Sustainability dependencies information and audit effort: empirical evidence from European firms

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Abstract

This study examines how information on sustainability dependencies, defined as a firm's reliance on natural, social, and economic resources that underpin its ability to generate value, relates to audit effort. While prior literature has largely focused sustainability impacts and externalities, we propose that information on sustainability dependencies is more relevant to auditors' assessments of audit risk. Drawing on a sample 145 publicly listed European firms between 2013 and 2022, we operationalize sustainability dependency information through two dimensions: the extent of sustainability-related financial disclosures and the alignment of sustainability disclosures across sustainability and annual financial reports. Using proprietary data from Datamaran, we find that both dimensions are associated with shorter audit report lags, suggesting reduced audit effort. Additional analyses indicate that these associations are not driven by audit pricing incentives and are consistent with lower perceived audit risk, as evidenced by a reduced likelihood of auditor dismissal. These findings contribute to the auditing literature by empirically validating the relevance of sustainability dependencies information for audit risk assessments. Moreover, our results highlight alignment across reporting channels as a credible signal of audit risk, supporting ongoing regulatory efforts to enhance the integration between financial and sustainability reporting.

1. Introduction

The role of financial auditors in evaluating sustainability-related risks and information has attracted growing attention from both practitioners and scholars (Turner & Meirich, 2023). Auditing standards require that auditors must obtain a deep understanding of their client's business environment, including its industry, operational complexity, and associated risks, to provide reasonable opinion that the financial statements are free from material misstatements (i.e. audit risk), whether due to error or fraud (IAASB, 2010; PCAOB, 2010).

As sustainability issues increasingly intersect with financial reporting, research has investigated how auditors incorporate sustainability factors into their assessment of audit risk (Asante-Appiah, 2020; Asante-Appiah & Lambert, 2023; Brooks & Cheng, 2024; Burke et al., 2019; Dal Maso et al., 2020; Koh & Tong, 2013; Hartlieb & Eierle, 2024; Lee et al., 2025; LópezPuertas-Lamy et al., 2017). A growing body of research have also started to focus on examining how sustainability information influences the auditing process and audit outcomes, such as audit pricing (Chen et al., 2016; Wang et al., 2020), audit quality (Al-Shaer, 2020), and audit effort (Wang & Wang, 2023).

Nevertheless, recent work highlights the importance of distinguishing between different types of sustainability information. Traditional sustainability reporting frameworks, such as the Global Reporting Initiative (GRI), primarily emphasize corporate impacts or externalities, that is, the firm's social and environmental effects on the broader system (Michelon et al., 2024; O'Dwyer & Unerman, 2020). In contrast, emerging frameworks such as the TCFD and ISSB increasingly focus on sustainability dependencies—a firm's reliance on natural, social, or economic resources that underpin its ability to generate value (O'Dwyer & Unerman, 2020; Barker & Mayer, 2023; Barker et al., 2018). These dependencies expose firms to material risks and opportunities that can affect their operations and financial position (Cooper & Michelon, 2022; Unerman et al., 2018). For example, fossil fuel reserves may lose value if regulatory changes render them "unburnable" (Bebbington et al., 2020), and violations of social norms can damage profitability through reputational harm or litigation (Capelle-Blancard & Petit, 2019). Governance structures such as executive integrity and employee relations are also

critical dependencies with clear financial implications (Asante-Appiah & Lambert, 2023; Friedman & Heinle, 2016). Thus, information on sustainability dependencies is assumed to be particularly important for financial stakeholders, as it reflects the firm's exposure to sustainability-related risks and opportunities and their potential financial implications (O'Dwyer & Unerman, 2020).

The potential distinction between types of sustainability information is central to our choice of conceptual framework. Auditors, whose primary responsibility is to assess audit risk, are less likely to be equally concerned with all types of sustainability information. Instead, they are more likely to focus on information that is financially material and directly affect financial reporting. Information on sustainability dependencies, which captures firms' exposure to sustainability-related risks and opportunities, is therefore particularly relevant for audit risk assessment. Such information is likely to influence the level of audit effort required to reduce audit risk to an acceptably low level (Zhang, 2018; Simunic, 1980; Simunic & Stein, 1996).

Building on this conceptual foundation, we empirically examine how information on sustainability dependencies influences audit effort, proxied by audit report lag (Asante-Appiah, 2020; Aobdia & Petacchi, 2023; Caramanis & Lennox, 2008; DeFond & Zhang, 2014; Knechel & Sharma, 2012). We focus on two different yet complementary dimensions of information on sustainability dependencies. First, we consider the extent of sustainability-related financial disclosures provided in the annual report (hereafter, *sustainability-related financial disclosures*). These disclosures typically appear in the front-end sections such as the strategic report or risk disclosures, and, in some cases, within the financial statements (Barker & Mayer, 2023; O'Dwyer & Unerman, 2020). They communicate how firms manage sustainability-related risks and opportunities and the associated financial implications (Lin et al., 2024; Wang et al., 2024). More extensive and higher-quality disclosures may assist auditors in assessing audit risk by clarifying the financial effects of sustainability dependencies, indicating the effectiveness of internal controls, or informing the complexity of audit engagements (Cho et al., 2013; de Villiers et al., 2011; Hummel & Schlick, 2016; Verrecchia, 1990). As such, we expect that firms providing more extensive sustainability-related financial disclosures are associated with lower audit risk, thereby requiring less audit effort.

Second, we examine the alignment of sustainability disclosures across the annual report and the standalone sustainability report (hereafter, *alignment of sustainability disclosures*). Recent research suggests that impact disclosures, typically found in standalone sustainability reports, can also provide information about a firm's sustainability dependencies (Barker & Mayer, 2023). This is because corporate impacts and externalities may become internalized as financial risks, particularly as sustainability-related concerns evolve (Cooper & Michelon, 2022), offering predictive insight into a firm's exposure to sustainability dependencies (Barker & Mayer, 2023). We thus argue that the alignment of sustainability disclosures reflects the consistency of sustainability information across reporting channels and may indicate that the firm embeds sustainability considerations into its broader corporate strategy and governance structures (Barth et al., 2017; Wang et al., 2024; Zhou et al., 2017). Furthermore, aligned disclosures may reduce ambiguity for auditors by presenting more consistent and accessible information about the firm's sustainability-related exposures and responses (Barth et al., 2024; Caglio et al., 2020). We therefore expect the greater alignment of sustainability disclosures is associated with lower audit effort.

We use proprietary data from Datamaran, an AI-powered ESG analytics platform, to measure sustainability-related financial disclosures and the alignment of sustainability disclosures. Our sample consists of 145 publicly listed European firms[1] (1152 firm-year observations) over the period 2013 to 2022. We focus on the European context due to its strong regulatory emphasis on sustainability reporting and institutional support for the integration of sustainability and financial reporting (Giner & Luque-Vilchez, 2022). The sample period begins in 2013, coinciding with the European Union's deliberation over the Non-Financial Reporting Directive (NFRD). This directive marked a significant turning point in the evolution of sustainability reporting across Europe (Cho et al., 2022; Christensen et al., 2021). We therefore consider 2013 an appropriate starting point, as the landscape of sustainability reporting prior to this year can be fundamentally different.

[1] We exclude firms with integrated reporting because the IIRC framework incorporates connectivity as one of its guiding principles, which may influence our assessment of alignment of sustainability disclosures metrics, potentially confounding our tests and affecting the validity of our results.

We find that more sustainability-related financial disclosures and greater alignment of sustainability disclosures are significantly associated with lower audit effort. To examine whether the observed reduction in audit report lag reflects information benefit of audit risk rather than commercial or pricing pressures, we test the association between both information dimensions and audit fees. This test is motivated by the possibility that faster audit completion may be driven by client pressure or fee negotiations, rather than by actual reductions in audit risk (DeFond & Zhang, 2014; Knechel & Sharma, 2012; Simunic, 1980). However, we find no significant relationship between alignment and audit fees, suggesting that the shorter audit lag is not attributable to pricing dynamics. Furthermore, we find that firms with more sustainability-related financial disclosures and greater alignment of sustainability disclosures are less likely to dismiss their auditors. Given that prior research indicates riskier client firms are more prone to auditor switches or dismissals (Ghosh & Tang, 2015), this finding implies that firms with higher alignment of sustainability disclosures tend to have lower audit risk. Together, these findings suggest that firms that communicate their sustainability dependencies more consistently across reports are perceived by auditors as lower-risk clients and benefit from more efficient audit processes.

This study provides several contributions. First, we extend the growing body of research examining sustainability information and auditing by highlighting sustainability dependencies information as financially material. While prior research has primarily focused on sustainability impacts and externalities, which are typically disclosed in sustainability reporting, we focus on the relevance of information on sustainability dependencies for auditors' assessments of audit risk. Although the conceptual research has proposed the importance of information on sustainability dependencies for financial stakeholders (e.g., Barker & Mayer, 2023; O'Dwyer & Unerman, 2020), empirical evidence in this area remains scarce. Our finding on the relationship between the alignment of sustainability disclosures and audit effort offers early empirical validation of its importance in the auditing context. More broadly, we encourage future research to disaggregate sustainability information and explore which forms are most relevant to economically consequential decisions such as auditing.

