Is ESG Assurance a Genuine Signal of Sustainability?

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Abstract

As sustainability reporting becomes more prevalent, ESG assurance—third-party verification of ESG disclosures—has been suggested in the literature as a possible way for firms to signal their commitment to sustainability; however, whether it truly reflects genuine dedication or merely symbolic behavior remains uncertain. This study examines whether ESG assurance signals true commitment by assessing the alignment between assured items and ESG materiality. Using hand-collected data from STOXX Europe 600 firms (2017–2022) and the SASB Materiality Map, we classify assured items as material or immaterial and construct two indicators: the Material Assurance Ratio and the Immaterial Assurance Ratio. We analyze their relationships with green patenting, environmental performance, institutional investor behavior, and analyst forecast accuracy. Firms with higher material assurance ratios show stronger sustainability outcomes—more green and CO_2-related patents, lower resource use, and greater institutional investor trust. In contrast, higher immaterial assurance ratios are linked to weaker sustainability performance and reduced appeal to socially responsible investors. While ESG assurance improves analyst forecast accuracy overall, markets have yet to fully consider assurance content. These findings emphasize that assurance on material ESG issues signals genuine sustainability commitment, whereas immaterial assurance may reflect symbolic actions—highlighting the need for improved standards and investor awareness.

Key words: Greenwashing, ESG assurance, ESG reporting, Corporate Sustainability, Materiality, Signaling Theory

JEL codes: G11, M14, Q56

1 Introduction

Over the past two decades, companies have increasingly published reports discussing environmental, social, and governance (ESG) topics. Alongside this trend, the practice of auditing these sustainability disclosures—known as ESG assurance—has emerged as a fast-growing global phenomenon. This is particularly evident in the European Union, where the Corporate Sustainability Reporting Directive (CSRD) mandates sustainability assurance to enhance the credibility of ESG reporting. Prior studies suggest that companies use ESG assurance to signal their commitment to sustainability to various stakeholders, including ESG-focused investors (Clarkson et al., 2019). However, as ESG assurance remains largely voluntary and regulatory standards continue to evolve, important questions arise: Can ESG assurance serve as a reliable signal of a firm's true commitment to sustainability—and, if so, how can this information help distinguish genuinely sustainable firms from those that are merely symbolic? In this paper, we seek to offer initial empirical insights into these questions by examining the associations between ESG assurance and sustainability outcomes. [1]

To examine these questions, we integrate ESG assurance with the concept of materiality, which is central to understanding the credibility of sustainability disclosures. In ESG reporting, materiality refers to the relevance of specific sustainability issues to a firm's financial performance and broader social impact (Jebe, 2019). Material ESG issues—those most relevant within a given industry—are associated with long-term value creation and responsible business conduct (Khan et al., 2016). By focusing on material issues, firms can better align with both financial goals and societal expectations. In contrast, companies that emphasize immaterial ESG topics may project an image of sustainability commitment while neglecting the issues that truly matter, potentially misleading stakeholders (Grewal et al., 2021). Materiality thus serves as a critical filter for assessing the credibility of sustainability efforts. This logic extends to ESG assurance: to provide meaningful signals, assurance should be aligned with material ESG issues, rather than applied indiscriminately.

ESG assurance, much like financial audits, involves third-party verification of a company's sustainability disclosures. By engaging independent auditors, companies aim to enhance the credibility and transparency of their ESG reporting, thereby strengthening stakeholder trust in their sustainability performance (Boiral et al., 2019; Fuhrmann et al., 2017; O'Dwyer and Owen, 2005).. However, the credibility of ESG assurance varies widely due to inconsistencies in scope (i.e., which ESG indicators are assured), depth (i.e., the level of assurance provided), and the methodologies applied across firms (Gipper et al., 2024). Moreover, firms may selectively assure immaterial topics to create a misleading perception of sustainability commitment, masking deficiencies in more critical areas (Gillet, 2012; Boiral et al., 2019).

ESG assurance can only function as a credible signal of sustainability when it is applied to material issues—those most relevant to a firm's core operations and stakeholder concerns.

[1] `https://www.knowesg.com/featured-article/esg-ratings-trust-and-greenwashing`

This is where signaling theory provides a useful conceptual foundation. According to signaling theory, firms convey unobservable qualities—such as a genuine commitment to sustainability—through actions that are both verifiable and costly to imitate (Connelly et al., 2011; Spence, 1978). Firms with stronger ESG intentions are more inclined to assure material ESG topics. Because these are not only the areas most critical to their own operations but also the issues that stakeholders care about most. By focusing on material topics, companies demonstrate alignment between their sustainability efforts and the actual concerns of investors, regulators, customers, and other relevant parties.

Providing assurance for material topics involves higher signaling costs. First, companies must make internal adjustments to meet assurance standards (Gipper et al., 2024). Second, they must allocate substantial resources to verify ESG dimensions that could materially affect long-term outcomes. Any mismatch between reported sustainability actions and actual performance on these material issues can result in reputational harm or regulatory consequences (Khan et al., 2016; Di Giuli and Kostovetsky, 2014; Eccles et al., 2014). Consequently, firms that are truly committed to sustainability are more willing to bear these costs, making material assurance a more trustworthy and informative indicator of their authenticity (BliegeBird and Smith, 2005).

To empirically examine the interplay between materiality and assurance, our study introduces a multi-stage approach to identify genuinely sustainable firms based on ESG disclosures. We hand-collected ESG assurance reports for companies in the STOXX Europe 600 index over the period 2017–2022 and extracted the specific ESG items that had been assured. Using the SASB Materiality Map, we classified each ESG item into one of four categories: (1) assured material, (2) assured immaterial, (3) unassured material, and (4) unassured immaterial.. This classification allows us to distinguish between firms that focus on assuring critical sustainability issues and those that concentrate on less relevant topics.

From this classification, we construct two key indicators: the Material Assurance Ratio and the Immaterial Assurance Ratio. These capture the proportion of material and immaterial ESG topics subjected to third-party assurance. We assume that firms with high immaterial but low material assurance are flagged as potential greenwashers, as they may use selective assurance to create an inflated impression of sustainability. In contrast, firms with the opposite pattern—high material assurance and low immaterial assurance—are considered genuinely committed to sustainability. We test how these assurance patterns relate to long-term sustainability commitment, realized environmental outcomes, and information asymmetry. This analysis provides a more refined and reliable assessment of a firm's true sustainability orientation and helps differentiate between substantive and symbolic ESG assurance practices.

We begin the empirical analysis by investigating whether the assurance ratios reflect a firm's commitment to sustainability. We use the number of green patents as a proxy for sustainability commitment (Cohen et al., 2020). Our findings show that, on average, firms that obtain ESG assurance experience a greater increase in green patent applications compared to those that do not. However, when we differentiate the types of assurance, a more nuanced picture emerges:

firms with a higher share of material assurance show a significant increase in green patenting, while those emphasizing immaterial topics experience a decline. This suggests that material ESG assurance aligns with genuine sustainability efforts, while immaterial assurance may be more symbolic.

We then examine whether the assurance ratios are associated with actual sustainability outcomes. Specifically, we focus on four dimensions of environmental performance: CO_2 emissions, energy consumption, water usage, and waste generation. Notably, firms with ESG assurance show higher CO_2 emissions on average—driven primarily by those focusing on immaterial topics. Material assurance, by contrast, shows no significant relationship with CO_2 emissions, which may reflect the long-term nature of emission reductions—often requiring decades to manifest (Bams and van der Kroft, 2023). To address this, we also examine the number of CO_2-related patents, which have been shown in the literature to predict long-term emissions reduction. We find that firms with more material assurance have more CO_2 patents, reinforcing the idea that material assurance signals authentic long-term environmental investment. Conversely, immaterial assurance is negatively associated with CO_2 patenting activity, indicating weaker engagement in meaningful carbon-reducing innovation.

For the other environmental dimensions—energy, water, and waste—we find that ESG-assured firms, on average, consume more resources. However, this is again driven by firms with a high immaterial assurance ratio. In contrast, firms with a high material assurance ratio demonstrate lower resource consumption across these dimensions, indicating better environmental performance. This pattern reinforces the interpretation that material assurance signals authentic long-term sustainability investment.

Next, we explore investor perceptions of ESG assurance and materiality by analyzing their association with institutional investor behavior. We find that only the material assurance ratio is significantly and positively associated with the number of institutional investors, including socially responsible investors (SRIs). In contrast, immaterial assurance ratios do not appear to attract institutional investors. According to Gipper et al. (2024), investors respond only to credible signals, which suggests that assurance focused on material ESG topics is perceived as a more trustworthy indicator of a firm's true sustainability commitment. These findings reinforce the notion that material assurance functions as a substantive signal capable of attracting informed, long-term capital, whereas immaterial assurance lacks signaling value in the eyes of discerning investors.

More importantly, we find that the immaterial assurance ratio is negatively associated with SRI ownership. That is, the higher the proportion of immaterial topics being assured, the less likely SRIs are to invest in the firm. In contrast, the material assurance ratio shows no significant effect on SRI ownership. This indicates that while immaterial assurance may succeed in attracting general investor interest, it fails to convince investors who prioritize genuine sustainability. Given that one of the main purposes of ESG assurance is to signal commitment to stakeholders and attract long-term capital, this result further supports the distinction between

substantive and symbolic assurance practices.

Finally, we test whether ESG assurance can reduce information asymmetry between firms and capital market participants, using analyst forecast accuracy as a proxy for information asymmetry. Our results show that obtaining ESG assurance is significantly associated with improved forecast accuracy, suggesting that the market does respond to the presence of assurance. However, when we examine the content of the assurance, we find that a higher material assurance ratio is positively—but not significantly—associated with forecast accuracy, while a higher immaterial assurance ratio is negatively (though also insignificantly) associated with it. These findings indicate that analysts currently acknowledge the presence of ESG assurance but do not yet differentiate based on what is being assured. In other words, while ESG assurance appears to reduce information asymmetry in general, the market has not fully incorporated the materiality dimension of ESG assurance into its evaluation of disclosure quality.

