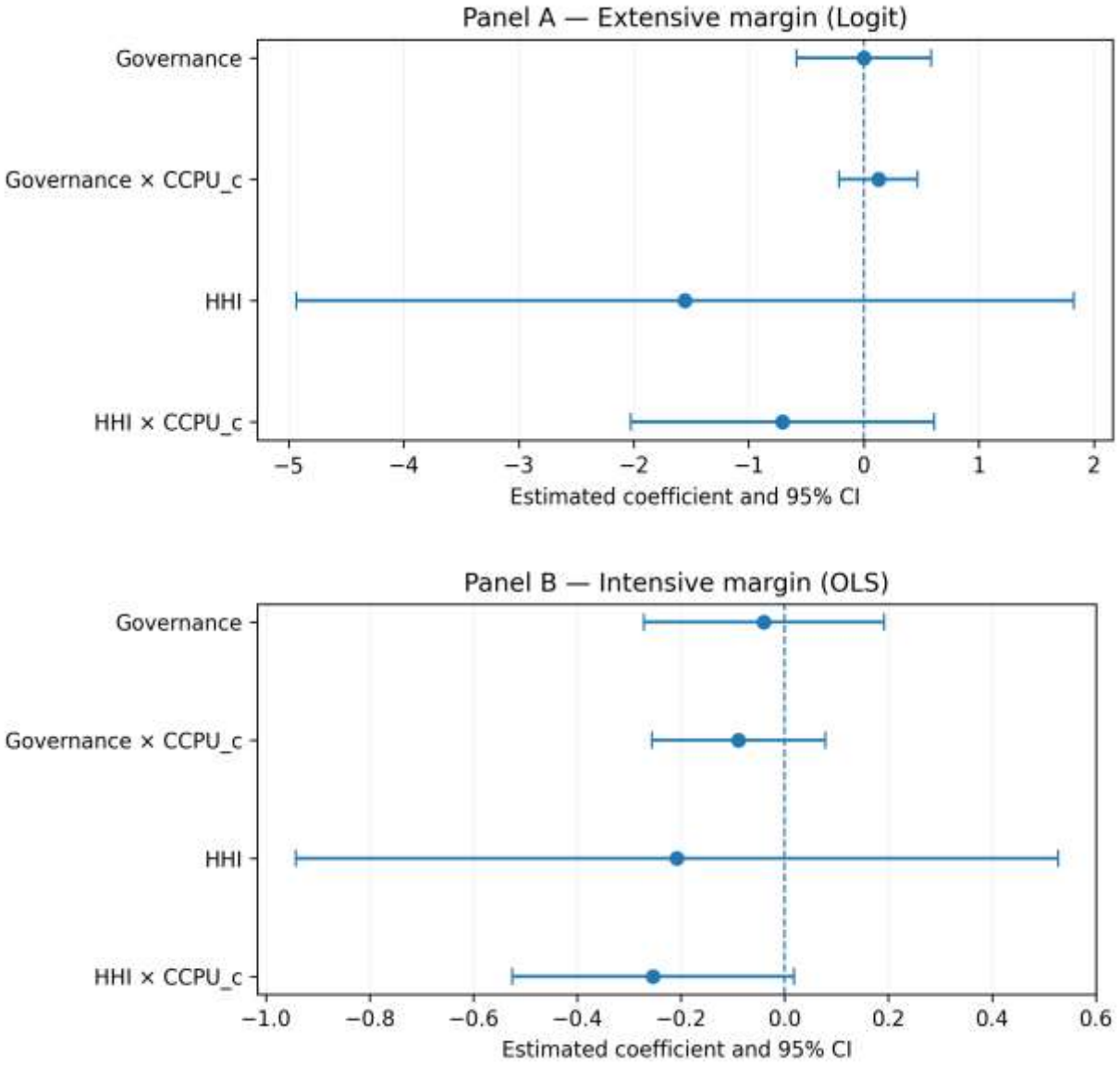
Note. The table reports the joint horse-race comparison under the M4 architecture with full firm-level controls, size as ln(total assets), NAICS-3 fixed effects, and NAICS-3 clustered standard errors, alongside the M5 year-fixed-effects robustness specification. CCPU enters directly in M4; CCPU_c is mean-centered and used only in the interaction terms. The direct CCPU effect is absorbed in M5.

