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ORIGINAL RESEARCH



Limiting environmental reporting flexibility: investor judgment based on the EU taxonomy

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Abstract

This experimental research investigates the effect of different types of environmental information on investor judgment. By examining three experimental cases varying the level of environmental disclosure, we evaluate the investment judgments of professional (Study 1) and private German investors (Study 2). Primarily, we investigate whether traditional, commonly disclosed environmental information affects investor judgments. Furthermore, we explore the effects of linking non-financial reporting elements to quantitative financial measures through the EU taxonomy by adding taxonomy indicators. Specifically, we operationalized the case where companies fall into a category of poor environmental performance by taxonomy classification. We find that only traditional environmental disclosure in combination with standardized taxonomy-aligned information (below average), influences the investment judgment. However, professional investors exhibit a significantly negative response, while private investors show a significantly positive reaction when constraining reporting flexibility through the inclusion of standardized taxonomy measures with poor performance. Consequently, we conclude that the connection between non-financial reporting elements and quantitative standardized financial measures enhances transparency for professional investors. Private investors, on the other hand, reward additional taxonomyaligned environmental information irrespective of its content. This implies that environmental information generally conveys positive signals to private investors, but uncertainty in investment judgment can be assumed.

Keywords EU taxonomy \cdot Investment judgment \cdot Non-financial disclosure \cdot CSR reporting \cdot ESG investment \cdot Experimental study

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1 Introduction

In the last decade, investors have increasingly called for companies to incorporate environmental, social, and governance (ESG) factors into their investment process (Iazzolino et al. 2023; Rau and Yu 2023; Sharma et al. 2024). To provide professional and other investors with the necessary information for 'green' investing, the European Non-Financial Reporting Directive $(NFRD)^1$ states that selected companies must submit a non-financial statement (on environmental, employee, and human rights issues) as part of their corporate reporting. In the past, this information, as well as transparency regulations about its quality and content, were inconsistent and not considered sufficient to identify greenwashing or to create a common understanding of green investments (Büyükőzkan and Karabulut 2018; Norang et al. 2023; Siew 2015; Yu et al. 2020). In response, the Commission of the European Union (EU) adopted a delegated act² in July 2021. This is part of the EU Commission's action plan, framed in 2018, to finance sustainable growth. This action plan also contains a revision of the NFRD, the so-called Corporate Sustainability Reporting Directive (CSRD) (Directive (EU) 2022/2464). As part of this regulation, the adoption of the EU taxonomy (Regulation (EU) 2020/852) as a standardized classification system for environmentally friendly economic activities draws attention to the issue of ensuring a common understanding of green investments.

Furthermore, this political instrument first requires certain companies to disclose their taxonomy-aligned information for the 2022 financial year. According to the EU Commission, this classification now represents an important turning point for market uncertainty. Based on the uniform information and standardized taxonomy measures, investors should be able to classify the green performance of companies clearly and define a taxonomy-aligned portfolio share. This transparency obligation is intended to attract investor attention and, in turn, encourage companies to improve their taxonomy-aligned performance. The study conducted by Hummel and Bauernhofer (2024) has documented that the introduction of the EU Taxonomy Regulation has catalyzed internal deliberations concerning corporate strategies aligned with sustainability, thereby fostering a competitive environment that encourages advancements in sustainability practices among firms.

As the EU taxonomy is limited to the classification and transparency of environmental information to date, the paper focuses on the impact of the environmental component of Corporate Social Responsibility (CSR) reporting on investors. Our investigation of traditional environmental information and the innovations introduced by the Taxonomy Directive builds on the findings of Rikhardsson and Holm (2008) on the effectiveness of integrating environmental information into investment decisions. Their results suggest that environmental disclosure positively affects investment allocation decisions. However, recent studies show that if non-financial information disclosed by companies is unreliable, this can be a barrier to integrating ESG factors into investment decisions (Hahn and Lülfs 2014; Yu et al. 2020).

¹ The NFRD (Directive 2014/95/EU) was implemented in Germany with §§289b, c, HGB.

 $^{^2}$ Article 8 (4) of EU Regulation 2020/852 of 18 June 2020 on the establishment of a framework to facilitate sustainable investment and amending Regulation (EU) 2019/2088.

The investigation is based on the idea that flexible non-financial reporting elements, which in our case reveal average environmental performance,³ leave room for interpretation regarding corporate environmental performance. These flexible non-financial qualitative reporting elements will now be linked to quantitative financial measures in the form of taxonomy performance indicators. This can highlight the performance more clearly and allow investors to define a taxonomy-aligned portfolio share. The EU Commission assumes that the standardized ratios in the form of taxonomy-aligned turnover shares and investment shares increasingly reveal companies in a poor environmental performance category that have previously taken advantage of the flexibility in non-financial reporting.⁴

Our first research objective investigates the impact of additional commonly disclosed environmental information on investor judgments. We designed our study by comparing a control group (FIN) receiving financial information only. The first treatment group (ECO_{\emptyset}) received both financial and additional commonly disclosed environmental information presented in an unstandardized format; as such the amount of information increased from financial information only (control group) to the first treatment group receiving both, financial information and additional commonly disclosed environmental information (environmental performance on average). Therefore, the first treatment group compares to the traditional information environment pre-EU taxonomy. Our second research objective focuses on examining the influence of linking non-financial reporting elements to quantitative financial measures through the EU taxonomy, especially in cases where companies fall into a poor environmental performance category. To operationalize this, we adopted the assumption of the EU Commission that standardized ratios through the taxonomy can increasingly identify companies with poor environmental performance, accounting for prior flexibility in non-financial reporting. As such, the second treatment group receives the largest amount of information: financial information, additional commonly disclosed environmental information (environmental performance on average), and unfavorable taxonomy information (taxonomy indicators below the industry average). Therefore, our design includes not only a control group (FIN) and the first treatment group (ECO_{\emptyset}) but also a second treatment group (EUT_{neg}), whereas the second treatment group captures the upcoming status quo of reporting requirements. This design allows us to compare the incremental effect of additional information provided. Accordingly, this research not only focuses on whether additional commonly disclosed environmental information affects investor judgments but also on whether linking non-financial reporting elements to quantitative financial measures through the EU taxonomy affects investors in a case where companies fall into a poor environmental performance category.

Using a between-subject experimental design in which we manipulate environmental disclosure, this research provides insight into a one-time investment-related judgment of professional German investors based on three different cases (financial, financial & environmental, and financial & environmental & negative taxonomy-aligned information) in a long-term investment case. By conducting a second online experiment, we

³ The indicators were adjusted as follows: In the ESG ranking (aggregation of MSCI ESG Rating, S&P Global ESG Score, Sustainalytics ESG Risk Rating) of the Dax 40 companies in Germany (see Haller (2021) 'DAX40 Nachhaltigkeitscheck 10–2021'), the fifteen best-ranked and the 15 worst-ranked companies were excluded. The environmental indicators in the experimental treatment were then determined, based on the information from these real listed companies with an average performance in the ESG ranking.

⁴ See Communication from the Commission. Guidelines on non-financial reporting (methodology for reporting non-financial information), C 215/2 C.F.R. (2017).

examine how the provided non-financial information is perceived by private investors. The manipulation of negative taxonomy-aligned information allows us to investigate whether linking non-financial reporting elements to quantitative financial measures in the new form of environmental reporting affects professional (Study 1) and private investors (Study 2) in a case where companies thus fall into a poor environmental performance category. To investigate the impact of linked qualitative and quantitative measures through taxonomy-aligned information in environmental reporting, we constructed three experimental groups. The first group, the control group, was provided with only financial information (FIN) in a financially profitable investment case. The first treatment group (ECO_Ø) was provided with the same financial information and additional commonly disclosed environmental information (FIN + ΔECO_{\emptyset}) in the unstandardized format but with room for interpretation of environmental performance. Here, we provided information indicating average environmental performance. In the second treatment group (EUT_{neg}), we added unfavorable taxonomy information $(EUT_{neg} = FIN + \Delta ECO_{\emptyset} + \Delta EUT_{neg})$ and compared investor judgments with the control group (FIN). By assessing the direction of investors' judgments, we gain insight into the perceived environmental performance. Thus, our experimental approach is framed, on the one hand, on the assumption of the EU Commission, that standardized ratios through the taxonomy increasingly reveal companies with poor environmental performance but previously used flexibility in non-financial reporting. Prospect theory and the findings of Lorraine et al. (2004) indicate a higher impact of negative news in the context of environmental information. Thus, if negative taxonomy-aligned information does not affect investors, this puts into perspective the effectiveness of additional taxonomy-aligned information in investment-related judgments.

To the best of our knowledge, this is the first study to examine the extent to which environmental and EU taxonomy information is reflected in investment judgments based on the manipulation of corporate information. Our contribution lies not only in analyzing environmental information for investment-related judgments even before EU regulations are fully implemented in companies but also in investigating information perceptions in the investment process. We observed only transparency-enhancing effects through the linkage between non-financial reporting elements to quantitative standardized financial measures in the study of professional investors. In contrast, private investors reward additional taxonomy-aligned environmental information, regardless of its content.

