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Climate reporting in the fast lane? The impact of corporate governance on the disclosure of climate-related risks and opportunities

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Abstract

Climate-related issues have become increasingly relevant, as reflected in current political and academic discourse. This development is also reflected in investors' capital allocation decisions and their demand for climate-related information. Considering the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD), we first investigate the climate-related disclosure quality of listed German firms. We use self-constructed scoring models based on the TCFD recommendations to measure disclosure quality. Second, we use regression analysis to investigate whether corporate governance can explain climate-related disclosure quality. The results indicate that disclosure quality is heavily dispersed across firms, with risk disclosure being better than disclosure of opportunities. Corporate governance factors exert distinct but mostly weak influence on climate-related disclosure quality and that institutional ownership promotes climate-related disclosure quality. We show several implications for research and practice and highlight the relevance for firms to implement a comprehensive approach to communicating climate-related issues.

KEYWORDS

climate-related disclosure quality, climate-related opportunities, climate-related risks, corporate governance, institutional ownership, Task Force on Climate-related Financial Disclosures (TCFD)

Abbreviations: CDP, Carbon Disclosure Project; CEO, Chief Executive Officer; CFO, Chief Financial Officer; CSO, Chief Sustainability Officer; CSRD, Corporate Sustainability Reporting Directive; DAX, German Stock Index; EC, European Commission; EFRAG, European Financial Reporting Advisory Group; ESG, Environmental, Social, and Governance; ESRS, European Sustainability Reporting Standard; EU, European Union; FSB, Financial Stability Board; FY, fiscal year; GAS, German Accounting Standard; GHG, greenhouse gas; GRI, Global Reporting Initiative; IPCC, Intergovernmental Panel on Climate Change; ISSB, International Sustainability Standards Board; MDAX, Mid-Cap DAX; NFRD, Non-Financial Reporting Directive; OLS, ordinary least squares; SDAX, Small-Cap DAX; SFDR, Sustainable Finance Disclosure Regulation; TCFD, Task Force on Climate-related Financial Disclosures; VIF, variance inflation factor.

1 | INTRODUCTION

Climate is the topic that currently dominates the debate on a more sustainable future, especially climate change risks (e.g., Gebhardt et al., 2022; Stroebe & Wurgler, 2021). The Intergovernmental Panel on Climate Change (IPCC) report shows the need for action as climate change progresses faster than expected (IPCC, 2021).

Through its Action Plan on Sustainable Finance (Action Plan, for short), the European Commission (EC) foresees redirecting money

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flows to sustainable projects to counteract climate change (European Commission, 2018). With this Action Plan, the EC attributes a significant role to financial market participants in transitioning toward a sustainable economy (European Commission, 2021).

The fact that climate issues, particularly climate change, are becoming increasingly important to the capital market is also underscored by BlackRock, the world's largest asset manager, as there has been a noticeable expansion on climate change in their "Dear CEO" letters in recent years (Pawliczek et al., 2021). Therefore, the Task Force on Climate-related Financial Disclosures (TCFD) recommendations can support the transition to a sustainable economy by providing investors with climate-related information (TCFD, 2021). According to Bingler et al. (2022), firms that disclose according to the TCFD can deliver on their readiness to address climate change.

Especially in view of climate change disclosure and the transition to a CO₂ reducing economy, the TCFD has joined forces as a standard setter to accelerate this development. The developed TCFD recommendations are the most popular de-facto reporting guideline for corporates' disclosure of climate-related issues (BlackRock, 2020; Deloitte, 2021; Gebhardt et al., 2023). They play a glaring role in developing uniform sustainability reporting standards in the current global regulatory debate. In some countries, such as New Zealand and the United Kingdom, the application of the TCFD is mandatory (e.g., External Reporting Board, 2023). Other countries, such as Australia, strive to adopt the TCFD (Australian Government, 2023), specifically to address the management of risks arising from climate change (Deloitte, 2021). As part of the new regulatory environment in Europe through the implementation of the Corporate Sustainability Reporting Directive (CSRD), the European Financial Reporting Advisory Group (EFRAG) bases the European Climate Standard European Sustainability Reporting Standard "E1" (ESRS E1) on the TCFD framework (EFRAG, 2022). As the ESRS have been adopted by the EC on July 31, 2023 (European Commission, 2023) and published in the Official Journal of the European Union on 22nd December 2023 (EU, 2023), climate reporting, and therefore the reporting on climate-related risks and opportunities, will become mandatory in Europe. Further, the International Sustainability Standards Board (ISSB) published a prototype for climate-related disclosures in March 2022, building on the TCFD recommendations, among others (ISSB, 2022). This development is an expression of the importance of the TCFD to policymakers.

For firms, disclosure on sustainability is becoming more important as investors increasingly demand and integrate sustainability information in their investment decisions (e.g., Amel-Zadeh & Serafeim, 2018). According to Krueger et al. (2020), information about climate-related risks is relevant for institutional investors. Moreover, investors need reliable data on climate-related issues to better assess climate-related risks and integrate them into their investment decisions and portfolio management approaches (Hain et al., 2022). The need for firms to act against climate change is reflected in the increasing disclosure of the environmental impact of firms' activities (inside-out perspective) and climate-related risks and opportunities due to increasing stakeholder pressure (Dahl & Fløttum, 2019;

Flammer et al., 2021). Investors increasingly exert pressure as climate-related risks evolve into investment risks (outside-in perspective), as again expressed in Larry Fink's Letter to CEOs in 2022 (BlackRock, 2022).

In corporate practice and literature, the provision, and investigations of climate-related information focus more on climate-related risks than potential opportunities (Dahl & Fløttum, 2019; Hummel et al., 2021; Kouloukoui et al., 2019; Krueger et al., 2020). However, institutional investors consider both climate-related risks and opportunities in their investment decision process—especially information on firms' management of these risks and opportunities (Park & Jang, 2021). Therefore, institutional investors pay close attention to whether firms follow the recommendations of the TCFD, which urges firms to disclose climate-related risks and opportunities (Eccles & Krzus, 2019; Gebhardt et al., 2023). Otherwise, they may no longer be considered in the investment process of investors, thereby risking the loss of access to resources from investors (Aureli et al., 2020) and, theoretically, their "license to operate" (Drempetic et al., 2020). This attention also increases the overall pressure on firms to provide useful and qualitative climate-related disclosures (Schaltegger & Hörisch, 2017). Merely providing information is not sufficient to address information asymmetries, which agency theory focuses on. Shareholders necessitate high-quality information that presents a comprehensive view of corporate governance and the firms' ability to generate value (Raimo et al., 2020; Vitolla et al., 2020).

However, since only a few studies investigate the disclosure of opportunities (Dahl & Fløttum, 2019; Haberl-Arkhusht & Sternisko, 2020; Solomon et al., 2011), many studies focus on risk disclosures or consider it as one topic. Evidence on the disclosure of climate-related opportunities is lacking. While several studies address environmental disclosure quality (Baalouch et al., 2019; Helfaya & Moussa, 2017; Hooks & van Staden, 2011; Li et al., 2022) only a few investigations focus on climate-related disclosure quality. For instance, Bingler et al. (2022) find that the disclosure quality is improvable. In addition, there is some literature investigating the determinants of risk disclosure quality (e.g., Hassan, 2014) or analyzing the determinants of environmental disclosures in general (Kouloukoui et al., 2018). However, a clear link to climate-related disclosure is missing. We therefore recognize a research gap in the disclosure quality of climate-related opportunities and the associated determinants, which we aim to close with the present study.

Our study contributes to the literature in several ways. First, to the best of our knowledge, it is the first to investigate the determinants of climate-related risks and opportunities disclosure according to the TCFD recommendations. Therewith, we build on the study of Bingler et al. (2022) and additionally analyze the disclosure quality of firms that do not support the recommendations of the TCFD. We also look at the determinants of climate-related disclosure quality. Second, since the literature mainly focuses on carbon disclosure and climate-related risk disclosure (Borghei, 2021), this paper is the first to provide insights into the disclosure quality of opportunities and the respective determinants. Thus, the study attempts to fill an existing gap in the literature. Third, Germany has one of the highest

ecological resource consumptions (Global Footprint Network, 2022; Guenther et al., 2016), and climate needs to be considered an essential part of the disclosure. Therefore, we provide insights into a country under pressure concerning the disclosure of climate-related issues.