The joint horse-race comparison does not identify a dominant main mechanism. Under M4, the focal main effects remain non-significant in both margins, while the intensive HHI × CCPU_c interaction is only marginal at the 10% level and is not robust to adding year fixed effects. In M5, all focal horse-race coefficients are non-significant: in the extensive margin, Gov_index (β = -0.002; p = 0.994), HHI (β = -0.384; p = 0.825), Gov_index × CCPU_c (p = 0.415), and HHI × CCPU_c (p = 0.214); in the intensive margin, Gov_index (β = -0.056; p = 0.671), HHI (β = -0.389; p = 0.314), Gov_index × CCPU_c (p = 0.354), and HHI × CCPU_c (p = 0.253).

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Figure 2 summarizes these results graphically: the 95% confidence intervals for all four focal effects cross zero in both margins.

Figure 2. Estimated coefficients for governance and market-structure mechanisms across the extensive and intensive margins



Note. Points are coefficient estimates and bars are 95% confidence intervals. The vertical line indicates a null effect. Panel A: Logit. Panel B: OLS. The plotted estimates correspond to the M5 year-fixed-effects robustness specification with full controls, size as ln(total assets), NAICS-3 and year fixed effects, and NAICS-3 clustered standard errors. Because Logit and OLS coefficients are on different scales, magnitudes should not be compared directly across panels.

4.5 Robustness and sensitivity analyses

Table 9. Summary of robustness analyses

Robustness check	Extensive margin	Intensive margin	Interpretation
M4 → M5: add year FE	GOV ext. p=.981; HHI ext. p=.838	GOV int. p=.683; HHI int. p=.354	Core conclusion unchanged after absorbing common annual shocks.
Firm-level clustering	GOV ext. p=.956; HHI ext. p=.378	GOV int. p=.736; HHI int. p=.452	Conclusion unchanged under firm-clustered inference.
LPM with firm + year FE	GOV p=.251; HHI p=.963; GOV×CCPU_c p=.552; HHI×CCPU_c p=.270	—	No focal association in the extensive-margin LPM.
VIF with fixed effects	HHI=20.67; Market share=5.51; Gov_index=1.46	—	HHI shares substantial variation with industry structure; governance does not show problematic VIF.
Threshold −0.5σ	HHI×CCPU_c: β=−2.004; p=.002	—	Moderation appears under the lower threshold; threshold-sensitive.
Threshold +0.5σ	HHI×CCPU_c: β=−1.477; p=.090	—	Marginal only; reinforces sensitivity to event definition.

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Robustness check	Extensive margin	Intensive margin	Interpretation
Oster coefficient stability	—	Governance, intensive margin: $\delta^* \approx 1.27$; $\beta^*(\delta=1) \approx -0.005$	Approximate diagnostic does not recover a substantive governance effect.
1%/99% winsorization	GOV p=.872; HHI p=.679	GOV p=.633; HHI p=.444	Main conclusion unchanged after limiting financial-variable tails.
HHI without market share	HHI p=.927; HHI×CCPU_c p=.185	HHI p=.717; HHI×CCPU_c p=.438	HHI inference is not driven by market share.
Gov_index with 7 unique dimensions	GOV p=.721; GOV×CCPU_c p=.139	GOV p=.840; GOV×CCPU_c p=.528	No effect attributable to empirical double weighting.

Note. M4 is the fully controlled main specification; M5 adds year fixed effects as the first robustness check. Additional robustness checks do not change the main conclusion. Winsorization is applied to leverage, ROA, MTB, cash/assets, PPE/assets, and ln(total assets). The HHI model without market share addresses the mechanical correlation between concentration and firm share. Because sustainability committee and CEO-chair separation are identical in this dataset, the seven-dimension Gov_index removes one duplicate only as a sensitivity test. The Oster diagnostic remains approximate and does not substitute for causal identification.

The sensitivity analyses preserve the main inference. Adding year fixed effects in M5 does not change the conclusion; winsorizing financial variables at 1%/99% leaves GOV and HHI non-significant in both margins; excluding market share from the HHI model and reconstructing governance using seven empirically unique dimensions likewise preserve the inference. The high HHI VIF indicates loss of precision in the presence of industry structure but does not by itself explain the null results. Alternative thresholds still show that HHI × CCPU_c can emerge under different event definitions, underscoring instability. Overall, the evidence supports a conclusion of no robust association rather than an assertion that the true effect is exactly zero.