The investigation has important implications for environmental disclosure practices based on information assessment by different investor types. By experimentally accounting for cognitive and behavioral aspects in the analysis of transparency-enhancing policies, we make an important theoretical contribution to the relationship between political regulations and investment-related judgments. Consequently, based on a better understanding of investor judgments, we provide practical and investor-oriented insights for standard setting, especially in the case of limited information processing by private investors. In the absence of additional legal regulations (e.g., in investment advisory) ensuring the attention of private investors to taxonomy indicators and the accurate labeling of information, the effectiveness of the EU Taxonomy Directive may face limitations. This contributes fundamentally to the EU Commission's goals of steering capital investments in a sustainable direction.

Our paper is structured as follows. In Sect. 2, we review the theoretical background of the EU taxonomy and the related literature and develop research hypotheses about investor judgment, based on the underlying theories. Section 3 describes our research methodology

for measuring investor perceptions of the investment case with different information cases, and Sect. 4 presents our results with an additional robustness analysis. In Sect. 5, we discuss our findings and conclude.

2 Background literature and hypotheses development

2.1 CSR reporting and the EU transparency requirements

With the EU taxonomy, the EU Commission presented a regulation for strengthening transparency regarding environmentally friendly activities in capital markets and to create a common understanding of green activities. This classification system is accompanied by a complete revision of the NFRD, which has been mandatory for large public-interest entities⁵ since January 2017 (Directive 2014/95/EU Article 1, 19a (1)). According to the NFRD, companies are required to disclose a non-financial report on activities relating to 'environmental, social and employee matters, respect for human rights, anti-corruption and bribery matters' as part of the annual report.⁶ To date, no standardized framework is required to publish this information, and each member state of the EU is responsible for verifying and auditing the reports provided by companies. Standard frameworks such as the Global Reporting Initiative (GRI) Standards and best practice guidelines have been established internationally, which has led to a heated debate between flexibility and standardization in recent years (Mittelbach-Hörmanseder et al. 2021). Therefore, much of the research to date is concerned with developing standards for defining and reporting on sustainability (e.g. Christensen et al. 2021). Research on the impact of CSR reporting focuses on the corporate perspective, for example, the impact of CSR reporting on corporate performance (see Friede et al. 2015 for an overview) and determines positive effects on firm valuation (Cahan et al. 2016; Nekhili et al. 2017; Sharma et al. 2024). According to Eccles and Serafeim (2011), CSR reporting is based on providing the public with non-financial information, e.g., on strategies for dealing with environmental or climate risks, or compliance with laws that are valuable to investors. These non-financial items are considered as leading indicators of a company's future performance. However, researchers also highlight that organizations often engage in symbolic compliance rather than actual compliance (Aboud et al. 2023; Kirk and Vincent 2014; Marquis et al. 2016; Yu et al. 2020). In this context, Du (2014) notes that while flexibility in environmental reporting does not necessarily imply greenwashing, it can promote greenwashing. The new EU Taxonomy requirements for companies, as part of the CSRD, address this risk of greenwashing. According to the new classification system, firms that provide non-financial reports must additionally disclose taxonomy-aligned information by the end of 2022. These disclosures initially refer to the environmental perspective and are to be understood as taxonomy-aligned environmentally friendly activities of companies.⁷ The report of the Technical Expert Group (TEG)⁸ describes the EU taxonomy as a standardized classification system that creates a

⁵ Companies listed in the EU are considered public-interest entities according to their activities and have more than 500 employees.

⁶ This may be a separate report or part of the management report (Directive 2014/95/EU Article 1, 19a (1)).

⁷ See Communication from the Commission. Guidelines on non-financial reporting (methodology for reporting non-financial information), C 215/2 C.F.R. (2017).

⁸ The EU Commission has established this Technical Expert Group on Sustainable Finance to support development in line with the legislative proposals of May 2018 (See EU Technical Expert Group (2020)).

common understanding of environmentally friendly activities and increases the transparency of CSR information. The report contains information on how companies must implement the taxonomy requirements by considering the flexibility of the NFRD. Companies are required to provide information on their activities that have been classified as environmentally taxonomy-aligned, in accordance with predetermined taxonomy performance thresholds and screening criteria. Activities labeled 'EU taxonomy-aligned' firstly contribute significantly to one of six predefined environmental objectives.⁹ Secondly, they do not violate the 'do not significant harm' principle, while achieving another environmental objective. Thirdly, they meet minimum social requirements. The TEG report contains an industry-specific¹⁰ catalog of criteria that can be used to classify environmentally friendly activities. Based on that catalog, companies can specify a percentage of turnover, capital expenditure, or operational expenditure considered taxonomy-aligned. The TEG explains that these criteria aim to establish a standardized and shared understanding of environmentally friendly activities, enabling financial intermediaries to define a taxonomy-aligned share of their portfolio (Schütze and Stede 2024).

2.2 Impact of CSR disclosure on investor judgment

The existing literature on non-financial disclosure encompasses two main approaches: archival studies utilizing capital market data¹¹ and experimental studies. Experimental approaches consider the cognitive processes of investors and focus on how investors perceive CSR disclosure. Khemir et al. (2019) provide a literature review on the information utility of non-financial information to investors within experimental research contexts. Overall, the findings highlight the significant relevance of non-financial disclosure. Rikhardsson and Holm (2008) confirm the effectiveness of environmental information in guiding decision-makers toward investment decisions. Moreover, the relevance of non-financial accounting information in investment decisions is acknowledged in accounting practice with the decision usefulness approach (Staubus 1999) and is reflected in conceptual accounting frameworks established by regulators such as the International Accounting Standards Board (IASB) and the Financial Accounting Standards Board (FASB).

Consistent with previous research, our theoretical foundation for the conceptualization of environmental disclosure is rooted in agency theory addressing the challenge of information asymmetry. Linking this theoretical background to non-financial disclosure, incorporating additional environmental information in corporate disclosures is anticipated to mitigate information asymmetry, aligning with prior research indicating the impact of non-financial factors on investor judgment (e.g., Esch et al. 2019). Cui et al. (2018) show that CSR influences information asymmetry and enhances the overall information environment.

⁹ The draft Taxonomy Directive first refers to the first two environmental objectives. Others are currently in development.

¹⁰ The classification is based on the NACE industry classification.

¹¹ With regard to CSR information, capital market studies explore determinants of profitability and utility maximization (Dangelico and Pujari 2010; Esch et al. 2019; Schwarz et al. 2002), and financial risks (Jamsson et al. 2011). Empirical studies highlight new risks and drivers, such as competitive advantages, external expectations, and related reputational effects affecting investment decisions based on non-financial information (Beal and Goyen 1998; Bollen 2007; Chatterji et al. 2009; Nilsson 2009; Paetzold and Busch 2014; Rosen et al. 1991; Statman 2004; Wong and Zhang 2022).

In addition, Iatridis (2013) shows that high-quality environmental information is found to be value-relevant and to improve investor perceptions of an investment.

However, unstandardized CSR reporting under the NFRD has given rise to a substantial debate in research and disclosure practice on the tradeoff between flexibility and standardization (Mittelbach-Hörmanseder et al. 2021; Young-Ferris and Roberts 2023). The literature highlights concerns about investor trust due to the flexibility of non-financial disclosure practices (Holder-Webb et al. 2009; Kothari 2019; Lougee and Wallace 2008; Masini and Menichetti 2012). The challenge of obtaining credible sustainability information poses a barrier for external stakeholders and complicates the asset selection process for investors (Yu et al. 2020). Signaling theory posits that listed companies transmit signals to investors to shape investment incentives, yet these signals are increasingly perceived as deceptive in non-financial reporting (Clarkson et al 2011; Spence 2002). This perception reflects the existing uncertainty among information recipients, stemming from a lack of transparency and a shared understanding of green investments.

Building on insights from Bowen and Aragon-Correa (2014) and Du (2014), companies exercise flexibility in disclosing or withholding information, which may benefit the companies themselves but comes at the expense of stakeholders. Additionally, according to Jin et al. (2024), there is a negative correlation between perceived ESG ambiguity and decision-making. While previous studies have demonstrated that additional environmental disclosure significantly influences investors (Abhayawansa and Guthrie 2010; Ghosh and Wu 2012; Rikhardsson and Holm 2008), more recent research indicates that uncertainty hampers the integration of ESG factors into investment decisions (Hahn and Lülfs 2014; Yu et al. 2020). Consequently, we propose the following hypothesis:

H1: The inclusion of commonly disclosed environmental information with average environmental performance does not affect investor judgment.

This research hypothesis is specifically tied to the concept of flexible disclosure, wherein interpretations related to non-financial performance are permissible. The way in which investors respond to the provided flexible environmental information serves as an indicator of their perceived environmental performance.

Aligned with agency theory, the adoption of standardized disclosure measures is positioned as an effective means to mitigate information asymmetry. Moreover, standardized disclosure facilitates a more certain interpretation of environmental performance. The explicit categorization and alignment with a standardized taxonomy of environmental information, as an ESG performance metric, aim to foster a shared understanding of green investments. As per the EU Commission's guidance, the use of standardized ratios within the taxonomy is expected to increasingly expose companies that previously used flexibility in non-financial reporting but fall into a poor environmental performance category. To operationalize the EU Commission's assumption that standardized indicators within the taxonomy can identify companies with inadequate environmental performance, we construct a scenario by introducing additional indicators that signal poor alignment of the taxonomy. We posit that the new disclosure format, incorporating taxonomy indicators, enhances transparency. Therefore, even in a case where the financial viability of an investment appears strong and commonly disclosed environmental information indicates average performance, the presence of additional negative taxonomy indicators is anticipated to influence investor judgment in line with the taxonomy-aligned information.