This study makes several important contributions to the literature on ESG assurance, sustainability commitment, and strategic disclosure. First, our research directly responds to the key questions raised by Gipper et al. (2024) about the role of ESG assurance in signaling corporate sustainability commitment, enhancing the credibility of ESG information, and improving its relevance for investor decision-making. Prior studies have primarily focused on whether companies provide assurance and at what level (e.g., limited vs. reasonable) (Casey and Grenier, 2015; Fuhrmann et al., 2017; Clarkson et al., 2019). In contrast, we propose a new content-based proxy—the material assurance ratio, which captures the proportion of assured ESG topics that are material to the firm's industry. We argue that companies assuring more material topics are more likely to be genuinely committed to sustainability, while those focusing on immaterial topics may be engaging in symbolic efforts.

Second, our study provides a novel perspective on the strategic motivations behind assurance practices. We introduce the idea of selective assurance, where firms may deliberately choose to assure either material or immaterial topics depending on their goals—either to show true sustainability commitment or to manage how they are perceived externally. This concept offers a potential framework for identifying symbolic versus substantive assurance behavior, and opens a new pathway for studying greenwashing through assurance choices.

Third, our research supports the call by Edmans (2023) for a more fine-grained approach to ESG research, particularly through the lens of materiality. Edmans emphasizes that instead of examining ESG as a broad, uniform construct, scholars should focus on which ESG issues actually matter in a given context. We respond to this recommendation by applying the concept of materiality to the ESG assurance setting. By evaluating whether the assured topics are material to the firm's industry, we move beyond general measures of assurance and offer a more targeted way to distinguish firms with genuine sustainability efforts from those that may be engaging in symbolic reporting. This extends the insight from Khan et al. (2016), who demonstrated that material ESG performance is more strongly linked to firm value, by applying the same principle to the domain of ESG assurance.

Finally, our findings offer practical implications for policymakers and standard-setters. As regulatory initiatives such as the EU's Corporate Sustainability Reporting Directive (CSRD) continue to evolve, understanding how companies use assurance—and which types of assurance actually build trust—is crucial. Our materiality-based approach provides a simple but effective tool for distinguishing between credible assurance practices and symbolic compliance, helping to inform the development of more meaningful ESG assurance standards.

The remainder of this paper is structured as follows: Section 2 reviews the relevant literature. Section 3 describes the methodology. Section 4 presents the results of our empirical analysis, and Section 5 concludes the study.

2 Literature Review

ESG assurance has emerged as a relatively new and evolving phenomenon over the past decade. As highlighted by Gipper et al. (2024), a key research priority is to assess whether, and under what conditions, ESG assurance provides trustworthy and decision-useful information for investors and stakeholders. The credibility of ESG assurance and its ability to reflect a firm's genuine sustainability commitment remains a subject of ongoing debate in recent literature.

One source of contention lies in the underlying motivations behind ESG assurance. Gipper et al. (2024), in their study of U.S. companies, find that peer pressure is a primary driver of ESG assurance adoption. Other studies suggest that firms adopt ESG assurance as a response to legitimacy concerns or to comply with regulatory expectations (Venkataraman et al., 2008), while some view it as a risk management tool. For example, Asante-Appiah and Lambert (2022) find that firms facing sustainability-related scandals tend to increase assurance expenditures in an effort to mitigate reputational damage.

Despite these strategic motives, Gipper et al. (2024) also show through interviews and empirical analysis that companies use ESG assurance to signal their commitment to sustainability to various stakeholders, particularly ESG-oriented investors. This highlights a dual role of ESG assurance—both as a symbolic response to external pressures and as a potential indicator of genuine commitment.

The effectiveness of ESG assurance also remains debated. Some scholars argue that ESG assurance improves the credibility and transparency of sustainability disclosures by validating the accuracy of reported information and ensuring alignment with actual sustainability efforts (Clarkson et al., 2019; Boiral et al., 2019; Owen et al., 2000; Michelon et al., 2015). Additionally, assurance providers can support internal improvements in control systems and management processes, thereby enhancing a firm's overall sustainability performance (O'Dwyer, 2011; Gillet, 2012).

However, critics argue that the voluntary nature of ESG assurance and the lack of standardized assurance guidelines result in considerable variability across firms—particularly in the choice of which ESG metrics are assured (Gipper et al., 2024). This "selective assurance"

practice undermines the credibility of ESG disclosures, as firms may choose to assure only favorable or immaterial topics, thereby creating a misleading image of sustainability performance (Gillet, 2012; Talbot and Boiral, 2015).

To address this conflict, we incorporate the concept of materiality into the analysis of ESG assurance. Edmans (2023) emphasizes that future ESG research could take materiality into account. Materiality in the context of sustainability reporting refers to the relevance and significance of information in influencing investor decisions (Jebe, 2019). Material ESG issues are those that are most critical to a firm's long-term success and societal obligations, making them central to evaluating true sustainability performance.

Firms that focus on material ESG issues—those deemed essential within their industry—tend to experience better financial outcomes and stronger reputations as responsible corporate citizens. Research shows that firms prioritizing material topics not only align more closely with long-term sustainability goals but also outperform those focusing on immaterial topics (Khan et al., 2016). In contrast, emphasizing immaterial issues may constitute a form of greenwashing, where firms attempt to improve their public image without addressing the most pressing sustainability challenges (Grewal et al., 2021).

Empirical evidence reinforces the importance of materiality in distinguishing genuine sustainability strategies. For example, Flammer (2021) finds that green bonds are more common in industries where environmental issues are financially material—suggesting that firms in such sectors engage in substantive, rather than symbolic, sustainability actions. Similarly, Lin et al. (2024) observe that national disclosure regulations have limited effects on firms already focusing on material ESG topics, indicating that materiality-based reporting is often embedded in core business strategies. Thus, firms that emphasize material ESG topics send a more credible signal of sustainability commitment, whereas those that focus on immaterial topics may be perceived as engaging in greenwashing. To provide a more robust framework for assessing ESG assurance, we draw on signaling theory. This theory posits that firms with superior ESG performance are more likely to signal their commitment by obtaining assurance on material ESG topics (Spence, 1978; Connelly et al., 2011). Assuring material issues communicates that a firm is addressing core sustainability challenges that have significant financial and environmental implications. In contrast, firms engaging in greenwashing may assure immaterial topics to create the illusion of responsibility, while avoiding scrutiny of their actual performance (Kim and Lyon, 2015; Khan et al., 2016).

A key aspect of signaling theory is the cost of signaling. Addressing material ESG issues typically entails higher signaling costs, as these topics are subject to greater investor and regulatory scrutiny. Failure to meet expectations on material issues can lead to reputational damage and financial consequences (Khan, 2019). Therefore, only firms with strong sustainability commitments are likely to incur the cost of assuring material issues, reinforcing the credibility of their signals (Mahoney et al., 2013; Wu et al., 2020). Moreover, high-commitment firms tend to allocate substantial resources toward assuring material topics, even when their performance is

imperfect. In contrast, low-performing or less-committed firms are more likely to avoid material topics and instead assure immaterial ones, thus masking poor sustainability practices while keeping signaling costs low (BliegeBird and Smith, 2005; Di Giuli and Kostovetsky, 2014; Eccles et al., 2014).

Building on this framework, we argue that the credibility of ESG assurance depends not only on whether assurance is provided but also on the materiality of the assured topics. Firms that assure material ESG topics are more likely to be genuinely committed to sustainability, while those assuring only immaterial topics may be using assurance as a tool for greenwashing.

3 Methodology

3.1 Sample and Data

Our sample includes 598 firms listed in the STOXX Europe 600 index during the period from 2017 to 2022. We identify STOXX 600 index membership using Refinitiv Eikon. We focus on European firms, as Europe has been at the forefront of ESG assurance adoption. The sample period ends in 2022, which marks the most recent year for which ESG assurance reports were available at the start of our data collection. By including all firms in the STOXX Europe 600 index over this period, we mitigate survivorship bias.

Independent Variable: To construct the Material Assurance Ratio and Immaterial Assurance Ratio, we first download the ESG items disclosed by each firm in our sample from Refinitiv Eikon for each year. We then classify these ESG items as either material or immaterial using the Sustainability Accounting Standards Board (SASB) Materiality Map. This framework categorizes ESG issues by their financial materiality across 11 sectors and 77 industries. Although SASB emphasizes financial materiality, it also reflects broader sustainability considerations, as its development incorporates both shareholder and stakeholder perspectives (Khan et al., 2016).

We then identify the ESG items that were assured by the firm. To do this, we manually collect ESG assurance reports from company websites. ESG disclosures tend to be highly unstructured and heterogeneous. Perhaps due to this variability, no commercial database currently provides systematic coverage of ESG assurance practices (Gipper et al., 2024). Therefore, we manually extract the ESG items that were assured by each firm in each year.

After identifying which ESG items received assurance, we classify the assured items into assured material and assured immaterial categories using the SASB framework. Likewise, we classify all ESG items into four categories: (1)Assured Material, (2)Assured Immaterial, (3)Unassured Material, (4)Unassured Immaterial.

Using these classifications, we construct two key measures:

Material Assurance Ratio (Rm) = Number of Assured Material ESG Items / Total Number of Material ESG Items

Immaterial Assurance Ratio (Ri) = Number of Assured Immaterial ESG Items / Total Number of Immaterial ESG Items

Sustainability Commitment: We primarily use green patents as a proxy for firms' sustainability commitment, following the approach of Cohen et al. (2020). Green innovation is typically costly and strategically important, making it a credible indicator of a firm's long-term commitment to sustainability rather than a symbolic or superficial action (Bams and van der Kroft, 2023; Cheng et al., 2025). Prior research has emphasized that environmental, or "green," technologies are among the most critical drivers of the green transition (OECD, 2011). By altering products, raw materials, or production processes, such innovations can reduce pollution at its source, offering a more sustainable approach than merely managing emissions after they occur (Ranson et al., 2015). As such, green patents serve as a meaningful reflection of both a firm's environmental commitment and the resources it is willing to devote to transformation.