2 | INSTITUTIONAL BACKGROUND OF THE TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES

The TCFD is a working group established by the Financial Stability Board (FSB) in 2015. The framework deals with how the financial sector can consider climate-related issues to make adequate decisions about climate-related risks. The TCFD began developing disclosure recommendations, which should lead to a more effective disclosure of climate-related risks and opportunities (TCFD, 2017). As a primary target, the TCFD recommendations should improve the climate-related disclosure to “promote more informed investment, credit, and insurance underwriting decisions; and enable stakeholders to understand better the concentrations of carbon-related assets in the financial sector and the financial system's exposures to climate-related risks” (Deloitte, 2021, p. 4).

In July 2017, the TCFD published 11 recommendations on climate-related disclosures, which are presented in Table 1. One of the goals is to enable investors and creditors to assess the impact of climate change on a firm's future financial performance (TCFD, 2017). For this purpose, the 11 TCFD recommendations are

composed of four categories: Governance, Strategy, Risk Management, Metrics and Targets.

The TCFD distinguishes between climate-related risks and opportunities by providing examples, potential financial impacts, and measurements. According to the TCFD, climate-related risks are divided into transition risks and physical risks. The final TCFD report also shows what financial impact may result from the risks (TCFD, 2017). Transition risks are risks that arise from the transformation to a decoupled economy. They are divided into policy and legal, technology, market, and reputational risks. An example of transition risks is price increases for greenhouse gas emissions within firms. This risk would have a potential financial impact that could be reflected in an increase in operating costs, for example, higher compliance costs. Physical risks are risks of direct or indirect consequences of climate change that can threaten a firm. According to the TCFD, physical risks are divided into acute and chronic. Examples of physical risks are extreme weather conditions or sea level rise, which also create financial impacts for firms, such as increasing capital costs due to damage to the firm's assets.

Climate-related opportunities are classified into resource efficiency, energy source, products and services, markets, and resilience. The TCFD also provides information on potential financial impacts resulting from these opportunities. Examples of climate-related opportunities are the use of lower emission energy sources and new technologies, which can reduce greenhouse gas (GHG) emissions and operational costs (TCFD, 2017).

TABLE 1 General objectives and the 11 recommended disclosures according to TCFD (2017).

Governance	Strategy	Risk management	Metrics and targets
General objectives			
Disclose the organization's governance around climate-related risks and opportunities.	Disclose the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material.	Disclose how the organization identifies, assesses, and manages climate-related risks.	Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.
Recommended disclosures			
(a) Describe the board's oversight of climate-related risks and opportunities. (RQSCORE: #1/ OQSCORE: #12)	(a) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term. (#3/ #14)	(a) Describe the organization's processes for identifying and assessing climate-related risks. (#6/NA)	(a) Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process. (#9/ #18)
(b) Describe management's role in assessing and managing climate-related risks and opportunities. (#2/ #13)	(b) Describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning. (#4/ #15)	(b) Describe the organization's processes for managing climate-related risks. (#7/NA)	(b) Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks. (#10/NA)
	(c) Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario. (#5/ #16)	(c) Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management. (#8/NA)	(c) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets. (#11/ #18)

Note: For a better understanding of the composition of the disclosure scores, we added a numbering in brackets. For instance, the disclosure recommendation (a) of the category Strategy is reflected in Question #3 of the RQSCORE and Question #14 of the OQSCORE (see Table A1).

Carbon disclosure, that is, the disclosure of carbon emissions and their impact on the environment, is motivated through profit making, credibility and risk containment (Luo et al., 2023) and driven by investor pressure (Liesen et al., 2015), growing stakeholder demand (Guenther et al., 2016), or participation in the Carbon Disclosure Project (CDP) (Luo et al., 2023). Research has been using the CDP rating to measure carbon or environmental disclosure, for example, to see if certain determinants have an impact on these (Ben-Amar & McIlkenny, 2015). In our research, we use TCFD as this framework is the basis for the CDP and is specifically relevant for assessing the quality of climate reporting. We intend to focus on TCFD in our analysis precisely because the European standard-setting process is based on TCFD.

There is also some research about the use of the TCFD recommendations. For example, David and Giordano-Spring (2022) find that, due to growing stakeholder pressure, climate-related disclosure has increased from 2015 to 2018 in the airline sector. However, according to TCFD recommendations, the disclosure quality is poor, especially in strategic directions of business activities about climate change (David & Giordano-Spring, 2022). In addition, Bingler et al. (2022) also find that mainly disclosures on the TCFD categories strategy and metrics and targets are not satisfactory. For firms, the voluntary disclosure of climate-related information following the TCFD recommendations could be helpful. Maji and Kalita (2022) find that it is positively associated with financial performance. Also, O'Dwyer and Unerman (2020) acknowledge the importance of using the TCFD recommendations for disclosures but also see great challenges for firms and investors. As important challenges, they state scenario planning, integrating climate-related risks into risk management on a firm level, aligning TCFD disclosures with other disclosure frameworks, and the assurance level for TCFD disclosures. In addition, Friedrich et al. (2022) focus specifically on whether European banks are compliant with the TCFD by finding that climate reporting improved over time, especially in the governance category, meaning that climate issues are becoming increasingly relevant for management. However, focusing on climate related risks, the study by Di Marco et al. (2022) shows the extent to which the European financial sector is adapting to the information requirements of the TCFD. One issue is organizational problems, as people mainly do not yet know how to set up information systems in order to effectively receive the required information and to implement the competences in the firms (Di Marco et al., 2022). For the proper implementation of the TCFD, further resources such as Huiskamp et al. (2022) may provide information on climate-related scenario analysis, for example, in order to integrate it as an integral part of corporate strategy to tackle climate risks.

By focusing only on climate-related risks, Amar et al. (2022) analyzed French firms' disclosure to assess their compliance with the TCFD. Over the past years, compliance with the TCFD has increased, especially on climate-related risks. The existing literature also identifies a lack of comparable climate-related information to the different levels of disclosure quality, as the TCFD will not be mandatory for all countries (Webster, 2020). Other studies that analyze climate risks on the basis of the TCFD focus, for example, on what information is

disclosed according to the TCFD and what types of climate risks are published (Demaria & Rigot, 2021), whereas we look at the quality of climate risk reporting and additionally climate opportunity reporting. As the study by Demaria and Rigot (2021) also calls for further research on determinants in this area, we see a starting point in providing these determinants for the quality of climate risks and opportunities. The lack of comparability makes it difficult for cross-border investors to consider climate-related information in their investment process. However, while there is some evidence about climate-related risks, there is nearly no evidence of the disclosure quality of climate-related opportunities. First, to close the gap in the existing literature, we provide insights into the disclosure quality of both climate-related risks and opportunities. Second, we investigate the determinants of climate-related disclosure quality aligned with the TCFD recommendations.

3 | THEORETICAL BACKGROUND, LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The growing relevance of environmental and climate-related disclosures is becoming increasingly noticeable in academic research. However, climate-related disclosures are still explored less than other sustainability research areas, especially when considering climate-related risks and opportunities. First, prior studies discover that firms have advantages in disclosing climate-related information. This kind of information can lead to a mitigation of carbon risk and, therefore, a reduction in the cost of capital (Alsaifi et al., 2021; Palea & Drogo, 2020). Additionally, firms are interested in implementing environmental reduction measures such as reducing carbon emissions, as this can improve their reputation and give them a competitive advantage (Yan et al., 2020). For instance, stakeholders, especially institutional investors, increasingly demand sustainability information and consider social, environmental, and ethical aspects in their investment decisions (e.g., Amel-Zadeh & Serafeim, 2018; Eccles et al., 2017; Hummels & Timmer, 2004). In this regard, climate reporting is examined in the context of integrated reporting (Bernardi & Stark, 2018; Raimo et al., 2022). The quality of integrated reporting is often linked to corporate governance mechanisms (Raimo et al., 2020, 2022; Vitolla et al., 2020). Integrated reporting has the advantage in corporate reporting, which is closely linked to financial reporting—a combination that is generally preferred by stakeholders as it offers transparency (Nishitani et al., 2021) and reduces information asymmetries (Cortesi & Vena, 2019). Ultimately, the holistic approach can provide stakeholders with a better overall view of corporate reporting (Hoque, 2017; Stubbs & Higgins, 2018).