Drawing on information overload theory, existing literature highlights how the scope and presentation of corporate disclosures can influence investor behavior (Chapman et al. 2019). Investors rationally exclude certain data when the cost of processing all relevant

information becomes prohibitively high (Pernagallo and Torrisi 2022). In this context, a study by Hummel and Bauernhofer (2024) revealed that capital market participants value the clarity provided by well-defined KPIs, such as taxonomy indicators. Sharma et al. (2024) observed positive effects e.g. for prediction accuracy when quantitative ESG data is integrated with financial growth metrics. Consequently, we suggest that incorporating quantitative financial measures alongside standardized taxonomy indicators through the EU taxonomy may lessen processing efforts and sway investor judgment towards taxonomy-aligned information. This leads to the formulation of the following hypothesis:

H2: Investor judgment is negatively affected by the inclusion of additional taxonomyaligned information with poor environmental performance.

Furthermore, the average effort required to process disclosed information is lower for large investors (Blankespoor et al. 2020; Olumekor and Oke 2024). In addition, research shows that investment decisions depend on investor type (Copeland et al. 1973). The decision is influenced by experience (Krisch 2018), psychological factors (Bakar and Yi 2016), culture, cognitive thinking (Li et al. 2022), or financial attitude (Talwar et al. 2021). However, financial and non-financial reporting does not distinguish between different types of investors. Köhler (2020) shows that non-professionals have difficulties in processing corporate information. According to Fiesenbicher (2015), the complexity of sustainable financial products and related information exceeds the level of knowledge of most private and, in some cases, even institutional investors. Financial and non-financial information is inherently complex and most likely serves to fulfill the needs of professional investors, as they have the greatest influence on the provision of financial capital (Ferreira and Matos 2008). At the same time, it is crucial to recognize that non-professional investors also rely on the information provided to make investment decisions.

Filling this research gap, we also explore how various environmental disclosure types are perceived by private investors. From the perspective of an information recipient, the new transparency regulation of the EU Commission, as part of the CSRD, should be an instrument for obtaining a better understanding of companies' non-financial performance. With the addition of taxonomy indicators as a linkage between qualitative non-financial reporting elements with quantitative measures, investors should be able to clearly classify the green performance. Given previous research within the information overload theory framework, which suggests that information overload diminishes decision quality even among cognitively sophisticated individuals and financial experts (Casey 1980; Iselin 1988; Malhotra 1982), it remains unclear whether the newly introduced standardized non-financial information mitigates this negative effect. Overall, we believe that a differentiation between professional and non-professional investors is required to shed light on the quality of the information provided by the new non-financial reporting requirements. To identify potential indicators of varied information perceptions, we implemented two studies—one involving professional investors and the other private investors—as elucidated below.

3 Research design

3.1 Experimental design

The purpose of our studies is to experimentally examine not only whether additional commonly disclosed environmental information affects investor judgments, but also whether linking non-financial reporting elements to quantitative financial measures through the EU taxonomy affects investors in a case where companies thus fall into a poor environmental performance category. The manipulation results in three different experimental cases of the provided information (financial, financial & environmental, and financial & environmental & negative taxonomy-aligned information) before asking about the long-term investment-related judgment.¹² Since we do not create a decision case through the online experiments, we do not measure investor decisions, but rather their perceptions of the investment case with the different treatment information. Thus, we conducted statistical tests to investigate the first research hypothesis of whether the inclusion of commonly disclosed environmental information with an average environmental performance affects investor judgment (H1). We also examine the effect of the linkage between non-financial reporting elements to standardized quantitative financial measures through the EU taxonomy, in a case where companies fall into a poor environmental performance category (H2). By conducting two investigations, one with professional and one with private investors, we aim to observe the effects for two types of investors.

The average differences between the experimental groups are used to measure the effects of the manipulation. The comparison of the average difference between the measurement of the control group, which is provided with only financial information (FIN), and the first treatment group with additional flexible environmental information (ECO_{\emptyset}) as well as between the measurement of FIN and EUT_{neg}¹³ (with financial & environmental & negative taxonomy-aligned information) reflects the impact of the additional information in the two treatment cases on the investment-related judgment.¹⁴ The different information directions are framed on the idea that the standardized taxonomy ratios reveal companies in a poor environmental performance category, but previously have taken advantage of the flexibility in non-financial reporting. Thus, we conduct two 2×1 (FIN vs. ECO_{\emptyset} & FIN vs. EUT_{neg}) between-subjects experimental designs, varying the level of environmental disclosures in the study with professional investors, and two 2×1 (FIN vs. ECO_{\emptyset} & FIN vs. EUT_{neg}) between-subjects experimental designs in the study of private investors, in order to examine our hypotheses.

3.2 Experimental case and dependent variables

Two online experiments are conducted to determine investor perceptions of three cases: a control group and two treatment groups. In Study 1, the participants in these three groups are professional investors, while Study 2 examines private investor judgment. The characteristics are presented in Table 1,¹⁵ which also includes demographic data of German

¹² We also asked participants for short-term investment-related judgment. The results can be seen in the part of additional analysis.

¹³ In the last experimental group EUT_{neg} , we added negative taxonomy information to the same financial and environmental information ($\text{EUT}_{\text{neg}} = \text{FIN} + \Delta \text{ECO}_{\varnothing} + \text{EUT}_{\text{neg}}$) and compared investor judgments with the control group (FIN).

¹⁴ By comparing the treatment groups ECO_{\emptyset} and EUT_{neg} we can only make a limited statement about the extent to which the additional taxonomy indicators have a separate effect compared to flexible commonly disclosed environmental reporting because of different information direction. But if even negative taxonomy information fails to have an impact, this finding provides insights into the value added by the taxonomy.

¹⁵ Additionally, the occupations of private investors (Figure C) and professional investors (Figure D) in the experimental sample are illustrated in the appendix.

	Category	Professionals $(n = 103)^a$	Privates $(n = 86)^a$	Shareholder structure in Germany (DAI, 2023) ^b
Age	18–29	19%	34%	16%
	30-44	36%	41%	32%
	45–59	31%	23%	24%
	+09	14%	2%	28%
Sex	male	71%	74%	62%
	female	27%	25%	38%
		2%	1%	N.A
Eductaion	High School Diploma low level ("Hauptschulabschluss")	%0	2%	13%
	High School Diploma medium level ("Mittlere Reife")	18%	36%	34%
	High School Diploma high level ("Abitur")	37%	33%	53%
	"Diplom" (Combination of Bachelor & Master)	18%	7%	N.A
	Bachelorstudy	15%	12%	N.A
	Masterstudy	13%	10%	N.A
Income	<1.000€	2%0	%6	10%
	$1.000 \in -1.999 \in$	13%	21%	26%
	2.000 €—3.999 €	37%	40%	49%
	> 4.000 €	42%	26%	12%
	,	8%	3%	2%
Investment experience	<1 year	6%	23%	N.A
	1–2 years	9%	25%	N.A
	2–5 years	16%	18%	N.A
	5-10 years	23%	10%	N.A
	>10 years	46%	24%	N.A

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^bSee https://www.dai.de/fileadmin/user_upload/DAL_23049_Aktionaerszahlen_240109_300dpi.pdf

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shareholders, sourced from the DAI (Deutsches Aktieninstitut). Our sample shows analogous features indicating its representativeness. Olumekor and Oke (2024) highlight the importance of socio-demographic factors such as age or gender for sustainable supportiveness. In line with Libby et al. (2002), the characteristics can be deemed homogeneous across our experimental groups.¹⁶ Aside from the varying environmental information, all other information provided to the study participants is held constant.

The following procedure is identical in both studies. We manipulate environmental disclosure at three levels: FIN, ECO $_{\emptyset}$, and EUT_{neg}. The direction of the provided information is framed in the case where companies use the flexibility of environmental disclosure before the taxonomy and fall into a poor environmental performance category through the linkage between non-financial reporting elements to quantitative financial measures by taxonomy indicators. Below, we declare the addition of information with delta (Δ). The control group received only positive financial company information (FIN). The second experimental group (ECO $_{\emptyset}$) was provided with financial and additional commonly disclosed environmental information (FIN + ΔECO_{α}) that portrays an environmental performance on average. As in previous studies (e.g., De Villiers and Van Staden 2012; Holm and Rikhardsson 2008), this experimental treatment presents a shortened version of qualitative and quantitative commonly disclosed environmental information in addition to the same financial information provided to the control group. Thus, the group ECO_{α} received environmental information that, in the literature, is not considered sufficient to create a common understanding of green performance (Büyükőzkan and Karabulut 2018; Prakash and Potoski 2012; Siew 2015; Yu et al. 2020). The third experimental group (EUT_{neg}) additionally received negative taxonomy information $(FIN + \Delta ECO_{\varnothing} + \Delta EUT_{neg})$. This treatment includes a share of taxonomy-aligned sales and investments in addition to the same financial and commonly disclosed environmental information as treatment group ECO_{α} .