Second, we contribute to the operationalization of the sustainability dependencies information

construct by proposing two measurable dimensions: (1) sustainability-related financial disclosures and (2) the alignment of sustainability disclosures. Our findings suggest that not the presence but the alignment of such information, especially across reporting channels, matters for auditing process. In this way, we also add to emerging conceptual frameworks that emphasize the role of communicating sustainability dependencies to financial decision-making (Barker & Mayer, 2023; O'Dwyer & Unerman, 2020).

This study also offers important practical implications for standard-setters and policymakers. TCFD, ISSB, and SASB have increasingly emphasized the need for financially-material sustainability information to support decision-useful reporting for financial stakeholders. Our findings support these efforts by showing that aligned disclosures of such information, particularly across financial and sustainability reporting channels, is relevant to auditors' assessments of risk and effort. Furthermore, our results contribute to ongoing discussions around improving the connectivity between financial and sustainability reporting (Accountancy Europe, 2019; GRI & IFRS, 2024; EFRAG, 2024). We show that alignment between sustainability disclosures may serve as a signal of internal reporting quality and reduce audit effort. This suggests that firms with more aligned corporate reporting practices not only benefit capital markets (Barth et al., 2024; Caglio et al., 2020; Wang et al., 2024; Zhou et al., 2017) but also support more efficient and effective audits.

The remainder of this paper is organized as follows. Section 2 provides the conceptual framework and section 3 presents relevant literature and develops our hypotheses. Section 4 describes the research design and sample selection process. Sections 5 and 6 present the descriptive statistics and empirical results. Section 7 presents the conclusion.

2. Conceptual framework

Recently, O'Dwyer and Unerman (2020) introduce the concept of sustainability dependencies to problematize the TCFD framework and call for further research into forms of corporate reporting that better address sustainability-related risks and opportunities. In light of the various types of sustainability information, the concept of sustainability dependencies offers a useful lens to understand how firms' information on sustainability dependencies is particularly

relevant to the financial auditing process.

Dependencies refers to firms' reliance on, and use of, some form of resource (such as natural capital) (Barker et al., 2018, p.15). Firms' dependencies on society, natural environment and the economy (i.e., sustainability dependencies) can expose them to significant risks and opportunities that materially affect corporate operations and financial positions (Cooper & Michelon, 2022; Unerman et al., 2018). For example, firms that depend on fossil fuel reserves may see their asset values deteriorate if climate policies render such resources "unburnable" (Bebbington et al., 2020). Violation of social norms can threaten firms' profitability and viability through decreased consumer demand or increased litigation risk (Capelle-Blancard & Petit, 2019). Moreover, firms' governance structures, including management integrity and employee relations, can significantly influence financial performance (Asante-Appiah & Lambert, 2023; Friedman & Heinle, 2016).

Information on sustainability dependencies provides critical insights into how firms manage potential sustainability-related risks, opportunities and associated financial implications. Typically, such information can be found in financial annual reports. In this paper, we refer to this information in the financial annual report as *sustainability-related financial disclosures*, following the TCFD framework and ISSB S1 and S2 (O'Dwyer & Unerman, 2020; Barker & Mayer, 2023). Sustainability-related financial disclosures in the front-end of the annual report - such as those in the strategic report or risk disclosures - provide important information about a firm's approach to sustainable value creation (Lin et al., 2024; Wang et al., 2024). Further, Barker and Mayer (2023) suggest that firms' financial statements under current IFRS standards are already influenced by some key sustainability dependences. For example, standards such as IAS 37 (contingent liabilities arising from waste and emissions) and IAS 19 (disclosures related to human rights and employee benefits) embed sustainability concerns into financial reporting practices (Burke et al., 2019; EFRAG, 2021). Accordingly, information on sustainability dependencies differs from broader sustainability reporting in that it specifically reflects material sustainability-related financial information, rather than solely focusing on firms' material impacts or externalities (Barker & Mayer, 2023; O'Dwyer & Unerman, 2020). Such information enables stakeholders to assess firms' physical and transactional risks and to more

effectively evaluate and estimate potential financial outcomes stemming from sustainability dependencies. Given the increasing financial materiality of sustainability issues, information on sustainability dependencies is likely to be highly relevant to auditors' risk assessments.

We argue that information on sustainability dependencies is particularly important for auditors because it directly informs their assessment of audit risk, which ultimately influences the level of audit effort required. *Audit risk* refers to the risk that the auditor expresses an inappropriate opinion when financial statements are materially misstated (ISA 200). Audit risk is conceptualized as a function of inherent risk, control risk and detection risk (ISA 315; Dusenbury et al., 2000; Houston et al., 1999; Hogan & Wilkins, 2008). *Inherent risk* is defined as "the susceptibility of an assertion about a class of transaction, account balance or disclosure to a misstatement that could be material, either individually or when aggregated with other misstatements, before consideration of any related controls" (ISA 200, 2018, p.6). *Control risk* is defined as "the risk that a misstatement that could occur in an assertion about a class of transaction, account balance or disclosure and that could be material, either individually or when aggregated with other misstatements, will not be prevented, or detected and corrected, on a timely basis by the entity's internal control" (ISA 200, 2018, p.6). Both risks are linked to the characteristics and governance of the audited firm itself. *Detection risk* is defined as "the risk that the procedures performed by the auditor to reduce audit risk to an acceptably low level will not detect a misstatement that exists and that could be material, either individually or when aggregated with other misstatements" (ISA 200, 2018, p.4). It reflects the effectiveness of the auditor's planning, testing, and professional judgment in carrying out the audit. The combined level of these three risks determines overall audit risk, which in turn affects the extent of audit effort required to reduce audit risk to an acceptably low level (Zhang, 2018; Simunic, 1980; Simunic & Stein, 1996).

Information on sustainability dependencies is theoretically relevant to audit risk. Firms' reliance on natural, societal, and economic resources exposes them to sustainability-related risks, such as regulatory shifts, resource scarcity, operational disruptions, and reputational threats, which can materially impact financial reporting. However, when firms provide extensive and high-quality information on their sustainability dependencies, this information can help auditors

better assess and manage audit risk. For example, sustainability dependencies potentially increase inherent risk by elevating the baseline likelihood that transactions and the recognition or evaluation of assets, liabilities and cash flows are misstated. Environmental exposures, for example, can significantly affect asset impairments or contingent liabilities under IFRS standards (Bebbington et al., 2020). However, firms providing information on their sustainability dependencies can improve auditors' understanding of how these may affect the financial reports. Moreover, given the complexities of sustainability information, managing such disclosures typically requires robust internal control mechanisms (Christensen et al., 2021; Dhaliwal et al., 2012). Firms that adequately address or disclose their sustainability dependencies may demonstrate effective internal controls, thereby lowering auditors' assessment of control risk. In addition, information on sustainability dependencies also informs detection risk by influencing auditors' ability to design and execute effective audit procedures. Detailed and consistent information may signal that the audit engagement will involve lower complexity or challenges in identifying potential misstatements and obtaining sufficient appropriate audit evidence.

Prior literature in financial auditing provides empirical support for the relevance of sustainability-related risks and opportunities to audit processes. Several studies find that auditors incorporate signals of sustainability-related risks, such as media coverage, CSR ratings, and reputational controversies, into their risk assessments and pricing decisions (Asante-Appiah, 2020; Burke et al., 2019; Cao et al., 2012; Koh & Tong, 2013). Research on CSR performance also suggests that poor sustainability performance can elevate audit risk and increase audit pricing (Brooks & Cheng, 2024; Garcia et al., 2021; LópezPuertas -Lamy et al., 2017). Although most studies focus on audit fees, some have specifically linked environment-related risks to heightened audit attention. For example, Sharma et al. (2018) find that firms undertaking environmental initiatives pay higher audit fees, reflecting auditors' concerns over environmental uncertainties. More recently, Hartlieb and Eierle (2024) show that U.S. firms facing greater physical and transition climate risks incur higher audit fees, suggesting that auditors actively respond to sustainability exposures. These findings collectively indicate that sustainability-related risks and information are important to auditors' risk assessments and

engagement planning, supporting the theoretical relevance of sustainability dependencies information for audit risk and audit effort.

Overall, the information disclosed on sustainability dependencies are expected to be relevant to the overall audit risk profile and the amount of audit effort required. Nevertheless, despite its theoretical relevance, empirical research examining the relationship between information on sustainability dependencies and audit effort remains scarce.

3. Literature review and hypotheses development

Prior research provides some support for the idea that sustainability reporting influences the auditing process, though much of the literature focuses on disclosures about firms' impacts and externalities (Michelon et al., 2024). Early work examines the issuance of standalone sustainability reports[2] and finds they are associated with variations in audit fees. For example, Chen et al. (2016) find that U.S. firms issuing such reports tend to pay higher audit fees. They argue that firms They argue that firms investing in voluntary sustainability reporting demonstrate stronger commitment to transparency and corporate reporting quality, prompting auditors to increase fees. However, Wang and Wang (2023) show that mandatory sustainability reporting can improve the information environment and reduce audit effort (as proxied by shorter audit report lags), while little effect on audit fees. Al-Shaer (2020) finds that high-quality sustainability reporting, which is characterized by governance mechanisms such as sustainability committees and executive incentives tied to sustainability goals, is associated with higher earnings management. Importantly, they find that lower-quality sustainability reporting necessitates greater audit effort, as reflected in longer audit report lags. Similarly, Wang et al. (2020) demonstrate that although firms offering loan guarantees typically face higher audit fees due to increased audit risk, the disclosure of more detailed sustainability information helps to mitigate the audit fee premium.