DISCUSSION

The findings refine the debate by shifting the question from "which mechanism explains greenwashing?" to "under what conditions are the associations observable and comparable?" When disclosure and performance must be observed simultaneously, the sample is held constant across mechanisms, and occurrence is separated from conditional intensity, neither aggregate governance nor HHI exhibits a robust main association in M4. The M5 year-fixed-effects robustness specification preserves that conclusion after absorbing common annual shocks.

The horse race provides no robust evidence that the internal mechanism (governance) or the external mechanism (concentration) dominates. A marginal HHI × CCPU_c result can appear in the intensive M4 horse race, but it disappears when year fixed effects are added in M5 and remains sensitive to alternative event thresholds. Robustness checks based on winsorization, an HHI model without market share, and a seven-dimension governance index corroborate the broader conclusion of instability rather than a persistent moderation effect.

The absence of statistical significance does not invalidate the theoretical channels of monitoring, informational capacity, or competitive discipline, nor does it demonstrate a structural effect equal to zero. Instead, it establishes a boundary condition: aggregate proxies for governance and concentration may be insufficient to identify, in isolation, the process generating disclosure-performance misalignment. Heterogeneity across board dimensions and methodological divergence across ESG providers reinforce the need for measures closer to verifiability and specific informational decisions (Berg et al., 2022; Lyon et al., 2023).

This boundary-condition interpretation is especially relevant for a literature in which greenwashing is operationalized in heterogeneous ways. Studies based on disclosure scores alone, controversies, textual claims, ESG-rating disagreement, or disclosure-performance gaps do not necessarily identify the same behavior. Likewise, governance measures range from individual board characteristics to composite indices, and competition can be proxied by concentration, product substitutability, or other industry characteristics. Significant associations obtained under one operationalization need not reproduce when the outcome requires simultaneous observation of disclosure and performance and when competing mechanisms are compared on an identical sample. The present evidence therefore does not overturn prior findings; it narrows the conditions under which aggregate governance and concentration measures can be interpreted as reliable predictors of relative disclosure-performance misalignment (Berg et al., 2022; Lyon et al., 2023).

CCPU does not provide robust moderation across the specifications. Gov_index × CCPU_c is non-significant in both margins, and HHI × CCPU_c does not remain significant when year fixed effects are added in M5. Alternative thresholds continue to reveal sensitivity in the competition interaction, precluding a structural interpretation. For investors, regulators, and auditors, the implication is caution: aggregate governance or industry concentration should not be used mechanically as greenwashing-risk markers without direct evidence on disclosure processes, underlying performance, and verifiability.

The threshold results reinforce this caution. The interaction between HHI and CCPU becomes statistically detectable under some alternative definitions of the extensive-margin event, but it is not stable at the canonical zero threshold or in the joint horse-race specification. Rather than selecting the threshold that produces significance, the analysis treats this variation as evidence that the competitive moderation channel is sensitive to how the event is defined. This is substantively informative: if a mechanism changes materially when observations close to zero are reclassified, the evidence is better characterized as definition-sensitive than as a stable structural relationship.

The Brazilian setting remains relevant because it combines growing pressure for ESG disclosure with unequal information coverage and institutional features characteristic of emerging markets (La Porta et al., 1998). The same inequality, however, constrains external validity because the analysis is conditional on firms for which disclosure and performance are simultaneously observable.

The findings also have practical implications for ESG screening. For investors and auditors, a strong aggregate governance score should not automatically be interpreted as protection against disclosure-performance misalignment, nor should industry concentration alone be treated as a reliable red flag. Screening procedures are likely to be more informative when governance and market indicators are combined with direct evidence

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on environmental outcomes, assurance, traceability, and the verifiability of specific claims. For regulators, the results support policies that improve comparability between what firms disclose and what they demonstrably achieve, because better observability can reduce the informational space in which symbolic and substantive environmental performance become difficult to distinguish.