In the main analysis, we then compare investor judgments of the two treatment groups with the control group (FIN). With different items, according to the literature (Anderson et al. 2022; Cianci and Kaplan 2008; Ghosh and Wu 2012; Hogan et al. 2017; Reimsbach et al. 2018), we implement a multi-measure approach and ask for an investment-related judgment. In both studies, we ask for *investment recommenda-tions*; the perceived *investment attractiveness*; a score on a *buying scale*; *the prob-ability of investing*, and the *investment amount*. In both investigations, these items are used to measure investment-related judgments on a clear and simple Likert scale (Ber-tram 2007; Stier 2013) to capture the assessment of an investment.¹⁷ Figure 1 depicts an excerpt from the experiment, specifically focusing on the inquiry related to investment-related judgment.

¹⁶ Table E in the appendix provides demographic data for participants across different experimental groups. It is evident that participants in the control group of the first study (professional investors) exhibit similar characteristics to professional investors in the other two experimental groups. Likewise, private investors in the control group of the second study demonstrate analogous characteristics to those in the remaining experimental treatment groups.

¹⁷ The measurement of the different items is based on different response scales to ensure respondents' attention during the experimental task and to mitigate random answering. We measured investment attractiveness on an 11-point scale ranging from 0 (absolutely not attractive) to 10 (absolutely attractive); investment recommendation on a five-point scale (strong sell/sell/hold/buy/strong buy); a score from 0 to 10 on a buying scale; a score from 0 to 100 for the probability of investing; and an amount between $0 \in$ and 500.000 \in .

Using an exploratory factor analysis according to Fabrigar et al. (1999), we identify a reliable measure of investment-related judgment in both studies.¹⁸ Based on the Kaiser–Meyer–Olkin-Criterion, we exclude the item *investment recommendation* in Study 2 with private investors and *investment amount* in both studies.¹⁹ In both studies, we identify one factor (judgment) according to the Minimum Average Partial test (MAP test) according to Velicer and Fava (1998) that is measured in Study 1 with four items and in Study 2 with three items.²⁰ Based on the identified items for measuring, on the one hand, professional investor judgment and, on the other hand, private investor judgment, we aggregate in each study the identified items to form a judgment score ranging from 1 to 5. Since two different constructions of measurement variables are established for the respective types of investors, our results are presented separately in two studies.

3.3 Experimental procedure

In both experimental studies, the documents sent to the participant groups (FIN, ECO_{\emptyset} , EUT_{neg}) are divided into five parts (see Fig. 2). We keep the presentation format and content of the information constant to prevent investors from evaluating a potential investment more favorably, simply because of a different format or content.

The studies contain an introduction in the first section of the experimental documents. The second section presents information about a fictitious company in a short case description with relevant data such as its size, sector, and strategy. All the information provided is based on reports of a real listed company from the consumer goods industry.²¹ We changed the name of the company to avoid potential risks of affecting judgment through prior knowledge. The company prensentation in the studies is illustrated in Fig. 3.

In addition, all three cases (FIN, ECO_{\emptyset} , EUT_{neg}) contain the same financial information in the second part of the documents, including balance sheet ratios and financial performance indicators adjusted to reflect the financial profitability of the company.²² This is done to ensure a consistent basis of comparison and avoid potential bias due to different perceptions of the company. The experimental documents are framed according to corporate and financial information. We created two more cases for the experimental treatments in which the information is manipulated as described before. By adding commonly

¹⁸ Bartlett's test of sphericity demonstrated that correlations between items were large enough for Factor Analysis (Study1: $\chi^2(10) = 447.84$, p < 0.001; Study2: $\chi^2(10) = 240.48$, p < 0.001). Thus, we can verify that data can be compressed meaningfully.

¹⁹ Kaiser–Meyer–Olkin measures show that sampling adequacy was acceptable with an overall MSA=0.79 in Study 1 and MSA=0.76 in Study 2 (>0.6). Thus, data suits for a factorial analysis. Study 1: MSA for each item (sampling adequacy for each variable in the model): attractiveness=0.81; recommendation 0.84; probability=0.77; buy-scale=0.74; amount=0.43 (<0.6). Study 2: MSA for each item (sampling adequacy for each variable in the model): attractiveness=0.82; recommendation 0.51(<0.6); probability=0.83; buy-scale=0.79; amount=0.41 (<0.6).

 $^{^{20}}$ In both studies MAP suggested that one factor should be retained. In Study 1 the factor was loaded by 4 items that explained 81% of the variance with factor loadings from 0.683 to 0.871. In Study 2 the factor was loaded by 3 items that explained 87% of the variance with factor loadings from 0.571 to 0.823.

²¹ The domestic sector was chosen so that the results would be as unaffected as possible by the prevailing market conditions during the period under study (in particular the COVID-19 pandemic and the Wirecard scandal).

²² As part of the post-experimental questions, we asked participants to rate the company's profitability. Results indicate no significant difference between the treatment cases. This indicates a homogeneous perception of the financial performance. As an example, Figure E in the appendix provides an overview of the responses from the raw data.

		Case	Study Ca	reHome	Investme	ent			
Long-term-Investme Suppose an investme year):	ent ent decision is a	long-term	cash item (the run-t	me of the	investmen	it is more	than one	
*1. Which recomme	ndation would	you conside	r to be fair	and appro	priate for t	he compar	ıy?		
Clear pure recommend	chase O Pur ation	chase) he	old () sell	C clea reco	r sell ommendat	ion	
* 2. <u>How likely</u> are y scale of 0% to 100%	you to <u>invest</u> in	CareHome	stocks <u>in tl</u>	ne long te	<u>m</u> as part o	of your div	ersified po	ortfolio? (on a	
0% (very unlikely)							10	0% (very likely)	
0									
* 4. Please indicate of attractive the <i>CareH</i>	on a scale from <i>come-share</i> is to	(1) "Very U you as an in	inattractive	Investme	nt" to (10)	"Very <u>attra</u>	s & currer	estment" how	
1 2 (very unattractive investment)	3	4	5	6	7	8	9	10 (very attractive investment)	
		\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	
* 5. On a scale from CareHome-stock dee 0 (definitely not bought)	(1) " <u>Definitely</u> cision as part of	Not Bough Your divers	<u>t</u> " to (100) sified portf	" <u>Definite</u> olio?	y Bought"	- How do ;	you rank y 00 (definitely	your y bought)	

Fig. 1 Excerpt of Questions Regarding Investment Judgment in the Experimental Study for All Participant Groups

disclosed environmental information to the constant financial information, we created the treatment ECO_{\emptyset} .²³ Additional taxonomy-aligned information to the same financial information and to commonly disclosed environmental information formed the manipulation for the treatment EUT_{neg} .²⁴

As the first treatment represents the case of commonly disclosed environmental information, discussed in the literature as an information base with flexibility, a shortened version of qualitative and quantitative non-financial information was provided and linked to the financial information.²⁵ The qualitative environmental information is from a summary

 $^{^{23}}$ We provide insights into the experimental documents of group FIN in the appendix in Table A, into ECO_{\varnothing} in Table B and Figure A, and insights into EUT_{neg} in the appendix in Figure B.

²⁴ We verified the knowledge of the treatment information by manipulation checks in the later part of the experimental documents.

 $^{^{25}}$ In the context of the form of non-financial reporting, Arnold et al. (2012) and Reimsbach et al. (2018) found that the integration of non-financial information was more useful for investors than in external reports.







Fig. 3 Excerpt of Company Information in a Brief Case Description from the Experimental Study for All Participant Groups

of the listed company's annual report to keep information realistic. Due to the necessarily limited scope of the experimental material (Lachmann et al. 2015), certain quantitative environmental indicators are selected. Following Arnold et al. (2012) and Reimsbach et al. (2018), we consider as common environmental information the most valuable indicators of the Global Reporting Initiative (GRI) for investment decisions.²⁶ Thus, we choose indicators that investors are most likely to look at when considering environmental criteria. To avoid forcing a clear direction of the effects of environmental information, we present environmental performance as the average.²⁷ As Khemir et al. (2019) also explain in their

²⁶ The GRI guidelines are now considered the standard for reporting sustainability information (Jackson et al. 2020; Katsouras and McGraw 2010; Willis 2003).

²⁷ The indicators were adjusted as follows: In the ESG ranking (aggregation of MSCI ESG Rating, S&P Glabal ESG Score, Sustainalytics ESG Risk Rating) of the Dax 40 companies in Germany (see Haller (2021) 'DAX40 Nachhaltigkeitscheck 10–2021'), the fifteen best-ranked and the 15 worst-ranked companies were excluded. The environmental indicators in the experimental treatment were then determined from the information on these real listed companies that have an average performance in the ESG ranking.

study, the idea is to determine whether the presence of average environmental information on average affects investor judgment. In the third group, participants were provided with information that, in addition to the presentation of the company, the financial information, and common environmental information, also contained the innovations of the EU Taxonomy. Thus, the experimental documents are extended by the information on the turnover shares and investment shares according to the taxonomy report of the Technical Expert Group (TEG). This quantitative information is supplemented with a brief explanation of the information, which represents the linkage between qualitative non-financial reporting elements with quantitative measures, and thus investors can clearly classify the green performance. We present the company's taxonomy indicators as being below the industry average to portray a worse taxonomy-aligned environmental performance in the new form of disclosure (EUT_{neg})²⁸ compared to commonly disclosed environmental information (ECO_{\varnothing}). According to the EU Commission, standardized ratios through the taxonomy increasingly should reveal companies in a poor environmental performance category that previously used flexibility in non-financial reporting. In such a scenario, we assume a transparency-enhancing effect, so that a company's environmental disclosure interpretation is clearer. We examine this transparency in the case where a company used flexibility in non-financial reporting before the implementation of the taxonomy and is then categorized below the industry average based on standardized taxonomy criteria and thresholds. By looking at the direction of investment-related judgment, we examine whether the new type of disclosure was helpful (transparency-enhancing) for investors wishing to interpret the environmental information. The prospect theory indicates that investors are more sensitive to negative news; accordingly, if the negative taxonomy information has no significant effect on investment-related judgment, then no argument could be made for the potential value of this political instrument in supporting green investments.