Collectively, these studies suggest that sustainability reporting can either increase or decrease

[2] The term "sustainability report" is used inconsistently in the literature. Many early studies equate it with corporate social responsibility (CSR) reports. In this paper, we follow the convention of treating standalone sustainability and CSR reports as comparable forms of sustainability reporting.

audit effort depending on the credibility, transparency, and financial relevance of the information provided. However, the literature has yet to focus explicitly on information on sustainability dependencies. Building on this gap, we argue that sustainability-related financial disclosures are likely to be associated with reduced audit effort.

In addition to the earlier theoretical reasoning linking information on sustainability dependencies to audit risk components, we draw on complementary empirical perspectives to further motivate our prediction. Auditors may assess lower audit risk for client firms that disclose more extensive sustainability-related financial disclosures for two reasons indicated from prior empirical research. First, from an information perspective, greater sustainability disclosures are observed to reduce information asymmetry among stakeholders (Cho et al., 2013; Verrecchia , 1990), signalling greater management integrity and a corporate culture emphasizing strong behavioural norms and long-term strategic orientations (de Villiers et al., 2011). Second, from a voluntary disclosure perspective, firms with better sustainability performance - and thus stronger management of sustainability-related financial risks - are more likely to be transparent about their activities (Hassan et al., 2020; Hummel & Schlick, 2016). Transparent disclosure behaviour is often interpreted by auditors as a signal of sound governance and effective risk management, suggesting a lower likelihood of material misstatements.

Together, these considerations suggest that firms providing more extensive sustainability-related financial disclosures are less likely to pose a low audit risk, thereby requiring less audit effort. Accordingly, we posit the following hypothesis:

> *H1: The extent of sustainability-related financial disclosures is negatively associated with audit effort.*

Building on the preceding discussion, we next consider another dimension of information on sustainability dependencies: the alignment of sustainability disclosures across the annual report and the sustainability report. Traditionally, the annual report focuses on financially material risks and opportunities relevant to investors, whereas the sustainability report addresses broader societal and environmental impacts for a wider range of stakeholders (O'Dwyer & Unerman,

2020). While sustainability reporting frameworks such as GRI primarily emphasize firms' environmental, social, and economic impacts on external stakeholders (O'Dwyer & Unerman, 2020), recent work suggests that these disclosures can also provide information regarding sustainability dependencies. Barker and Mayer (2023) propose that impact disclosures may offer predictive insights into firms' future financial risks and thus sustainability dependencies, particularly through the internalization of externalities as social and environmental factors evolve (Cooper & Michelon, 2022). We thus argue that the degree to which sustainability disclosures are consistently communicated across corporate reports reflects a firm's capacity to integrate and manage sustainability dependencies in a financially relevant manner. Greater alignment of sustainability disclosures may signal that a firm integrates sustainability dependencies into its overall corporate strategy and operations.

From an audit perspective, such alignment reduces uncertainty among stakeholders, including auditors, regarding the firm's long-term viability and exposure to sustainability-related risks (Barth et al., 2017; Wang et al., 2024; Zhou et al., 2017). As a result, auditors may perceive lower audit risk for firms with more alignment of sustainability disclosures.

In addition, prior literature on integrated reporting suggests that better alignment of sustainability disclosures likely reduces the complexity of understanding information on sustainability dependencies, thereby lowering auditors' processing costs and enabling a more holistic view of the firm. For example, empirical evidence shows that corporate voluntary reporting often contain firm-specific information that helps mitigate the complexity of financial information (e.g., Ball et al., 2012; Li & Yang, 2016). Further, studies examining the textual attributes of integrated reports show that high-quality, connected financial and sustainability disclosures provide more firm-specific information, which is reflected in stock prices (Barth et al., 2024) and valued by capital markets (Caglio et al., 2020). Similarly, auditors may benefit from the alignment of sustainability disclosures and spend less efforts.

Together, we posit that greater alignment of sustainability disclosures is associated with lower audit risk and less audit effort. Accordingly, we propose the following hypothesis:

H2: The alignment of sustainability disclosures is negatively associated with audit effort.

4. Data and research design

4.1. Sample and data collection

The initial sample includes European firms with available data on accounting fundamentals and sustainability-related activities in Thomson Reuters Eikon from 2013 to 2022. Firms from financial institutions are excluded from the analysis as they subject to different levels of regulatory requirements, stakeholder scrutiny and sustainability dependencies. The sample period begins in 2013 because that is the year when the EU started discussing the adoption of the NFRD, which mandates firms to disclose non-financial information alongside their annual reports. This directive marked a significant shift in the sustainability reporting landscape in Europe (Cho et al., 2022; Christensen et al., 2021). Consequently, we believe the reporting environment prior to 2013 was fundamentally different, making 2013 an appropriate starting point for our study.

We focus on firms that issue standalone sustainability reports and annual reports, excluding those that issue integrated reports, for two main reasons. First, integrated reports are prepared in accordance with the IIRC's Integrated Reporting Framework, which is designed to provide insights into resources and relationships (i.e., the six "capitals") and incorporates a connectivity principle3 that links information about these capitals with financial information. As a result, sustainability reporting under the IR framework can differ significantly from that of firms that do not follow this approach. Second, for the purpose of our study, analysing firms with standalone sustainability reports and annual reports allows us to explicitly examine the alignment of sustainability disclosures across the two reports.

We obtain auditing-related data from Audit Analytics, and corporate financial fundamentals and sustainability reporting-related data from Thomson Reuters Eikon. Data on sustainability-related financial disclosures are retrieved from Datamaran. Table 1 summarizes the sample

[3] The six capitals are financial, manufactured, intellectual, human, social and relationship, and natural (IIRC, 2021). Connectivity of information is one of six principles guiding the content and presentation of the integrated report. IR framework (IIRC, 2021, p.26) defines connectivity as: "An integrated report should show a holistic picture of the combination, interrelatedness and dependencies between the factors that affect the organization's ability to create value over time."

selection process. Our initial sample comprises 48227 observations (2123 firms) covered by Asset 4 database from 2013 to 2022 that have relevant accounting and sustainability data. After deleting observations due to missing data required to construct audit report lag and other main variables and firms in financial institutions, our sample includes 1152 observations from 145 firms. Table 2 Panel A presents the sample distribution by country, and Panel B shows the distribution by year. Nearly half of our sample come from Germany, Spain and United Kingdom, and the sample appear consistently distributed over the study period.

[Insert Table 1 about here]

[Insert Table 2 about here]

4.2. Data on sustainability-related financial disclosures

Datamaran is an advanced AI-powered platform that analyses extensive data sources to provide insights into ESG factors, including material issues, sustainability reporting, and regulatory developments. Using natural language processing (NLP), it quantifies narrative disclosures from a wide range of sources, such as annual financial reports, sustainability reports, SEC filings, regulatory documents (both mandatory and voluntary), as well as social media and online news (Yaghmaei & van de Poel, 2021; Wang et al., 2025). For example, Datamaran data has been utilized in prior sustainability literature to measure international mandatory and voluntary legislations (e.g., Hoepner et al., 2021).

We rely primarily on the emphasis index data of Datamaran to measure the two dimensions of information on sustainability dependencies: sustainability-related financial disclosures and the alignment of sustainability disclosures.

Developed by Datamaran's data science team, the methodology combines quantitative and qualitative approaches to assess emphasis. The index captures the relative importance of a sustainability topic within a report on a continuous scale. Its calculation considers variables such as the number of sentences referencing the topic ("hits"), the prominence of its location (e.g., greater weight if mentioned in the CEO letter compared to footnotes), the density of mentions per sentence (avoiding redundancy), and the overall frequency of topics within the document (Datamaran, 2023). To sum up, the emphasis index reflects the overall importance of

a sustainability topic to a firm as indicated in the report's disclosures and a higher index for a topic indicates greater importance of the topic to the firm.

We believe that the emphasis index data of Datamaran is well-suited for this study for the following reasons. Empirical social and environmental studies using content analysis methods suggest that the extent of disclosure can serve as an indication of the importance of an issue to the reporting entity (Krippendorff, 2018; Milne & Adler, 1999; Vourvachis & Woodward, 2015). Since the emphasis index directly measures the degree to which a particular sustainability topic is explicitly discussed in a report, capturing both the breadth of its coverage and the depth of the disclosures, it provides a meaningful representation of a corporation's reliance on or emphasis of a sustainability issue (i.e., corporate dependences). Moreover, the Datamaran dataset encompasses a wide range of entities globally, and its emphasis index data are standardized and comparable across reports. This ensures consistency and reliability in measuring sustainability-related financial disclosures and the alignment of sustainability disclosures across the sample.