However, the quality of provided climate-related disclosure is still insufficient. Panfilo and Krasodomska (2022) find that European firms with an existing regulatory reporting landscape due to the Non-Financial Reporting Directive (NFRD) do not lead to a higher voluntary disclosure quality of climate-related risks. Further, Lombardi et al. (2021) show that, for Italian firms some of the required climate-

related information from stakeholders is missing or not presented in sufficient detail. Also, Berthelot and Robert (2011) find that climate-related disclosure quality is very low for Canadian firms. In particular, firms have weaknesses in the disclosure of how they integrate climate-related issues into their firm strategy and in the strategy's resilience (Berthelot & Robert, 2011; Bingler et al., 2022; Moreno & Caminero, 2022). In addition, Kouloukoui et al. (2018) find a low level of climate-related risk disclosure after an analysis of the 100 largest firms in the world. This finding is surprising because institutional investors see great importance in climate-related risks and integrating them into their investment decision process (Ilhan et al., 2023; Krueger et al., 2020).

Moreno and Caminero (2022) find that firms in the oil and energy sector make the greatest effort to disclose climate-related information. Subsequently, focusing on specific firms in the energy sector, Dahl and Fløttum (2019) show that firms see climate change primarily as a business risk, although, some firms see climate change as a business opportunity or a business responsibility.

From a theoretical perspective, according to stakeholder theory and neo-institutional theory, current literature argues that when firms enhance transparent communication, it contributes to their "license to operate" (Drempetic et al., 2020). In turn, it can be argued that when transparent climate-related information is disclosed, it addresses the expectations of stakeholders and enables firms to comply with institutional pressure (e.g., analysts and investors) and demand, information on sustainability issues (Amel-Zadeh & Serafeim, 2018; García-Sánchez et al., 2020a; Ioannou & Serafeim, 2015). This institutional pressure is escalating as investors face their own reporting obligations concerning sustainability information, thus demanding more comprehensive information from firms (e.g., due to regulations like the SFDR). Particularly in light of stakeholders' increasing demand for integrated disclosures of financial and non-financial information, it is crucial for managers to recognize that they should operate in the best interest of their shareholders (Eisenhardt, 1989; Vitolla et al., 2020). From the lens of agency theory, it can be argued that it is in the managers' interest to disclose climate-related information—beyond regulatory requirements—in order to align with the interest of shareholders (Vitolla et al., 2020), as well as to serve the interests of all stakeholders (Giannarakis et al., 2018).

The evidence on climate-related opportunities is underrepresented in literature on climate-related disclosure and studies investigating the TCFD recommendations. Therefore, this study aims to contribute to existing literature by giving evidence on the disclosure quality of both climate-related risks and opportunities. Additionally, we investigate the determinants that influence climate-related risk and opportunity disclosure quality. To do so, we formulate the following hypotheses for different determinants.

3.1 | Sustainability integration

Sustainability has become a management function (Gebhardt et al., 2022; Wiengarten et al., 2017). In this context, sustainability

committees within boards of directors lead firms to improve their disclosure quality, for example, by promoting management activities concerning stakeholder interest (Peters & Romi, 2014). Moreover, Amran et al. (2014a) also show that establishing a sustainability committee is associated with better environmental disclosure quality. This finding is explained by the fact that the sustainability committee has higher knowledge and skills in this field. The positive influence of a sustainability committee on the environmental disclosure quality is also supported by (Raimo et al., 2021). In contrast, the study by Baalouch et al. (2019) indicates that the existence of a sustainability committee has no positive influence on environmental disclosure quality. However, other studies find that sustainability committees lead to a better sustainability disclosure quality (Gallego-Álvarez & Pucheta-Martínez, 2020; Pucheta-Martínez & Gallego-Álvarez, 2019; Velte & Stawinoga, 2020). In addition, Fuente et al. (2017) find a positive association between a sustainability committee and the adoption of the GRI guidelines. In return, using the GRI guidelines is associated with better disclosure quality.

In general, anchoring sustainability in the management board speaks for an increased organizational and strategic relevance in the firm in terms of sustainability (Wiengarten et al., 2017). As a result, some studies are focusing especially on typical management positions, like the CEO and the Chief Financial Officer (CFO). The managerial ability of CEOs has an especially positive influence on the disclosure of comparable sustainability information, which is useful and relevant for stakeholders (García-Sánchez et al., 2020a). In addition, García-Sánchez et al. (2021) show that CEOs have a greater opposition to integrated reporting, although integrated reporting helps close information gaps between management and investors. Focusing on CFOs, Guo et al. (2021) find that CFOs with more accounting expertise increase the disclosure of sustainability information. In addition, Thun and Zülch (2022) find that the presence of a Chief Sustainability Officer (CSO) improves the firm's sustainability disclosure, and when sustainability falls within the CFO's purview, the CFO positively influences sustainability disclosure as well.

Because of the intense focus on sustainability committees in literature, Velte and Stawinoga (2020) outline a remarkable research gap regarding the presence of CSOs. They find that the existence of a CSO influences decisions regarding external assurance on sustainability reports and performance. Further, Thun and Zülch (2022) show that CSOs positively impact the sustainability disclosure quality and quantity. This finding may reflect that CSOs are responsible for sustainability activities and communicating them to the firm's stakeholders (Peters & Romi, 2014). Likewise, the actual responsibility of a committee (subfunction, which assists the management board) for sustainability depends on whether the committee reports to the C-level. Otherwise, it may be the case that sustainability committees take on more of a symbolic character rather than bringing about substantive change (Velte & Stawinoga, 2020). Velte and Stawinoga (2020) conclude that in the case of implementing a CSO and a sustainability committee, the CSO should be responsible for the strategic alignment and the sustainability committee for the operative

alignment, whereby a clear division of these tasks is important. However, this separation cannot be achieved if only one of the two mechanisms is implemented. In this case, either the CSO or the sustainability committee must have the appropriate expertise for strategic and operational alignment. In light of the evidence on sustainability integration, we derive the following hypotheses:

H1a. The existence of a Chief Sustainability Officer and/or sustainability committee reporting to the C-level is positively related to climate-related disclosure quality.

H1b. The responsibility of the Chief Executive Officer or the Chief Financial Officer for sustainability is positively related to climate-related disclosure quality.

3.2 | Corporate governance

Corporate governance is recognized as a potential impact factor on sustainability disclosure quality in literature. Effective corporate governance is generally associated with a solid effort to implement sustainability disclosure practices (Bae et al., 2018). The findings of Ben-Amar and McIlkenny (2015) highlight that board effectiveness, measured by individual potential, group potential (CEO/chair split, share structure), and past practices based on the evaluation of results from board decisions, have a positive impact on the disclosure quality of climate-related risks. Furthermore, Peters and Romi (2014) show that corporate governance mechanisms increase environmental risk disclosure. A study by Adel et al. (2019), which focuses on corporate governance characteristics and their impact on sustainability disclosure, shows that director ownership is positively related to sustainability disclosure quality. A recent study by Friedrich et al. (2022) found that the governance category in TCFD-based disclosures has increased considerably more than other categories over the last 4 years, indicating that management is significantly more engaged with climate reporting. In addition, the combination of governance and strategy can enhance firms reporting quality, especially the integration of climate awareness in the corporate governance structures (climate governance) that results in a better financial and climate performance. Climate governance means that firms will integrate the handling of climate-related opportunities and climate-related risks into their management approach and have an awareness of climate issues, especially with respect to their stakeholders (Aibar-Guzmán et al., 2023).

Meanwhile, regarding social and environmental disclosure, Michelon and Parbonetti (2012) find no link between board compensation characteristics and sustainability disclosure quality. Overall, these findings support that corporate governance mechanisms lead to higher quality in sustainability disclosures. Therefore, we formulate the following hypothesis:

H2. Corporate governance is positively related to climate-related disclosure quality.

It has to be stressed that Hypothesis H2 relates to corporate governance in general. While our econometric models also include other determinants from the corporate governance realm (e.g., board size), this particular determinant is intended to capture overall corporate governance performance following prior studies on corporate governance (Baraibar-Diez et al., 2019; Gebhardt et al., 2022).