Based on the treatment information, participants are asked in the third part of the experiments to make an investment-related judgment for a long-term investment based on the described items.²⁹ The fourth part of the documents is a survey on the classification of the presented information (e.g., the weighting of the information presented) including manipulation checks and questions on process measurement in terms of the comprehensibility and usefulness³⁰ of the presented information. To assess the effectiveness of the treatment information, we integrated a manipulation check question in the experimental documents of the different treatment cases. We asked participants to rate whether the provided information included environmental information (first treatment group) or taxonomy-aligned information (second treatment group). They assessed whether they recognized the treatment information, on a five-point Likert scale from 1 = definitely not agree to 5 = definitely agree.

In the last part, demographic information (e.g., gender, age, experience, profession, and income) is requested. In the first study, professional investors are also asked to provide information on how they have accounted for sustainability aspects in their daily business.³¹

²⁸ To make the direction of the given information understandable, we added the industry average of these ratios.

²⁹ As in Levhari and Levy (1977), the maturity of the long-term investment was defined from a minimum of one year.

³⁰ For verification of the underlying decision usefulness approach, questions were asked about the usefulness of the non-financial information provided in the ECO_{\emptyset} and EUT_{neg} groups. 89.95% of participants ranked the non-financial information as useful.

³¹ The inclusion of additional questions in the first study accounts for the variation in average processing times. Professional investors exhibited an average processing time of 9 min and 50 s, while private investors required an average of 7 min and 10 s.

Following Wason et al. (2002), we pre-tested the material for internal consistency and plausibility. Three professional investors, three Ph.D. students with topic-related knowledge, and three private investors without a deep understanding of sustainability and investments formed the pre-test group.³²

3.4 Sample

Our samples for the two investigations are composed of two types of participants: professional and private German³³ investors. The experiment was conducted using the online tool SurveyMonkey.³⁴ Participants in the online panel 'SurveyMonkey Audience' can be recruited via the survey software.³⁵ This online panel has been used in many previous studies, especially in the fields of health-related theories and psychological research (Barlett and Gentile 2012; Gollust et al. 2012; Gore and Widiger 2013; May et al. 2011; Waller et al. 2012). Gill et al. (2013) emphasize the efficiency and user-friendly procedure of this online panel and conclude that an improvement in data quality and a reliable sample of participants and valid data was obtained. In addition, Kimball (2019) points out that the careful design of the questionnaire and its distribution by a professional intermediary create a representative environment for the respondents. This is often seen as crucial to obtaining unbiased responses (Levitt and List 2007; List et al. 2006).

The online panel includes participants from various countries and covers the respective participant groups of German professional and private investors for our experimental concept. Our target groups are German participants, while for the classification of professional investors, we select participants currently employed in positions requiring the assessment of investment information. We define the criterion for private investors according to the panel item *stock trading*. Each of the three cases of the experimental documents (FIN, ECO_{\emptyset}, EUT_{neg}) was sent to a minimum of 100 professional (Study 1) and 100 private German investors (Study 2).³⁶ The resulting usable responses vary between the cases (see Table 2). The average exclusion rate is approximately 75%. The high exclusion rate of responses results on the one hand from dropouts and failed manipulation checks. In the first study, 38,1% of the participants and 37,5% of participants in the second study failed the treatment-manipulation checks.³⁷ Additionally, we made further adjustments in the main analysis, considering factors such as reparticipation, current investments of private investors, professional investors' investment experience, processing time,³⁸ manipulation

³² Suggested changes for plausibility and comprehensibility led to minor revisions and ensured appropriateness.

³³ Given that our study encompasses not only professionals but also private investors of diverse ages, backgrounds, and experiences, we acknowledge the potential risk of bias due to language restrictions that would arise in an international study. Thus, our decision to focus on German participants is strategic.

³⁴ We did not compensate participants directly. They were compensated through the survey tool.

³⁵ Kittur et al. (2008) point out that such a tool expands the potential user pool to include anyone connected to the internet.

³⁶ The studies were conducted in May 2021.

³⁷ Participants who failed the manipulation checks did not agree or definitely did not agree that the provided information contained the treatment information. As an example, Figure F depicts the results of the manipulation checks.

³⁸ A lower limit of processing time of four minutes refers to case FIN (with the smallest scope). For each case, the mean value of the processing time was subtracted by the standard deviation and thus represented the lower limit of processing time.

checks, and professional investors' job descriptions. In total, we received 103 usable documents in the first study of professional investors, and 89 usable documents in the second study of private investors.

4 Analysis and presentation of results

4.1 Statistical tests

As our models for both studies include between-subject factors (treatment information), the analysis is based on simple single factorial models. To examine the research hypotheses about the impact of commonly disclosed environmental and taxonomy-aligned information on investment-related judgment (H1 & H2), we use a single factor-design analysis of variance (ANOVA) in both studies.³⁹ The variances of the mean values are compared within the different experimental groups. Post hoc tests are used to identify the direction of effects so that we run pairwise comparison tests. To ensure the reliability of the significance tests, we verify whether the requirements for an ANOVA model are met.⁴⁰

5 Results

To illustrate the direction of participants' investment perceptions between the treatment groups, measured by the described judgment variable, we plotted the mean values by treatment information in Fig. 4 for both investigations and marked the significant differences detected by the post hoc tests (Table four) for better visualization. A comparison between the effects in both studies reveals that the reaction within the treatment groups differs between professional and private investors. Compared to the control group (FIN), professional investor judgment seems to be negatively affected in both treatment groups (ECO_{\emptyset} & EUT_{neg}) (left plot). In contrast, private investors' perception of the investment seems to be positively affected (right plot).

Table 3 shows the results of the ANOVAs for both studies. The results of the first study reveal significant effects of the different environmental disclosures at three levels on professional investor judgments (p=0.0727). The second study proves that the additional average environmental information (ECO_{\varnothingleq}) and negative taxonomy-aligned information (EUT_{neg}) have a significant impact on the investment-related judgment of private investors (p=0.030).

To examine the direction of these significant effects, we look at the results of the post hoc tests in Table 4. These results enable the investigation of transparency-enhancing effects, i.e., the direction of effects in a case where companies use flexibility in commonly disclosed environmental information and fall into a poor environmental performance category through the linkage between non-financial reporting elements and quantitative

³⁹ We checked whether covariates such as age or income needed to be included in the model. Due to the low and nonsignificant correlation with the dependent variables (p > 0.05), we rejected this.

⁴⁰ To test the assumption of a normal distribution, we ran a Shapiro–Wilk test, which revealed nonnormally distributed data in most subsamples. Therefore, we carried out a logarithmic transformation of the data to normalize the distribution skewness. We also tested for variance homogeneity with a Levene test, as the measurement variation should be equally distributed across all possible values of the independent variables. The test showed variance homogeneity (p > 0.05).

Experimental group	Treatment	Investor type	Recipients	All Recipients but without dropouts	After adjustment ^a & exclusion due to manipulation-checks
Control group	FIN	Professional	123	84	25
		Private	121	62	28
First treatment	ECOø	Professional	124	94	41
group	~	Private	108	59	31
Second treatment	EUT _{neg}	Professional	134	79	37
group		Private	115	61	27
		Professional	381	257	103
		Private	344	182	86

Table 2 Overview of Participants in Both Studies

^aAfter adjustment by processing time, capital investment, investment experience, professional investor occupation

financial measures by taxonomy indicators (H1 & H2). By looking at the results of the first study, we see that professional investor judgment was significantly lower (-0.49) in the second treatment group (EUT_{nes}) than in the control group (p = 0.067). Compared to the control group, the first treatment group (ECO $_{\alpha}$) of professional investors was not significantly affected by the additional environmental information (p=0.325).⁴¹ Thus, we can accept H1 (The inclusion of commonly disclosed environmental information with average environmental performance does not affect investor judgment.) as well as H2 (Investor judgment is negatively affected by the inclusion of additional taxonomy-aligned information with poor environmental performance.) in the study with professional investors. The results of the second investigation also reveal significant differences between the control group (FIN) and the second treatment group (EUT_{neg}). However, in contrast to professional investors, private investor judgment improves significantly (+0.57), although the information shows a poor taxonomy performance (p=0.034). In Study 2, the treatment group with average commonly disclosed environmental information (ECO_{α}) was not significantly affected by the additional environmental information (p=0.104), leading to the acceptance of H1.⁴² However, the results of the study with private investors show that investor judgment is affected positively by (less good) additional taxonomy-aligned information so H2 can be rejected in this case.43

As a main result, we can identify that investment-related judgments depend on the given information and differ between investor types. A key finding is that flexible commonly disclosed environmental information with average performance seems to be interpreted

⁴¹ As part of our post-experimental questions, we asked participants two related questions (whether the company acts sustainably and to rate the company's sustainable performance). We do not find conflicting results (untabulated).