We collect annual patent data from PATSTAT and identify green patents using three widely recognized classification systems: the OECD's ENV-TECH classification, the WIPO IPC Green Inventory, and the Y02/Y04S tagging scheme developed by the European Patent Office (Favot et al., 2023). To assess the breadth and focus of firms' environmental innovation efforts, we further categorize green patents into several domains, including GHG emissions, energy, air quality, water, and waste, following the classifications used in (Cohen et al., 2020). Additionally, we distinguish between prevention-oriented and control-oriented green technologies based on the framework proposed by (Cheng et al., 2025). Prevention technologies, also known as source reduction technologies, aim to reduce pollution at its origin by redesigning products or fundamentally changing production processes. In contrast, control technologies, or end-of-pipe solutions, manage pollutants after they have been generated, typically by installing cleanup systems that do not alter the underlying production process. This distinction allows us to further capture the depth and quality of firms' sustainability-oriented investment and commitment. The full process used to retrieve and classify patent data is detailed in the Appendix.

Sustainability Performance: To measure firms' actual sustainability performance, we collect environmental performance data from Refinitiv Eikon, focusing on four key indicators: carbon emissions, energy use, water consumption, and waste generation. These indicators have been widely used in prior literature to capture the environmental impact of corporate activities (Gibson Brandon et al., 2022; Heath et al., 2023). As raw values may be affected by firm size, we scale each of these variables by total assets (in millions of euros) and apply a log transformation using the formula $\ln(1 + x)$ to normalize their distribution and reduce the influence of outliers.

These indicators serve as concrete and observable outcomes of firms' operational sustainability. For example, reduced CO_2 emissions may indicate increased energy efficiency or a shift toward cleaner energy sources, while lower water and energy consumption often reflect improved resource management and eco-efficient technologies. Waste reduction may signal enhanced circularity practices or investment in cleaner production methods. These real outcomes

provide a direct view into firms' environmental footprint and allow us to assess whether firms that obtain ESG assurance—particularly on material issues—demonstrate superior sustainability performance in practice.

Institutional Investors and SRI Investors: We measure institutional ownership using the Factset Ownership database. Factset has been widely used (Ferreira and Matos, 2008; Dyck et al., 2019) and reports institutional investors' equity holdings collected directly from fund reports, regulatory authorities (e.g., 13F reports), found associations, and fund management companies themselves.

To assess how institutional investors—especially those committed to responsible investment—respond to firms' ESG assurance practices, we construct yearly firm-level measures of institutional ownership using data from FactSet. Specifically, we download the list of institutional investors holding shares in each firm at the end of each calendar year. To identify socially responsible investors (SRI), we obtain the annual list of signatories to the Principles for Responsible Investment (PRI) from the PRI's official website (Dyck et al., 2019). We then perform name matching between PRI signatories and the institutional investor names in our FactSet data to distinguish SRI investors from non-SRI institutional investors. This name mapping procedure follows the methodology proposed by Bremer (2023), which has been applied in recent studies on sustainable investment.

Based on this classification, we compute the number and ownership share (as a percentage of total shares outstanding) of both SRI and non-SRI institutional investors for each firm-year observation. These measures allow us to examine whether assurance on material ESG topics enhances trust among responsible investors, who may value credible sustainability commitments more than superficial symbolic actions. Differentiating between SRI and non-SRI investors is important because the former are more likely to incorporate ESG considerations into their investment decisions. An increase in SRI ownership may reflect greater confidence in a firm's long-term sustainability strategy and the credibility of its ESG disclosures—especially when these are externally assured. Regarding institutional investors and SRI, a recent investor survey by PwC finds that investors perceive ESG reporting as containing unsupported claims and would have more confidence in the information with assurance (PricewaterhouseCoopers (PwC), 2023). If investors indeed perceive assurance as credibility enhancing, ESG assurance should attract a broader investor base (Gipper et al., 2024).

Information Asymmetry: To evaluate the extent to which ESG assurance reduces information asymmetry between firms and capital market participants, we use financial analysts' earnings forecast accuracy as a proxy, following Cuadrado-Ballesteros et al. (2017). This measure captures the degree to which available information enables analysts to accurately predict firm performance, thus serving as an indirect indicator of transparency and disclosure quality.

Specifically, we calculate forecast accuracy as the absolute difference between a firm's actual earnings per share (EPS) and the median of analysts' forecasted EPS, scaled by the share price at year-end:

$$\text{Information Asymmetry}_{it} = \frac{P_{it} \cdot \text{EPS}_{it} - \text{Median Forecasted EPS}_{it}}{P_{it}} \tag{1}$$

where EPS_{it} is the actual earnings per share of firm i in year t, and P_{it} is the firm's stock price at the end of year t. A smaller absolute error implies greater forecast accuracy, which in turn reflects lower information asymmetry.

The forecast data—both actual EPS and analysts' consensus forecasts—are obtained from FactSet. This method provides a market-based measure of informational quality that is widely used in prior research (Marquardt and Wiedman, 1998). It is particularly suitable for our study, as it allows us to assess whether greater assurance on material ESG topics leads to improved financial transparency and more reliable investor expectations.

Control Variable: We control for a range of firm-level characteristics that have been shown in prior literature to influence sustainability-related outcomes such as green innovation, environmental performance, institutional ownership, and information asymmetry (Gipper et al., 2024; Cheng et al., 2025; Cuadrado-Ballesteros et al., 2017; Heath et al., 2023). These control variables help isolate the effect of ESG assurance by accounting for alternative explanations of variation in the dependent variables. We mainly include six firm characteristics, including (1) firm size, (2) ROA (3) book-to-market (4) leverage (6) loss indicator, and (6) age. Definitions and data sources for all control variables are provided in the Appendix. Including these controls ensures that our analysis focuses on the incremental effects of ESG assurance practices, particularly regarding materiality, rather than confounding firm characteristics.

3.2 Research design

Given the relatively limited year-over-year variation in our key independent variables—Material Assurance Ratio and Immaterial Assurance Ratio—we adopt a pooled ordinary least squares (OLS) regression model with both year and industry fixed effects. The limited variation is consistent with the observation that the ESG items assured by a given firm tend to remain stable over time. This pattern is also supported by Lin et al. (2024), who document persistent assurance practices within firms across years. Therefore, using a pooled regression approach allows us to leverage cross-sectional variation while controlling for time-invariant firm characteristics and broader time trends.

To examine the role of ESG assurance—distinguished by materiality—we estimate the following regression model using all firms in the STOXX Europe 600 index that issued at least one ESG assurance report during the sample period from 2017 to 2022:

$$Y_{it} = \beta_1 \text{Rm}_{it} + \beta_2 \text{Ri}_{it} + \gamma X_{it} + \delta_t + \theta_j + \varepsilon_{it} \tag{2}$$

where:

- Y_{it} denotes the dependent variable for firm i in year t,
- Rm_{it} is the ratio of assured material ESG items, calculated as $\frac{\text{Assured Material Items}}{\text{Total Material Items}}$,
- Ri_{it} is the ratio of assured immaterial ESG items, calculated as $\frac{\text{Assured Immaterial Items}}{\text{Total Immaterial Items}}$,
- X_{it} is a vector of control variables,
- δ_t represents year fixed effects,
- θ_j represents industry fixed effects based on the Sustainable Industry Classification System (SICS),
- ε_{it} is the error term.

The dependent variables include four main outcome measures: (1) green patent count (as a proxy for sustainability commitment), (2) sustainability performance (measured by actual environmental indicators), (3) institutional investor engagement, and (4) information asymmetry (proxied by analyst forecast accuracy). All continuous variables are winsorized at the 1st and 99th percentiles to mitigate the influence of extreme outliers.

Year fixed effects are included to control for macroeconomic trends and other time-varying factors that may influence all firms, such as the general decline in patenting activity observed across Europe (Joint Research Centre, 2020), or the increasing emphasis on environmental performance over time.

Industry fixed effects are defined based on the 64-industry classification from the Sustainable Industry Classification System (SICS), which aligns with the SASB materiality map. This alignment is crucial because the SASB framework defines material ESG issues at the industry level. Including SICS fixed effects allows us to account for differences in baseline patenting behavior and environmental impacts across industries. For instance, firms in high-emission industries—such as energy and materials—tend to generate more patents related to pollution control technologies than those in lower-emission sectors (Cohen et al., 2020). reenwashing Measure

4 Result

We begin by presenting univariate descriptive statistics for all control variables. Detailed descriptive statistics for each dependent variable are provided separately in the relevant regression result sections. In Table 1, we compare firm-year observations from the STOXX Europe 600 index across several dimensions. Specifically, we contrast: (i) firm-years in which ESG reports include some form of third-party assurance ("Sample A") versus those without any assurance

("Sample None A"); and (ii) firm-years where the Material Assurance Ratio exceeds the Immaterial Assurance Ratio ("Sample M") versus those where the Immaterial Assurance Ratio exceeds the Material Assurance Ratio ("Sample IM").