4.3. Empirical models

We test the association between audit effort and sustainability-related financial disclosures (H1) and the association between audit effort and the alignment of sustainability disclosures (H2) based on the following model:

$$AULAG_{it} = \beta_0 + \beta_1 Disclosures_{it} \; or \; [\beta_1 Alignment_{it}] + CONTROLS \; + \; INDUSTRY, COUNTRY, YEAR \; FIXED \; EFFECTS + \epsilon_{it} \quad (1)$$

Detailed definitions of all variables are provided in Appendix A.

Dependent variable: Audit lag (AULAG)

The dependent variable, AULAG, is the natural logarithm of audit lag, which is our proxy for audit effort. Audit lag is defined as the number of days between a firm's fiscal year-end and the audit report date. In the audit literature, audit report lag is widely recognized as a direct measure of audit effort, reflecting the total audit hours dedicated to the engagement (Asante-Appiah, 2020; Aobdia & Petacchi, 2023; Caramanis & Lennox, 2008; DeFond & Zhang, 2014; Knechel

& Sharma, 2012).

Independent variables:

Sustainability-related financial disclosures (Disclosures)

The independent variable, *Disclosures*, captures the extent of sustainability-related financial disclosures presented in a firm's annual report. It is constructed using Datamaran's emphasis index, which quantifies the breadth of coverage and the depth of the disclosures of sustainability-related topics across a firm's report. Specifically, we calculate *Disclosures* as the sum of emphasis scores for all identified sustainability topics disclosed in the annual report for a given firm-year (see Section 3.2 for details).

As previously discussed, these disclosures, appearing primarily in front-end sections or financial statements in the annual report, indicate firms' exposures to sustainability-related risks and opportunities and their implications for financial reporting. Consistent with Barker and Mayer (2023) and O'Dwyer and Unerman (2020), these disclosures are not merely general sustainability information but reflect financially material sustainability dependencies. We therefore argue that the extent of sustainability-related disclosures in the annual report serves as an empirical proxy for the extent of the firm's information on sustainability dependencies.

We hypothesize that auditors will spend less effort for client firms with greater sustainability-related financial disclosures. Accordingly, we expect a negative sign on β_1, the coefficient on *Disclosures*.

Alignment of sustainability disclosures (Alignment)

H2 investigates whether there is an association between audit effort (AULAG) and the alignment of sustainability disclosures across the annual report and sustainability report (Alignment). We propose that firms that report sustainability disclosures in both their annual financial reports and sustainability reports in a more aligned approach are more likely to be perceived as posing lower audit risk, thereby reducing the audit effort required. We construct the variable Alignment, based on Datamaran's emphasis index, which measures the alignment of sustainability disclosures between the annual report and the sustainability report.

Construction of Alignment

We compute *Alignment* using cosine similarity, which quantifies the angular distance between two vectors of emphasis scores for the same set of sustainability topics disclosed in both reports (Brown et al., 2023; Qiu et al., 2023). In other words, In this framework, the sustainability-related financial disclosures in the annual report serve as the reference, and we assess how closely the sustainability report mirrors these themes in emphasis. The specific steps are as follows:

First, we create a vector of topics N for a firm, where N is the unique number of sustainability topics disclosed in the firms' annual report. The value for each topic is its Datamaran emphasis index. Second, let vectors $x_i = (x_{i1}, x_{i2}, \dots, x_{iN})$ and $y_i = (y_{i1}, y_{i2}, \dots, y_{iN})$ represent firm i's annual report and sustainability report, respectively. Third, we compare the angles of normalised emphasis score vectors to compute cosine similarity (Alignment), using the following formula:

$$\boldsymbol{Alignment_{i,t}} = \mathbf{cos}(\boldsymbol{\alpha_{ij}}) = \frac{\sum_{\mathbf{n=1}}^{\mathbf{N}}(\boldsymbol{x_{i,n,t}} * \boldsymbol{y_{i,n,t}})}{\sqrt{\sum_{\mathbf{n=1}}^{\mathbf{N}}(\mathbf{x_{i,n,,t}^2})} * \sqrt{\sum_{\mathbf{n=1}}^{\mathbf{N}}(\mathbf{y_{i,n,t}^2})}}$$

where $Alignment_{it}$ represents the degree of alignment of sustainability disclosures between the firm i's annual report and sustainability report in year t. $x_{i,n,t}$ represents the emphasis index value of the n^{th}sustainability topic in the annual report for firm i in year t, and $y_{i,n,t}$ represents the emphasis index of the n^{th} sustainability topic in the sustainability report for firm I in the year t.

The $Alignment_{it}$ ranges from 0 to 1, where a higher value indicates greater alignment in how the firm reports its sustainability dependencies across the two reports. Full details of the calculation process are provided in Appendix B.

Control variables

Following prior research, we include a set of control variables commonly associated with audit effort, proxied by audit report lag (Aobdia & Petacchi, 2023; Asante-Appiah, 2020; Knechel & Sharma, 2012). To account for client-level risk and complexity, we control for firm size (SIZE), profitability (ROA), financial leverage (LEV), bankruptcy risk (Altman Z-score, ZSCORE),

growth opportunities (market-to-book ratio, MTB), merger and acquisition activity (M&A), and foreign operations (FOREIGN). We also include a measure of asset structure (INVRET), calculated as the ratio of inventories and receivables to total assets (Huang et al., 2024; Hay, 2013).

To account for the influence of corporate governance factors, we include GOVSCORE, a governance performance score based on Refinitiv's ASSET4 data, which captures sustainability-related policies, board structure, executive compensation, and shareholder rights (Dal Maso et al., 2020).

We account for audit-specific attributes such as audit fees (AUFEE), audit related non-audit fees (NOAUFEE), whether the client firm announce restatement during the year (MISSTATE), and whether the audit is performed in busy audit search (in December: DEC). We also control for auditor characteristics, including whether the firm is audited by a Big 4 auditor (BIG4) and whether the audit engagement is in the auditor's first year (FIRST_AUDIT).

Finally, we control for firms' exposure to ESG-related reputational risks using ESGCONTROVERSIES, a measure of environmental, social, and governance controversies derived from global media sources (Asante-Appiah, 2020; Burke et al., 2019; Koh and Tong, 2013). A lower score indicates greater frequency or severity of CSR-related negative events, which may increase auditor scrutiny[4].

All regression models include year, Fama-French 30 industry, and country fixed effects. Standard errors are clustered at the firm level. Continuous variables are winsorised at the 1st and 99th percentiles to mitigate the influence of outliers.

5. Results

5.1. Descriptive statistics

Table 3 presents summary statistics for all variables used in the main regression analyses. The average value of the natural logarithm of audit report lag (AULAG) is 4.14 (SD = 0.29), broadly

[4] For more detailed information about the ESG controversies score, see Tomson Reuters (2019): Environmental, social & governance scores guide

consistent with prior literature (e.g., Asante-Appiah, 2020; Knechel & Sharma, 2012). Mean audit fees (AUFEE = 14.12), which is measured in natural logarithmic form, is also in line with previous studies (e.g., Christensen et al., 2024; Xu et al., 2023).

We find that 1152 observations that have sustainability-related financial disclosures in the annual report while only 530 observations that have both sustainability-related financial disclosures in the annual report and sustainability disclosures in the standalone sustainability reports. The variable capturing the extent of sustainability-related financial disclosures (*Disclosures*) has a mean of 30.79 and a standard deviation of 16.91, with values ranging from 0.96 to 76.00. This indicates substantial variation in the degree to which firms report their sustainability dependencies within annual reports. The alignment of sustainability disclosures (*Alignment*) has a mean value of 0.75 (SD = 0.14), with values ranging from 0.32 to 0.98, suggesting that most firms demonstrate moderate to high consistency in how sustainability topics are disclosed across annual and sustainability reports.

To further elaborate on our two primary independent variables—*Disclosures* and *Alignment*—we examine the underlying topic-level patterns based on Datamaran's emphasis index. As described earlier, both variables are derived from this index, which quantifies the relative prominence of sustainability topics in corporate reports by considering frequency, positional importance and contextual density. We interpret the emphasis index as a reflection of a firm's perceived importance or strategic emphasis on a given sustainability issue, thereby offering insight into the firm's information sustainability dependencies.

Table 4 reports the ten most and least emphasised sustainability topics in firms' annual (Panel A) and sustainability reports (Panel B). In annual reports, high-emphasis topics include "GHG emissions & reductions" (1.34), "Transition to renewable energy" (1.31), and "Board effectiveness" (1.27), themes that are closely linked to climate-related risks and strategic planning. In contrast, topics such as "Intellectual property", "Holistic & patient-centric approach to healthcare", "Access to health care & medicine" receive comparatively little emphasis, perhaps due to their lower financial materiality or sector-specific materiality. Sustainability reports tend to prioritise topics such as "GHG emissions and reductions" (1.81), "Occupational health and safety" (1.54), "Energy use, conservation, and reductions" (1.50),

“Transition to renewable energy” (1.39) and “Water” (1.29), reflecting broader stakeholder concerns and external impacts. Interestingly, “Intellectual property” remains among the least emphasised topics across both reporting formats (0.12 on average).