⁴² As part of our post-experimental questions we asked participants two related questions (whether the company acts sustainably and to rate the company's sustainable performance). We do not find conflicting results (untabulated).

⁴³ The non-significant difference between ECO and EUT leads to the assumption, that taxonomy information seems to affect investor judgment only in combination with commonly disclosed environmental information as in future reporting practice.



Fig. 4 Means Plot with a 95% Confidence Interval for Professional Investor Judgment (Left Plot) and Private Investor Judgment (Right Plot) with Different Treatment Information

Table 3 Results of Two Separate ANOVAs for Professional and Private Inve	stors
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Main Effects: Dependent Variable	Sample	Effect	F-Value	p. adj
Professional Investor Judgment	Professional investors	Treatments (FIN/ECO _Ø / EUT _{neg})	2.691	0.0727*
Private Investor Judgment	Private investors	Treatments (FIN/ECO _Ø / EUT _{neg})	3.647	0.030**

Statistical significance: p < 0.1; p < 0.05; p < 0.01 with two-tailed *p*-values (Mauchly Test for Sphericity as well as Greenhouse Geisser and Huynh–Feldt corrected *p*-values were computed for the respective effects)

Table 4	Results of Post	Hoc Tests for	the Investigation	n of the Direction	of Investor Reactions	(H1 a	& H2)
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Pairwise t test: Dependent Variable	Comparison groups	Diff	p. adj
Study 1: Professional Investors			
Professional Investor Judgment	FIN vs. ECO_{\emptyset}	-0.29	0.325
Professional Investor Judgment	FIN vs. EUT _{neg}	-0.49	0.067*
Professional Investor Judgment	ECO _Ø vs. EUT _{neg}	-0.20	0.325
Study 2: Private Investors	-		
Private Investor Judgment	FIN vs. ECO _Ø	0.44	0.104
Private Investor Judgment	FIN vs. EUT _{neg}	0.57	0.034**
Private Investor Judgment	ECO_{\emptyset} vs. EUT_{neg}	0.14	0.485

Statistical significance: p < 0.1; p < 0.05; p < 0.01 with two-tailed *p*-values (Mauchly Test for Sphericity as well as Greenhouse Geisser and Huynh–Feldt corrected *p*-values were computed for the respective effects)

differently by different investor types. While professional investor judgment worsens, the investment-related judgment of private investors improves, but not significantly. Furthermore, this reaction is also identified in the treatment with standardized taxonomy-aligned information. The linkage between non-financial reporting elements and quantitative financial measures by taxonomy indicators affects the judgment of private and professional investors, but in different directions and only in combination with common environmental reporting. A comparison between the treatment groups and the control group reveals that the manipulation of information has a positive impact on investment-related judgments among private investors (despite negative taxonomy-aligned information). In contrast, the investment-related judgment by professional investors is negatively affected by the manipulation of additional taxonomy-aligned information, so we can only identify transparency-enhancing effects for professional investors when a company falls into a poor environmental performance category through standardized taxonomy information.

Within the framework of the information overload theory, the discrepancy between professional and private investors can be explained by the challenges that private investors encounter in processing non-financial information, as articulated by Köhler (2020). This divergence may also be linked to the probability that the reported information primarily serves to fulfill the needs of professional investors, considering their predominant influence on the provision of financial capital (Ferreira and Matos 2008). As highlighted in Krische's study (2018), investment decisions are shaped by investors' experience. The disparity in investment experience between professional and private investors in this study is outlined in Table 1, with a majority of professional investors boasting an investment experience of more than 10 years, while most private investors have an investment experience ranging from 1 to 2 years. Consequently, it appears that private investors face greater processing efforts in dealing with the provided information. In line with Pernagallo and Torrisi (2022), investors tend to selectively exclude information when the cost of processing all relevant information becomes excessively high.

5.1 Additional analysis

We performed data analysis using the complete sample of participants who did not drop out of the experimental studies. Similar to Kotzian et al. (2020), who investigated the sensitivity of excluding participants due to manipulation checks, we examine in the additional analysis the reaction of professional investors (Study 1) and the reaction of private investors (Study 2), without excluding participants through the adjustment and manipulation checks as was done in our main analysis. By considering the entire sample, including those investors who may not pay close attention to additional environmental information, we aim to provide a more realistic depiction of the capital market scenario.

Table 5 presents the results of the two separate ANOVAs for both studies and Table 6 provides the results of the pairwise comparison post hoc tests. Our analysis confirms the results of Study 1, in which professional investor judgment is significantly negatively affected by negative taxonomy-align information (p=0.095). In this sample, where we included those participants who did not recognize any additional information detected by manipulation check questions, the EUT_{neg} treatment no longer appears to significantly affect private investor judgment (p=0.24), although this information was negatively tainted. Thus, we cannot observe any significant results in Study 2, but Fig. 5 shows that the direction of investor reactions is similar to the main analysis. Private investors reward additional environmental information, whether in the ECO_{\varneeq} case or the EUT_{neg} case, while

Main Effects: Dependent Variable	Sample	Effect	F-Value	p. adj
Professional Investor Judgment	Professional investors	Treatments (FIN/ECO _Ø / EUT _{neg})	2.788	0.063*
Private Investor Judgment	Private investors	Treatments (FIN/ECO _Ø / EUT _{neg})	1.922	0.149

 Table 5
 The Results of Two Separate ANOVAs for Professional and Private Investors, Including All Participants Who Did Not Drop Out of the Experiment

Statistical significance: *p < 0.1; **p < 0.05; ***p < 0.01 with two-tailed *p*-values (Mauchly Test for Sphericity as well as Greenhouse Geisser and Huynh–Feldt corrected *p*-values were computed for the respective effects)

Table 6 Results of Post Hoc Tests, Including All Participants Who Did Not Drop Out of the Experiment

Pairwise t test: Dependent Variable	Comparison groups	Diff	p. adj
Study 1: Professional Investors			
Professional Investor Judgment	FIN vs. ECO _Ø	-0.25	0.114
Professional Investor Judgment	FIN vs. EUT _{neg}	-0.29	0.095*
Professional Investor Judgment	ECO _Ø vs. EUT _{neg}	-0.04	0.735
Study 2: Private Investors	-		
Private Investor Judgment	FIN vs. ECO _Ø	0.22	0.24
Private Investor Judgment	FIN vs. EUT _{neg}	0.30	0.24
Private Investor Judgment	ECO_{\emptyset} vs. EUT_{neg}	0.08	0.91

Statistical significance: p < 0.1; p < 0.05; p < 0.01 with two-tailed *p*-values (Mauchly Test for Sphericity as well as Greenhouse Geisser and Huynh–Feldt corrected *p*-values were computed for the respective effects



Fig. 5 Means Plot with 95% confidence interval for Professional Investor Judgment (Left Plot) and Private Investor Judgment (Right Plot) with the full sample of participants who did not drop out of the experiment

professional investors are slightly negatively affected. It seems that if investor attention is not drawn to the additional treatment information, professional investors appear more likely to consider taxonomy information than private investors.

6 Discussion and conclusion

The main finding of these experimental studies is that the linkage between non-financial reporting elements and quantitative financial measures by taxonomy indicators affects the judgment of professional and private investors, but in different directions. When a company falls into a poor environmental performance category through standardized taxonomy information (EUT_{neg}), we observed a positive impact on investment-related judgments among private investors (despite negative taxonomy-aligned information). In contrast, the investment-related judgment for a long-term investment of professional investors is negatively affected by additional taxonomy-aligned information. Thus, we can only identify transparency-enhancing effects by linking non-financial reporting elements to quantitative standardized financial measures for professional investors. Our results indicate that private investors reward additional taxonomy-aligned environmental information, independent of the content. Furthermore, our robustness analysis with all participants without excluding participants who failed the manipulation checks reveals that if attention is not drawn to treatment information, taxonomy information has limited effects on private investors, even if taxonomy performance is poor.

In the two studies, we investigate the impact of flexible environmental disclosure on investor information judgment and the extent to which the EU taxonomy, as the linkage between non-financial reporting elements and quantitative financial measures, is helpful (transparency-enhancing) for the interpretation of information by professional and by private investors. The investigation is based on the assumption that non-financial reporting elements with flexibility, displaying in our case average performance, allow for interpretation regarding corporate environmental performance. If these flexible nonfinancial qualitative reporting elements are now linked to quantitative financial measures in the form of taxonomy performance indicators, this can highlight the performance more clearly and allow investors to define a taxonomy-aligned portfolio share. The EU Commission assumes that the standardized ratios in the form of taxonomyaligned turnover shares and investment shares increasingly reveal companies in a poor environmental performance category that have previously taken advantage of the flexibility in non-financial reporting. We investigate this scenario by analyzing the effect of standardized taxonomy information on a company that falls into a poor environmental performance category, despite having flexibility in environmental disclosure with room for interpretation. The research methodology provides insight into the investmentrelated judgment of professional and private investors based on three cases. By manipulating the provided company information, the potential effects of different environmental disclosures on individual investment-related judgments are observed. Additionally, the effects of the planned EU taxonomy as a standardization are examined even before it has been fully implemented in companies.