Table 1: Descriptive Statistics by Subsample (Control Variable)

Variable	Sample	N	Mean	SD	Min	P25	P75	Max
Rm	A	2517	0.393	0.369	0.000	0.000	0.750	1.000
	None A	1049	0.000	0.000	0.000	0.000	0.000	0.000
	M	1437	0.656	0.255	0.100	0.500	0.833	1.000
	IM	342	0.110	0.196	0.000	0.000	0.200	0.800
Ri	A	2526	0.220	0.239	0.000	0.000	0.364	3.000
	None A	1049	0.000	0.000	0.000	0.000	0.000	0.000
	M	1447	0.319	0.232	0.000	0.176	0.429	3.000
	IM	341	0.251	0.218	0.043	0.050	0.350	0.867
Cash	A	2520	0.100	0.101	0.000	0.035	0.132	1.728
	None A	1021	0.140	0.204	0.000	0.034	0.154	2.566
	M	1440	0.104	0.091	0.000	0.045	0.138	0.744
	IM	338	0.088	0.082	0.001	0.027	0.123	0.696
NetPPE	A	2390	0.231	0.219	0.000	0.061	0.355	1.465
	None A	965	0.171	0.205	0.000	0.015	0.245	1.283
	M	1356	0.253	0.209	0.000	0.087	0.384	1.465
	IM	324	0.184	0.228	0.000	0.010	0.275	0.964
Leverage	A	2525	0.251	0.143	0.000	0.146	0.345	0.947
	None A	1033	0.188	0.165	0.000	0.049	0.289	1.078
	M	1443	0.252	0.134	0.000	0.156	0.339	0.837
	IM	338	0.225	0.155	0.002	0.101	0.322	0.659
Size	A	2522	9.467	1.316	0.000	8.706	10.272	12.942
	None A	1021	8.247	2.076	0.000	8.036	9.200	12.106
	M	1441	9.635	1.391	0.000	8.825	10.481	12.942
	IM	338	9.425	1.049	7.168	8.665	10.202	12.243
Age	A	2533	3.218	0.461	0.000	3.135	3.497	3.611
	None A	1049	2.948	0.724	0.000	2.833	3.434	3.611
	M	1447	3.261	0.433	0.000	3.178	3.497	3.611
	IM	342	3.245	0.513	0.000	3.178	3.497	3.611
ROA	A	2521	0.097	0.081	-0.234	0.051	0.127	1.256
	None A	1021	0.106	0.143	-0.757	0.040	0.142	1.916
	M	1440	0.102	0.085	-0.234	0.061	0.127	1.256
	IM	338	0.098	0.090	-0.083	0.020	0.136	0.483
Book-to Market	A	2507	0.650	0.609	-0.776	0.250	0.862	6.235
	None A	970	0.495	0.622	-0.051	0.158	0.620	6.903
	M	1432	0.601	0.532	-0.776	0.253	0.798	5.201
	IM	338	0.673	0.646	-0.001	0.247	0.892	6.235
Loss Indicator	A	2522	0.085	0.279	0.000	0.000	0.000	1.000
	None A	1021	0.091	0.288	0.000	0.000	0.000	1.000
	M	1441	0.105	0.307	0.000	0.000	0.000	1.000

Variable	Sample	N	Mean	SD	Min	P25	P75	Max
	IM	338	0.053	0.225	0.000	0.000	0.000	1.000

Consistent with prior literature, firms that obtain ESG assurance tend to be larger, older, and more highly levered. For example, larger and more established firms may attract greater scrutiny from investors, who demand transparency through third-party assurance (Simnett et al., 2009). These firms are also more likely to have sufficient resources to engage in assurance practices. Additionally, firms with greater reliance on external financing may pursue ESG assurance to lower their cost of capital, as certain investor segments show preferences for ESG performance (Casey and Grenier, 2015). Firms aiming to appeal to sustainable investors or seeking inclusion in sustainability indices are also more likely to assure their ESG disclosures (Clarkson et al., 2019). We observe similar patterns for firms with a higher Material Assurance Ratio, suggesting that firms prioritizing the assurance of material ESG issues also tend to exhibit these characteristics.

4.1 Assurance and sustainability commitment

We conduct further analysis to explore whether different types of ESG assurance serve as signals of genuine sustainability commitment. As shown in Table 2, we begin with detailed descriptive statistics for various categories of green patents across different subgroups.

Firms that obtain ESG assurance exhibit a significantly higher average number of green patents (mean = 6.35) compared to firms without assurance (mean = 1.86), suggesting that assurance is positively associated with green innovation. Moreover, firms with a higher Material Assurance Ratio have an even greater average green patent count (mean = 9.75), in stark contrast to those with a higher Immaterial Assurance Ratio, whose mean is only 0.65. This pattern indicates that firms focusing their assurance efforts on material ESG topics are more strongly committed to environmental innovation.

These findings are robust to alternative classifications of green patents. When we follow prior literature and categorize patents into "pollution control" and "pollution prevention" types, we observe similar patterns across subgroups. Likewise, when we further disaggregate green patents into seven distinct categories—such as GHG emissions reduction, energy efficiency, and others—we continue to find consistent evidence: firms with material ESG assurance consistently outperform their counterparts in green innovation metrics.

Since the number of green patents is a count variable, a standard linear regression model is not appropriate. Instead, count data models such as Poisson regression or negative binomial regression are more suitable for our analysis. The Poisson model assumes that the mean and variance of the dependent variable are equal. However, in our data, the variance of patent counts (28.433^2) significantly exceeds the mean (6.352), indicating the presence of overdispersion.

Overdispersion can lead to biased and inefficient estimates, particularly underestimating

Table 2: Descriptive Statistics by Sample (Green Patent)

Variable	Sample	N	Mean	SD	Min	p25	p75	Max
Green	A	2533	6.352	28.433	0.000	0.000	1.000	539.000
	None A	1049	1.862	15.820	0.000	0.000	0.000	235.000
	M	1447	9.748	35.843	0.000	0.000	3.000	539.000
	IM	342	0.646	3.069	0.000	0.000	0.000	32.000
Control	A	2533	0.783	3.919	0.000	0.000	0.000	72.000
	None A	1049	0.158	0.804	0.000	0.000	0.000	8.000
	M	1447	1.169	4.961	0.000	0.000	0.000	72.000
	IM	342	0.164	1.034	0.000	0.000	0.000	11.000
Prevention	A	2533	3.818	19.886	0.000	0.000	0.000	366.000
	None A	1049	0.871	10.512	0.000	0.000	0.000	201.000
	M	1447	5.860	25.058	0.000	0.000	1.000	366.000
	IM	342	0.275	1.643	0.000	0.000	0.000	19.000
GHG	A	2533	1.777	14.052	0.000	0.000	0.000	313.000
	None A	1049	0.289	3.809	0.000	0.000	0.000	114.000
	M	1447	2.553	17.432	0.000	0.000	0.000	313.000
	IM	342	0.120	0.883	0.000	0.000	0.000	13.000
Energy	A	2533	1.771	10.808	0.000	0.000	0.000	191.000
	None A	1049	0.508	7.655	0.000	0.000	0.000	158.000
	M	1447	2.860	14.031	0.000	0.000	0.000	191.000
	IM	342	0.064	0.336	0.000	0.000	0.000	3.000
Water	A	2533	0.084	0.585	0.000	0.000	0.000	13.000
	None A	1049	0.026	0.263	0.000	0.000	0.000	6.000
	M	1447	0.113	0.662	0.000	0.000	0.000	13.000
	IM	342	0.041	0.602	0.000	0.000	0.000	11.000
Waste	A	2533	0.144	0.738	0.000	0.000	0.000	10.000
	None A	1049	0.044	0.412	0.000	0.000	0.000	7.000
	M	1447	0.229	0.944	0.000	0.000	0.000	10.000
	IM	342	0.029	0.264	0.000	0.000	0.000	4.000
Air Quality	A	2533	0.698	5.053	0.000	0.000	0.000	119.000
	None A	1049	0.051	0.456	0.000	0.000	0.000	10.000
	M	1447	1.019	6.333	0.000	0.000	0.000	119.000
	IM	342	0.058	0.481	0.000	0.000	0.000	6.000
Biodiversity	A	2533	0.185	1.045	0.000	0.000	0.000	17.000
	None A	1049	0.054	0.383	0.000	0.000	0.000	5.000
	M	1447	0.279	1.299	0.000	0.000	0.000	17.000
	IM	342	0.047	0.293	0.000	0.000	0.000	3.000
Product Design	A	2533	0.587	2.680	0.000	0.000	0.000	37.000
	None A	1049	0.200	2.519	0.000	0.000	0.000	56.000
	M	1447	0.935	3.451	0.000	0.000	0.000	37.000
	IM	342	0.094	0.696	0.000	0.000	0.000	9.000

standard errors and inflating the significance of coefficients in the Poisson model. To address this issue, we adopt a negative binomial regression, which generalizes the Poisson model by including an overdispersion parameter and provides more reliable standard error estimates.

Furthermore, the likelihood ratio (LR) test of the overdispersion parameter (α) confirms the presence of overdispersion, as α is statistically significant at the 1% level. Based on this evidence, we conclude that the negative binomial regression is the most appropriate modeling approach for our dependent variable.

Table 3: Regression Results on Green Patent

VARIABLES	(1) GreenPatent	(2) GreenPatent	(3) GreenPatent	(4) GreenPatent	(5) GreenPatent
Non Assurance	-0.816***				
	(-5.88)				
Assurance		1.320***	0.276	0.538***	0.044
		(9.13)	(1.58)	(3.91)	(0.30)
Rm			2.578***		1.575***
			(11.73)		(7.75)
Ri			-1.107***		-0.711**
			(-3.18)		(-2.18)
Cash	0.418			1.643***	1.327**
	(0.78)			(2.79)	(2.30)
NetPPE	-3.270***			-2.299***	-2.196***
	(-7.45)			(-5.11)	(-4.89)
Leverage	0.012			-2.563***	-2.307***
	(1.27)			(-5.45)	(-4.85)
Size	0.848***			1.039***	0.907***
	(16.75)			(21.10)	(16.99)
Age	-1.046***			-1.022***	-1.009***
	(-8.03)			(-7.79)	(-7.65)
ROA	0.082			-0.022	-0.016
	(0.14)			(-1.47)	(-1.00)
BMValue	0.353***			-0.396***	-0.356**
	(3.16)			(-2.78)	(-2.44)
LossIndicator	0.727***			0.382**	0.328*
	(3.98)			(2.15)	(1.84)
Constant		-0.756*	-0.899**	0.372	0.549
		(-1.70)	(-2.10)	(0.47)	(0.74)
lnalpha	1.235***	1.577***	1.451***	1.118***	1.053***
	(25.38)	(33.78)	(27.89)	(18.89)	(16.99)
Year Fixed Effects	YES	YES	YES	YES	YES
Industry Fixed Effects	YES	YES	YES	YES	YES
Observations	3,289	3,582	3,565	3,245	3,230
Pseudo R^2	0.000	0.1504	0.1654	0.1910	0.1981

Note: This table presents regression results where the dependent variable is the number of green patents. Robust z-statistics are reported in parentheses. All models include year and industry fixed effects.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 3 presents the regression results examining the association between ESG assurance and firms' sustainability commitment, proxied by the number of green patents. Given that our goal is to explore whether ESG assurance can serve as a credible signal of sustainability commitment, we focus on correlations rather than causal interpretations.

