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Research article

Behind the green mirage: Financial damages of greenwashing and the role of board environmental orientation

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Abstract: Greenwashing is a legitimation firm strategy that responds to the increasing demand for environmental engagement. In this study, we examined its impact on firms' financial soundness from creditor and investor viewpoints, exploring the interplay between sustainability spin and economic resilience, and considering the moderating role of "Board Environmental Orientation". Using a sample of 1,276 listed European firms over 2002–2022, we showed that high levels of greenwashing worsen firms' financial soundness by increasing the cost of debt and the credit risk. However, firms with highly environmentally-oriented boards may be perceived as more reliable and more likely to implement effective environmental practices, mitigating the negative effect of greenwashing on their financial soundness. Our findings underscored the financial advantages of proactive environmental management and revealed how credible sustainability governance structures, particularly at the board level, can buffer against reputational and financial risks associated with greenwashing. By highlighting this moderating role, we contribute to a better understanding of how firms can maintain financial resilience while navigating increasingly demanding sustainability expectations. The validity of results is supported by several robustness tests: We performed linear regressions with instrumental variables and incorporate a range of well-established, theoretically grounded indicators of credit risk.

Keywords: Greenwashing; financial soundness; cost of debt; distance to default, Z-score; board environmental orientation

JEL Codes: G34, M14

Abbreviations: GW: greenwashing; BEO: board environmental orientation; DtD: distance to default

1. Introduction

Since the approval of the Corporate Sustainability Reporting Directive (CSRD) in 2022, the EU has developed a series of measures aimed at ensuring stakeholders' access to information to facilitate their decision-making through an accurate assessment of companies' environmental impact. In addition to enhancing the quality and scope of environmental reporting, these directives address a phenomenon of great contemporary relevance: The so-called "greenwashing" (GW).

As a strategy to engage in symbolic communication about environmental issues without adopting real practices (Huang et al., 2024), GW is employed by companies that appear transparent and publish large quantities of environmental, social, and governance (ESG) data but perform poorly in those aspects (Yu et al., 2020), thus creating a gap between symbolic and substantive ESG conduct (Roulet and Touboul, 2015). Consequently, it may be viewed as decoupling poor environmental performance from its positive communication (Delmas and Burbano, 2011) or simply using selective environment disclosure (Attig et al., 2024) to preserve reputation and legitimacy in the eyes of stakeholders (Lyon and Maxwell, 2011; Marquis et al., 2016).

Legitimacy is crucial for firms' financial soundness, as it facilitates access to low-cost debt and enhances solvency by preserving cash flows and reducing credit risk. Reputation plays a central role in this process; thus, if stakeholders detect GW, financial soundness is jeopardized. The growing relevance of GW arises from increasing ESG awareness and the use of environmental engagement as a key legitimation strategy (Lee and Raschke, 2023). While undetected GW may temporarily help firms manage environmental pressures and appear "green" (Li et al., 2023), misleading ESG claims undermine credibility and entail financial harm (He et al., 2022; Huang et al., 2024; Lee and Raschke, 2023; Torelli et al., 2020; Walker and Wan, 2012).

Researchers have addressed the role of corporate governance in improving environmental performance (Ali et al., 2025) and combating GW (Chen and Dagestani, 2023; Ma and Ahmad, 2024; Yu et al., 2020). These researchers explore the effects of different governance variables separately, suggesting the potential role of specific board characteristics in reducing GW. Given the negative financial consequences of GW, the possible role of corporate governance as a counterpoint (Torelli et al., 2020) emerges as a hot research question.

Amid the increasing regulatory emphasis on corporate environmental disclosure, where GW occupies a central role, and in light of its substantial financial consequences from a reputational standpoint, together with the expanding academic interest in corporate governance as a mechanism to curb GW, we investigate the moderating effect of corporate governance on the relationship between GW and financial soundness. Furthermore, we introduce what, to the best of our knowledge, constitutes the first comprehensive measure of Board Environmental Orientation (BEO) within this line of research. By doing so, we advance the understanding of the intersection between GW, financial soundness, and corporate governance, a domain of pressing contemporary relevance for regulators and financial stakeholders.

Using a sample of listed firms from 22 European countries over the period 2002–2022, we employ multiple fixed-effects regressions controlling simultaneously for firm-, industry-, and time-specific heterogeneity to test the baseline relationship between GW and financial soundness. We then explore the potential mitigating effect of BEO on the relationship between GW and firms' financial soundness, which

constitutes our second objective. The results indicate that GW not only worsens financial soundness by increasing the cost of debt and credit risk, but also that BEO positively moderates this relationship. These findings are further confirmed in the robustness analysis using instrumental variables.

This study contributes to the strand of literature that highlights on firms' financial vulnerability in the face of GW. Specifically, we extend the research on GW by analyzing both creditor and investor responses. While researchers have shown that greenwashing is associated with a higher cost of debt (Chen and King, 2014; Hou et al., 2023) and diminished investor confidence and financial stability (Du, 2015; Lins et al., 2017; Schwertner and Sohn, 2024), we extend this literature by adopting a broader and more integrative perspective. Specifically, we conceptualize financial soundness as a composite construct encompassing both credit risk, measured through the distance to default (DtD) and the Altman Z-score, and the cost of debt. This approach enables us to capture the multidimensional nature of firms' financial challenges dealing with greenwashing practices. Moreover, we assess the pertinence of the analysis of the market's reaction to GW (investors' response) by referring to the number of analysts covering the sampled firms. Supposedly, the higher the degree of disclosure by firms, the greater the analyst coverage, which increases the number of investors interested owing to the reduction of estimated risks and informational asymmetries (Lang and Lundholm, 1996). Finally, we introduce an integrative measure of BEO to examine the moderating role of corporate governance in this relationship. The BEO index is conceptualized as a latent construct capturing the board's collective credibility toward environmental issues. Rather than representing a mere summation of attributes, it reflects the complementarity and interdependence among board characteristics that jointly shape a board's environmental stance. Moreover, the holistic dual-stakeholder approach combined with the moderating role of BEO capture the reputational and financial consequences no researcher has integrated before.

The article is structured as follows: In Section 2, we review the literature on the causes and effects of GW, its impact on financial soundness, and the role of BEO in this relationship, leading to the formulation of our hypotheses; in Section 3, we present the models, variables, and methodology employed; in Section 4, we report the results and discussion of the main analysis, as well as robustness checks; and in Section 5, we present the conclusions.

2. Literature review

2.1. Reasons and effects of GW

The roots of GW lie in the need to legitimize the company. Legitimacy is a critical factor for firms as it helps them access resources and improve financial performance (Torelli et al., 2020). Legitimacy theory (Suchman, 1995) suggests that, owing to regulatory external factors, companies must constantly assess whether society perceives them as operating within the rules. Moreover, according to institutional theory (Oliver, 1991), companies seek to adjust themselves to social systems and rules by expecting that compliance with institutional standards will lead them to greater access to resources and social legitimacy. Based on agency theory (Jensen and Meckling, 1976), the conflict of interests between shareholders and managers can lead the latter to prioritize short-term goals and embark on GW attitudes. Finally, signaling theory (Spence, 2002) explains that positive environmental disclosures offset other negative aspects of firms' exposure and behavior, leading them to undertake purely symbolic actions to signal stakeholders their values and commitment with

the environment and letting them take advantage of the natural information asymmetry between the signaler and receiver.