The procedure in both studies, with professional (Study 1) and private investors (Study 2) was the same. Using an ANOVA, we compared the investment-related judgment based on only financial information to the judgment with additional commonly disclosed

environmental information in a first step. The additional information, in this case presents an average performance to avoid explicitly forcing a specific direction of consideration. Descriptive results indicate that the direction of investor reaction to the provided flexible environmental information (ECO_Ø) leaves room for interpretation and a different perceived environmental performance between professional and private investors. Average environmental information is negatively interpreted by professional investors. More experienced investors who are professionally associated with capital investments do not see average environmental information as adding much value. This differs for private investors, whose investment-related judgment is positively affected by this information. However, our results indicate no significant impact on investor judgment for this type of environmental information (according to the NFRD with an average performance). By manipulating company information with additional negative taxonomy-aligned information in a second treatment case, we further investigate whether the new type of disclosure as part of the upcoming CSRD is helpful for investors wishing to interpret the environmental information and whether investors recognize the (less good) taxonomy indicators. In terms of credible and transparent disclosures on environmental activities, the standardized taxonomy should create a common understanding of the company's environmental performance through a linkage between non-financial reporting elements and quantitative financial measures. We examine this when a company falls into a poor environmental performance category through standardized taxonomy measures. The direction of professional and private investor judgment in the case of additional negative taxonomy-aligned information is the same as in the first case, but here the results are significant. If we assume that the EU taxonomy shows a standardized environmental performance, our results indicate that taxonomyaligned information is helpful for professional investors, as they recognize and penalize negative information. In contrast, private investors reward environmental information, even if taxonomy-aligned information is negative.

In contrast to previous studies (Abhayawansa and Guthrie 2010; Ghosh and Wu 2012; Rikhardsson and Holm 2008), our investigation yielded no evidence that additional commonly disclosed environmental information with an average performance significantly influences investors. In both studies, treatment information according to the NDRD did not significantly impact the judgments of both professional and private investors. Drawing from the underlying theories, it appears that investors in both studies find additional negative taxonomy-aligned information useful for investment-related judgment (Khemir et al. 2019). Moreover, for professional investors, incorporating taxonomy information alongside commonly disclosed environmental information reduces information asymmetry. However, in line with Staubus (1999) and Hassel et al. (2005), investors guided by the decision criterion of usefulness are likely to react in the direction of the provided information. While this effect is evident in the study examining professional investors' judgment, private investors do not exhibit the predicted reaction. This aligns with the findings of Köhler (2020) and Fiesenbicher (2015), who highlight challenges in processing corporate information for private investors and an overload of sustainable information. The results suggest that, as signaling theory emphasizes, environmental information generally conveys positive signals to private investors, but there is an assumed uncertainty in information processing. Consequently, it appears that private investors face greater processing efforts in dealing with the provided information. In line with Pernagallo and Torrisi (2022), private investors tend to selectively exclude information when the cost of processing all relevant information becomes excessively high. This uncertainty in information processing may stem from a high level of uncertainty associated with the taxonomy, as described by Norang and Store-Valen (2023), and limited attention in the decision-making process (Nekrasov et al. 2023).

We included participants who had failed the manipulation checks, to check for robustness and provide further insight into the impact of the EU taxonomy. For the capital market, it is likely that there are also professional and private investors who are not specifically directed to pay attention to such taxonomy-aligned information. In this scenario where the manipulation checks failed, we see robust results, at least in the investigation with professional investors. However, additional negative taxonomyaligned information no longer significantly affects the investment-related judgment of private investors, although the information was negatively tainted and should have had a higher impact, according to prospective theory. These findings are in line with Nekrasov et al. (2023) about the impact of limited attention on financial decisionmaking and put into perspective the impact of additional taxonomy-aligned information in investment-related judgments of private investors. Thus, if investors are not attentive to the information, then professional investors seem more likely to consider taxonomy-aligned information than private investors. We see similarities with the results of the study by Lucarelli et al. (2023). This does not refer to taxonomy-aligned corporate investments, but to taxonomy-eligible investments. It shows that the introduction of the EU taxonomy itself has not led to an increase in corporate investment in taxonomy-eligible companies. Instead, uncertainty as to whether a company is taxonomy-eligible plays a more important role in explaining variation in corporate investment.

In the experimental analysis of transparency-enhancing policies, we offer practical insights oriented towards investors for standard setting, grounded in an improved comprehension of investor judgments, especially in cases of limited information processing. If transparency obligations, such as those outlined in the EU taxonomy, are intended to mitigate information asymmetry and uncertainty in investors' decisionmaking processes, additional measures would prove advantageous. In the absence of legal regulations (e.g., in investment advisory) ensuring the attention of private investors to taxonomy indicators and the accurate labeling of information, the effectiveness of the EU Taxonomy Directive may face limitations. The significance of investor attention is underscored by Zhang and Zhan's (2024) empirical analysis, demonstrating that investor attention can markedly enhance the ESG standards of listed companies. Consequently, our findings on limited information processing carry substantial implications for policy and environmental disclosure practices aligned with the EU Commission's objective of directing capital towards sustainable businesses.

The limitations of this studies are related to the experimental method. One of the most important points is that the scope of the experimental material was necessarily limited (Lachmann et al. 2015). We chose financial and non-financial information that surveys and studies have shown to be the most useful for investors and are considered common and best practice. In addition, we used negative taxonomy-aligned information in the studies to investigate whether the taxonomy is helpful for the interpretation of information in the case of a company falling into a poor environmental performance category through standardized taxonomy measures. Future studies could investigate the impact of different visualization formats, as previous research has shown that the format of presentation of key indicators also influences how decision-makers weigh financial and non-financial information (Cardinaels and van Veen-Dirks 2010). Comparative studies among several EU countries should analyze the impact of culture on the consideration of (taxonomy-aligned) environmental information in investment decisions.

Appendix

In million €	2017	2018	2019	Change 18/19
Sales revenue	20,029	19,899	20,114	+1.1%
EBIT (operating profit)	3,055	2,899	3,116	+7.5%
Return on sales (EBIT-margin)	15.3%	14.6%	15.5%	+0.9 PP (percentage points)
EBITDA	4,133	3,977	4,074	+2.4%
operational cash flow	2,468	2,698	3,241	+20.1%
Research and development expenses	469	484	499	+3.1%
Investment expenses (CapEx) ^a	700	837	842	+0.6%
Financial liabilities	2,356	2,082	2,045	- 1.8%
Earnings after taxes	2,541	2,103	2,330	+10.8%
Balance sheet figures:				
Total assets in million €	28,339	29,562	31,403	+6.2%
Equity ratio in % ^a (equity / total assets)	55.2%	57.5%	59.3%	+1.8 PP
Dept-equity ratio in % ^a (liabilities/ equity)	44.8%	42.5%	40.7%	- 1.8 PP
Asset coverage I in % ^a (equity / long term assets)	78.8%	81.4%	83.6%	+2.2 PP
Financing structure in % ^a (short term liabilities/liabilities in total)	61.1%	71.9%	66.6%	- 5.3 PP
Return on equity in % ^a (ROE) (net income/equity)	16.2%	12.4%	12.5%	+0.1 PP
Key figures for the share:				
Price-earnings-ratio (at the year-end price in €)	17.24	16.11	17.50	+8.6%
Earnings per share (EPS) in €	5.80	4.80	5.32	+10.8%
EV/EBITDA (EBITDA-Multiple)	11.5x	10.1x	10.2x	
Dividend return at the end of the year	1.62%	1.94%	1.98%	+ 0.04 PP

 Table 7
 Exctract of the Experimental Documents: Financial Information—Key Performance Indicators and Balance Sheet Ratios. (Part of FIN)

^anot defined by International Financial Reporting Standards (IFRS)

Table 8	Excerpt of the	Experimental	Documents:	Quantitative	Environmental	Information.	(Part of	ECO _Ø)
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	2017	2018	2019	Change 18/19
Environmental impact				
CO ₂ -emissions – direct & indirect in kt	679	666	665	- 0.15%
Further relevant indirect CO2-emissions in kt	353	380	373	- 1.84%
Waste in kt	255	245	244	- 0.41%
Of which dangerous waste (exported) in kt	4.9	4.5	4.4	- 2.22%
Recycling-rate	70%	60%	66%	+6%
Sewage volume in Mio. m ³	13.1	13.5	13.2	- 2.22%
Water extraction in Mio. m ³	14.00	14.65	13.95	- 4.78%
Energy efficiency				
Energy consumption (GWh)	2,194	2,227	2,240	+0.58%
Energy intensity in KWh per ${\ensuremath{\varepsilon}}$ revenue	0.1511	0.1501	0.1387	- 7.59%

Table 9	Results of ANOVAs and Post Hoc Tests for Every Single Item in the First Study