3.3 | Board characteristics

Recent literature generally focused on the effects of certain board characteristics (e.g., board size) on disclosure quality (e.g., integrated reporting quality) (Vitolla et al., 2020). There are empirical findings which state that board size is positively associated with the extent of environmental disclosures (Mahmood et al., 2018). This finding is supported for sustainability reporting in general (Bae et al., 2018; Hu & Loh, 2018; Wang, 2017). However, Amran et al. (2014b) find no significant link, especially with climate-related disclosure quantity. This finding shows, in turn, that a larger number of board members does not necessarily influence firms' decisions on climate-related disclosures. However, they expect more members to increase the effort for disclosures. That the size of a firm's board positively affects the level of environmental information disclosure is also supported by Raimo et al. (2022). Based on the findings of the previous literature, we formulate the following hypothesis:

H3a. Board size is positively related to climate-related disclosure quality.

There is some evidence that board diversity influences sustainability disclosure quality. Raimo et al. (2022) show that gender diversity is an important influence factor for the integrated disclosure of environmental information. One reason for this finding could be that board diversity contributes to varied perspectives in decision-making processes within the firm. Consequently, female leaders may play a significant role in driving certain achievements (Pucheta-Martínez & López-Zamora, 2018). For example, decision making can also be the way in which reporting mechanisms are organized. Liao et al. (2015) argue that the proportion of women on boards is related to the propensity for GHG emission disclosure. This result could be the case as women might pay more attention to environmental issues (Post et al., 2011), and firms with a higher percentage of women on boards are more socially responsible (Setó-Pamies, 2015). Furthermore, Ben-Amar et al. (2017) find that female representation on the board enhances the board's effectiveness in terms of stakeholder management and therefore promotes the adoption of sustainability initiatives related to climate-related disclosure. Mahmood et al. (2018) and Adel et al. (2019) also support that the existence of female directors leads to better sustainability disclosure quality. These findings in literature led us to the following hypothesis:

H3b. Female members on the board are positively related to climate-related disclosure quality.

3.4 | Ownership structure

A frequently studied determinant of disclosure quality in literature is ownership structure. For example, Bae et al. (2018) observe a positive relationship between institutional ownership and the disclosure quality of sustainability information according to the GRI. Further, Flammer et al. (2021) find that environmental shareholder activism, predominantly originating from institutional investors, increases climate-related risk disclosure quality. Additionally, there is evidence that institutional investors influence the disclosure regarding climate change, especially with the view on the publication of the CDP questionnaire (Cotter & Najah, 2011). Regarding carbon risk, awareness is higher when firms have a higher proportion of institutional ownership, which can be associated with a better carbon disclosure quality (Kordsachia et al., 2022). From the perspective of integrated reporting of environmental information (Raimo et al., 2022), it was also found that institutional ownership has a generally positive influence on integration quality (Raimo et al., 2020). From prior findings, we conclude that institutional ownership has a positive influence on the interactively reported environmental information. Therefore, we formulate the following hypothesis:

H4a. Institutional ownership is positively related to climate-related disclosure quality.

Regarding the association between ownership concentration and the quality of climate-related disclosure, there is less evidence in literature. Generally, there is evidence that accounting quality improves with the percentage of free float (Daske & Gebhardt, 2006). Additionally, Gamerschlag et al. (2011) find that the shareholder structure within a sample of German firms, precisely a more dispersed share ownership structure, is positively associated with the disclosure quantity of sustainability information, for example, environmental topics. That means the higher the proportion of free float, the higher the disclosure quantity. In contrast, Winter and Zülch (2019) find no association between ownership structure, measured according to the free float, and strategy disclosure quality. Based on the prior empirical results, we expect that the positive effects outweigh the negative ones, thus the following hypothesis being formulated:

H4b. Free float is positively related to climate-related disclosure quality.

4 | DATA AND METHODOLOGY

4.1 | Sample selection and data collection

The starting point of our sample are 160 German firms listed in the DAX, MDAX, and SDAX indices, as Germany is one of the countries consuming the most ecological resources (Global Footprint Network, 2022). Further, German firms have improved their sustainability reporting in the last decades, especially since the introduction of

the NFRD, and the disclosure quality is higher than in other European countries like Italy (Mion & Loza Adaui, 2019). Like Gamerschlag et al. (2011), we argue that a single-country sample has advantages in studying disclosure quality. In our case, the sample is homogenous regarding the legal and political environment. In addition, disclosure supporting the TCFD recommendations is entirely voluntary in Germany. This level of data quality provides a profound basis for further research on the determinants of climate-related disclosure quality.

The release of the Sustainable Finance Disclosure Regulation (SFDR) in 2019 led to future expanded disclosure requirements on the investor side and increased the need for firm-specific data (European Commission, 2019). During the 2020 annual general meeting season, the firms whose investors were dissatisfied with the progress regarding climate action felt pressure through voting actions (BlackRock, 2020). Due to this investor pressure and because the disclosure quality in the fiscal year (FY) 2020 is considered to be the best since the introduction of the TCFD recommendations (TCFD, 2021), we use the FY 2020 firm disclosures as the basis for our investigation. In addition, FY 2020 disclosures are the latest completely available set of sustainability disclosures when collecting the data and, therefore, best reflect upon the current state of disclosure quality for the 160 sample firms.

We retrieve the data for our study in two ways. First, we perform a manual content analysis of climate-related disclosure using a predefined questionnaire based on the TCFD recommendations (see Table A1), which easily be used with other samples. Content analysis is common in studies investigating environmental and climate disclosures (Demaria & Rigot, 2021; Guthrie, 2014). We analyze annual and sustainability reports with the questionnaire, representing essential data sources for investors (Gassen & Schwedler, 2010; Permatasari & Narsa, 2022). These are also examined if there are references to TCFD or CDP reports. The data collected in the first step serve us to determine the level of climate-related disclosure quality according to the TCFD recommendations. Second, we retrieve data from Refinitiv ESG and Datastream to complement the sample for a multivariate analysis of determinants.

As shown in Panel A of Table 2, missing data availability regarding independent variables reduces the sample by 57 observations due to data gaps in Refinitiv ESG or Datastream. It should be stressed that our sample is intentionally not reduced only to those firms that follow the TCFD recommendations because the information demand (and expectations) from stakeholders regarding climate-related disclosures concerns firms regardless of their compliance with TCFD recommendations. Instead, our sample considers both TCFD-compliant firms and non-compliant firms. The final sample consists of 103 observations and is used for regression analysis (NB: the sample for descriptive data analysis of climate-related disclosure quality encompasses 160 observations since there are no missing data for dependent variables). Panel B reports the sample compositions by industry and displays the means of our three dependent variables by industry. It is evident that the disclosure quality of both climate-related *risks* (RQSCORE) and *opportunities* (OQSCORE) and the *overall* score (ROQSCORE) differ substantially between industries.

TABLE 2 Sample characteristics.

Panel A					
Step		Obs.	Unit		
1	DAX, MDAX, and SDAX firms, index constituents as of 31 December 2020 (used for descriptive analysis)		160	Firms	
2	The reduction caused by missing data availability in Refinitiv ESG/Datastream (independent variables only)		−57	Firms	
3	Final sample size (used for regression analysis)		103	Firms	
Panel B					
Industry		Obs.	Mean ROQSCORE	Mean RQSCORE	Mean OQSCORE
1	Basic materials	14	0.567	0.630	0.469
2	Financials	14	0.560	0.623	0.459
3	Utilities	5	0.556	0.691	0.343
4	Telecommunications	5	0.511	0.545	0.457
5	Consumer Staples	6	0.481	0.561	0.357
6	Consumer discretion	32	0.438	0.517	0.313
7	Industrials	33	0.426	0.521	0.277
8	Energy	5	0.344	0.455	0.171
9	Health care	16	0.344	0.449	0.179
10	Real estate	14	0.329	0.409	0.204
11	Technology	16	0.313	0.398	0.179
Total		160	0.431	0.515	0.298

Note: Industry classification is based on Datastream item INDM2 (ICB industry name). The data in Panel B is sorted by the mean of ROQSCORE (descending). All metric variables are winsorized at the 1st and 99th percentiles. For definitions of ROQSCORE, RQSCORE, and OQSCORE, see Section 4.2 and Table A2.