[Insert Table 4 about here]

To assess how consistently firms report sustainability disclosures across reports, Panel C of Table 4 presents the ten sustainability topics with the largest and smallest absolute differences in emphasis index between annual and sustainability reports. This comparison directly informs the construction of our *Alignment* variable. Topics such as "Board effectiveness", "GHG emissions & reductions", and "Occupational health & safety" exhibit the greatest divergence in emphasis across reports. Conversely, topics such as "Intellectual property" and "Access to health care & medicine" show minimal emphasis divergence. These findings seem suggest the difference exist between the sustainability disclosures of the two reports considering their targeted audience, investors vs. broader stakeholders. Collectively, these findings highlight the need to consider both the extent of sustainability-related financial disclosures (*Disclosures*) and the thematic alignment of sustainability disclosures (*Alignment*) to accurately capture how firms provide information on sustainability dependencies and how such reporting may affect audit effort.

The descriptive statistics of the other control variables indicate that few firms (2.9%) announced financial restatements during the audit period. Most audits (approximately 85.9%) occurred during the busy auditing season in December, and a majority (88.2%) were conducted by Big 4 accounting firms. Additionally, auditors generally were not performing the audit for the firm for the first time, with only 14.7% of audits representing a first-time engagement.

Table 5 presents the correlation matrix. It shows some moderate correlations between our control variables, such as audit fees, big 4, corporate size, ROA and leverage. We test variance inflation factors (VIFs) for the controls and the highest VIF is 4.96, well below the cutoff threshold of 10 to trigger multicollinearity concerns (Kennedy , 2008).

5.2. Multiple regression results

Table 6 presents the OLS regression results examining the association between audit effort

(proxied by audit report lag, AULAG), sustainability-related financial disclosures (H1), and the alignment of sustainability disclosures (H2). We estimate four model specifications: Column (1) reports the baseline model including only control variables; Columns (2) and (3) add Disclosures and Alignment individually; and Column (4) presents the full model with both independent variables of interest.

[Insert Table 6 about here]

The results indicate that sustainability-related financial disclosures (*Disclosures*) are significantly associated with audit report lag in Columns 2, providing support for H1. We also find that Alignment of sustainability disclosures (Alignment) exhibits a statistically significant negative association with audit report lag in both Columns (3) and (4), offering support for H2. This suggests that firms exhibiting greater thematic consistency across annual and sustainability reports are perceived as lower-risk clients, enabling auditors to complete audits more efficiently. Economically, a one standard deviation increase in Alignment (approximately 0.14) is associated with a 2.1% to 2.3% reduction in audit report lag, relative to the sample mean of 4.15. Taken together, these results imply that the extent of information provide by firms and how firms communicate their sustainability dependencies, particularly the alignment across reporting channels, may influence audit risk perceptions more than the volume of disclosure alone.

Among the control variables, the leverage ratio (LEV) is consistently and negatively associated with AULAG, suggesting that firms in larger size—often viewed as having more auditing barging power and better governed—tend to experience shorter audit delays. This finding aligns with prior research showing that firms in larger size demand and receive more efficient audits (e.g., Aobdia & Petacchi, 2023; Asante-Appiah, 2020). In contrast, M&A, which measures whether the firm is undertaking merger or acquisition activities during the fiscal year, is positively and significantly associated with audit report lag in Column 1-2. This finding is consistent with prior studies suggesting that firms undertaking mergers or acquisitions tend to have more estimation-intensive and judgment-laden accounts. As a result, auditors must adjust their audit planning to verify the complex activities, which increases audit effort and leads to longer audit completion times (Bedard & Johnstone, 2004; Ghosh & Tang, 2015; Gul et al.,

2003). We also find that firms announced financial restatements during the fiscal year (MISSTATE) tend to have longer audit report lag, which is consistent with the prior literature (Ghosh & Tang, 2015; Knechel & Payne, 2001; Knechel & Sharma, 2012; Lee et al, 2008; Whitworth & Lambert, 2014). The variable BIG4, representing the audit is performed by big 4 audit firms, is marginally significant and positive, suggesting that audits conducted by these firms may be subject to greater scheduling constraints or delays (Lee et al., 2025).

6. Additional analyses

6.1 Audit fees

Audit fees are also commonly used in the literature as a proxy for audit effort albeit noisy (Aobdia , 2019; Christensen et al., 2024; Knechel & Sharma, 2012). Prior research suggests that audit fees reflect a combination of the audit workload, risk premium and audit market dynamics (e.g., Knechel & Sharma, 2012; Simunic, 1980). Therefore, it is possible that the observed negative association between the alignment of sustainability disclosures and audit report lag reflects pricing considerations rather than differences in audit effort per se. If this is the case, audit report lag may not convey additional informational value beyond what is already captured in audit fees.

To address this possibility, we examine whether our two primary independent variables, Disclosures and Alignment, are significantly associated with audit fees. Table 7 presents the OLS regression results. Across all model specifications, the coefficients for both variables are negative but statistically insignificant, suggesting that neither the extent of sustainability-related financial disclosures nor the degree of alignment of sustainability disclosures has a detectable relationship with audit fees. These findings imply that the shorter audit lags observed among firms with more alignment of sustainability disclosures are unlikely to be driven by fee-related incentives such as cost-cutting or client-driven incentives. Instead, they point toward improved audit efficiency resulting from greater alignment.

[Insert Table 7 about here]

6.2 Auditor dismissal

Auditor dismissal has been recognised in the literature as an outcome associated with client risk and audit complexity. Prior research finds that riskier clients, such as those receiving going-concern opinions, are more likely to experience auditor turnover, either through dismissals or resignations (Chow & Rice, 1982; Geiger et al., 2002; Ghosh & Tang, 2015). Management may proactively replace auditors perceived as too strict or uncooperative (Craswell, 1988), or auditor-client tensions may become irreparable, especially when audit opinions conflict with managerial expectations (Burks & Stevens, 2022; Teoh, 1992).

To further test whether the observed association between the alignment of sustainability disclosures and audit effort reflects meaningful information advantages, we examine whether firms with more aligned disclosures are also less likely to dismiss their auditors. If higher alignment of sustainability disclosures indeed reflects lower audit risk, we should observe fewer auditor dismissals for such firms.

Table 8 presents both logit regression models using auditor dismissal as the dependent variable. Across most specifications, we find that both the sustainability-related financial disclosures and the alignment of sustainability disclosures are significantly and negatively associated with the likelihood of auditor dismissal. These findings support the interpretation that when firms report their sustainability dependencies in a more aligned manner, they are perceived as less risky audit clients, resulting in greater auditor retention.

[Insert Table 8 about here]

Taken together with the earlier findings on effort (proxied by audit report lag) and auditor dismissal, these results support the interpretation that alignment of sustainability disclosures improves audit efficiency. While firms with higher alignment do not appear to benefit from lower audit fees, they experience fewer restatements and lower auditor turnover, the outcomes that are consistent with reduced perceived audit risk and improved audit quality.

7. Discussions and conclusions

This study provides empirical evidence on how sustainability-related information, particularly

that related to firms' sustainability dependencies, affects audit effort. Using data from 145 publicly listed European firms over the period 2013–2022, we show that while the extent of sustainability-related financial disclosures and the alignment of sustainability disclosures across annual report and sustainability report are both associated with shorter audit report lags, and lower likelihood of auditor dismissal. These results suggest that auditors perceive firms with more consistent sustainability reporting as lower-risk clients, enabling more efficient audit without compromising audit quality.

The findings of this study have several important practical implications. For auditors, our results highlight the potential value of incorporating sustainability information, particularly information on sustainability dependencies, into audit risk assessment procedures (Hickman et al., 2020). Even in the absence of mandatory sustainability assurance, firm-specific sustainability risks appear to carry meaningful implications for audit planning and execution. These risks can inform both current financial misreporting concerns, by providing information relevant to measurement and estimation areas influenced by sustainability factors, and future risks related to going concern assessments (Dal Maso et al., 2020; Hartlieb & Eierle, 2024; Lee et al., 2025; Sautner et al., 2023).

Firms also stand to benefit from these insights. Beyond potential reputational advantages (Birkey et al., 2016; Martínez-Ferrero & García-Sánchez, 2018), high-quality sustainability reporting may reduce auditors' perceived risk, leading to more efficient audit processes and, potentially, improvements in overall reporting quality. Firms that invest in more consistent integration of financial and sustainability reporting, or foster collaboration between finance and sustainability reporting teams, may be better positioned to produce coherent, decision-useful information that auditors can rely on more effectively.

For regulators and standard setters, this study provides empirical support for initiatives by bodies such as the ISSB, TCFD, and SASB that emphasize financially material sustainability reporting (Barker & Mayer, 2023; Khan et al., 2016; Schiehll & Kolahgar, 2020). Our results also reinforce the value of connectivity, the consistency and integration between financial and sustainability reporting, which lies at the heart of emerging European standards such as those advanced by EFRAG (GRI & IFRS, 2024; EFRAG, 2024). By showing that such integration is

not merely symbolic but functionally linked to audit efficiency and financial reporting quality (Barth et al., 2024; Caglio et al., 2020; Wang et al., 2024; Zhou et al., 2017), this study lends support to regulatory efforts aimed at harmonizing corporate reporting frameworks.