Study 1: Professional Investors				
Main Effects: Dependent Variable	Sample	Effect	F-Value	p. adj
Investment Attractiveness	Professional investors	Treatments (FIN/ ECO _Ø /EUT _{neg})	0.479	0.621
Investment Probability	Professional investors	Treatments (FIN/ ECO _Ø /EUT _{neg})	0.512	0.601
Buy Scale to Invest	Professional investors	Treatments (FIN/ ECO _Ø /EUT _{neg})	0.054	0.954
Investment Amount	Professional investors	Treatments (FIN/ ECO _Ø /EUT _{neg})	0.863	0.425
Investment Recommendation	Professional investors	Treatments (FIN/ ECO _Ø /EUT _{neg})	3.8	0.0257**
Post Hoc Tests				
Pairwise t test: Dependent Variable	Comparison groups	Diff		p. adj
Investment Attractiveness	FIN vs. ECO _Ø	-0.118		0.895
Investment Probability	FIN vs. ECO _Ø	-0.279		0.615
Buy Scale to Invest	FIN vs. ECO _Ø	-0.019		0.994
Investment Amount	FIN vs. ECO _Ø	0.210		0.725
Investment Recommendation	FIN vs. ECO _Ø	-0.248		0.397
Pairwise t test: Dependent Variable	Comparison groups	Diff		p. adj
Investment Attractiveness	FIN vs. EUT _{neg}	-0.257		0.602
Investment Probability	FIN vs. EUT _{neg}	-0.252		0.661
Buy Scale to Invest	FIN vs. EUT _{neg}	-0.081		0.947
Investment Amount	FIN vs. EUT _{neg}	-0.110		0.923
Investment Recommendation	FIN vs. EUT _{neg}	-0.463		0.023**

Statistical significance: *p < 0.1; **p < 0.05; ***p < 0.01 with two-tailed *p*-values (Mauchly Test for Sphericity as well as Greenhouse Geisser and Huynh–Feldt corrected *p*-values were computed for the respective effects)

Main Effects (ANOVA): Dependent Variable	Sample	Effect	F-Value	p. adj
Investment Attractiveness	Private investors	Treatments (FIN/ECO _Ø /EUT _{neg})	2.968	0.057*
Investment Probability	Private investors	Treatments (FIN/ECO _Ø /EUT _{neg})	3.38	0.039**
Buy Scale to Invest	Private investors	Treatments (FIN/ECO _Ø /EUT _{neg})	1.101	0.584
Investment Amount	Private investors	Treatments (FIN/ECO _Ø /EUT _{neg})	1.261	0.289
Investment Recommendation	Private investors	Treatments (FIN/ECO _Ø /EUT _{neg})	0.514	0.6
Post Hoc Tests		-		
Pairwise t test: Dependent Variable	Comparison groups	Diff		p. adj
Investment Attractiveness	FIN vs. ECO _Ø	+0.587		0.021**
Investment Probability	FIN vs. ECO_{\emptyset}	+0.523		0.180
Buy Scale to Invest	FIN vs. ECO_{\emptyset}	+0.212		0.765
Investment Amount	FIN vs. ECO _Ø	+0.060		0.963
Investment Recommendation	FIN vs. ECO _Ø	-0.208		0.650
Pairwise t test: Dependent Variable	Comparison groups	Diff		p. adj
Investment Attractiveness	FIN vs. EUT _{neg}	+0.626		0.021**
Investment Probability	FIN vs. EUT _{neg}	+0.784		0.030**
Buy Scale to Invest	FIN vs. EUT _{neg}	+0.320		0.567
Investment Amount	FIN vs. EUT _{neg}	+0.090		0.305
Investment Recommendation	FIN vs. EUT _{neg}	-0.006		0.999

Table 10 Results of ANOVAs and Post Hoc Tests for Every Single Item in the Second Study

Study 2: Private Investors

Statistical significance: p < 0.1; p < 0.05; p < 0.05; p < 0.01 with two-tailed *p*-values (Mauchly Test for Sphericity as well as Greenhouse Geisser and Huynh–Feldt corrected *p*-values were computed for the respective effects)

	Category	Professionals $(n = 103)$	Privates (<i>n</i> = 86)
Age FIN	18–29	20%	36%
	30-44	32%	25%
	45–59	32%	39%
	60+	16%	0%
Age ECO _ø	18–29	17%	29%
	30-44	39%	48%
	45–59	29%	16%
	60+	15%	6%
Age EUT _{neg}	18–29	19%	37%
.8	30–44	38%	48%
	45–59	32%	15%
	60+	11%	0%
Sex FIN	male	68%	79%
	female	32%	21%
	-	0%	0%
Sex ECO _Ø	male	78%	55%
C C	female	20%	42%
	-	2%	3%
Sex EUT _{neg}	male	68%	89%
8	female	30%	11%
	-	3%	0%
Eductaion FIN	High School Diploma low level ("Hauptschulabschluss")	0%	0%
	High School Diploma medium level ("Mittlere Reife")	20%	50%
	High School Diploma high level ("Abi- tur")	48%	25%
	"Diplom" (Combination of Bachelor & Master)	4%	11%
	Bachelor	16%	14%
	Master	12%	0%
Eductaion ECO_{\emptyset}	High School Diploma low level ("Hauptschulabschluss")	0%	3%
	High School Diploma medium level ("Mittlere Reife")	20%	35%
	High School Diploma high level ("Abi- tur")	29%	29%
	"Diplom" (Combination of Bachelor & Master)	20%	10%
	Bachelor	17%	10%
	Master	15%	13%

 Table 11 Demographics for a Comparison of Each Category

Table 11 (c	ontinued)
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	Category	Professionals (n = 103)	Privates (<i>n</i> = 86)
Eductaion EUT _{neg}	High School Diploma low level ("Hauptschulabschluss")	0%	4%
	High School Diploma medium level ("Mittlere Reife")	14%	22%
	High School Diploma high level ("Abi- tur")	35%	44%
	"Diplom" ("Combination of Bachelor & Master")	30%	0%
	Bachelor	11%	15%
	Master	11%	15%
Income FIN	<1.000 €	0%	18%
	1 000 €—1 999 €	12%	28%
	2.000 €-3.999 €	32%	32%
	>4 000 €	52%	22%
	-	4%	0%
Income ECO~	<1.000€	0%	4%
u u u u	1.000 €—1.999 €	10%	23%
	2.000 €—3.999 €	37%	52%
	>4.000 €	41%	15%
	-	12%	6%
Income EUT _{neg}	<1.000 €	0%	7%
neg	1.000 €—1.999 €	17%	11%
	2.000 €—3.999 €	43%	37%
	>4.000 €	32%	41%
	-	8%	4%
Investment experience	<1 year	4%	19%
FIN	1–2 years	8%	28%
	2–5 years	24%	22%
	5–10 years	24%	10%
	> 10 years	40%	21%
Investment experi-	<1 year	5%	13%
ence ECO _Ø	1–2 years	10%	23%
	2–5 years	12%	10%
	5–10 years	29%	16%
	>10 years	44%	39%
Investment experi-	<1 year	9%	37%
ence EUT _{neg}	1–2 years	9%	26%
	2–5 years	13%	22%
	5–10 years	17%	4%
	> 10 years	53%	11%

Highlights in the area "Environment"

Responsibility for achieving the climate targets is firmly anchored in our management level. With the attitude that <u>climate protection and energy efficiency pay off in the long term</u> - for our environment as well as for our business - we are looking at new legal requirements. With greenhouse gas emissions, severage, and waste our economic activities impact the environment as well.

Responsibly we set ourselves the goal to reduce our direct and indirect greenhouse gas emissions by 60% compared to 2006 until 2030 and reach <u>climate neutrality until 2040</u>. Until 2025 we also want to improve our energy efficiency by 9.5% compared to the last reporting year.

Fig. 6 Excerpt of the Experimental Documents: Qualitative Environmental Information. (Part of ECOg)

Taxonomy information

The taxonomy regulation of EU Commission defines sustainable economic activities in relation to climate change based on fixed criteria. With the help of this taxonomy classification system, corporate activities that contribute to climate protection and adaptation to climate change are classified as ecologically sustainable ("taxonomy-compliant").

This makes it possible to indicate the proportion of our generated sales that are achieved with environmentally sustainable activities according to the EU criteria. The share of investments in taxonomically sustainable activities can also be defined:

Taxonomy-aligned share of sales = 8.9% (10% sector average)

Taxonomy-aligned investment share = 12.1% (14% sector average)

Fig. 7 Excerpt of the Experimental Documents: Taxonomy Information. (Part of EUT_{nes})



Fig. 8 Employment (Position & Sector) of Private Investors in the Experimental Sample with 6% Students, 5% Young Professionals, 42% Employees, 25% Management Positions, 15% Executive Staff, and 7% Board Members



Fig. 9 Employment of Professional Investors in the Experimental Sample in an Investment Company (21%), a Bank (20%), an Insurance Company (23%), in the Public Sector (29%), a Fund Company (4%), and a Foundation (2%)



Fig. 10 Excerpt from the Raw Data for the Question on the Profitability of the Fictitious Company



Fig. 11 Example of Manipulation Checks for Professional Investors in the ECO_{\emptyset} Treatment from the Raw Data

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Declarations

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Competing interests The authors declare that they have no competing interests.

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