4.2 | Measuring disclosure quality

Based on existing literature (i.e., Broberg et al., 2010; Elzahar et al., 2015; Jones, 2007; Marston & Shrivs, 1991; Tsalavoutas & Smith, 2010), we construct scoring models as a measurement of disclosure quality: ROQSCORE is the climate-related Risk and Opportunity Disclosure Quality Score, RQSCORE is the climate-related Risk Disclosure Quality Score and OQSCORE is the climate-related Opportunity Disclosure Quality Score. To address the existing gap in literature, we investigate the disclosure quality of climate-related risks and opportunities not only as a whole but also look at the individual components, that is, risks and opportunities. For this purpose, only the TCFD recommendations explicitly applicable to climate-related opportunities are used to determine the disclosure quality of opportunities. More precisely, the calculation of the OQSCORE (see Table A1) excludes the three recommendations from the Risk Management category and the one from the Metrics and Targets category, which asks for Scope 1, Scope 2, and, if appropriate, Scope 3 GHG emissions and the related risks (see Table 1). As a result, the disclosure quality of climate-related opportunities is based on seven TCFD recommendations.

Further, all TCFD disclosure recommendations apply to climate-related risks. The calculation of RQSCORE is based on all 11 recommendations (see Table A1) (TCFD, 2021). Finally, ROQSCORE includes

all recommendations upon which the two individual scores are based and is calculated similarly to the other two scores as follows:

$$ROQ_i = \sum_{k=1}^n d_{k,i}$$

$$ROQSCORE_i = ROQ_i / ROQ^{max}$$

where ROQ_i is the total number of recommendations k disclosed by firm i and where ROQ^{max} is the maximum number of disclosure recommendations that can be disclosed, that is, 18. All three scores are a continuous variable between 0 and 1, where 1 means that information concerning all 18 recommendations is disclosed.

4.3 | Multiple regression analysis

Table A2 contains definitions for all variables. We group the independent variables (determinants) derived from the literature into three categories: governance, ownership, and control variables. All metric variables are winsorized at the 1st and 99th percentiles to ease the impact of outliers (Jost et al., 2021; Ottenstein et al., 2022).

To analyze the determinants for the overall score ROQSCORE, RQSCORE, and OQSCORE, respectively, we estimate three multivariate

ordinary least squares (OLS) models with fixed effects for the industries reported in Table 2. Regression results are shown in Table 4.

$$Y_i = \beta_0 + \beta_1 * INTEGRATION1_i + \beta_2 * INTEGRATION2_i + \beta_3 * BOARDSIZE_i + \beta_4 * BOARDFEM_i + \beta_5 * GOV_i + \beta_6 * INSTITUTIONALSHARES_i + \beta_7 * FREEFLOAT_i + \beta_8 * FRAMEWORK_i + \beta_9 * LIMITED_i + \beta_{10} * REASONABLE_i + \beta_{11} * DIFFERENTAUDITOR_i + \beta_{12} * LNNUMLISTINGS_i + \beta_{13} * XLISTING_i + \beta_{14} * LNMCP_i + \beta_{15} * LEV_i + \beta_{16} * ROE_i + \varphi * INDUSTRYFE + \varepsilon_i \quad (1)$$

where Y_i is the dependent variable of the respective equation (see Table 4). All three models shown in Table 3 intentionally include the same explanatory variables (see Equation (1)) since all these variables are supposed to influence climate-related disclosure quality, independently of whether the dependent variable concerns risks or opportunities.

5 | RESULTS AND DISCUSSION

5.1 | Descriptive statistics

Table 3 shows descriptive statistics for all variables. Notably, the final sample mean of ROQSCORE is 0.406, pointing to a relatively low average disclosure quality. In line with Bingler et al. (2022), the average disclosure quality of *risks* and *opportunities* shows considerable potential for improvement. It could be explained only partly by our sample construction featuring both TCFD-compliant firms and non-compliant firms. The average disclosure quality concerning *risks* is much higher than concerning *opportunities* (RQSCORE: 0.489 vs. OQSCORE: 0.275). First, we attribute this to the history of German disclosure regulation. The German Accounting Standard (GAS) 20 has required firms to report on material opportunities since 2012, but GAS 5 has required firms to report on risks for a longer time. Like in financial disclosure, which focuses on financial materiality – the materiality definition of TCFD (TCFD, 2022) – the low mean of OQSCORE may be attributable. Second, the management board in German firms is required to consider risks due to the mandatory implementation of risk management (§ Section 91 German Stock Corporation Act). Further, they need to address going concern risks in preparing the annual financial statements (§ Section 252 (1) no. 2 German Commercial Code).

In Panel B Table 2, the mean values of climate-related disclosure quality (ROQSCORE, RQSCORE, and OQSCORE) are shown for the full sample of 160 observations. It is evident that the means by industries strongly differ. Literature on climate-related disclosure (Dahl & Fløttum, 2019) has examined whether industries that are more sensitive to the consequences of climate change (e.g., energy, utilities, or industrials such as the automotive industry) also have different climate disclosure quality than those industries which are less affected by climate change. Table 2 shows that climate-sensitive industries such as Basic Materials, Financials, and Utilities exhibit mean values of more than 10 percentage points higher than climate-related disclosure

quality above the grand mean of 0.431 (ROQSCORE).¹ All in all, the result that the industries like Basic Materials, Financials, Utilities, and Telecommunications feature better climate-related disclosure quality (industry means >.5) can be explained by stakeholder theory and neo-institutional theory. These firms address the expectations of stakeholders and comply with their institutional pressure by disclosing climate-related risks and opportunities (García-Sánchez et al., 2020b; Ioannou & Serafeim, 2015). The same pattern can be seen for RQSCORE and OQSCORE. As expected and due to the industry concentration, only a few utility and energy firms exist in this sample. “Industrials” comprise 33 firms from a broader range of industries and is in line with the grand mean. “Energy firms” climate-related disclosure quality is about 10 percentage points below the grand mean, which is against the expectation and surprising in the light of neo-institutional theory but may be attributable to the small group of five firms.

The high standard deviations of all dependent variables expose severe quality differences across the sample that are worth investigating in a multivariate analysis. Further, the average firm has about 28% women on its board and institutional investors hold about one-third of its shares. 59% of investigated firms receive limited sustainability assurance, 6% receive reasonable assurance, and 35% receive no external assurance, respectively.

5.2 | Regression results

Table 4 shows the results of the regression analysis. All models are overall statistically significant at $p < .01$ (see F statistics). R^2 and adjusted R^2 reveal that the models explain a large portion of the variance in the dependent variables. The models are run with regular standard errors since it is precluded that heteroscedasticity is an issue, using the Breusch–Pagan/Cook–Weisberg test and Cameron & Trivedi's decomposition of IM tests (not tabulated).

The categorical variable *INTEGRATION1* is one if the firm has a CSO or a sustainability committee reporting to the C-Level, and zero otherwise. Like Baalouch et al. (2019), our measurement requires a sustainability committee to have a direct link to the C-level (i.e., reporting to the C-level) to address agency concerns regarding sustainability issues. *INTEGRATION1* is solely significant in Model (3) ($p < .05$) with a negative coefficient, and therefore, concluding that Hypothesis H1a is rejected. In this vein, Baalouch et al. (2019) find that an environmental committee has no significant influence on the quality of environmental disclosure and argue that a committee might be a legitimacy tool.

INTEGRATION2 is a categorical variable being one if the CEO or the CFO is responsible for sustainability, and zero otherwise. *INTEGRATION2* is positively related in Model (2) ($p < .05$), that is, the model explaining climate-related risk disclosure. This finding is in line with Amran et al. (2014b) and Helfaya and Moussa (2017) and can be

¹Note that there is no taxonomy for climate-sensitive industries and that the examples for climate-sensitive industries described above may be “climate-sensitive” for different reasons (e.g., financial firms and utilities).

TABLE 3 Summary of descriptive statistics.