Like any empirical study, this research is subject to several limitations that offer opportunities for further research. First, our analysis focuses on publicly listed firms in Europe, a context characterized by relatively advanced sustainability reporting practices and regulatory oversight. Consequently, the generalizability of our findings to other regions, particularly those with less mature sustainability reporting frameworks or different institutional conditions, may be limited. Future research could explore whether similar relationships between information on sustainability dependencies and audit are observed in jurisdictions such as North America, Asia, or emerging markets, where auditors may face different expectations or information environments. Along similar lines, our findings may not extend to firms of all sizes. In particular, it remains unclear whether auditors respond to information on sustainability dependencies for private companies, which make up a significant portion of some economies (Beuselinck et al., 2023; Hope et al., 2013).

Second, our proxies for sustainability dependency information are based on text analytics. While this method enables systematic measurement across a broad sample, our alignment measure primarily captures the thematic alignment of disclosures across reports and may not fully reflect how impact-focused disclosures complement financially material sustainability dependencies information. Nevertheless, we view alignment as a meaningful quality dimension of information on sustainability dependencies and a credible signal of underlying reporting integration. Future work could build on this by combining text-based approaches with manual coding, third-party assurance reviews, or case-based analyses to assess other aspects of information on sustainability dependencies such as its quality, credibility or completeness.

Third, while audit report lag serves as a widely accepted proxy for audit effort, it does not capture all dimensions of audit effort (DeFond & Zhang, 2014). Future research could investigate alternative or complementary audit effort indicators, such as engagement partner workload (Aobdia & Petacchi, 2023), materiality threshold set by the auditor (Livne et al., 2024), or the nature and frequency of key audit matters disclosed in audit reports (Rousseau &

Zehms, 2024), to deepen our understanding of how sustainability-related information affects audit processes.

Finally, there is the possibility that unobserved confounding factors may influence the documented associations. While we employ a range of control variables to mitigate omitted variable bias, we cannot fully rule out the influence of other latent firm characteristics. Future research could address this by using experimental or quasi-experimental designs.

In addition, this study opens several promising avenues for future research. It highlights the importance of disaggregating sustainability information by financial materiality, moving beyond generalized sustainability reporting. Researchers can further examine how different types of sustainability disclosures, dependencies versus impacts, mandatory versus voluntary, map onto economically meaningful outcomes such as audit effort, pricing, or assurance decisions. Moreover, our operationalization of alignment between reporting channels introduces a measurable construct that may be extended to other contexts, such as tax transparency or regulatory filings, to explore how consistency in corporate disclosures influences financial auditing.

8. Tables

Table 1: Sample selection process

Observations from firms in EU, EAA and EFTA with necessary data from Datastream and Asset4 in the period between 2014-2022	48227	2123
obs. Dropped and reasons for dropping		
Missing necessary data from Audit Analytics	-2114	-189
Firms in financial institutions	-2346	-435
Missing necessary data from Datamaran (in the period between 2014-2022)	-42615	-1354
Remaining sample	**1152**	**145**

Notes: Table 1 reports the sample section process.

Table 2: Sample distribution

Panel A: Sample distribution by country

Country of incorporation	Freq.	Percent	Cum.
Austria	49	4.25	4.25
Belgium	39	3.39	7.64
Denmark	25	2.17	9.81
Finland	60	5.21	15.02
France	60	5.21	20.23
Germany	140	12.15	32.38
Greece	8	0.69	33.07
Ireland	39	3.39	36.46
Italy	77	6.68	43.14
Luxembourg	16	1.39	44.53
Netherlands	56	4.86	49.39
Norway	79	6.86	56.25
Poland	36	3.12	59.38
Portugal	31	2.69	62.07
Spain	109	9.46	71.53
Sweden	39	3.39	74.91
Switzerland	73	6.34	81.25
United Kingdom	216	18.75	100.00
Total	1152	100.00	

Panel B: Sample distribution over time

	Freq.	Percent	Cum.
2013	98	8.51	8.51
2014	101	8.77	17.27
2015	105	9.11	26.39
2016	108	9.38	35.76
2017	111	9.64	45.40
2018	120	10.42	55.82
2019	126	10.94	66.75
2020	135	11.72	78.47
2021	139	12.07	90.54
2022	109	9.46	100.00
Total	1152	100.00	

Notes: Panel A of Table 2 reports sample distribution by country.

Notes: Panel B of Table 2 reports sample distribution by year

Table 3. Summary statistics

	N	Mean	SD	Min	p25	Median	p75	Max
Sustainability dependencies related variables:								
Disclosures	1152	30.793	16.908	0.960	17.426	28.804	41.934	76.000
Alignment	530	0.753	0.140	0.319	0.687	0.783	0.849	0.980
Audit-related variables:								
AULAG	1152	4.144	0.287	3.401	3.970	4.111	4.344	4.779
AUFEE	1152	14.117	1.437	10.686	13.265	14.025	14.946	17.677
MISSTATE	1152	0.029	0.167	0.000	0.000	0.000	0.000	1.000
DEC	1152	0.859	0.349	0.000	1.000	1.000	1.000	1.000
BIG4	1152	0.882	0.323	0.000	1.000	1.000	1.000	1.000
FIRST AUDIT	1152	0.147	0.354	0.000	0.000	0.000	0.000	1.000
Other control variables:								
SIZE	1152	16.029	1.363	12.744	15.156	15.919	16.730	19.463
ROA	1152	0.037	0.057	-0.165	0.013	0.037	0.065	0.255
LEV	1152	0.294	0.143	0.000	0.199	0.275	0.375	0.710
MTB	1152	2.235	1.634	0.132	1.133	1.730	2.871	9.313
M&A	1152	0.141	0.348	0.000	0.000	0.000	0.000	1.000
FOREIGN	1152	0.878	0.328	0.000	1.000	1.000	1.000	1.000
GOVSCORE	1152	57.379	20.835	9.730	42.350	58.290	74.550	94.480
ESGCONTROVERSIES	1152	84.936	27.848	3.450	82.160	100.000	100.000	100.000

Note: Table 3 reports distributional properties for the variables in the main model. All variables are defined in Appendix A

Table 4: Topics with highest and lowest emphasis index in the reports

Panel A: Topics with highest and lowest emphasis index in the annual reports

Topic name	Top 10	Bottom 10
GHG emissions & reductions	1.344	
Transition to renewable energy	1.313	
Board effectiveness	1.269	
Energy use, conservation & reductions	1.160	
Occupational health & safety	1.148	
Public health risks	1.088	
Employee incentives & benefits	1.046	
Investor relations	1.024	
Climate change risks & management	0.932	
Business ethics	0.925	
Marketing & selling practices		0.204
Market access		0.194
Business model innovation		0.189
Solvency & financial management		0.180
Financial access, literacy & advice		0.171
Employee transportation		0.161
Responsible pricing		0.161
Intellectual property		0.133
Holistic & patient-centric approach to h		0.129
Access to health care & medicine		0.107

Panel B: Topics with highest and lowest emphasis index in the sustainability reports

Topic name	Top 10	Bottom 10
GHG emissions & reductions	1.810	
Occupational health & safety	1.539	
Energy use, conservation & reductions	1.499	
Transition to renewable energy	1.388	
Water	1.293	
Human rights	1.268	
Climate change risks & management	1.196	
Business ethics	1.123	
Biodiversity	1.033	
Fair & inclusive workplace	0.942	
Employee transportation		0.206
Drug resistance & pharmaceuticals in the		0.202
Business model innovation		0.201
Responsible pricing		0.198
Holistic & patient-centric approach to h		0.191
Financial access, literacy & advice		0.176
Access to health care & medicine		0.148
Consumer rights		0.147
Market access		0.138
Intellectual property		0.120

Panel C: Topics with the highest and lowest emphasis index difference between AR and SR

Topic name	Top 10	Bottom 10
Board effectiveness	1.139	
GHG emissions & reductions	1.114	
Occupational health & safety	0.996	
Employee incentives & benefits	0.920	
Investor relations	0.919	
Energy use, conservation & reductions	0.904	
Transition to renewable energy	0.871	
Human rights	0.808	
Water	0.800	
Business ethics	0.786	
Consumer rights		0.184
Solvency & financial management		0.179
Market access		0.176
Business model innovation		0.174
Financial access, literacy & advice		0.160
Employee transportation		0.158
Responsible pricing		0.157
Holistic & patient-centric approach to h		0.143
Intellectual property		0.125
Access to health care & medicine		0.110

Notes: Panel A lists the ten sustainability topics with the highest and lowest emphasis indices in annual reports over time, as derived from Datamaran. The emphasis index measures the relative importance given to each topic in the annual report, averaged across the sample years. **Panel B** lists the ten sustainability topics with the highest and lowest emphasis indices in sustainability reports over time, as derived from Datamaran. The emphasis index measures the relative importance given to each topic in the sustainability report, averaged across the sample years. **Panel C** lists the ten sustainability topics with the greatest and smallest differences in emphasis indices between a firm's sustainability and annual reports over time, as derived from Datamaran. The emphasis index measures the relative importance assigned to each topic in a given report, averaged across the sample years.