In Column (1), we find that firms without any ESG assurance exhibit significantly fewer green patents, with a negative and highly significant coefficient on the Non Assurance indicator. Column (2) reinforces this finding: firms with ESG assurance are positively associated with

green patent output (coefficient = 1.320, $p < 0.01$), even after controlling for firm characteristics and fixed effects. These results suggest that, in general, firms that obtain ESG assurance are more likely to engage in environmental innovation, implying that ESG assurance may reflect a stronger sustainability commitment.

However, Columns (3) to (5) delve deeper into the type of assurance by incorporating materiality. Once we distinguish between the assurance of material versus immaterial ESG issues, a more nuanced pattern emerges. Specifically, assurance of material sustainability topics is positively and significantly associated with green patenting activity, suggesting that when firms focus assurance on topics that are financially and sustainably relevant, the assurance serves as a meaningful signal of genuine sustainability efforts.

In contrast, assurance of immaterial topics is associated with a significantly negative coefficient, indicating that firms may be selectively assuring less relevant ESG items, potentially to mislead stakeholders about their sustainability commitment. This pattern is consistent with concerns about "greenwashing," where firms may use assurance strategically to create a façade of responsibility without committing to substantive environmental actions.

The results highlight the importance of considering what is being assured—not just whether assurance is present. ESG assurance in general may appear to be a positive signal, but only when it aligns with material sustainability concerns does it reflect a credible and meaningful commitment to long-term environmental performance.

To gain a more nuanced understanding of how firms strategically allocate their innovation efforts in the context of sustainability, we further disaggregate green patents into specific categories: Control, Prevention, GHG, Air Quality, Energy, Water, Waste, and Product Design. The results reveal several noteworthy patterns.

First, firms with a higher materiality ratio (Rm) are significantly more likely to increase innovation efforts across nearly all green patent categories. Notably, the strongest positive effect of Rm appears in Prevention patents (coef. = 1.814, z = 8.46), which are designed to reduce pollution at its source. This finding aligns with the idea that firms with a more credible sustainability strategy—signaled by focusing assurance efforts on material issues—are more inclined to engage in transformative innovations that support long-term sustainability transitions. In contrast, while Control patents also increase with Rm (coef. = 1.555, z = 6.12), the effect is slightly lower, suggesting a strategic preference for upstream, preventive solutions over downstream, end-of-pipe controls.

Second, the immaterial ratio (Ri) is negatively associated with green patenting overall. This effect is especially pronounced for Prevention patents (coef. = -1.056, z = -3.19), where the magnitude of reduction is greater than for Control patents (coef. = -0.775, z = -1.89). This suggests that firms emphasizing immaterial topics in their ESG assurance are less likely to commit to meaningful, source-level innovation, possibly reflecting a form of greenwashing or symbolic compliance.

The differentiated patterns also extend to thematic environmental patent types. Specifically,

Table 4: Regression Results on ESG Assurance and Detailed Patent Categories

VARIABLES	Control	Prevention	GHG	Air Quality	Energy	Water	Waste	Product Design
Rm	1.555***	1.814***	1.623***	1.830***	1.306***	1.369***	1.279***	1.423***
	(6.12)	*(8.46)*	*(5.63)*	*(5.59)*	*(5.43)*	*(3.21)*	*(3.58)*	*(5.36)*
Ri	-0.775*	-1.056***	-1.102***	-0.882*	-0.438	-0.082	0.683	-0.035
	(-1.89)	*(-3.19)*	*(-2.85)*	*(-1.86)*	*(-1.12)*	*(-0.14)*	*(1.35)*	*(-0.08)*
Assurance	-0.030	0.126	0.033	0.451	0.675**	-0.470	-1.153***	0.119
	(-0.14)	*(0.67)*	*(0.12)*	*(1.20)*	*(2.42)*	*(-0.97)*	*(-3.54)*	*(0.48)*
Cash	2.402***	1.634***	3.450***	1.970*	0.484	0.220	1.152	1.463**
	(3.33)	*(2.58)*	*(4.06)*	*(1.74)*	*(0.42)*	*(0.13)*	*(1.58)*	*(2.00)*
NetPPE	-1.239**	-1.986***	-1.638***	-2.524***	-0.166	-0.131	-1.746**	-1.243**
	(-2.48)	*(-3.98)*	*(-2.65)*	*(-3.38)*	*(-0.31)*	*(-0.18)*	*(-2.40)*	*(-2.06)*
Leverage	-1.704***	-3.672***	-3.988***	-3.973***	-1.866***	-1.314	-1.449*	-2.847***
	(-2.90)	*(-6.42)*	*(-4.67)*	*(-4.32)*	*(-2.73)*	*(-1.45)*	*(-1.94)*	*(-4.24)*
Size	0.842***	0.876***	0.843***	0.756***	0.961***	0.768***	0.794***	0.733***
	(13.01)	*(15.36)*	*(9.92)*	*(7.65)*	*(14.68)*	*(6.82)*	*(7.90)*	*(10.13)*
Age	-0.400***	-1.010***	-0.529***	-0.121	-0.957***	-0.634**	-0.494**	-0.547***
	(-2.93)	*(-7.82)*	*(-3.17)*	*(-0.72)*	*(-6.32)*	*(-2.47)*	*(-2.25)*	*(-3.56)*
ROA	0.168	-0.030***	0.264	0.076	-0.037***	0.739***	0.051	-0.031***
	(1.11)	*(-2.96)*	*(1.53)*	*(0.30)*	*(-2.85)*	*(3.20)*	*(0.23)*	*(-2.83)*
Book-to-Market	-0.475**	-0.571***	-0.697***	-1.001**	-0.676***	-0.203	0.234	-0.361**
	(-2.32)	*(-3.51)*	*(-4.11)*	*(-2.55)*	*(-3.64)*	*(-0.33)*	*(1.22)*	*(-2.41)*
Loss Indicator	0.018	0.340*	0.543***	0.167	0.512**	-2.539***	-0.826**	0.226
	(0.08)	*(1.77)*	*(2.72)*	*(0.55)*	*(2.41)*	*(-2.70)*	*(-2.41)*	*(1.26)*
lnalpha	0.790***	0.932***	1.081***	1.003***	0.602***	-0.067	0.811***	0.725***
	(7.98)	*(12.26)*	*(9.50)*	*(7.61)*	*(4.65)*	*(-0.14)*	*(4.41)*	*(4.86)*
Constant	-17.028***	-2.525**	-28.027	-20.383***	-17.621	-16.189***	-19.402***	-3.811***
	(-30.55)	*(-1.98)*	*(-0.00)*	*(-23.27)*	*(.)*	*(-16.85)*	*(-19.37)*	*(-3.02)*
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,230	3,230	3,230	3,230	3,230	3,230	3,230	3,230
Pseudo R^2	0.2710	0.2510	0.2774	0.3161	0.3033	0.3463	0.2819	0.2723

Robust z-statistics in parentheses
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Rm is positively and significantly associated with the number of patents related to GHG reduction (coef. = 1.623, z = 5.63) and Air Quality (coef. = 1.830, z = 5.59), whereas Ri shows significant negative effects in both domains (GHG: coef. = -1.102, z = -2.85; Air Quality: coef. = -0.882, z = -1.86). These patterns reinforce the view that materiality-driven ESG assurance is associated with deeper environmental engagement, while immaterial assurance is not.

For other green patent categories (Energy, Water, Waste, and Product Design), the relationship with Rm remains consistently positive and statistically significant, while Ri exhibits mostly insignificant or even positive (but insignificant) coefficients. Importantly, the assurance indicator itself is largely insignificant across most specifications and even negatively associated with Product Design innovation (coef. = -1.153, z = -3.54). This suggests that ESG assurance, when considered in isolation, is not a reliable signal of green innovation commitment. Instead, it is the focus of assurance—whether on material or immaterial topics—that reveals a firm's true environmental orientation.

These results underscore the central role of Rm as a meaningful indicator of genuine sustainability-driven innovation. While firms may obtain ESG assurance for signaling purposes, only those aligning assurance with material sustainability concerns appear to translate such efforts into substantive technological change. This supports our overarching argument that materiality-focused assurance provides a more credible signal to stakeholders and may better reflect a firm's authentic commitment to environmental transition.

4.2 Assurance and sustainability performance

Next, we examine the relationship between ESG assurance and firms' sustainability performance, with particular attention to different types of assurance coverage. As shown in Table 5, firms with ESG assurance tend to exhibit slightly worse environmental performance across all four dimensions—CO_2 emissions, energy use, water consumption, and waste generation—compared to firms without assurance ("None"). For example, the average CO_2 emissions for assured firms is 2.548, while it is 1.852 for non-assured firms. Similarly, assured firms have higher energy use (4.673 vs. 3.847) and water consumption (4.693 vs. 3.647). These patterns are consistent with prior research suggesting that companies may seek external assurance as a form of risk management, particularly when their sustainability performance is relatively poor.

When we further distinguish between types of assurance, firms with material-topic assurance ("M") show even higher levels of resource use and emissions. For instance, firms in the "M" group have an average CO_2 emission of 2.927, energy use of 5.187, and water consumption of 5.156, all of which are higher than those in the "None" group. This implies that such firms may face greater external scrutiny or internal pressure related to key sustainability issues, prompting them to obtain assurance as a responsive measure. Firms in the "Immaterial" group ("IM") generally perform slightly better than the "M" group, but still worse than firms without assurance.

These findings suggest that obtaining ESG assurance does not necessarily indicate superior sustainability performance. Rather, assurance may serve as a governance response to address poor performance and reduce perceived risk. This supports the view that ESG assurance can function more as a risk management tool than a signal of strong environmental commitment.