Variable	N	M	SD	min	p25	p50	p75	max
Dependent variables								
ROQSCORE	103	0.406	0.326	0.000	0.111	0.333	0.722	1.000
RQSCORE	103	0.489	0.350	0.000	0.182	0.455	0.818	1.000
OQSCORE	103	0.275	0.323	0.000	0.000	0.143	0.571	1.000
Governance								
INTEGRATION1	103	0.476	0.502	0.000	0.000	0.000	1.000	1.000
INTEGRATION2	103	0.612	0.490	0.000	0.000	1.000	1.000	1.000
BOARDSIZE	103	10.650	5.606	3.000	6.000	12.000	16.000	21.000
BOARDFEM	103	27.683	14.111	0.000	16.670	31.250	37.500	55.560
GOV	103	64.243	18.510	24.430	49.810	64.020	79.720	96.280
Ownership								
INSTITUTIONALSHARES	103	0.305	0.304	0.000	0.000	0.221	0.563	0.936
FREEFLOAT	103	66.029	23.849	15.000	47.000	70.000	86.000	100.000
Control variables								
FRAMEWORK	103	3.175	1.917	0.000	2.000	3.000	5.000	6.000
LIMITED	103	0.592	0.494	0.000	0.000	1.000	1.000	1.000
REASONABLE	103	0.058	0.235	0.000	0.000	0.000	0.000	1.000
DIFFERENTAUDITOR	103	0.068	0.253	0.000	0.000	0.000	0.000	1.000
LNNUMLISTINGS	103	0.456	0.597	0.000	0.000	0.000	1.099	2.197
XLISTING	103	0.136	0.344	0.000	0.000	0.000	0.000	1.000
LNMCAP	103	15.117	1.360	12.834	14.030	15.097	15.899	18.152
LEV	103	0.604	0.180	0.138	0.505	0.603	0.717	0.957
ROE	103	7.761	23.836	-92.520	-0.750	7.760	15.920	122.400

Note: All metric variables are winsorized at the 1st and 99th percentiles. For variable definitions, see Table A2.

explained by agency theory. The anchoring of social responsibility in the firm through strong enforcement by the board of directors forms a basis for improving disclosure quality, as shown by Amran et al. (2014a). However, given that the regression coefficient of *INTEGRATION2* is merely positive and only significant in Model (2), we do not see adequate support for Hypothesis H1b and thus must reject it.

Another hypothesized determinant of climate-related disclosure quality is *GOV*, which is a proxy for a firm's overall corporate governance (Gebhardt et al., 2022; Jost et al., 2021). *GOV* is measured using Refinitiv's Governance Pillar Score, which is based on the governance information disclosed by the firm. The estimated regression coefficients of *GOV* are virtually zero and statistically insignificant in all models. Thus, Hypothesis H2 must be rejected.

BOARDSIZE has negative coefficients in all models ($p < .05$). This finding is in line with Wang (2012), who argues that the CEO on smaller boards has greater incentives to deal with risks and consequently bear these risks. In contrast, Pucheta-Martinez and Gallego-Álvarez (2019) find a positive relationship between the size of the board and sustainability disclosure quality. Furthermore, Bae et al. (2018) find that a great number of board members remarkably impacts the disclosure of economic, environmental, and social sustainability due to their joint expertise and experience. Adding to this picture of mixed

results, Adel et al. (2019) find no significant relationship between larger board size and corporate social responsibility disclosure quality. Finally, since our coefficient estimates for *BOARDSIZE* are negative and statistically significant at $p < .05$ in Models (1) through (3), we reject hypothesis H3a. This result shows, in turn, that a larger number of board members does not necessarily influence firms' decisions to make climate-related disclosures. Interestingly and in contrast to the regression coefficients, most pairwise correlations between *ROQSCORE*, *RQSCORE*, and *OQSCORE* with *GOV* are positive and highly significant at $p < .01$ (Table A3).

The variable *BOARDFEM* has a positive and significant coefficient in Models (1) and (3) ($p < .05$), but is insignificant in Model (2). These results support hypothesis H3b, albeit not particularly strongly, especially given the small coefficient magnitudes. Our finding is in line with the consensus in literature that board diversity is positively related to sustainability disclosure quality (e.g., Adams et al., 2015; Baalouch et al., 2019; Dienes & Velte, 2016; Harjoto et al., 2015). They find that women on the board positively influence disclosure, environmental disclosure quality, compliance, and stakeholder orientation. Ben-Amar et al. (2017) go even further and find that women in boards magnify the fruitfulness of stakeholder management and foster the adoption of sustainability initiatives.

TABLE 4 Drivers of climate-related risks and opportunities disclosure.

	Model (1)	Model (2)	Model (3)
<i>Dependent variable</i>	ROQSCORE	RQSCORE	OQSCORE
<i>Independent variable</i>			
Governance			
INTEGRATION1	−0.016	0.051	−0.122**
INTEGRATION2	0.062	0.108**	−0.011
BOARDSIZE	−0.013**	−0.011**	−0.015**
BOARDFEM	0.003**	0.003	0.004**
GOV	0.000	0.001	0.000
Ownership			
INSTITUTIONALSHARES	0.132**	0.180**	0.058
FREEFLOAT	0.001	0.000	0.001
Control variables			
FRAMEWORK	0.087***	0.087***	0.088***
LIMITED	0.107**	0.083	0.144***
REASONABLE	0.064	0.044	0.097
DIFFERENTAUDITOR	0.082	0.119	0.025
LNNUMLISTINGS	0.104***	0.101**	0.109**
XLISTING	−0.011	−0.032	0.021
LNMCAP	0.074***	0.073***	0.075***
LEV	0.066	0.009	0.155
ROE	0.000	0.000	0.001
Industry fixed effects	Yes	Yes	Yes
Constant term	Yes	Yes	Yes
N	103	103	103
F statistic	15.013***	13.082***	9.405***
R ²	0.837	0.817	0.763
Adjusted R ²	0.781	0.755	0.682

Note: All metric variables are winsorized at the 1st and 99th percentiles. For variable definitions, see Table A2. OLS regressions are run with regular standard errors. All regressions include a constant term. Multicollinearity: The maximum variance inflation factor (VIF) of independent variables is 3.25. Estimator: Alternatively, we rerun our models with tobit and fractional probit estimators, which yield similar results and let our main findings unchanged. Fixed Effects: We do not employ fixed effects for stock indices (DAX /MDAX/SDAX) due to collinearity problems with LNMCAP.

*Significance at the 10% level.

**Significance at the 5% level.

***Significance at the 1% level.

Two proxies in the regression analysis capture ownership structure, the percentage of institutional shares, and the percentage of free float ownership. First, the variable *INSTITUTIONALSHARES* is positively related in Model (1) and Model (2) ($p < .05$), but insignificant in Model (3). This finding can be explained not only by agency theory but also by stakeholder theory: by disclosing transparent climate-related information, firms address stakeholders' expectations and comply with their institutional pressure, in this case, institutional investors.

This finding is supported by Kordsachia et al. (2022). Their results indicated that long-term institutional investors positively affect firms' climate-related risk disclosure. According to Cotter and Najah (2011), the presence of institutional investors positively relates to the quality of climate change disclosure by large firms. Our finding undermines

that institutional ownership promotes better transparency on climate-related issues (Raimo et al., 2020; and Aibar-Guzmán et al., 2023, in a broader context). This link is triggered by a higher firm carbon risk awareness, which is increased by sustainable institutional ownership (Kordsachia et al., 2022). Given the positive and significant coefficients in Model (1) and Model (2), the results provide support for Hypothesis H4a, especially concerning a link between disclosure quality of climate-related risks (as well as overall climate-related disclosure quality). Regarding the disclosure of climate-related opportunities, our findings do not reveal a link to institutional ownership, given the insignificant coefficient in Model (3).

Second, regarding the fraction of free float ownership (*FREEFLOAT*), all coefficient estimates are positive, which is directionally in line with the expectation, but statistically insignificant.

Therefore, we do not see support for Hypothesis H4b and reject this hypothesis.

Regarding the control variables and in line with Zarzycka and Krasodomska (2022), *FRAMEWORK* has positive and highly significant coefficients in all models. While prior literature does not analyze the number of sustainability reporting frameworks used by the firms, we find that using multiple frameworks positively relates to climate-related disclosure quality. The variable *LIMITED* is positively related and significant in Model (1) ($p < .05$) and Model (3) ($p < .01$), but insignificant in Model (2). However, *REASONABLE* is not significant in any model. Our findings regarding *LIMITED* are in line with Baalouch et al. (2019) and Braam et al. (2016). These studies found a positive association between external assurance and the reliability and quality of firm (environmental) disclosure. Our results show that limited assurance promotes climate-related disclosure quality, but it appears that reasonable assurance has no marginal impact beyond that. The coefficient estimates for *DIFFERENTAUDITOR* are positive as expected in Models (1) through Model (3), however, are not statistically significant. As expected, and in line with literature, firm size (e.g., Vitolla et al., 2020) and capital market orientation (*LNNUMLISTINGS*) positively influence climate-related disclosure quality, which can be explained from the lens of agency theory due to the increased attention and pressure.