Table 5: Correlations matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Disclosures	1.000									
(2) Alignment	0.486***	1.000								
(3) AULAG	-0.055*	-0.008	1.000							
(4) AUFEE	0.266***	0.085*	-0.126***	1.000						
(5) MISSTATE	0.031	0.010	0.075**	-0.032	1.000					
(6) DEC	-0.182***	-0.042	-0.029	-0.036	-0.085***	1.000				
(7) BIG4	0.044	0.013	0.006	0.477***	-0.002	-0.051*	1.000			
(8) FIRST_AUDIT	0.080***	0.105**	0.077***	-0.041	0.046	0.035	-0.076***	1.000		
(9) SIZE	0.331***	0.206***	-0.057*	0.601***	-0.086***	-0.010	0.027	0.030	1.000	
(10) ROA	0.013	0.059	-0.081***	-0.100***	-0.037	0.012	-0.035	-0.019	-0.156***	1.000
(11) LEV	0.078***	0.023	0.090***	-0.055*	0.059**	-0.124***	0.021	0.010	0.082***	-0.291***
(12) MTB	-0.044	-0.053	-0.139***	-0.022	0.025	-0.069**	0.043	-0.046	-0.179***	0.274***
(13) M&A	-0.066**	-0.044	0.033	-0.032	-0.010	-0.019	0.024	0.009	-0.041	0.014
(14) FOREIGN	0.045	-0.077*	-0.231***	0.228***	0.001	-0.005	-0.046	0.005	0.040	0.047
(15) GOVSCORE	0.289***	0.191***	-0.127***	0.285***	0.034	-0.046	0.011	-0.035	0.343***	-0.005
(16) ESGCONTROVERSIES	-0.163***	-0.092**	-0.044	-0.350***	-0.008	0.002	-0.043	-0.036	-0.459***	0.107***

Variables	(11)	(12)	(13)	(14)	(15)	(16)
(11) LEV	1.000					
(12) MTB	0.107***	1.000				
(13) M&A	0.026	0.032	1.000			
(14) FOREIGN	-0.193***	0.048*	-0.001	1.000		
(15) GOVSCORE	-0.019	-0.065**	0.006	0.073**	1.000	

Notes: Table 5 reports the correlation matrix. * Represent significance level of .10. ** Represent significance level of .05. *** Represent significance level of .01. Variable definitions are reported in Appendix A.

Table 6: Audit lag model

VARIABLES	Pred. Sign	(1) AULAG	(2) AULAG	(3) AULAG	(4) AULAG
Disclosures	-		**-0.001****		0.000
			(-2.082)		(0.170)
Alignment	-			**-0.216****	**-0.222****
				(-2.422)	**(-2.281)**
SIZE	-	-0.024*	-0.019	-0.035*	-0.035*
		(-1.828)	(-1.400)	(-1.734)	(-1.733)
ROA	-	-0.100	-0.090	0.100	0.100
		(-0.700)	(-0.618)	(0.403)	(0.403)
LEV	+	0.057	0.059	-0.016	-0.016
		(0.709)	(0.736)	(-0.144)	(-0.143)
MTB	-	0.004	0.005	-0.007	-0.007
		(0.521)	(0.550)	(-0.718)	(-0.718)
M&A	+	0.039*	0.033*	0.047	0.047
		(1.954)	(1.687)	(1.434)	(1.452)
FOREIGN	+	-0.001	-0.004	-0.026	-0.026
		(-0.026)	(-0.116)	(-0.538)	(-0.547)
GOVSCORE	-	-0.001	-0.000	0.000	0.000
		(-0.922)	(-0.764)	(0.467)	(0.437)
AUFEE	+	-0.001	-0.001	0.007	0.007
		(-0.075)	(-0.051)	(0.502)	(0.499)
MISSTATE	+	0.109***	0.108***	0.085*	0.086*
		(3.054)	(3.082)	(1.855)	(1.863)
DEC	+	0.031	0.029	-0.028	-0.028
		(0.712)	(0.648)	(-0.565)	(-0.561)
FIRST_AUDIT	+	-0.011	-0.010	0.021	0.021
		(-0.670)	(-0.619)	(0.922)	(0.933)
BIG4	?	0.067*	0.068*	0.085	0.085
		(1.758)	(1.796)	(1.579)	(1.576)
ESGCONTROVERSIES	-	-0.000	-0.000	-0.000	-0.000
		(-1.109)	(-1.082)	(-1.379)	(-1.373)
Constant		4.519***	4.472***	4.754***	4.758***
		(23.903)	(23.412)	(17.159)	(17.026)
Observations		1,152	1,152	529	529
R-squared		0.630	0.633	0.748	0.748
Industry FE		Yes	Yes	Yes	Yes
Country FE		Yes	Yes	Yes	Yes
Year FE		Yes	Yes	Yes	Yes

Notes: Table 6 presents OLS regression results examining the relationships between audit effort (AULAG), sustainability-related financial disclosures (H1), and alignment of sustainability disclosures (H2). Column (1) includes only the control variables. Column (2) adds Disclosures to the controls. Column (3) replaces Disclosures with Alignment, while Column (4) includes both Disclosures and Alignment alongside all controls. See Appendix A for detailed variable definitions. Standard errors are clustered by firm. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, based on two-tailed tests.

Table 7: Audit fee model

VARIABLES	Pred. Sign	(1) AUFEE	(2) AUFEE	(3) AUFEE	(4) AUFEE
Disclosures			-0.001		-0.000
			(-0.559)		(-0.114)
Alignment				0.194	0.209
				(0.696)	(0.724)
SIZE	+	0.502***	0.508***	0.521***	0.522***
		(11.526)	(11.833)	(10.393)	(10.483)
ROA	-	-0.318	-0.325	-0.605	-0.607
		(-0.495)	(-0.507)	(-0.736)	(-0.739)
LOSS	+	0.037	0.033	0.165	0.164
		(0.419)	(0.372)	(1.574)	(1.571)
CURRENT RATIO	+	0.004	0.004	0.004	0.004
		(0.063)	(0.054)	(0.071)	(0.067)
INVRET	+	1.003**	1.011**	1.929***	1.932***
		(2.448)	(2.457)	(4.150)	(4.170)
FOREIGN	+	0.598***	0.595***	0.670***	0.672***
		(3.893)	(3.869)	(4.134)	(4.155)
DEC	+	0.351***	0.350***	0.396**	0.396**
		(2.842)	(2.844)	(2.023)	(2.017)
FIRST_AUDIT	+	0.009	0.009	0.154*	0.154*
		(0.156)	(0.165)	(1.820)	(1.806)
BIG4	+	1.174***	1.178***	1.318***	1.317***
		(5.718)	(5.728)	(8.404)	(8.401)
AUDITORSPECIAL	+	0.411	0.410	0.513**	0.514**
		(1.474)	(1.474)	(2.008)	(2.028)
NOAUFEE	+	0.293***	0.293***	0.329***	0.328***
		(8.195)	(8.186)	(8.522)	(8.594)
Constant		0.124	0.072	-1.336*	-1.354*
		(0.187)	(0.109)	(-1.682)	(-1.689)
Observations		1,044	1,044	480	480
R-squared		0.809	0.810	0.859	0.859
Industry FE		Yes	Yes	Yes	Yes
Country FE		Yes	Yes	Yes	Yes
Year FE		Yes	Yes	Yes	Yes

Notes: Table 6 presents OLS regression results examining the relationships between audit fees (AUFEE), sustainability-related financial disclosures (H1), and alignment of sustainability disclosures (H2). Column (1) includes only the control variables. Column (2) adds Disclosures to the controls. Column (3) replaces Disclosures with Alignment, while Column (4) includes both Disclosures and Alignment alongside all controls. See Appendix A for detailed variable definitions. Standard errors are clustered by firm. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, based on two-tailed tests.

Table 8: Auditor turnover model

VARIABLES	Pred. Sign	(1) Dismissal	(2) Dismissal	(3) Dismissal	(4) Dismissal
Disclosures			**-0.016***		-0.007
			(-1.679)		(-0.467)
Alignment				**-3.479****	**-3.247***
				(-1.960)	**(-1.709)**
SIZE	+	0.042	0.106	0.307	0.321
		(0.291)	(0.715)	(1.367)	(1.417)
ROA	-	-2.245	-2.130	-1.847	-1.982
		(-0.885)	(-0.859)	(-0.472)	(-0.504)
LEV	+	-0.458	-0.515	-1.720	-1.778
		(-0.483)	(-0.558)	(-1.231)	(-1.282)
MTB	+	0.047	0.059	0.175	0.175
		(0.605)	(0.753)	(1.195)	(1.197)
M&A	+	0.004	-0.079	-0.845	-0.868
		(0.012)	(-0.218)	(-1.145)	(-1.171)
FOREIGN	+	0.255	0.231	-0.877	-0.855
		(1.020)	(0.931)	(-1.491)	(-1.454)
INVRET	+	-2.839**	-2.820**	-4.553	-4.507
		(-2.159)	(-2.117)	(-1.577)	(-1.567)
GOVSCORE	-	0.002	0.003	0.013	0.013
		(0.273)	(0.450)	(1.117)	(1.183)
Board Size	+	-0.026	-0.030	0.084	0.082
		(-0.679)	(-0.785)	(1.426)	(1.382)
AUFEE	-	-0.106	-0.097	-0.330*	-0.334*
		(-0.640)	(-0.584)	(-1.748)	(-1.759)
MISSTATE	+	0.572	0.540	2.403***	2.363***
		(1.012)	(0.938)	(3.457)	(3.273)
FIRST_AUDIT	+	2.365***	2.387***	1.665***	1.659***
		(7.096)	(7.117)	(3.049)	(3.058)
AUDITORSPECIAL	-	-0.281	-0.302	0.066	0.076
		(-0.500)	(-0.549)	(0.087)	(0.101)
ESGCONTROVERSIES	-	-0.002	-0.001	-0.004	-0.004
		(-0.465)	(-0.386)	(-0.672)	(-0.677)
		(1.039)	(1.095)	(3.007)	(2.990)
Constant		-2.896	-3.855**	-2.480	-2.662
		(-1.621)	(-2.114)	(-0.670)	(-0.706)
Observations		1,104	1,104	456	456
Industry FE		Yes	Yes	Yes	Yes
Country FE		Yes	Yes	Yes	Yes
Year FE		Yes	Yes	Yes	Yes