GW is built based on an external accusation (Seele and Gatti, 2017); thus, detection seems to be the key factor in this process. However, not all stakeholders react in the same way owing to their different risk perceptions and information demands (Attig et al., 2024). Creditors have better abilities (and real possibilities) to gather and verify information about borrowers and identify GW practices, while investors have more limited capabilities and tend to rely more on the information disclosed by firms (Du, 2015). In any case, GW damages stakeholders' trust in firms, which undermines financial performance (He et al., 2022; Walker and Wan 2012) and intention to invest (Pizzetti et al., 2021); even more in the increasingly stringent European regulatory framework (Li et al., 2023).

2.2. Impact of GW on firms' financial soundness

Companies use sustainable practices as signals to show environmental compromise and attract possible investors. In fact, companies with better ESG policies disclose more voluntary information, which enhances transparency and stakeholder trust. However, when sustainability is misleading, we can assume that stakeholders would penalize dishonest behaviors (Uyar et al, 2020). Additionally, based on agency theory (Fama and Jensen, 1983; Jensen and Meckling, 1976), the prioritization of short-term goals of self-interested managers when embarking on GW attitudes will reduce return, imply higher leverage (to cover possible fines), and damage reputation (Treepongkaruna et al., 2024). Conversely, the lack of transparency and asymmetric information create agency costs, increasing lenders' perceived risk and negatively affecting access to capital. Finally, from the viewpoint of institutional theory, firms' strategic decisions try to align corporate values with societal values for positive external evaluation (Berrone et al., 2017); however, when sustainability signals lack credibility, stakeholders trust is undermined and negatively impact financial soundness.

Nevertheless, the uncovering of GW implies reputational risk by damaging market confidence and credit ratings. GW indicates a lack of real commitment to long-term sustainable strategies; in response, creditors and investors discern a strategic inconsistency that increases the perception of financial risk.

The literature shows that better ESG performance leads to greater access to external finance (and/or at lower cost) and lower risks (Sharfman and Fernando, 2008; Goss and Roberts, 2011; Hoepner et al., 2016; Nandy and Lodh, 2012; Zhang, 2022). Conversely, GW practices entail substantial costs due to damaged public reputation, operational challenges, increased regulatory scrutiny, and penalties (Du, 2015), which subsequently have a long-term negative impact on firms' performance (Zahid et al., 2025; Ali et al., 2025). GW also undermines the credibility of environmental disclosure, constituting a barrier for loan access (Xing et al., 2021) and/or imposing higher prices for them as the possible costs of loan recovery and the reputational damage are significant (Attig et al., 2024). Nonetheless, GW can undermine all the benefits derived from rigorous disclosure, damaging firms' legitimacy with their stakeholders. If creditors and investors perceive that the company is lying about its sustainable practices, they demand higher interest rates, while reputational and financial risks increase.

We therefore propose two distinct hypotheses that address a specific financial channel through which GW may negatively affect firms:

First, from the viewpoint of creditors, a bank's lending decision is primarily guided by the likelihood of the borrower's default and the consequent loss given default. Although GW is initially

unrelated to such metrics, its associated reputational harm incentivizes lenders to adjust loan pricing to avoid any direct or indirect costs on their loan recovery and reputational capital (Attig et al., 2024). A compensation for such additional reputation risk is also a result of informational asymmetries and moral hazard concerns (Chen and King, 2014; Hou et al., 2023) derived from short-term goals that threaten firms' reliability. Transparent and coherent information reduces risk premiums (Zhang et al, 2024), but GW undermines this process, increasing funding costs (Gigante and Manglaviti, 2022; Peng and Xie, 2024).

H1a: GW practices negatively affect cost of debt, thus increasing funding costs.

Second, solvency reflects firms' ability to meet long-term obligations and is influenced by investor perception of credit risk (Campbell et al., 2008; Dichev, 1998). Since Merton's distance to default is based on market expectations, investors are also key stakeholders in our study. Their monitoring power is more limited than that of banks (Attig et al., 2024), which leads them to rely more on the information disclosed by firms (Du, 2015). Although nuanced regarding the lenders (Attig et al, 2024), their reaction to GW is also negative (Berrone et al., 2017; Du, 2015; Lins et al., 2017) because GW harms stakeholders' trust (Schwertner and Sohn, 2024). Accordingly, GW may reduce the firm's credit risk, signaling weaker financial soundness.

H1b: GW practices negatively affect solvency, thus increasing credit risk.

2.3. BEO in the relationship between GW and financial soundness

Corporate governance literature highlights the role of executives and board members in implementing monitoring measures to combat false environmental claims (Torelli et al., 2020).

As firms' ultimate decision-making body (Adams and Ferreira, 2007), with risk management and reporting duties (Desjardins and Willis, 2011; Galbreath, 2010), the board's responsibility in GW is significant. In fact, certain characteristics of the board may contribute to reducing such irresponsible behaviors and associated costs (Jain and Zaman, 2020), thus smoothing the harm that GW practices impose on both financial performance (Walker and Wan, 2012) and reputation (Grappi et al., 2013).

Although researchers address the effective role of boards in combating GW (Chen and Dagestani, 2023; Yu et al., 2020), their impact on the financial consequences of GW remains underexplored. Studies on corporate governance have progressively broadened the range of board attributes found to positively influence firms' performance in the field of Corporate Social Responsibility (CSR), or, more specifically, their environmental performance, such as board independence, gender diversity among directors, and the financial expertise of the audit committee, among others (Helfaya and Moussa, 2017). Considering the coexistence of these characteristics, the literature has developed the concept of Board CSR Orientation (Shaukat et al., 2016; Helfaya and Moussa, 2017), which has been explained through different theoretical frameworks. From the Resource-Based View, the board's CSR orientation is understood as a comprehensive strategy motivated by the internal development of competitive advantage and the pursuit of external legitimacy (Shaukat et al., 2016). The more specific environmental orientation has been identified, from an agency theory perspective, as one of the major determinants of firms' adoption of proactive environmental strategies, as it mitigates managerial myopia toward related costs. Moreover, since BEO's components are individually associated with tighter control over firms' environmental strategy, their collective influence on environmental monitoring is expected to be substantial (Moussa et al., 2020).

Complementarity or substitutability of corporate governance internal and external mechanisms as drivers of improved performance has been examined with heterogeneous results (Ward et al., 2009; Misangyi and Acharya, 2014), but few researchers have investigated the interplay among internal mechanisms themselves, although they should operate more effectively in a mutually reinforcing manner (Aguilera et al., 2008). In this regard, there is an academic stream that rejects independence among corporate governance mechanisms (e.g., Hoskisson et al., 2009; Schepker and Oh, 2013; Yoshikawa et al., 2014) and emphasizes the distinctive nature of each mechanism to explain why firms may adopt different configurations depending on contextual circumstances (Oh et al., 2018). Accordingly, firm outcomes depend on this bundle of governance mechanisms (Aguilera et al, 2012), which collectively constitute the organization's governance environment (Yoshikawa et al., 2014). To effectively foster CSR, synergy must exist among corporate governance components (Oh et al. 2018), and this complementarity helps mitigate agency problems. Based on this reasoning, and following Moussa et al. (2020), we develop a board environmental orientation measure that encompasses six internal corporate governance mechanisms: board independence, existence of a CSR audit committee, diversity of board affiliations, gender diversity of executives, presence of sustainability-based compensation incentives for executives, and audit committee's financial expertise. Considering the relevance of BEO in relation to firms' environmental strategy and the individual impact of its components on the dimensions of financial soundness addressed in this article, namely, the cost of external financing and the credit risk, it is scientifically relevant to extend the research stream on BEO, traditionally focused on corporate strategy issues, toward its financial implications.