5.3 | Robustness checks

To challenge the robustness of our empirical findings, we perform several robustness checks, as presented hereinafter. Firstly, in our main analyses (see Tables 3 and 4), all deployed metric variables are winsorized at the 1st and 99th percentiles. This outlier treatment procedure is common empirical practice and aims to enhance empirical results' robustness. However, it is possible that winsorizing has an undesired (or adverse) impact on the analysis results. Therefore, we rerun the main analyses without prior winsorizing of the dataset, which yields similar results (not tabulated) and leaves our main findings unchanged.

Second, we check our regression models for multicollinearity with variance inflation factors (VIF). Multicollinearity is an important concern in any research design like ours, which relies on regression analysis. One of the classical assumptions of linear regression is that no perfect multicollinearity is present. Therefore, we determine the VIFs for each regression model, with and without industry-fixed effects. The maximum VIF of independent variables is 3.25, and thereby well below the threshold of 10 (Wooldridge, 2012). Thus, we conclude that multicollinearity is not an issue here.

Third, we use other regression estimators that better account for the measurement scale of our dependent variables (averaged values, variables between 0 and 1, endpoints included). We use two such estimators: tobit and fractional probit. The fractional probit model fits our models with continuous 0 to 1 dependent variables. The Tobit model is a censored regression model that accounts for our dependent variables' censored nature. Therefore, we rerun our regression models with tobit and fractional probit estimators, which

yields similar results (not tabulated) and keeps our main findings unchanged. Please note that our main results are regression models run with OLS estimators (Table 4) to enable comparability with other studies since OLS is the most commonly used estimator.

6 | CONCLUSIONS

We investigate which firm characteristics influence climate-related disclosure quality. In preparation for this, we measure the climate-related disclosure quality using three self-constructed scores (*risks*, *opportunities*, and *overall* climate-related disclosure quality). The individual scores are based on the TCFD recommendations. Our results indicate that institutional ownership is positively related to climate-related disclosure quality, especially concerning *risks*. Moreover, board size is negatively related to climate-related disclosure quality, while a higher fraction of women on board promotes disclosure quality, especially concerning *opportunities*.

Our study has some limitations, which offer potential for future research. First, while we believe that the findings from our regression analysis are generalizable to some extent, our results regarding the level of climate-related disclosure quality reflect the German capital market. An empirical investigation of firms from different countries could be performed using the disclosure scores presented in this paper to provide an international overview. Here, we see an opportunity for future research to deploy the same measurements, which are immediately based on the recommendations of the TCFD. Second, we focus on the FY 2020 firm disclosures as the quality is considered to be the best since the introduction of the TCFD recommendations. Potential future research could be an event study for countries that introduce mandatory disclosure according to the TCFD to investigate the effect of regulation on climate-related disclosures over time and the real effects of such regulations. We specifically suggest conducting empirical studies with panel data sets in such instances. Third, we focus on the determinants of climate-related disclosure quality. Future studies can further examine why firms do not disclose adequately or at all. For this, we believe that qualitative research methods such as semi-structured interviews could be informative.

Our findings also have implications for disclosing firms, investors, and regulators alike. Disclosing firms, especially firms listed on the stock-market, should be aware of the increasing demand for disclosure of climate-related risks and opportunities by institutional investors. From a theoretical point of view, this is particularly important to ensure their "license to operate" (Drempetic et al., 2020). Firms should at least compile relevant information to serve investor inquiries. Firms should consider the pros and cons of voluntarily disclosing TCFD-aligned disclosures, as such voluntary and proactive disclosure would send a positive signal of transparency to the market. In addition, our findings show that the use of sustainability reporting frameworks is an effective lever to improve climate-related disclosure quality, not only regarding climate-related risks, but also opportunities. In turn, firms should factor in demand for information covered by the TCFD recommendations in their decision-making, and which

framework(s) they use for sustainability disclosure. Based on our findings, practitioners may further consider obtaining limited assurance for their sustainability reports to increase climate-related disclosure quality significantly.

From an investor perspective, the negative relationship of firm size, measured by market capitalization, provides an interesting insight. Therefore, when dealing with small- and mid-cap firms, institutional investors should expect a lower level of public climate-related risk and opportunities disclosure than for large caps and blue-chips. In our view, this opens an avenue for dialogue with the firm for investors. From a practical corporate governance perspective, our findings provide insights into the nexus of board composition and climate-related disclosure. We find that a smaller and more female board provides better climate-related disclosure.

For regulators, it should become clear that a globally accepted guideline for disclosing climate-related issues is imperative. Such standards would provide orientation for disclosing firms and increase the comparability of disclosure for the recipients, such as investors. In the light of our findings (esp. high variance of disclosure quality) and the literature, reports considering the TCFD recommendations may be an option for regulators to address the comparability issue. For practitioners, it is essential to adopt a comprehensive management approach to communicate *both* climate risks and opportunities of similar quality to the public transparently, thus remaining attractive to their stakeholders and especially investors (Eccles et al., 2017; Eccles & Krzus, 2018).

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APPENDIX A

TABLE A1 Questionnaire for data collection.

RQSCORE		
TCFD category	Question no.	Question
Governance	#1	Does the organization describe the management board's oversight of climate-related risks?
	#2	Does the organization describe the management board's role in assessing and managing climate-related risks?
Strategic	#3	Does the organization describe the climate-related risks the organization has identified over the short, medium, and long term?
	#4	Does the organization describe the impact of climate-related risks on the organization's businesses, strategy, and financial planning?
	#5	Does the organization describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario?
Risk management	#6	Does the organization describe the organization's processes for identifying and assessing climate-related risks?
	#7	Does the organization describe the organization's processes for managing climate-related risks?
	#8	Does the organization describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management?
Metrics and targets	#9	Does the organization describe the metrics used by the organization to assess climate-related risks in line with its strategy and risk management process?
	#10	Does the organization describe Scope 1, Scope 2 and, if appropriate, Scope 3 greenhouse gas (GHG) emissions and the related risks?
	#11	Does the organization describe the targets used by the organization to manage climate-related risks and its performance against the targets?
OQSCORE		
TCFD category	Question no.	Question
Governance	#12	Does the organization describe the management board's oversight of climate-related opportunities?
	#13	Does the organization describe the management board's role in assessing and managing climate-related opportunities?
Strategic	#14	Does the organization describe the climate-related risks the organization has identified over the short, medium, and long term?
	#15	Does the organization describe the impact of climate-related opportunities on the organization's businesses, strategy, and financial planning?
	#16	Does the organization describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario?
Metrics and targets	#17	Does the organization describe the metrics used by the organization to assess climate-related opportunities in line with its strategy and risk management process?
	#18	Does the organization describe the targets used by the organization to manage climate-related opportunities and its performance against the targets?

Note: Questions 1# till #11 of the questionnaire constitute the RQSCORE, and questions #12 till #18 constitute the OQSCORE. All questions taken together constitute the ROQSCORE.

TABLE A2 Definition of variables.