Table 5: Descriptive Statistics by Sample (Sustainability Performance)

Variable	Sample	N	Mean	SD	Min	p25	p75	Max
CO_2	A	2,395	2.548	1.998	0.000	0.678	3.802	8.221
	None A	778	1.852	1.652	0.000	0.324	3.034	7.523
	M	1,379	2.927	1.981	0.000	1.335	4.423	7.734
	IM	327	1.940	1.759	0.000	0.183	3.062	7.043
Energy	A	2,210	4.673	2.484	0.005	2.880	6.201	10.632
	None A	633	3.847	2.239	0.013	1.812	5.569	10.312
	M	1,281	5.187	2.379	0.005	3.861	6.720	10.632
	IM	294	3.707	2.267	0.022	1.230	5.465	8.820
Water	A	1,955	4.693	2.972	0.011	2.452	6.794	12.474
	None A	390	3.647	2.513	0.001	1.037	5.403	10.618
	M	1,156	5.156	2.766	0.062	3.368	6.985	12.474
	IM	259	3.785	3.175	0.021	0.815	4.804	12.474
Waste	A	1,452	0.773	1.176	0.000	0.048	1.032	9.918
	None A	223	0.680	1.183	0.000	0.008	1.012	9.678
	M	911	0.809	1.063	0.000	0.106	1.118	7.056
	IM	116	0.563	0.927	0.000	0.017	0.664	4.095

Tables 6 and 7 present regression results analyzing the relationship between ESG assurance and multiple indicators of environmental performance, including CO_2 emissions, energy consumption, water use, and waste generation. These results shed light on how the presence and focus of ESG assurance relate to firms' actual environmental outcomes.

Starting with CO_2 emissions and energy consumption (Table 6), the full-sample regressions indicate that ESG assurance is initially positively associated with CO_2 emissions (column 1), suggesting that firms obtaining assurance tend to have higher emissions. However, this relationship loses significance when controlling for materiality or restricting the sample to assured firms (columns 2 and 3). For energy consumption, no significant relationship with ESG assurance is observed in either the full sample or subsample of assured firms (columns 4–6). This suggests that simply having ESG assurance does not systematically translate into better environmental performance in these dimensions.

Critically, when decomposing assurance by its focus on immaterial versus material ESG topics, a clearer pattern emerges. Assurance concentrated on immaterial topics (Ri) shows a positive and significant association with both CO_2 emissions and energy consumption (columns 3 and 6), indicating that a higher proportion of assurance devoted to non-material issues correlates with worse environmental outcomes. In contrast, assurance focused on material topics (Rm) is not significantly related to either metric, implying that assurance targeted at key sustainability issues does not necessarily result in immediate measurable improvements. This finding aligns with the understanding that corporate sustainability transitions are gradual, long-term processes.

Turning to water use and waste generation (Table 7), a similar pattern is observed. Assurance on immaterial topics remains significantly and positively associated with both water

Table 6: Regression Results on CO_2 Emissions and Energy Consumption

VARIABLES	(1) CO_2	(2) CO_2	(3) CO_2	(4) Energy	(5) Energy	(6) Energy
Ri		0.315**	0.306*		0.632***	0.639***
		(1.99)	(1.92)		(3.33)	(3.32)
Rm		0.081	0.026		-0.119	-0.155
		(0.90)	(0.28)		(-1.16)	(-1.44)
Assurance	0.111**	-0.023		0.063	-0.019	
	(2.17)	(-0.40)		(1.02)	(-0.27)	
Cash	-0.148	-0.021	0.583**	0.668***	0.699***	1.123***
	(-0.82)	(-0.12)	(2.17)	(3.15)	(3.29)	(4.60)
NetPPE	0.959***	0.938***	0.302	2.134***	2.148***	1.585***
	(4.38)	(4.31)	(1.21)	(9.20)	(9.34)	(5.98)
Leverage	0.001**	0.503***	0.741***	0.183	0.197	0.332
	(2.49)	(2.80)	(3.28)	(0.85)	(0.91)	(1.25)
Size	-0.011	-0.027	-0.011	-0.010	-0.022	-0.038
	(-0.57)	(-1.33)	(-0.46)	(-0.42)	(-0.89)	(-1.42)
Age	0.130**	0.150***	0.114	0.157**	0.152**	0.097
	(2.34)	(2.70)	(1.61)	(2.41)	(2.34)	(1.26)
ROA	0.465**	-3.796***	-5.041	0.015	0.015	0.014
	(2.10)	(-3.64)	(-1.64)	(1.36)	(1.40)	(1.37)
Book-to-Market	0.185***	0.183***	0.213***	0.275***	0.273***	0.315***
	(6.06)	(5.89)	(5.81)	(7.80)	(7.73)	(7.34)
Loss Indicator	0.198***	0.147**	0.066	0.237***	0.229***	0.155*
	(2.88)	(2.14)	(0.91)	(2.87)	(2.74)	(1.72)
Constant	1.415***	1.292***	0.982***	3.528***	3.435***	3.237***
	(5.40)	(4.78)	(3.28)	(10.67)	(9.55)	(9.21)
Year Fixed Effects	YES	YES	YES	YES	YES	YES
Industry Fixed Effects	YES	YES	YES	YES	YES	YES
Observations	2,986	2,924	2,217*	2,702	2,689	2,100*
R-squared	0.747	0.747	0.771	0.801	0.802	0.821

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Column (3)(6): Sample restricted to firms with ESG assurance (Assurance = 1)

Table 7: Regression Results for Water and Waste

VARIABLES	(1) Water	(2) Water	(3) Water	(4) Waste	(5) Waste	(6) Waste
R_i		1.366***	1.377***		0.305*	0.392**
		(5.43)	(5.39)		(1.74)	(2.24)
R_m		-0.184	-0.255*		-0.084	-0.173
		(-1.32)	(-1.78)		(-0.76)	(-1.54)
Assurance	0.158*	-0.070		-0.037	-0.064	
	(1.78)	(-0.71)		(-0.51)	(-0.81)	
Cash	-0.762*	-0.559	0.251	-0.120	-0.072	0.412
	(-1.89)	(-1.40)	(0.52)	(-0.53)	(-0.32)	(1.52)
NetPPE	1.599***	1.658***	1.077***	0.516**	0.519**	0.297
	(4.40)	(4.57)	(2.60)	(2.43)	(2.45)	(1.36)
Leverage	-0.371	-0.277	-0.205	0.008	0.008	0.011
	(-1.04)	(-0.79)	(-0.50)	(0.99)	(1.03)	(1.08)
Size	0.051*	0.022	0.022	0.035	0.027	0.038
	(1.69)	(0.70)	(0.67)	(1.43)	(1.15)	(1.47)
Age	0.240**	0.214**	0.243**	-0.071	-0.075	-0.096*
	(2.39)	(2.18)	(2.01)	(-1.48)	(-1.56)	(-1.77)
ROA	-7.749***	-7.478***	-8.615***	-0.053	-0.057	-0.078
	(-5.96)	(-5.80)	(-4.30)	(-0.92)	(-0.96)	(-1.05)
Book-to-Market	0.476***	0.467***	0.487***	0.021	0.020	0.008
	(7.74)	(7.13)	(6.82)	(0.68)	(0.66)	(0.22)
LossIndicator	0.265**	0.254**	0.166	-0.027	-0.029	-0.033
	(2.38)	(2.26)	(1.35)	(-0.46)	(-0.49)	(-0.53)
Constant	1.889***	2.151***	1.949***	0.064	0.061	0.054
	(4.41)	(5.05)	(4.03)	(0.37)	(0.35)	(0.30)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	2,191	2,181	1,817*	1,586	1,576	1,362*
R-squared	0.770	0.776	0.780	0.579	0.580	0.590

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Column (3)(6): Sample restricted to firms with ESG assurance (Assurance = 1)

consumption (columns 1–3) and waste generation (columns 4–6), reinforcing the notion that ESG assurance focused on less relevant issues corresponds with poorer environmental performance. Assurance on material issues, however, continues to lack a significant relationship with these environmental outcomes.

An important methodological distinction across both tables is between the full-sample regressions (columns 1, 2, 4, and 5) which include all firms regardless of assurance status, and the subsample regressions (columns 3 and 6) restricted to firms with ESG assurance (Assurance = 1). The subsample analyses enable a more nuanced examination of how the relative allocation of assurance across material and immaterial topics influences environmental outcomes, independent of whether assurance is present.

Overall, these findings suggest that ESG assurance—particularly when disproportionately focused on immaterial topics—may serve more of a symbolic or strategic signaling function rather than driving substantive improvements in environmental performance. This underscores the necessity of moving beyond a binary measure of assurance presence and instead critically assessing the content and focus of ESG assurance to better understand its true impact on corporate sustainability.

4.3 Assurance and Institutional Investor

Table 8 reports the descriptive statistics for variables related to investor characteristics and ownership structures, segmented by different sample groups. In terms of the number of institutional investors, firms with immaterial assurance exhibit a relatively high average (mean = 0.275) compared to the "None" group (mean = –0.522), suggesting that firms emphasizing immaterial topics in ESG assurance attract more institutional investors than firms without any assurance. This pattern is even more pronounced for the number of SRI investors, with the IM group (mean = 0.329) again demonstrating a higher average than the "None" group (mean = –0.548).

When examining institutional ownership, the IM group also shows a slightly higher average ownership share (mean = 0.540) compared to other groups, although the variation (SD = 0.274) is relatively contained. This contrasts with the "None" group, which has a similar average institutional ownership (mean = 0.463) but substantially less dispersion (SD = 0.277) than the full sample. Notably, the full sample includes extreme values, as reflected by a maximum institutional ownership of 48.124%, indicating the presence of firms with highly concentrated institutional holdings.

For SRI ownership, firms in the IM group again have the highest mean value (0.338), compared to 0.264 in the M group and 0.287 in the "None" group. This suggests that SRI investors may be more inclined to invest in firms that obtain ESG assurance—even when that assurance is focused on immaterial topics.