Board independence. Weak corporate governance structures foster default risk and lead to financial instability (Ballester et al., 2020), while greater scrutiny by independent directors mitigates GW (Ma and Ahmad, 2024; Yu et al., 2020). In the case of firms' financial soundness, independent directors tend to maintain closer oversight and disclose information, which helps mitigate agency problems and information asymmetries for stakeholders such as creditors (Bhojraj and Sengupta, 2003; Kanagaretnam et al., 2007; Klein, 2002; Switzer et al., 2018a), thereby reducing the firms' risk of default (Bhojraj and Sengupta, 2003; Switzer et al., 2018a; Switzer et al., 2018b). Ultimately, banks reward firms with a notable number of independent directors by offering them cheaper loans (Anderson et al., 2004; Bhojraj and Sengupta, 2003; Ertugrul and Hegde, 2008; Fields et al., 2012; Lin et al., 2014).

CSR committee. CSR committees play a particularly critical role in preserving firms' reputation and maintaining relationships with stakeholders through the monitoring and advising on CSR activities (Kuzey et al., 2024). Their existence is positively related to the environmental disclosure of firms and promotes their legitimacy (Helfaya and Moussa, 2017; Uyar et al., 2020), which distances them from GW (Uyar et al., 2020). Regarding the financial advantages of CSR committees, not only do they promote financial stability in the financial sector (Orazalin et al., 2024), but they are also skilled in accessing funding, complementing the better pricing conditions provided by board independence (Kuzey et al., 2024).

Board members' various affiliations. The negative effect of "busy boards" on the cost of debt in the financial sector is well supported. It has been attributed to lenders' satisfaction owing to the shareholders' reduced discretion (Chakravarty and Rutherford, 2017; Trinh et al., 2020) and is sustained even for inside directors (Liu and Paul, 2015; Masulis and Mobbs, 2011). Additionally, the presence of multiple directorships is associated with a lower number of lawsuits related to environmental violations (Kassinis and Vafeas, 2002). Given these associations, expecting that the presence of multiple directorships also mitigates default risk is reasonable (Kor and Sundaramurthy, 2009).

Gender diversity of executives. It appears that the presence of women on corporate boards reduces firms' environmental misbehavior (Fleitas-Castillo et al., 2025), which is consistent with the literature suggesting a negative relationship between female board representation and greenwashing (e.g., Chen and Dagestani, 2023; Liu, 2024; Ma and Ahmad, 2024; Zahid et al., 2025). When women's presence is substantial, firms improve their environmental disclosure (Liu, 2024; Zahid et al., 2025); agency costs are reduced (Liu, 2024) and financial constraints decrease (Liu, 2024). Conversely, most studies in economics agree that women are more risk-averse than men (Francis et al., 2015). In this regard, female executives tend to produce more conservative financial reports than their male counterparts (Francis et al., 2015; Ho et al., 2015) and even contribute to detecting fraudulent financial disclosures (Luo et al., 2018). Considering that banks appreciate accuracy in information and the reduction of information asymmetries (Luo et al., 2018), they would provide cheaper loans to firms with female CEOs and CFOs (Francis et al., 2013; Luo et al., 2018; Usman et al., 2018). Additionally, the default risk is lower as a result of the less risky strategic decisions made by female CEOs, as stated in upper echelons and social role theories (Abinzano et al., 2023). Finally, the presence of female CEOs improves the accuracy of analysts' predictions, while female CFOs enhance predictions only in firms that experience important information asymmetries (Datta et al., 2022), such as in the case of greenwashers.

Sustainability compensation incentives for executives. Firms engaged in substantial sustainable actions offer considerable environmental incentives in executive compensation, whereas the lack of a connection between mere reporting and compensation incentives may reveal a potential situation of GW (Ratti et al., 2023). Such integration of environmental objectives into compensation schemes aligns executives' goals with firms' environmental objectives (Berrone and Gomez-Mejía, 2009; Bui and de Villiers, 2017; Guenther et al., 2016; Hong et al., 2016) and enhances firms' legitimacy, thereby reducing the risk of failure and improving financial performance by meeting the expectations of multiple stakeholders (Berrone and Gomez-Mejía, 2009).

Audit committee's financial expertise. The audit committee's financial expertise positively influences CSR reporting (Dwekat et al., 2020; Helfaya and Moussa, 2017; Mohammadi et al., 2021; Pucheta-Martínez et al., 2021) and enhances the reliability of such disclosures (Al-Shaer and Zaman, 2018; Dwekat et al., 2022), thus validating the monitoring role of the audit committee suggested by resource-dependence theory, which is parallel to a monitoring function stemming from agency theory (Al-Shaer and Zaman, 2018). Moreover, reducing information asymmetries derived from financial expertise (Mahdy et al., 2024) lowers default risk, results in a lower cost of debt, and generates a positive market reaction (Defond et al., 2005).

Consequently, companies whose boards of directors are environmentally oriented (BEO) can smooth the negative impact of GW as stakeholders are confident that the board or other mechanisms will monitor and correct these practices. As a result, we pose the following hypothesis:
H2: Environmentally oriented boards of directors (BEO) reduce the negative impact of GW practices on firms' financial soundness

3. Models and variables

3.1. Models and sample

We estimate our models using panel data regression with multiple fixed effects, following Correia (2017). This approach explicitly exploits the panel structure of the data, controlling simultaneously for

firm, industry, and time specific heterogeneity. By including multiple fixed effects, we address potential endogeneity from unobserved, time-invariant factors, thus improving the reliability and unbiasedness of our estimates. Standard errors are clustered at the year-industry level, and all specifications consistently use the 49 Fama-French industry portfolios, ensuring comparability with established benchmarks. This methodology enables us to isolate the truly relevant effects while accounting for observed and unobserved confounding factors in the panel.

We conduct a multivariate analysis to contrast our hypotheses by adding control variables that influence the relationship between firm financial soundness and GW. We test the first two hypotheses using the following empirical model:

$$Financial\ Soundness_{it} = \boldsymbol{\alpha_0} + \boldsymbol{\alpha_1} Financial\ Soundness_{it-1} + \boldsymbol{\alpha_2} GW_{it} + \boldsymbol{\alpha_j X_{it}} + \boldsymbol{\alpha_k F_{it}} + \boldsymbol{\varepsilon_{it}} \quad (1)$$

Financial soundness for firm *i* in year *t* is the dependent variable (proxied by cost of debt and credit risk measures), and the variable GW captures the effect of greenwashing on financial soundness. To address potential reverse causality, we include a lag of the dependent variable, allowing the model to account for prior financial conditions and better isolate the effect of greenwashing on subsequent financial soundness. A vector *X* of additional firm-specific explanatory variables is included, with their effects summarized by corresponding coefficients. The model also incorporates a vector of *F* fixed effects for unobserved heterogeneity across sectors, countries, and years.

Additionally, to contrast our second hypothesis, we include the BEO index as moderating effect of GW on financial soundness:

$$Financial\ Soundness_{it} = \boldsymbol{\alpha_0} + \boldsymbol{\alpha_1} Financial\ Soundness_{it-1} + \boldsymbol{\alpha_2} GW_{it} + \boldsymbol{\alpha_3} BEO_{it} + \boldsymbol{\alpha_4} GW * BEO_{it} + \boldsymbol{\alpha_j X_{it}} + \boldsymbol{\alpha_k F_{it}} + \boldsymbol{\varepsilon_{it}} \quad (2)$$

We examine the impact of GW on the firm's financial soundness using a sample of listed firms from 22 European countries[1] with data from 2002 to 2022. We obtain financial and corporate governance data from Thomson Reuters Eikon, while macroeconomic information is provided by the World Bank database. Continuous variables are winsorized at the 1% level to limit the influence of extreme outliers. We exclude financial firms from the sample, as well as any observations with missing values. After these adjustments, our final sample comprises 1,276 firms with 8,158 firm-year observations in the general model.