Variable	Source	Scale	Refinitiv code	Definition
Dependent variables				
ROQSCORE	Manual	Metric	-	The quality of disclosure of climate-related risks and opportunities according to TCFD, with 1 being the maximum possible score, and 0 the lowest. See Section 4.2.
RQSCORE	Manual	Metric	-	The quality of disclosure of climate-related risks according to TCFD, with 1 being the maximum possible score, and 0 being the lowest. See Section 4.2.
OQSCORE	Manual	Metric	-	The quality of disclosure of climate-related opportunities according to TCFD, with 1 being the maximum possible score, and 0 being the lowest. See Section 4.2.
Governance				
INTEGRATION1	Manual	Dichoto-mous	-	Categorical variable which is 1 if the firm has a Chief Sustainability Officer (CSO) or a sustainability committee that is reporting to the C-Level, and 0 otherwise.
INTEGRATION2	Manual	Dichoto-mous	-	Categorical variable which is 1 if the CEO or CFO is responsible of sustainability, and 0 otherwise.
BOARDSIZE	Refinitiv	Metric	CGBSDP060	The total number of board members at the end of the fiscal year
BOARDFEM	Refinitiv	Metric	CGBSO03V	Percentage of females on the board.
GOV	Refinitiv	Metric	CGSCORE	Refinitiv's Governance Pillar Score; Refinitiv's Governance Pillar Score is the weighted average relative rating of a firm based on the reported governance information and the resulting three governance category scores.
Ownership				
INSTITUTIONAL-SHARES	Manual	Metric	-	The fraction of institutional shareholdings to total shareholdings, with 1 being the highest possible value and 0 the lowest.
FREEFLOAT	Refinitiv	Metric	NOSHFF	The fraction of free float shares to total shareholdings. The free float number of shares represents the total amount of share capital freely available to ordinary investors and is expressed as a percentage of total number of shares.
Control variables				
FRAMEWORK	Manual	Ordinal	-	Number of frameworks that firms apply in sustainability reporting. Any number of frameworks larger than 5 frameworks is coded 6, hence the scale is ordinal.
LIMITED	Manual	Dichoto-mous	-	Categorical variable which is 1 if the audit opinion for the firm's sustainability reporting is "limited," and 0 otherwise.
REASONABLE	Manual	Dichoto-mous	-	Categorical variable which is 1 if the audit opinion for the firm's sustainability reporting is "reasonable," and 0 otherwise.
DIFFERENT-AUDITOR	Manual	Dichoto-mous	-	Categorical variable which is 1 if the firm's auditors of the financial report and the sustainability report are not identical, and 0 otherwise.
LNNUMLISTINGS	Refinitiv	Metric	Derived from WC05427	The log of the number of stock exchanges that the firm is listed.
XLISTING	Refinitiv	Dichoto-mous	Derived from WC05427	Cross-listing: Categorical variable which is 1 if the firm is listed on at least one foreign stock exchange.
LNMCAP	Refinitiv	Metric	WC08001	The log of market capitalization (Market Price-Year End * Common Shares Outstanding).
LEV	Refinitiv	Metric	WC03351, WC02999	Leverage: Total liabilities divided by total balance sheet assets.
ROE	Refinitiv	Metric	WC08301	Return on equity: (Net Income Bottom Line-Preferred Dividend Requirement) /Average of Last Year's and Current Year's Common Equity * 100.

TABLE A3 Pairwise correlations.

Variable	1	2	3	4	5	6	7	8	9
1. ROQSCORE24	1	0.986***	0.878***	0.272***	0.253***	0.502***	0.354***	0.489***	0.406***
2. RQSCORE	0.977***	1	0.807***	0.287***	0.244**	0.525***	0.373***	0.482***	0.363***
3. OQSCORE24	0.931***	0.831***	1	0.169*	0.239**	0.352***	0.236**	0.462***	0.419***
4. INSTITUTIONALSHARES	0.321***	0.341***	0.251**	1	0.406***	0.136	0.103	0.033	0.128
5. FREEFLOAT	0.243**	0.230**	0.239**	0.342***	1	0.266***	0.107	0.091	0.268***
6. INTEGRATION1	0.484***	0.525***	0.361***	0.186*	0.249**	1	0.121	0.298***	0.172*
7. INTEGRATION2	0.331***	0.380***	0.212**	0.111	0.112	0.121	1	0.199**	0.155
8. BOARDSIZE	0.494***	0.481***	0.460***	0.079	0.037	0.293***	0.218**	1	0.423***
9. BOARDFEM	0.446***	0.421***	0.439***	0.157	0.270***	0.212**	0.168	0.489***	1
10. GOV	0.538***	0.550***	0.457***	0.356***	0.343***	0.344***	0.332***	0.308***	0.463***
11. LIMITED	0.418***	0.420***	0.375***	0.106	0.114	0.276***	0.312***	0.313***	0.247**
12. REASONABLE	0.221**	0.213**	0.211**	−0.079	0.04	0.261***	−0.057	0.233**	0.015
13. FRAMEWORK	0.772***	0.771***	0.689***	0.210**	0.234**	0.492***	0.351***	0.489***	0.306***
14. DIFFERENTAUDITOR	−0.067	−0.077	−0.042	−0.097	0.003	−0.026	−0.101	−0.131	−0.054
15. LNNUMLISTINGS	0.306***	0.292***	0.296***	0.05	0.225**	0.228**	0.034	0.349***	0.119
16. XLISTING	0.271***	0.264***	0.253**	0.109	0.191	0.246**	0.084	0.340***	0.108
17. LNMCP	0.586***	0.565***	0.557***	0.174	0.108	0.310***	0.182	0.488***	0.270***
18. LEV	0.228**	0.190**	0.253**	0.05	0.036	0.166	−0.061	0.508***	0.164
19. ROE	−0.015	−0.019	−0.008	−0.017	0.062	0.026	−0.086	−0.173	−0.019

Note: $n = 103$ (final sample) for all correlations. Parametric Pearson's r correlations are reported below the diagonal. Nonparametric Spearman's r_s correlations are reported above the diagonal. All metric variables are winsorized at their 1st and 99th percentiles. For variable definitions, see Table A2.

*Significance at the 10% level.

**Significance at the 5% level.

***Significance at the 1% level.

TABLE A3 (Continued)

Variable	10	11	12	13	14	15	16	17	18	19
1. ROQSCORE24	0.551***	0.419***	0.193*	0.784***	−0.051	0.263***	0.264***	0.543***	0.203**	−0.082
2. RQSCORE	0.552***	0.407***	0.208**	0.769***	−0.068	0.266***	0.268***	0.546***	0.197**	−0.098
3. OQSCORE24	0.437***	0.366***	0.193*	0.700***	−0.017	0.238**	0.244**	0.475***	0.230**	−0.009
4. INSTITUTIONALSHARES	0.351***	0.126	−0.036	0.256***	−0.142	0.008	0.071	0.101	0.1	−0.053



TABLE A3 (Continued)

Variable	10	11	12	13	14	15	16	17	18	19
5. FREEFLOAT	0.366***	0.105	0.059	0.207**	0.027	0.206**	0.193*	0.11	0.046	0.061
6. INTEGRATION1	0.360***	0.276***	0.261***	0.504***	-0.026	0.211**	0.246**	0.315***	0.165*	0.017
7. INTEGRATION2	0.324***	0.312***	-0.057	0.345***	-0.101	-0.008	0.084	0.173*	-0.083	-0.190*
8. BOARDSIZE	0.324***	0.292***	0.253***	0.474***	-0.135	0.311***	0.324***	0.491***	0.482***	-0.181*
9. BOARDFEM	0.399***	0.275***	0.055	0.371***	-0.052	0.073	0.06	0.204**	0.111	0.031
10. GOV	1	0.324***	0.305***	0.462***	-0.107	0.075	0.188*	0.395***	0.161	0.073
11. LIMITED	0.335***	1	-0.300***	0.324***	0.224**	-0.075	-0.017	0.188*	0.104	-0.116
12. REASONABLE	0.314***	-0.300***	1	0.200**	-0.067	0.223**	0.385***	0.241**	0.289***	0.043
13. FRAMEWORK	0.497***	0.325***	0.195**	1	-0.087	0.182*	0.181*	0.440***	0.197**	-0.066
14. DIFFERENTAUDITOR	-0.072	0.224**	-0.067	-0.085	1	-0.086	0.118	-0.075	-0.071	0.132
15. LNNUMLISTINGS	0.106	-0.052	0.253**	0.209**	-0.091	1	0.486***	0.163	0.019	-0.146
16. XLISTING	0.19	-0.017	0.385***	0.186	0.118	0.555***	1	0.327***	0.179*	-0.086
17. LNMCP	0.409***	0.18	0.279***	0.454***	-0.091	0.219**	0.347***	1	0.273***	0.161
18. LEV	0.133	0.109	0.275***	0.206**	-0.039	0.077	0.206**	0.288**	1	-0.088
19. ROE	0.175	-0.126	0.17	-0.046	0.081	-0.043	0.051	0.097	-0.206**	1

Note: $n = 103$ (final sample) for all correlations. Parametric Pearson's r correlations are reported below the diagonal. Nonparametric Spearman's r_s correlations are reported above the diagonal. All metric variables are winsorized at their 1st and 99th percentiles. For variable definitions, see Table A2.

*Significance at the 10% level.

**Significance at the 5% level.

***Significance at the 1% level.