These descriptive statistics reveal meaningful differences across the assurance-based sub-

Table 8: Descriptive statistics by sample group (Investor and Ownership)

Variable	Sample	N	Mean	SD	Min	p25	p75	Max
Institutional Investors	A	2522	0.217	1.023	-1.662	-0.524	0.701	4.388
	None A	1021	-0.522	0.694	-1.662	-1.019	-0.157	2.916
	M	1441	0.402	1.084	-1.662	-0.395	0.968	4.388
	IM	338	0.275	0.990	-1.567	-0.404	0.677	3.183
SRI Investors	A	2507	0.214	1.004	-1.977	-0.479	0.740	4.583
	None A	977	-0.548	0.749	-2.035	-1.130	-0.085	2.040
	M	1432	0.384	1.033	-1.838	-0.305	0.925	4.583
	IM	338	0.329	1.035	-1.977	-0.317	0.983	2.980
Institutional Ownership	A	2522	0.449	0.974	0.000	0.272	0.546	48.124
	None A	1021	0.463	0.277	0.000	0.265	0.659	1.427
	M	1441	0.463	1.274	0.000	0.285	0.538	48.124
	IM	338	0.540	0.274	0.024	0.309	0.778	1.074
SRI Ownership	A	2507	0.265	0.141	0.000	0.170	0.337	0.794
	None A	977	0.287	0.172	0.000	0.160	0.385	1.110
	M	1432	0.264	0.133	0.000	0.176	0.335	0.790
	IM	338	0.338	0.186	0.001	0.190	0.492	0.794

samples. Firms with a higher share of assurance devoted to immaterial topics tend to be associated with a greater number of both institutional and sustainable investors, as well as higher levels of ownership by these groups. This pattern suggests that the mere act of obtaining ESG assurance—regardless of its substantive focus—may serve as a positive signal to investors. As such, companies may be incentivized to publish ESG assurance reports even when their actual sustainability practices are limited, viewing assurance as a strategic tool to attract investment from institutional and responsible investors.

Table 9 presents regression results examining the relationship between ESG assurance and investor engagement, measured by the number of institutional and sustainable (SRI) investors. Across all specifications, ESG assurance is positively and significantly associated with both types of investors at the 1% level. This finding aligns closely with Gipper et al. (2024), who argues that investors perceive assurance as enhancing the credibility of ESG disclosures, thereby attracting a broader investor base.

In our extended analysis (columns 1 and 2), we differentiate between assurance on material and immaterial topics. The results show that the positive association between ESG assurance and investor presence is primarily driven by assurance on material issues. In contrast, assurance focused on immaterial topics shows no statistically significant impact on investor interest once materiality is accounted for.

This nuance adds a critical layer to Gipper's framework. While Gipper et al. (2024) emphasizes the general signaling effect of assurance, our results suggest that investors are not uniformly responsive to all forms of ESG assurance. Rather, they appear to selectively respond to assurance that targets issues deemed financially and sustainably material. This implies that assurance serves not merely as a symbolic certification, but as a targeted signal of credibility,

Table 9: Regression Results: Institutional and SRI Investors

VARIABLES	(1) Institutional Investors	(2) SRI Investors	(3) Institutional Investors	(4) SRI Investors
R_m	0.194***	0.145**		
	(2.80)	(2.10)		
R_i	0.163	0.151		
	(1.43)	(1.36)		
Assurance	0.321***	0.325***	0.231***	0.252***
	(10.54)	(10.50)	(6.78)	(7.30)
Cash	0.317***	0.324***	0.288**	0.301**
	(2.80)	(2.64)	(2.54)	(2.45)
NetPPE	-0.456***	-0.459***	-0.422***	-0.431***
	(-5.40)	(-5.10)	(-4.91)	(-4.72)
Leverage	-0.001	-0.001	-0.000	-0.000
	(-0.68)	(-0.62)	(-0.57)	(-0.53)
Size	0.362***	0.345***	0.347***	0.333***
	(27.69)	(28.38)	(26.33)	(27.00)
Age	0.299***	0.338***	0.289***	0.327***
	(8.31)	(10.82)	(8.04)	(10.51)
ROA	1.597***	1.704***	1.551***	1.666***
	(7.36)	(7.63)	(7.14)	(7.46)
Book-to-Market	-0.253***	-0.298***	-0.250***	-0.296***
	(-10.10)	(-11.07)	(-9.99)	(-10.98)
Loss Indicator	-0.099**	-0.162***	-0.109**	-0.168***
	(-2.12)	(-3.60)	(-2.30)	(-3.69)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Constant	-4.791***	-5.008***	-4.613***	-4.801***
	(-30.08)	(-30.89)	(-28.06)	(-29.25)
Observations	3,289	3,289	3,274	3,274
R-squared	0.476	0.501	0.482	0.505

Notes: Robust t-statistics in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

especially when it pertains to strategically relevant sustainability areas.

Overall, these findings reinforce the idea that ESG assurance can be a powerful mechanism for enhancing investor trust—but only when it is substantively aligned with material stakeholder concerns. Firms seeking to attract institutional or responsible investors may thus benefit more from strategically focused assurance, rather than from a blanket or symbolic approach.

Table 10 presents regression results examining the relationship between ESG assurance and both socially responsible investment (SRI) ownership and overall institutional ownership. In Columns (1) and (2), where only the overall assurance indicator is included, the results indicate that ESG assurance is not significantly associated with either SRI or institutional ownership. This suggests that the presence of assurance, in isolation, is insufficient to influence capital allocation decisions by institutional or SRI investors. This finding aligns with Gipper et al. (2024), who document an increase in the number of institutional investors following ESG-related disclosures, yet do not observe a corresponding rise in aggregate institutional ownership. Similarly, Lopez-de Silanes et al. (2024) report that ESG ratings are strongly correlated with the number of institutional investors, but not with the extent of their ownership, reinforcing the distinction between investor attention and investment commitment.

However, when incorporating the materiality dimension in Columns (3) and (4), the results reveal a more nuanced pattern. Notably, in Column (3), ESG assurance becomes statistically significant and positively associated with SRI ownership, suggesting that investors who priori-

Table 10: Regression Results on SRI and Institutional Ownership

VARIABLES	(1) SRI Ownership	(2) Institutional Ownership	(3) SRI Ownership	(4) Institutional Ownership
R_i			-0.066***	-0.065
			(-3.92)	(-1.40)
R_m			-0.018	0.063
			(-1.59)	(0.59)
Assurance	0.008	0.035	0.025***	0.028*
	(1.25)	(1.12)	(3.62)	(1.93)
Cash	-0.050**	0.077	-0.048**	0.069
	(-2.50)	(0.51)	(-2.38)	(0.49)
NetPPE	-0.090***	-0.128***	-0.095***	-0.122**
	(-5.26)	(-3.00)	(-5.57)	(-2.33)
Leverage	0.000	0.001	0.000	0.001
	(1.18)	(1.10)	(1.15)	(1.07)
Size	-0.021***	-0.030***	-0.018***	-0.032***
	(-9.55)	(-5.55)	(-8.39)	(-2.80)
Age	0.056***	0.116***	0.057***	0.113***
	(8.79)	(2.74)	(8.78)	(2.91)
ROA	0.146***	0.264***	0.154***	0.261***
	(5.18)	(3.30)	(5.54)	(3.93)
Book-to-Market	-0.009*	-0.039**	-0.010**	-0.039**
	(-1.93)	(-2.38)	(-2.02)	(-2.49)
Loss Indicator	-0.004	0.001	-0.001	0.000
	(-0.43)	(0.05)	(-0.12)	(0.01)
Year Fixed Effect	YES	YES	YES	YES
Industry Fixed Effect	YES	YES	YES	YES
Constant	0.284***	0.340**	0.279***	0.380***
	(9.96)	(2.33)	(9.31)	(4.21)
Observations	3,289	3,289	3,274	3,274
R-squared	0.252	0.033	0.263	0.033

Notes: Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

tize socially responsible investing respond favorably to assurance when it is considered alongside materiality. Furthermore, the coefficient on assurance for immaterial ESG issues, captured by the interaction term Ri, is significantly negative, indicating that assurance on topics deemed immaterial may actually deter SRI investors. This implies that these investors are not simply reacting to the presence of ESG assurance per se, but are attentive to whether the assurance material issues. Assurance of immaterial topics may be interpreted as a symbolic gesture lacking substantive commitment, or even as an indication of greenwashing. In contrast, assurance focused on material ESG dimensions appears to strengthen the perceived credibility of the firm's sustainability efforts and enhances its attractiveness to SRI investors. These findings underscore the importance of aligning assurance practices with material ESG concerns in order to positively influence investor perceptions and behavior.

4.4 Assurance and Information Asymmetry

To assess whether ESG assurance mitigates information asymmetry between firms and capital market participants, we employ analysts' earnings forecast accuracy as a proxy, consistent with Cuadrado-Ballesteros et al. (2017). Specifically, forecast accuracy is calculated as the absolute difference between actual and median forecasted earnings per share (EPS), scaled by year-end stock price. A smaller value reflects higher forecast accuracy and, by extension, lower

information asymmetry, as it suggests that market participants have better access to reliable and decision-useful information.

Table 11 reports the descriptive statistics for forecast accuracy across different subsamples. The full sample (Panel A) comprises 2,013 firm-year observations, with a mean forecast inaccuracy of 0.313 and substantial variation (standard deviation = 0.981). Firms without ESG assurance exhibit a slightly lower mean inaccuracy (0.301), whereas those with assurance on material ESG issues (M) display a comparable mean (0.298). Interestingly, the lowest level of forecast inaccuracy is observed among firms that assure immaterial ESG topics (IM), with a mean of 0.192. This suggests that the mere presence of assurance, even on less financially relevant ESG matters, may correlate with improved analyst forecast performance, possibly due to a signaling effect or greater transparency overall.

Table 11: Descriptive Statistics of Information Asymmetry by Sample

Variable	Sample	N	Mean	SD	Min	p25	p75	Max
ForecastAccuracy	A	2,013	0.313	0.981	0.000	0.016	0.204	12.735
	None A	716	0.301	0.793	0.000	0.011	0.187	10.402
	M	1,272	0.298	0.973	0.000	0.016	0.192	12.735
	IM	235	0.192	0.636	0.000	0.012	0.123	6.000

Table 12: Regression Results: Information Asymmetry

VARIABLES	(1) Information Asymmetry	(2) Information Asymmetry
Rm		-0.102
		(–1.49)
Ri		0.015
		(0.10)
Assurance	**–0.134*****	**–0.127*****
	(–3.91)	(–2.90)
Cash	0.268**	0.274**
	(2.44)	(2.48)
Leverage	0.081	0.043
	(0.71)	(0.41)
Size	0.043***	0.051***
	(3.30)	(4.39)
ROA	–0.573*	–0.704**
	(–1.65)	(–2.09)
Book-to-Market	0.296***	0.277***
	(3.10)	(3.06)
Loss Indicator	0.133*	0.133*
	(1.83)	(1.89)
Year Fixed Effect	Yes	Yes
Industry Fixed Effect	Yes	Yes
Constant	0.460	0.597
	(0.80)	(0.90)
Observations	2,511	2,651
R-squared	0.167	0.169

Robust t-statistics in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 12 presents the regression results examining the effect of ESG assurance on information asymmetry, measured by analysts' forecast accuracy. In both model specifications, the overall ESG assurance indicator is significantly and negatively associated with forecast inaccuracy (–0.127 and –0.134; p ¡ 0.01), suggesting that ESG assurance improves the quality of

sustainability disclosures, thereby reducing information asymmetry between firms and capital market participants.