3.2. Dependent variables

As stated in H1a and H1b, financial soundness is measured using two variables: The cost of debt (CDEBT) and the credit risk, the latter proxied by the distance to default (DtD) and the Z-score.

CDEBT impacts on a firm's financial soundness by affecting its capacity to meet debt obligations and maintain liquidity. Elevated borrowing costs heighten financial risk and default probability, while lower costs enhance creditworthiness and reduce solvency concerns (Dainelli et al., 2024). Excessive debt at high costs can destabilize a firm, whereas an optimal balance supports profitability and growth.

[1] Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, the Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom.

Effective management of debt costs and leverage is essential for ensuring long-term financial resilience. This variable is calculated as financial expenses to total debt (García and Herrero, 2021).

DtD measures the difference between a firm's assets value and its debt obligations (Do and Vo, 2023; Foster et al, 1998; Ho et al, 2020). A higher DtD indicates stronger financial soundness, reflecting a lower risk of insolvency and enhanced ability to withstand economic shocks. Specifically, our model includes Merton's distance to default, calculated as the number of standard deviations by which the firm's asset value exceeds the debt threshold. This metric considers the level and volatility of its assets relative to its liabilities.

According to Merton (1974), a firm's total value follows a geometric Brownian motion. This model views a firm's equity as a call option on its underlying assets, with debt acting as the strike price. We derive the relationship between equity (E) and assets (V_A) using the Black-Scholes option pricing framework. D represents the book value of debt (default threshold) and is computed as the short-term debt plus half the long-term debt; μ_A is the expected return on the firm's assets; and T is set to 1 year. The risk-free-rate $\boldsymbol{r_f}$ is obtained from the 1-year Euribor, available from ECB.

$$\text{DtD} = \frac{\ln\left(\frac{V_A}{D}\right)+\left(\mu_A - 0.5\cdot\sigma_A^2\right)\cdot T}{\sigma_A\cdot\sqrt{T}} \tag{3}$$

where

$$E = V_A \cdot N(d_1) - e^{-r_f T} D \cdot N(d_2) \tag{4}$$

The final dependent variable to measure credit risk is Z-score[2], derived from Altman's Z-score model (Altman, 1968). This indicator serves as a proxy for a firm's likelihood of default or financial distress, with higher values indicating lower credit risk.

Delving into investors reactions and market perspectives, we assess the pertinence of incorporating market response to GW in terms of DtD and Z-score, based on analyst coverage. CSR disclosure attracts coverage from analysts (Dhaliwal et al., 2011; Gao et al., 2016), which helps reduce information asymmetries by improving firms' transparency and reliability (Cheng et al., 2014; He and Ismail, 2024). This facilitates decision-making both for financial institutions, enabling them to fulfil their social interests (Hamrouni et al., 2019), and for investors, whose trust and loyalty are reinforced (Atif and Ali, 2021). Indeed, Cao et al. (2024) identify financial gains associated with ESG disclosure quality, attributable to enhanced reputation, leading to increased investor confidence, and improved analyst coverage, which brings greater investor attention.

Following Amiram et al. (2018) and Chang et al. (2006), we determine the number of analysts tracking a company (COV) by identifying the number of analysts who provide annual earnings forecasts.[3]

For this supplemental analysis, we construct a dummy variable indicating high analyst coverage, equal to one if the firm experienced an increase in analyst coverage and zero otherwise. This variable captures the moderating effect of analyst attention on the relationship between greenwashing and credit

[2] Z-score=1.2(Working capital/total assets) +1.4(Retained earnings/ total assets) +3.3(EBIT /total assets) + 0.6(Market value of equity/ total liabilities) + (Sales/ total assets).

[3] If a company does not have any analysts covering it, we assume it has no analyst coverage at all.

risk. We then re-estimate the DtD and Z-score parameters including the interaction between greenwashing and the high coverage dummy.

3.3. Explanatory variables

Researchers traditionally measure GW using aggregate ESG scores. In this regard, Todaro and Torelli (2024) distinguish ESG-washing and greenwashing, depending on whether the three pillars or just environmental practices are considered, respectively. We aim to narrow the concept of greenwashing by focusing exclusively on the environmental pillar, thereby adhering to its original definition and avoiding a potential distortion of an imperfect measure.

Consequently, as the following equation shows, we calculate the GW variable as the ratio between the normalized ENVIRONMENTAL disclosure score and normalized EMISSIONS performance score. In the numerator's case, we conduct a principal component analysis (PCA) over several scores in environmental pillar (emissions, environmental innovation, and emissions resources use), and the principal component (ENV_SCORE) represents a synthesized environmental score (standardized and rescaled to a 0–100 range). Regarding the denominator, we measure reductions in emissions through the inverse of log transformation of direct emissions standardized and scaled score ranging from 0 to 100 (INV_EMI_SCORE).

Finally, based on the calculation of Yu et al. (2020) and Zahid et al. (2025), greenwashing is the ratio of the rescaled environmental score to the inverse emissions index, providing a composite metric that balances environmental score against emissions efficiency.

$$\mathrm{GW} = \frac{\left(\frac{ENV\_SCORE_i - \overline{ENV\_SCORE}}{\delta ENV\_SCORE}\right)}{\left(\frac{INV\_EMI\_SCORE_i - \overline{INV\_EMI\_SCORE}}{\delta INV\_EMI\_SCORE}\right)} \tag{5}$$

If GW is greater than 1, then the firm is engaging in a level of disclosure about emissions that exceeds its performance.

Finally, the models include vector $\boldsymbol{X}$ as a set of control variables with the potential to influence various aspects of a firm's overall financial soundness, such as profitability, leverage, research and development expenses, sales, capital expenditures, market-to-book, liquidity, CEO board member, or GDP growth. A detailed description of these variables can be found in Table 1. Finally, with vector $\boldsymbol{F}$, we incorporate dummy variables to control for sector, country, and year effects.

Table 2 provides the summary statistics for the financial and greenwashing variables. The mean cost of debt of European listed firms is 4.81%, with a distance to default value of 4.2 showing their financial soundness with a standard deviation of 8.39 and 7.85, respectively. Regarding the greenwashing factor, a mean value higher than 1 shows how the firms attempt to portray their actions as far more environmentally friendly than they are. Table 3 reports the correlations between the main variables included in the analysis, displaying how they co-vary and giving context to the subsequent empirical analyses.

Table 1. Variable definitions.

	Definition
Dependent variables	
CDEBT	Financial expenses to total debt (García and Herrero, 2021)
DtD	Distance to default (Merton, 1974; Vassalou and Xing, 2004)
Z-score	1.2(Working capital/total assets) +1.4(Retained earnings/ total assets) +3.3(EBIT /total assets) + 0.6(Market value of equity/ total liabilities) + (Sales/ total assets). (Altman, 1968)
Explanatory variable	
GW	Index calculated as the ratio between the normalized environmental disclosure score (ENV_SCORE) and the normalized emissions performance score (INV_EMI_SCORE)
Control variables	
PROF	Operating income before depreciation to total assets
LEV	Sum of short and long-term debt divided by total assets
RDA	RandD expenses relative to total assets
SALES	Logarithm of revenues
CAPEX	Capital expenditures to total assets
MtoB	Company's current stock price multiplied by the total number of outstanding shares plus total assets minus total equity, divided by total assets
LIQ	Current assets to current liabilities
CEO_Board	Dummy variable equal to 1 if the CEO is a board member, and 0 otherwise
G_GDP	Annual GDP growth at the purchaser's prices for each country

Table 2. Descriptive statistics.