Notes: Table 6 presents OLS regression results examining the relationships between the likelihood of auditor dismissal (Dismissal), sustainability-related financial disclosures (H1), and alignment of sustainability disclosures (H2). Column (1) includes only the control variables. Column (2) adds Disclosures to the controls. Column (3) replaces Disclosures with Alignment, while Column (4) includes both Disclosures and Alignment alongside all controls. See Appendix A for detailed variable definitions. Standard errors are clustered by firm. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, based on two-tailed tests.

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Appendix A: Variable Definitions

Variables	Measurements	Source
Sustainability dependencies measures		
Disclosures	The total emphasis index for all sustainability topics disclosed in a firm's annual report in a given year. Based on Datamaran's emphasis index metric, this index reflects how prominently and extensively a firm addresses its sustainability dependencies. A higher Disclosure score indicates more comprehensive sustainability-related disclosures.	Datamaran
Alignment	Firm-year alignment score calculated as the cosine similarity between the emphasis index vectors of sustainability topics in the annual report and the sustainability report. The score ranges from 0 to 1, with a higher value indicating greater alignment of sustainability disclosures across the sustainability report and the annual report, reflecting a more integrated and comprehensive approach to reporting these dependencies.	Datamaran
Audit measures		
AULAG	The natural log of the number of days between the client's fiscal year-end date and the audit report signature date.	Audit Analytics
DISMISSAL	One for firms that announce an auditor dismissal during the year, 0 otherwise	Audit Analytics
AUFEE	The natural log of total audit fees for fiscal year t.	Audit Analytics
RESTATE	One for firms that have subsequently restated their financial reports, 0 otherwise	Audit Analytics
Control variables		
SIZE	Log of total assets at fiscal year-end	Datastrea m
ROA	Return on assets, measured as net income divided by total assets at fiscal year-end.	Datastrea m
LEV	Leverage ratio, measured as total debt divided by total assets at fiscal year-end.	Datastrea m
MTB	Market-to-book ratio, measured as the firm's market value of equity divided by its book value of equity.	Datastrea m
INVRET	The ratio of (inventory + accounts receivable) to total assets.	Datastrea m

ZSCORE	The decile rank of Altman's (1968) Z-score for non-financial firms, where a lower decile indicates greater financial distress.	Datastream
M&A	Indicator variable equal to 1 if year-over change in total assets is obove +20% or below -20% and 0 otherwise, following Dal Maso et al., (2020)	Datastream
FOREIGN	Indicator variable set to 1 if the firm has foreign operations, and 0 otherwise.	Datastream
GOVSCORE	Corporate governance score from Asset4, which 'measures a company's systems and processes to ensure that board members and executives act in the best interests of long-term shareholders...' (Asset4 Glossary). A higher score indicates stronger governance practices.	Asset4
DEC	Indicator variable equal to 1 if the client's fiscal year end is in December and 0 otherwise	Datastream
NOAUFEE	The natural logarithm of total non-audit service fees for fiscal year t.	Audit Analytics
MISSTATE	Indicator variable set to 1 if the firm announces a financial statement restatement during the year, and 0 otherwise.	Audit Analytics
FIRST AUDIT	One if the audit engagement is the auditor's first time auditing the client firm, 0 otherwise	Audit Analytics
AUDITSPECIAL	One if the company is audited by an industry specialist auditor, where an industry specialist is an auditor with 50 percent or more market share, based on audit fees, measured at the office city level and two-digit SIC.	Audit Analytics
BIG4	Indicator variable equal to 1 if the auditor is a big 4 auditor 0 otherwise.	Audit Analytics
ESGCONTROVERSIES	Corporate ESG controversies score from Asset4, which measures "a company's exposure to environmental, social and governance controversies and negative events reflected in global media." (Asset4 Glossary).	Asset 4
Variables in additional tests		
ASSURANCE	Indicator variable set to 1 if the firm obtains external assurance on its sustainability reports, and 0 otherwise.	Asset4
ASSUROR_BIG4	Indicator variable set to 1 if the sustainability report is assured by a Big 4 firm, and 0 otherwise.	Asset4
JOINT_PRO	Indicator variable set to 1 if the same auditor performs both the sustainability report assurance and the financial statement audit, and 0 otherwise.	Asset4, Audit Analytics

ES Score	The firm's combined social and environmental performance score, calculated as the average of its environmental performance score and social performance score from Asset4.	Asset4
ESG Controversies	The ESG Controversies Category Score measures a company's exposure to environmental, social, and governance controversies and negative events, as reflected in global media (Asset4 Glossary). A higher score indicates a greater number or severity of CSR-related controversies.	Asset4
CSRCOMMITTEE	Indicator variable set to 1 if the firm maintains a dedicated CSR committee, and 0 otherwise.	Asset4
BOARD_DIVERSITY	Percentage of female on the board.	Asset4
BOARD_INDEPEND	Percentage of independent board members as reported by the company	Asset4
CEODUALITY	Indicator variable set to 1 if the CEO also serves on the firm's board (e.g., CEO is also board chair), and 0 otherwise.	Asset4
CSRCOMPENSATION	Indicator variable set to 1 if the firm includes CSR-related KPIs in directors' compensation plans, and 0 otherwise.	Asset4

Appendix B: Illustration of the computation process of Alignment

To illustrate the calculation process of **Alignment** variable, we randomly select a firm's data in 2015 from Datamaran as an example.

***Calculation of* Alignment**

The computation of Alignment involves the following three steps:

Step 1: Constructing the emphasis index vector for the annual report.

Using Datamaran data, we obtain the emphasis score values for 34 sustainability topics discussed in the annual report of the firm in 2015. These values form the vector emphasis_index_ar:

[0.166 1.428 0.374 0.166 0.166 0.087 0.374 0.491 0.166 0.240
0.166 0.087 1.065 0.087 0.374 0.240 1.001 0.087 0.087
0.087 0.087 0.166 0.087 0.087 0.309 0.087 0.087 0.166
0.166 0.309 0.166 0.087 0.087 0.087]

Step 2: Constructing the emphasis index vector for the sustainability report.

Next, we extract the emphasis index values for the same sustainability topics from the 2015 sustainability report. For this firm, the topic "ExecComp" is not discussed in the sustainability report, so its value is 0. This forms the vector emphasis_index_sr:

[1.014 1.743 0.944 1.328 1.140 0.380 0.789 1.465 0.605 0
0.441 0.170 1.641 1.014 0.908 0.654 0.870 1.465 0.980 0.245
1.014 0.980 0.605 1.527 1.169 0.553 0.789 0.441 0.553
0.245 0.380 0.245 0.088 0.701]

Step 3: Calculating Alignment using the cosine similarity model.

The Alignment variable is computed as the cosine of the angle between the vectors emphasis_index_ar and emphasis_index_sr, using the following formula (A.1):

$$Alignment_{it} = \frac{\sum_{n=1}^{N}(x_{i,n,t} * y_{i,n,t})}{\sqrt{\sum_{n=1}^{N}(x_{i,n,,t}^2)} * \sqrt{\sum_{n=1}^{N}(y_{i,n,t}^2)}}$$

where $x_{i,n,t}$ represents the emphasis index value of the n^{th}sustainability topic in the annual report for firm i in year t, and $y_{i,n,t}$ represents the emphasis index of the n^{th} sustainability topic in the sustainability report for firm i in the year t.

Interpretation of Alignment variable:

- A score close to 1 indicates high corporate reporting alignment on sustainability dependencies, meaning the firm emphasizes sustainability topics similarly in both reports.
- A score close to 0 indicates low alignment, suggesting discrepancies in topic emphasis between the reports.

For the example firm in 2015, the value of Alignment is 0.794, calculated as:

- $$\frac{(0.166*1.014)+(1.428*1.743)+(0.374*0.944)+\cdots+(0.087*0.701)}{\sqrt{0.166^2+1.428^2+0.374^2+\cdots+0.87^2}*\sqrt{1.014^2+1.743^2+0.944^2+\cdots+0.701^2}}$$