When incorporating the proportions of assurance allocated to material and immaterial ESG topics in Column (2), the coefficients on both variables are statistically insignificant. However, their signs are consistent with theoretical expectations: the coefficient on Rm is negative (–0.102), indicating that assurance focused on financially material ESG issues is associated with reduced information asymmetry, while the coefficient on Ri is positive (0.015), suggesting that assurance targeting immaterial topics may offer limited informational value or even introduce noise. Although these estimates are not statistically significant at conventional levels, the contrasting signs imply that not all assurance is equally meaningful—investors and analysts appear to respond more favorably to assurance when it is aligned with financially relevant sustainability topics.

These results underscore the importance of considering materiality alignment in ESG assurance practices. ESG assurance that focuses on issues deemed immaterial may fail to reduce information asymmetry and, in some cases, may even be interpreted as a signal of superficial reporting or greenwashing.

5 Conclusion

Our study investigates the role of ESG assurance as a signal of corporate sustainability commitment, emphasizing the importance of aligning assurance practices with material ESG issues. The findings indicate that ESG assurance, in general, is not a reliable standalone signal of genuine sustainability commitment. In fact, companies that assure a higher proportion of immaterial ESG topics tend to demonstrate lower levels of sustainable investment, as measured by green patenting activity. In contrast, firms that prioritize assurance of material ESG topics show stronger alignment with long-term sustainability efforts, though the relationship is statistically significant only in certain dimensions. These results suggest that immaterial assurance reflect symbolic behavior, potentially diverting attention and resources away from impactful sustainability initiatives.

Moreover, we find that ESG assurance does not uniformly translate into better sustainability performance. On average, firms with ESG assurance display higher levels of resource consumption and CO_2 emissions—an outcome primarily driven by those focusing on immaterial topics. Conversely, firms with a higher material assurance ratio tend to show more favorable environmental performance, although the effects are more muted, possibly due to the long-term nature of sustainability transitions. These patterns reinforce the view that assurance of immaterial topics can mislead stakeholders and may even hinder substantive progress.

Importantly, our findings suggest that investors are capable of discerning the difference between symbolic and substantive ESG assurance. Both overall assurance and material assurance ratios are positively associated with the number of institutional and socially responsible

investors , while immaterial assurance shows no such effect. Notably, a higher immaterial assurance ratio is negatively associated with SRI ownership proportion, indicating that these investors perceive immaterial assurance as a red flag. This highlights the potential for material assurance to act as a credible signal that attracts long-term, sustainability-oriented capital.

Finally, when examining the relationship between ESG assurance and information asymmetry, we find that the market currently recognizes the presence of assurance but pays less attention to what is actually being assured. In our analysis, overall ESG assurance is positively associated with lower information asymmetry, as measured by analyst forecast accuracy. However, the share of material assurance—assurance on ESG topics deemed financially material—is only positively but not significantly associated with reduced information asymmetry. In contrast, non-material assurance is negatively (albeit insignificantly) related to forecast accuracy, suggesting that assuring irrelevant ESG topics may even mislead or dilute the usefulness of disclosures.

Our findings provide a nuanced answer to the central question: ESG assurance alone is not a reliable signal of genuine sustainability commitment. What matters is what is being assured. Assurance focused on immaterial ESG topics not only fails to drive meaningful sustainability outcomes but may actively mislead stakeholders and attract skepticism from responsible investors. In contrast, material assurance—though not always statistically significant—shows consistent associations with more credible sustainability behavior, investor trust, and reduced information asymmetry. These results underscore the urgent need for stakeholders to look beyond the presence of ESG assurance and critically evaluate its content. Only by aligning assurance with financially material ESG issues can we distinguish truly committed firms from those engaging in symbolic sustainability practices.

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A Appendix I

This table presents variable definitions for our empirical tests.

Variable	Definition
ESG Reporting and Assurance	
Rm	The ratio of assured material ESG topics. Material Assurance Ratio = Number of Assured Material ESG Items / Total Number of Material ESG Items. From firm's assurance report.
Ri	The ratio of assured immaterial ESG topics. Immaterial Assurance Ratio = Number of Assured Immaterial ESG Items / Total Number of Immaterial ESG Items. From firm's assurance report.
Assurance	Indicator variable equal to 1 if a firm issues ESG reports and obtains assurance in a year, 0 otherwise. From each firm's official website.
Green Innovation (PATSTAT)	
Green Patent	Number of green patents filed by the firm, following Favot et al. (2023).
Prevention Patent	Number of pollution prevention patents, following Cheng et al. (2025).
Control Patent	Number of pollution control patents, following Cheng et al. (2025).
GHG Patent	Number of GHG patents, following Cohen et al. (2020).
Energy Patent	Number of energy-related patents, following Cohen et al. (2020).
Water Patent	Number of water-related patents, following Cohen et al. (2020).
Waste Patent	Number of waste-related patents, following Cohen et al. (2020).
Air Quality Patent	Number of air quality patents, following Cohen et al. (2020).
Biodiversity Patent	Number of biodiversity-related patents, following Cohen et al. (2020).
Product Design Patent	Number of product design patents, following Cohen et al. (2020).
Sustainability Outcomes (Refinitiv Eikon)	

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Table 13 – continued from previous page

Variable	Definition
CO_2	Log-transformed (ln(1+x)) Scope 1 + Scope 2 CO_2 emissions scaled by total assets (in millions of dollars).
Energy	Log-transformed (ln(1+x)) energy use scaled by total assets (in millions of dollars).
Water	Log-transformed (ln(1+x)) water withdrawal scaled by total assets (in millions of dollars).
Waste	Log-transformed (ln(1+x)) hazardous waste scaled by total assets (in millions of dollars).
Information Asymmetry	
Forecast Accuracy	Analysts' earnings forecast accuracy, following Cuadrado-Ballesteros et al. (2017). From PATSTAT.
Investor Trust (FactSet and PRI)	
SRI Ownership	Percentage of shares owned by socially responsible investors (SRIs).
Institutional Ownership	Percentage of shares owned by institutional investors.
Number of SRIs	Number of SRIs from PRI list, following Heath et al. (2023).
Number of Institutional Investors	Number of institutional investors from FactSet, standardized to mean 0 and variance 1, following de Silanes et al. (2024) and Gipper et al. (2024).
Firm Characteristics (Compustat)	
NetPPE	Net property, plant, and equipment scaled by lagged total assets.
Cash	Cash from assets-in-place scaled by lagged total assets.
Age	Natural log of (current fiscal year – first year with data in Compustat).
Leverage	Total liabilities divided by total equity at fiscal year-end.
Loss Indicator	1 if earnings per share excluding extraordinary items ¡ 0, 0 otherwise.
Book-to-Market	Book value of equity divided by market value of equity at fiscal year-end.
ROA	Earnings before extraordinary items divided by average total assets.
Size	Natural log of market value of equity at fiscal year-end.

B Appendix II

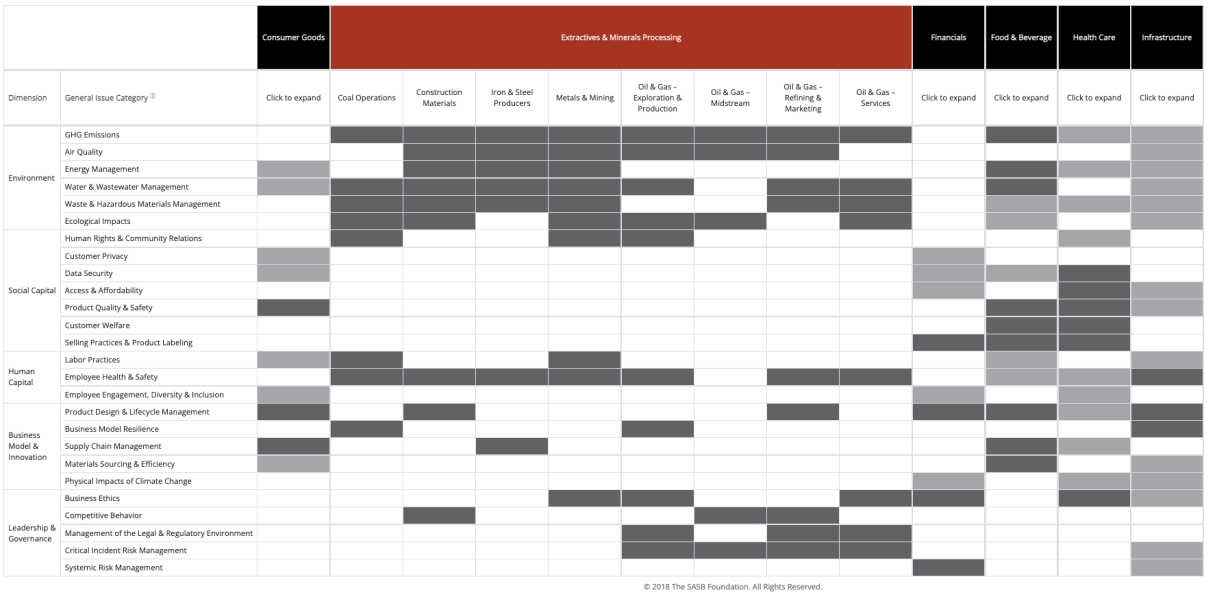

Figure 1: Enter Caption