	Mean	SD	Median	Min	Max
Dependent variables					
CDEBT	0.0481	0.0839	0.0325	0.0000	0.8666
DtD	4.2596	7.8497	2.8937	−41.9470	31.8551
Zscore	1.3630	1.0433	1.2402	−0.8987	6.7545
Explanatory variables					
GW	1.4653	0.8323	1.2947	0.2293	6.8080
Control variables					
PROF	0.1230	0.0785	0.1149	−0.5715	0.5060
LEV	0.1988	0.1320	0.1836	0.0000	0.7217
RDA	0.0129	0.0275	0.0000	0.0000	0.2431
SALES	21.7905	1.6352	21.7780	13.1475	24.9027
CAPEX	−0.0470	0.0379	−0.0380	−0.2739	0.0000
MtoB	2.2307	3.5246	1.4005	0.4505	35.6066
LIQ	1.5045	0.9687	1.2849	0.1601	20.9148
CEO_Board	0.6188	0.4857	1.0000	0.0000	1.0000
G_GDP	0.0231	0.0843	0.0157	−0.2264	0.3692

Table 3. Correlation analysis.

	CDEBT	DtD	Zscore	GW	PROF	LEV	RDA	SALES	CAPEX	MtoB	LIQ	CEO_Board	G_GDP
CDEBT	1												
DtD	0.0775*	1											
Zscore	0.3114*	0.3313*	1										
GW	−0.0511*	−0.1341*	−0.2287*	1									
PROF	0.0835*	0.1087*	0.3646*	−0.0368*	1								
LEV	−0.1617*	−0.1864*	−0.5759*	0.0632*	−0.0286*	1							
RDA	0.0607*	0.0736*	0.2436*	−0.0742*	0.0222*	−0.1279*	1						
SALES	−0.0799*	−0.1157*	−0.1607*	0.6883*	0.0645*	0.0305*	−0.0297*	1					
CAPEX	−0.0126	0.0095	0.0008	−0.0651*	−0.2231*	−0.1027*	0.0072	0.0512*	1				
MtoB	0.1071*	0.1140*	0.3790*	−0.1178*	0.2134*	−0.0857*	0.1497*	−0.0945*	−0.0181	1			
LIQ	0.1149*	0.1116*	0.3608*	−0.1571*	0.0169	−0.1318*	0.1263*	−0.2580*	0.0265*	0.1170*	1		
CEO_Board	−0.0073	−0.0270*	−0.0708*	0.0148	0.0048	0.0979*	−0.1260*	−0.0168	0.0580*	−0.0859*	−0.0497*	1	
G_GDP	−0.0234*	0.0265*	0.0637*	−0.0378*	0.0439*	−0.0374*	0.0059	−0.0284*	−0.004	0.0268*	0.0166	−0.0703*	1

3.4. Moderating effect

As explained, we develop a multidimensional index to measure BEO using six board characteristics following Moussa et al. (2020): (1) Board independence ([IND] – % of independent directors), (2) CSR sustainability External Audit ([CSR_AUD] – a dummy equal one if the firm has a CSR external audit and zero otherwise), (3) multiple directorships ([MULT_DIR] – the average number of directorships held by board members), (4) gender diversity ([GENDER] – % of female managers), (5) adoption of a sustainability-based compensation policy ([CSR_COMP] – dummy variable equal one if the firm implements a compensation policy tied to environmental sustainability efforts and zero otherwise), and (6) audit committee's financial expertise ([AUD_EX] – % of members with financial expertise). We derive a principal component from the six preceding variables related to the board characteristics. A higher mean score across these attributes indicates stronger sustainable and environmentally supportive board practices.

Table 4. Principal Component Analysis of BEO.

	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Comp. 6
IND	0.4642	0.3157	0.0961	0.321	−0.7229	−0.2234
CSR_AUD	0.4369	0.0025	−0.7002	−0.2314	0.2285	−0.4616
MULT_DIR	0.2766	0.7356	0.0274	0.1722	0.4652	0.3683
GENDER	0.3318	−0.5014	0.0774	0.7244	0.3282	−0.0068
CSR_COMP	0.4866	−0.321	−0.1185	−0.3318	−0.2078	0.702
AUD_EX	0.4125	−0.0692	0.6926	−0.423	0.2407	−0.3294

Table 4 presents the loadings of the first principal component obtained through PCA. The loading values show the contribution of each variable to the first component. In this case, the variables CSR_COMP or IND exhibit the highest values, which suggests that these variables are the major drivers of this component.

This implies that the first component can be interpreted as an indicator of Board Environmental Orientation as it groups dimensions related to the adoption of sustainable practices by corporate governance.

4. Results and discussion

4.1. Major findings

Table 5 presents the results of the regression examining the impact of GW on different financial soundness variables (cost of debt, Merton's DtD, and Z-score). The positive coefficient of GW in the first column indicates that lenders penalize firms that disclose positive practices without actually adopting them, supporting Hypothesis 1.a. In line with empirical studies (e.g., Chen and King, 2014; Hou et al., 2023), we find that creditors, who face informational and reputational risks, demand higher premiums, which raises debt financing costs. The negative coefficients of GW in columns 2 and 3 reflect the damage caused on investor confidence (Du, 2015; Lins et al., 2017; Schwertner and Sohn, 2024), which materializes in an increased credit risk, confirming Hypothesis 1.b. These findings extend existing knowledge by providing robust evidence that greenwashing not only affects short-term

financing costs but also exacerbates credit risk, reinforcing the importance of transparency for both creditors and investors. They highlight that the financial consequences of GW are not uniform but operate through multiple channels, supporting and refining agency and legitimacy theories: stakeholder mistrust and market penalties emerge as tangible costs of misaligned corporate disclosures. By explicitly linking GW to measurable solvency outcomes, our results provide a more nuanced understanding of how corporate misrepresentation impacts firm soundness, offering empirical support for theoretical claims that have been largely conceptual.

In Table 6, we repeat the analysis using a dummy variable for analyst coverage; equal to one if a firm experience an increase in analyst coverage (High_ana) and zero if coverage decreases. We examine the moderation effect between GW and this dummy variable. The results show that the interaction is particularly significant for Merton's DtD, indicating that the negative impact of greenwashing on credit risk is stronger for firms with increasing analyst coverage. This finding suggests that analysts, when more actively covering a firm, are better able to detect and incorporate the effects of greenwashing into their assessments (Du, 2015; Schwertner and Sohn, 2024).

The results of the analysis of the moderating role of BEO on the relationship between corporate GW, cost of debt, the distance to default, and Z-score are displayed in Table 7.

The interaction between GW and BEO mitigates the negative effect of GW on financial soundness in all cases (columns 1, 2, and 3). The first column shows that a higher BEO reduces the positive impact of GW on the cost of debt. Columns 2 and 3 show that BEO minimizes the negative effect of GW on the distance to default, supporting the idea that the negative impact of GW on financial soundness can be mitigated in firms with environmentally oriented boards as stakeholders trust their ability to monitor and correct these practices (Al-Shaer and Zaman, 2018; Bui and de Villiers, 2017; Dwekat et al., 2022; Helfaya and Moussa, 2017; Kassinis and Vafeas, 2002; Liu, 2024; Uyar et al., 2020; Zahid et al., 2025).