Several limitations delimit these implications. The analytical sample is selected by the joint availability of disclosure and performance data and therefore overrepresents firms with denser ESG information environments. The dependent variable combines two providers whose methodologies are not identical, so part of the measured gap may reflect provider-specific design choices despite within-year standardization. Governance is potentially endogenous to disclosure strategy, and industry-level clustering leaves a finite number of NAICS-3 clusters, which can limit precision. Finally, evidence from listed Brazilian firms may not generalize to smaller firms, private firms, or institutional settings with different enforcement and disclosure regimes. These limitations favor an associational interpretation and point to future designs using richer claim-level data, assurance information, regulatory shocks, or alternative identification strategies.

CONCLUSION

This study examined corporate governance, product-market concentration, and climate policy uncertainty using a two-part model applied to a canonical dataset of 970 firm-year observations from 105 Brazilian firms with an observable disclosure-performance gap. The direct comparison uses 942 observations in the extensive margin and 516 positive observations in the intensive margin.

The central conclusion is that neither corporate governance nor HHI shows a robust main association with greenwashing in the fully controlled M4 specification, which combines firm-level controls, NAICS-3 fixed effects, firm size measured as ln(total assets), and standard errors clustered by NAICS-3. Corporate governance is non-significant in the extensive margin ($\beta = 0.026$; $p = 0.929$) and intensive margin ($\beta = -0.039$; $p = 0.750$). HHI is likewise non-significant in the extensive margin ($\beta = -1.419$; $p = 0.398$) and intensive margin ($\beta = -0.255$; $p = 0.550$). M5 adds year fixed effects as a robustness specification and preserves the same substantive inference.

Climate policy uncertainty does not provide robust evidence of moderation. The interaction terms are non-significant in the separate fully controlled models, and the M5 year-fixed-effects robustness specification leaves all focal interactions non-significant. Threshold and other sensitivity checks show that any competition-related moderation is specification-sensitive. Thus, H1, H2, and H3 are not supported by the main specifications.

The organizational-capacity and competitive-discipline channels remain theoretically plausible, but the current data do not identify either as the dominant empirical mechanism. Future research should examine more direct measures of environmental verifiability, alternative governance constructs, broader ESG coverage, and research designs with greater power to address endogeneity and industry heterogeneity.

ACKNOWLEDGMENT / FUNDING

The authors acknowledge the financial support provided by the Fundação de Amparo à Pesquisa e Inovação do Espírito Santo (FAPES), Brazil.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

RESEARCH ETHICS APPROVAL AND CONSENT

Not applicable. The study uses only secondary corporate and market data and involves neither human participants nor animals.

APPENDIX A. EXPLORATORY DECOMPOSITION OF THE GOVERNANCE INDEX

The table reports the main effects and CCPU_c interactions in the intensive margin for empirically distinct index components, estimated with the full firm-level control set, NAICS-3 and year fixed effects, and NAICS-3 clustered standard errors as an exploratory robustness analysis. In the analytical dataset, sustainability committee and CEO-chair separation take exactly the same values; therefore, the decomposition does not present two artificially identical rows. Because multiple tests are performed and the aggregate index remains non-significant, these results are interpreted exclusively as exploratory heterogeneity.

Component	N	Main β	p	β × CCPU_c	p
Size/composition	516	-0.026	0.531	-0.054	0.149
Affiliation	516	0.050**	0.023	0.037	0.229
Experience	515	0.070**	0.042	-0.106***	0.005
Independence	516	0.013	0.747	-0.059*	0.096
Gender diversity	516	-0.045	0.176	0.029	0.408
Sustainability committee	515	-0.051	0.219	-0.037	0.255
Non-executives	515	-0.040	0.371	0.053	0.144

Note. * p < 0.10; ** p < 0.05; *** p < 0.01. Decomposition models include the full control set, size as ln(total assets), NAICS-3 and year fixed effects, and NAICS-3 clustered standard errors. N varies from 515 to 516 depending on component availability. Affiliation remains positively associated with greenwashing intensity (β = 0.050; p = 0.023), as does experience (β = 0.070; p = 0.042); Experience × CCPU_c remains negative (β = -0.106; p = 0.005). Independence × CCPU_c is only marginal at the 10% level (β = -0.059; p = 0.096). These findings do not replace inference from the aggregate index and should be interpreted as exploratory in light of multiple testing.

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