These findings extend the literature by showing that board environmental orientation is not merely a formal characteristic but a functional mechanism that can attenuate the financial penalties of greenwashing. They refine our understanding of corporate governance effects on sustainability-related risks, providing a critical perspective on how board composition can shape the magnitude of GW's impact on financial soundness, and highlighting the practical importance of aligning board expertise with stakeholder expectations.

Table 5. Effect of greenwashing on financial soundness.

	(1) CDEBT	(2) DtD	(3) Z-score
$CDEBT_{t-}$	0.284***		
	[0.0476]		
DtD_{t-1}		0.109***	
		[0.0201]	
$Z\text{-score}_{t-1}$			0.599***
			[0.0169]
GW	0.00702***	−1.099***	−0.0757***
	[0.00192]	[0.337]	[0.0121]
PROF	−0.0347	10.76***	2.118***
	[0.0261]	[1.798]	[0.133]
LEV	0.0337**	−13.46***	−1.634***
	[0.0139]	[1.700]	[0.0897]
RDA	−0.0202	3.488	1.093***
	[0.0753]	[5.002]	[0.338]
SALES	−0.00506***	−0.226	0.0211***
	[0.000987]	[0.147]	[0.00681]
CAPEX	0.0556	−4.996	0.503**
	[0.0351]	[3.696]	[0.239]
Z-score	0.0257***		
	[0.00451]		
CDEBT		2.876*	1.802***
		[1.573]	[0.221]
Mtob	−0.000485	0.0859**	0.0216***
	[0.000854]	[0.0340]	[0.00530]
LIQ	−0.00302*	0.578***	0.103***
	[0.00169]	[0.207]	[0.0142]
CEO_Board	0.00280	0.187	0.0359*
	[0.00277]	[0.419]	[0.0186]
G_GDP	−0.0135	5.001*	0.0834
	[0.0215]	[2.757]	[0.117]
Constant	0.127***	−2.896	−0.349**
	[0.0266]	[5.343]	[0.172]
Observations	8,158	8,460	7,846
R-squared	0.228	0.118	0.844
Industry dummies	YES	YES	YES
Time dummies	YES	YES	YES
Country dummies	YES	YES	YES
Adj. Rsq	0.219	0.108	0.842

Note: This table reports the results of the baseline model on the impact of GW on cost of debt (1), Merton's Distance to Default (2), and Altman's Z-score (3). Variable definitions are in Table 1. All regressions are estimated using linear regression with multiple fixed effects, primarily capturing firm-specific effects. Coefficients are excluded for

simplicity. Parentheses show t-statistics with robust standard errors. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Market perception of greenwashing.

	(1)	(2)
	DtD	Z-score
DtD_{t-1}	0.110***	
	[0.0201]	
$Z\text{-}score_{t-1}$		0.447***
		[0.0726]
GW	−0.810**	−3.149***
	[0.355]	[0.778]
High_ana	1.288**	−1.130
	[0.612]	[1.932]
High_ana*GW	−0.750*	−0.0806
	[0.459]	[0.819]
PROF	10.71***	43.07***
	[1.795]	[11.97]
LEV	−13.51***	−28.44***
	[1.692]	[4.935]
RDA	3.651	−8.832
	[5.000]	[29.11]
SALES	−0.234	0.992*
	[0.146]	[0.577]
CAPEX	−4.897	9.402
	[3.726]	[21.67]
MtoB	0.0846**	1.317***
	[0.0339]	[0.456]
CDEBT	2.869*	259.4***
	[1.572]	[42.11]
LIQ	0.565***	2.945***
	[0.206]	[0.914]
CEO_Board	0.180	1.859
	[0.418]	[1.951]
G_GDP	4.820*	−25.65**
	[2.750]	[12.42]
Constant	−2.964	−40.33***
	[5.354]	[13.49]
Observations	8,460	7,928
R-squared	0.119	0.518
Industry dummies	YES	YES
Time dummies	YES	YES
Country dummies	YES	YES

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	(1) DtD	(2) Z-score
Adj. Rsq	0.108	0.512
Marginal effects		
A) GW (High analyst coverage)	−1.5601***	−3.2296***
B) GW (Low analyst coverage)	−0.8103**	−3.1490***
A-B	−0.7498*	−0.0806

Note: This table reports the results of the baseline model examining the impact of GW on solvency and the moderating effect of high analyst coverage. The interaction term between GW and the dummy variable for increased analyst coverage captures this moderating relationship. All regressions include firm fixed effects. Parentheses show t-statistics with robust standard errors. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 7. Moderating effect of Board Environmental Orientation.

	(1) CDEBT	(2) DtD	(3) Z-score
$CDEBT_{t-1}$	0.273***		
	[0.0507]		
DtD_{t-1}		0.110***	
		[0.0216]	
$Z\text{-score}_{t-1}$			0.595***
			[0.0177]
GW	0.0101***	−1.683***	−0.0939***
	[0.00207]	[0.367]	[0.0131]
BEO	0.00107	−0.350	−0.0200*
	[0.00177]	[0.250]	[0.0114]
GW*BEO	−0.00184*	0.582***	0.0164***
	[0.00104]	[0.191]	[0.00600]
PROF	−0.0482	12.71***	2.243***
	[0.0302]	[2.042]	[0.145]
LEV	0.0381***	−13.77***	−1.612***
	[0.0145]	[1.844]	[0.0921]
RDA	0.0140	1.594	0.919***
	[0.0855]	[5.189]	[0.349]
SALES	−0.00544***	−0.278*	0.0256***
	[0.00111]	[0.157]	[0.00749]
CAPEX	0.0629*	−3.673	0.601**
	[0.0379]	[3.890]	[0.255]
Z-score	0.0277***		
	[0.00480]		
CDEBT		2.863*	1.905***
		[1.652]	[0.229]

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	(1) CDEBT	(2) DtD	(3) Z-score
MtoB	−0.000381	0.0789**	0.0216***
	[0.000950]	[0.0378]	[0.00582]
LIQ	−0.00312*	0.641***	0.104***
	[0.00175]	[0.214]	[0.0149]
CEO_Board	0.00288	0.0705	0.0416**
	[0.00293]	[0.430]	[0.0199]
G_GDP	−0.0128	4.286	0.0527
	[0.0213]	[2.750]	[0.123]
Constant	0.127***	6.338*	−0.481**
	[0.0354]	[3.723]	[0.188]
Observations	7,505	7,754	7,250
R-squared	0.238	0.126	0.845
Industry dummies	YES	YES	YES
Time dummies	YES	YES	YES
Country dummies	YES	YES	YES
Adj. Rsq	0.228	0.115	0.843

Note: This table reports the results of the baseline model on the impact of GW on solvency considering the moderating effect of BEO. Variable definitions are in Table 1. All regressions are estimated using linear regression with multiple fixed effects, primarily capturing firm-specific effects. Parentheses show t-statistics with robust standard errors. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.2. Robustness analysis

To further strengthen the reliability and validity of our findings, we conduct additional robustness analyses using an instrumental variable (IV) approach. Specifically, we estimate a two-stage least squares (2SLS) regression with robust standard errors. This method helps to address potential endogeneity concerns arising from reverse causality or omitted variable bias. We employ two lagged instrumental variables that are theoretically and empirically related to greenwashing but not directly to the firm's financial soundness, satisfying the relevance and exogeneity conditions required for valid instrumentation. One of the instruments captures the average greenwashing level of other firms within the same country–industry–year group, excluding the firm. The second instrument is a dummy variable indicating "green" firms, following Alessi et al. (2021). It is based on a synthetic indicator that combines CO_2 emission intensity and ESG scores. Emission intensity is inversely ranked and standardized from 0 to 100, then averaged with the ESG score, assigning equal weights to both components. Firms above the annual median of this composite measure (Green_brown) are classified as green (1), while those below are classified as brown (0). This approach allows us to obtain consistent and unbiased estimates, reinforcing the robustness of our major results.

As shown in Table 8, our major findings remain consistent, supporting the validity of our hypotheses. Wald and Anderson tests confirm that the instruments are relevant and valid, ensuring that potential endogeneity is addressed. To address potential concerns about the exclusion restriction, we acknowledge that both instruments could correlate with broader contextual factors. However, the inclusion of country-year and industry-year fixed effects mitigate these risks by absorbing common

shocks and unobserved heterogeneity. Therefore, the instruments primarily capture firm-level variation in greenwashing behaviour**,** rather than structural or sectoral effects.

The results indicate a negative relationship between greenwashing and financial soundness, which, while moderate in magnitude, is consistent across specifications. This suggests that higher greenwashing is generally associated with lower financial performance, highlighting the robustness of our conclusions.

Table 8. Two-stage least squares (2SLS) estimates and robustness checks.

	(1) CDEBT	(2) DTD	(3) Z-score	(4) CDEBT	(5) DTD	(6) Z-score
$CDEBT_{t-1}$	0.296***			0.276***		
	[0.044]			[0.044]		
DtD_{t-1}		0.116***			0.112***	
		[0.023]			[0.024]	
$Z\text{-score}_{t-1}$			0.577***			0.571***
			[0.018]			[0.019]
GW	0.013**	−3.429***	−0.191***	0.021***	−4.306***	−0.255***
	[0.005]	[0.985]	[0.032]	[0.006]	[1.142]	[0.038]
GW*BEO				−0.004***	1.164***	0.045***
				[0.002]	[0.274]	[0.009]
BEO				0.003	−1.062***	−0.046***
				[0.002]	[0.332]	[0.014]
PROF	−0.048*	10.569***	2.283***	−0.070**	12.213***	2.442***
	[0.026]	[2.036]	[0.132]	[0.028]	[2.234]	[0.142]
LEV	0.041***	−14.045***	−1.737***	0.049***	−14.718***	−1.760***
	[0.014]	[1.601]	[0.080]	[0.015]	[1.676]	[0.083]
RDA	−0.032	6.443	1.404***	0.001	1.939	1.039**
	[0.071]	[5.829]	[0.386]	[0.078]	[6.532]	[0.417]
SALES	−0.007***	0.584*	0.062***	−0.008***	0.496	0.071***
	[0.002]	[0.347]	[0.012]	[0.002]	[0.341]	[0.012]
CAPEX	0.057	−6.350	0.432*	0.062	−4.265	0.469*
	[0.038]	[4.369]	[0.233]	[0.039]	[4.365]	[0.242]
Z-score	0.027***			0.029***		
	[0.005]			[0.005]		
CDEBT		2.922	1.961***		3.177*	2.069***
		[1.815]	[0.206]		[1.867]	[0.207]
Mtob	−0.000	0.094***	0.021***	−0.000	0.075**	0.020***
	[0.001]	[0.034]	[0.003]	[0.001]	[0.035]	[0.003]
LIQ	−0.004*	0.823***	0.112***	−0.004*	0.866***	0.114***
	[0.002]	[0.141]	[0.013]	[0.002]	[0.145]	[0.013]
CEO_Board	0.003	0.305	0.044**	0.004	0.304	0.043**
	[0.003]	[0.480]	[0.020]	[0.003]	[0.496]	[0.021]

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	(1) CDEBT	(2) DTD	(3) Z-score	(4) CDEBT	(5) DTD	(6) Z-score
G_GDP	0.009	4.184	0.010	0.007	4.002	−0.022
	[0.021]	[3.359]	[0.142]	[0.022]	[3.422]	[0.145]
Constant	0.124***	−10.681	−0.937***	0.138***	−6.630	−1.035***
	[0.037]	[6.569]	[0.232]	[0.037]	[6.294]	[0.227]
Observations	5,927	6,207	5,794	5,690	5,946	5,568
R-squared	0.246	0.122	0.844	0.245	0.126	0.844
Industry dummies	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
R squared	0.246	0.122	0.844	0.245	0.126	0.844
Wald (coefficient)	6.090	12.110	35.720	10.870	14.210	44.930
Wald (p-value)	0.014	0.001	0.000	0.001	0.000	0.000
Anderson-Rubin (coefficient)	27.810	23.110	59.660	30.600	26.710	62.780
Anderson-Rubin (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Note: This table reports the results of the baseline model on the impact of GW on financial soundness (first three columns) and the moderating effect of BEO (last three columns), estimated using instrumental variable regression (2SLS). Variable definitions are in Table 1. The relevance and validity of the instruments are confirmed through Wald and Anderson-Rubin tests. Parentheses show t-statistics with robust standard errors. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

In Tables 9A and 9B, we employ alternative credit risk measures to test our major and moderating models, respectively. In both tables, column 1 reports results using the Probability of Default (PD) derived from Merton's Distance to Default, which captures the likelihood that the market value of a firm's assets will fall below its debt obligations within the specified horizon. Columns 2 and 3 present estimations using the DtD and the Probability of Default (naive PD) computed through the simplified approach proposed by Bharath and Shumway (2008), in which the DtD incorporates the value of the firm's equity, the value of debt, and volatility. Finally, column 4 in both tables includes the binary variable Failure, which takes the value 1 for firms in the lowest tercile of the DtD distribution, representing those with the weakest financial health. Because this variable is binary, we estimate it using a logit model, which enables us to assess whether greenwashing also increases the likelihood of belonging to the most financially vulnerable firms.

$$\text{DtD\_naive} = \frac{\mathbf{ln}\left(\frac{\text{equity\_value}+\text{debt\_value}}{\text{debt\_value}}\right)+\left(\mu-\mathbf{0.5}\cdot\text{NAIVE\_V}^{\mathbf{2}}\right)}{\text{NAIVE\_V}} \tag{6}$$

Table 9A. Robustness analysis: Alternative measures of credit risk.

	(1) PD	(2) DtD_Naive	(3) PD_Naive	(4) FAILURE
PD_{t-1}	0.0523***			
	[0.0114]			
DtD_naive_{t-1}		0.575***		
		[0.0164]		
PD_naive_{t-1}			0.346***	
			[0.0279]	
$Default_{t-1}$				0.374***
				[0.0822]
GW	0.0342***	−0.328***	0.00551*	0.183**
	[0.00891]	[0.0775]	[0.00284]	[0.0834]
PROF	−0.423***	8.360***	−0.162***	−1.399**
	[0.0577]	[0.695]	[0.0315]	[0.606]
LEV	0.434***	−5.777***	0.139***	1.430***
	[0.0366]	[0.378]	[0.0198]	[0.372]
RDA	−0.482**	5.566***	−0.0360	0.300
	[0.188]	[1.790]	[0.0740]	[1.873]
SALES	−0.00126	0.191***	−0.00699***	−0.0357
	[0.00408]	[0.0401]	[0.00159]	[0.0407]
CAPEX	0.235**	2.032*	0.0410	3.073**
	[0.110]	[1.230]	[0.0475]	[1.229]
CDEBT	−0.113**	7.239***	0.0494***	1.462***
	[0.0464]	[0.980]	[0.0131]	[0.554]
MtoB	−0.00514***	0.109***	−0.000456*	0.00782
	[0.00155]	[0.0207]	[0.000266]	[0.0134]
LIQ	−0.0331***	0.350***	−0.00835***	−0.145**
	[0.00593]	[0.0521]	[0.00154]	[0.0586]
CEO_Board	−0.00655	0.164	0.00171	−0.119
	[0.0125]	[0.121]	[0.00666]	[0.145]
G_GDP	−0.108	2.508***	−0.0830**	−2.669***
	[0.0859]	[0.696]	[0.0393]	[0.919]
Constant	0.926***	−4.647***	0.171***	1.271
	[0.108]	[1.127]	[0.0411]	[1.353]
Observations	8,460	8,263	8,263	3,140
R-squared	0.127	0.738	0.242	0.0557
Industry dummies	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES
Adj. Rsq	0.117	0.734	0.233	

Table 9B. Robustness analysis: Alternative measures of credit risk and analyst coverage moderation.

	(1) PD	(2) DtD_Naive	(3) PD_Naive	(4) FAILURE
PD_{t-1}	0.0490***			
	[0.0117]			
DtD_naive_{t-1}		0.568***		
		[0.0166]		
PD_naive_{t-1}			0.342***	
			[0.0282]	
$Default_{t-1}$				0.368***
				[0.0833]
GW	0.0459***	−0.458***	0.0117***	0.373***
	[0.00826]	[0.0823]	[0.00331]	[0.103]
BEO	0.0109	−0.0269	0.00787***	0.222***
	[0.00749]	[0.0699]	[0.00260]	[0.0824]
GW*BEO	−0.0104**	0.110***	−0.00775***	−0.191***
	[0.00445]	[0.0387]	[0.00170]	[0.0498]
PROF	−0.468***	9.558***	−0.182***	−2.023***
	[0.0662]	[0.780]	[0.0356]	[0.655]
LEV	0.419***	−5.904***	0.137***	1.533***
	[0.0388]	[0.397]	[0.0213]	[0.380]
RDA	−0.421**	4.464**	0.0197	1.962
	[0.200]	[2.084]	[0.0921]	[1.917]
SALES	−0.00342	0.178***	−0.00721***	−0.0397
	[0.00428]	[0.0436]	[0.00172]	[0.0432]
CAPEX	0.198*	2.707**	0.0156	2.687**
	[0.116]	[1.314]	[0.0506]	[1.270]
MtoB	−0.00543***	0.111***	−0.000348	0.0123
	[0.00166]	[0.0223]	[0.000286]	[0.0136]
CDEBT	−0.134***	7.469***	0.0452***	1.585***
	[0.0497]	[0.996]	[0.0142]	[0.536]
LIQ	−0.0337***	0.351***	−0.00865***	−0.139**
	[0.00613]	[0.0542]	[0.00165]	[0.0583]
CEO_Board	−0.00554	0.235*	0.00362	−0.137
	[0.0130]	[0.128]	[0.00686]	[0.148]
G_GDP	−0.0658	2.520***	−0.0675*	−2.282**
	[0.0893]	[0.717]	[0.0397]	[0.954]
Constant	0.830***	−3.747***	0.122***	0.592
	[0.165]	[1.093]	[0.0389]	[1.016]
Observations	7,754	7,585	7,585	2,972
R-squared	0.130	0.736	0.246	0.0639
Industry dummies	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES
Adj. Rsq	0.119	0.732	0.237	

Note: Tables 9A and 9B present robustness analyses using different measures of credit risk as dependent variables. Table 9A reports the baseline estimations, while Table 9B includes the moderating effect of analyst coverage. All regressions are estimated using linear models with multiple fixed effects, except for FAILURE, which is estimated using logit models. Parentheses show t-statistics with robust standard errors. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5. Conclusions

GW has traditionally been explained from a multi-theoretical perspective, constructed around companies' pursuit of legitimacy with their stakeholders. Furthermore, GW has implications for the agency relationships between managers and other stakeholders, with particular relevance to creditors and investors in this study. Despite being conducted with a legitimizing purpose, GW, as a misleading behavior, poses a threat to firms' financial soundness, and if detected, it may undermine creditors' and investors' confidence in the firms, severely affecting debt financing costs and credit risk.

We first examine how GW affects a firm's financial soundness from a dual-stakeholder approach that capture response of creditors and investors through the cost of debt and solvency measures (Merton's distance to default in contexts with high analyst coverage), respectively. Using a sample of 1,276 European firms from 2002 to 2022, we find that GW increases the cost of debt and credit risk, thereby harming firms' financial soundness. The literature suggests that certain characteristics of top management (board independence, existence of a CSR committee, board members' various affiliations, gender diversity among executives, use of sustainability-linked compensation incentives, and financial expertise of the audit committee) have a positive impact on firms' financial soundness. Following Moussa et al. (2020), we construct an integrated measure of the board's environmental orientation (BEO) and test its effect on the relationship between GW and financial soundness. When introducing BEO, we observe that the negative effect of GW on financial soundness is mitigated for firms with an environmentally oriented board, thereby altering the original relationship.

GW is often measured through ESG scores, which may be imprecise as they include social and governance dimensions not necessarily related to green actions. This study contributes to the literature in this field since we focus exclusively on the environmental pillar for a more accurate assessment. Moreover, our findings demonstrate that, as a strategy to communicate misleading ESG information, GW harms firm financial soundness by increasing the cost of debt and the credit risk. This occurs as reputational damage leads to worse (and more expensive) access to market financing and higher financial risks. We also identify the significant effect of GW on stakeholder confidence, whose reaction drives the negative financial consequences. These results contribute to integrating elements from signaling, legitimacy, institutional, and agency theories. Finally, we contribute to the literature by demonstrating how the configuration of an environmentally oriented board mitigates the negative effects of GW on firms' financial soundness. We reveal that the board of directors serves as a protective mechanism against the financial threats posed by GW and suggest that companies disclosing misleading environmental information may use the board as a shield without necessarily adopting more responsible environmental practices.

Our results have implications for creditors and investors who should incorporate board characteristics into their assessment of firms' risk. Additionally, policymakers should consider companies' evasion mechanisms when designing policies aimed at achieving substantive changes in environmental performance and disclosure, which is especially relevant in the increasingly stringent European regulatory context following the implementation of the Corporate Sustainability Reporting Directive.

Author contributions

Paula Castro contributed to drafting the manuscript and was involved in refining the analysis and argumentation Additionally, she was involved in the empirical analysis, methodology, and in writing the original draft.

Cristina Gutiérrez-López led the conceptualization of the study and contributed to the theoretical framework. She also played a key role in the critical revision and editing of the final version.

Juan Guerrero-Calderón assisted in the preparation of the original draft, particularly in articulating results and discussion. Furthermore, he contributed to the reviewing and editing of the manuscript to ensure clarity and coherence.

Borja Amor-Tapia contributed to data curation and the development of the study methodology. He was also involved in the project's conceptual design and contributed to the writing, review, and editing of the manuscript.

Use of AI tools declaration

The authors declare they have not used artificial intelligence (AI) tools in the creation of this article.

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Conflict of interest

All the authors declare no conflicts of interest in this paper.

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