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Do Female Directors Promote Science-Based Emission-Reduction Targets?

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ABSTRACT

This study investigates the impact of board gender diversity on the voluntary recognition of science-based emission-reduction targets (SBT) as a major tool of substantive corporate climate management. SBT refers to the aim of the Paris Climate Agreement to decrease global warming to below 2.0°C and preferably to 1.5°C. Grounded in the stakeholder agency, critical mass and upper-echelons theories, the panel includes 2016 observations from 336 firms with headquarters in a European Union (EU) member state between 2016 and 2021. The results reveal that the ratio and critical mass of female directors, female nonexecutives, and female members in the audit committee are positively related with SBT, while female CEOs show insignificant results. To the best of our knowledge, this is the first empirical study on the relationship between board gender diversity and SBT. The findings highlight the relevance of sustainable boards in achieving better carbon management practices.

1 | Introduction

The voluntary inclusion of *science-based emission-reduction targets (SBT)* is related to greenhouse gas (GHG) reduction ambitions that are in line with the goals of the Paris Agreement. The Paris Agreement includes the intention to decrease global warming to well-below 2°C above pre-industrial levels and efforts to decrease warming to 1.5°C (SBTi 2025). SBT are more effective and objective, compared with other emission targets, as they are directly connected with climate science and cannot be manipulated easily by top managers (Mateo-Marquez et al. 2024). Since 2014, the *science-based target initiative (SBTi)* has developed different methods and tools to support firms to set and realize their SBT. Recently, a great number of over 4200 firms were members of the SBTi in 2023 (SBTi 2024). Consequently, SBT can be classified as the "best practice" for Public Interest Entities (PIEs), and these targets are explicitly demanded by various stakeholders (Bendig et al. 2023).

Empirical research on the SBTi focused on specific *consequences* of corporate inclusion of SBT for firms, e.g., financial performance (Ben-Amar et al. 2024; Bendig et al. 2023), carbon reporting (Bingler et al. 2024), environmental (carbon) performance (Li et al. 2025; Romito et al. 2024; Coen et al. 2022), carbon management (Kuo and Chang 2021), or moderators of the link between carbon and financial performance (Saikia and Maji 2024). However, potential *determinants* of the decision to include SBT have been neglected so far, such as board gender diversity. We only identified the study of Mateo-Marquez et al. (2024) on specific firm- and country-related drivers of SBT. While board-level supervision of climate-related issues positively contributes to SBT, female directors were not included (Mateo-Marquez et al. 2024). While empirical research on the impact of board gender diversity on overall CSR has reached a great attraction, we stress a huge research gap to analyze the relationship between female directors and SBT at different board levels. Both meta-analyses (e.g., Alfi et al. 2025; AlJanadi 2025; Wu et al. 2022) and literature reviews (e.g., Fernandez-Torres et al. 2024; Banno et al. 2023; Campopiano et al. 2023) stressed a positive relationship between board gender diversity and CSR. More recently, researchers have relied on environmental subpillars with a focus on carbon (Velte 2025a; Bergmann

et al. 2025), illustrating a positive influence of female directors on carbon performance and reporting. However, carbon variables are heterogeneously used and lack comparability (Busch and Lewandowski 2017). A differentiation between symbolic and substantive climate management is not possible with the inclusion of overall carbon performance and reporting metrics. An explicit reference to SBT and the SBTi as effective and ambitious carbon management is justified (Bendig et al. 2023) because SBT measures are more precise than overall carbon performance and reporting attributes.

The major motivation of this study is to analyze the unknown relationship between *female directors and SBT*, whereas we recognize different board levels. Researchers assume that female directors are more sensitive to climate issues due to gender-specific socialization, which emphasizes altruism, benevolence, and universalism (Glass et al. 2016; Liu 2018; Nadeem et al. 2020). As these personality traits relate to greater sensitivity for climate risks, gender diverse boards are regarded as more likely to respond adequately to environmental stakeholder interests, leading to an increased voluntary recognition of SBT. Moreover, as female directors are more independent than their male colleagues by tendency ("old-boys-network"), their monitoring role as nonexecutive directors or members in the audit committee should be increased in line with stakeholder interests (Glass et al. 2016).

Our study includes 2016 observations from 336 firms with headquarters in a European Union (EU) member state and included in the CDP database (formerly: Carbon Disclosure Project) between 2016 and 2021. The *EU focus* is useful in view of the EU Green Deal project and the aim to reach climate neutrality by 2050. Since the 2017 business year, big PIEs have had to publish nonfinancial declarations based on the EU Nonfinancial Reporting Directive (NFRD). Moreover, the Taxonomy Directive of 2020, the Corporate Sustainability Reporting Directive (CSRD) of 2022, the European Sustainability Reporting Standards (ESRS) of 2023, and the Corporate Sustainability Due Diligence Directive (CSDDD) of 2024 pressure firms to implement solid climate transition plans and precise carbon reporting on SBT. Finally, another EU directive of 2022 obliges non-small listed corporations to implement fixed gender quotas in their boards of directors for future years. We use the ratio of female directors as a starting point and recognize critical mass and upper echelon theories, whether a critical mass of female directors and CEO gender affect SBT. Then, the monitoring function of the board is focused by female nonexecutive directors and female directors on the audit committee. Thus, we stress the need for analyses of gender diversity heterogeneity and its contribution to SBT as a signal for ambitious climate management. We found that the ratio and critical mass of female directors, female nonexecutives, and female directors on the audit committee *increase* the probability of setting SBT. However, results on female CEOs are insignificant.

Our paper makes a major contribution to prior studies in two ways. First, to the best of our knowledge, this is the first study on the impact of *female directors on SBT*. Except for Mateo-Marquez et al. (2024), possible drivers of corporate inclusion of SBT have been neglected in empirical research. We also rely on recent calls for conducting empirical research on SBT (Bendig et al. 2023). Second, we contribute to the increasing research activities on board gender diversity and corporate environmental outputs. We analyze in detail in which board contexts female directors promote SBT. Third, we stress the urgent need for regulatory and practical bodies to recognize the complementary relationship between board gender diversity and ambitious climate management in their decision-making.

2 | Theoretical Framework, Literature Review and Hypotheses

2.1 | Female Directors and SBT

The impact of board gender diversity on SBT can be explained through multiple theories, such as stakeholder, legitimacy, and resource dependency theories. We recognize stakeholder agency theory (Hill and Jones 1992) as a combination of principal agent and stakeholder theories as a fundament in line with other studies (Velte 2025a) and add critical mass (Kanter 1977) (see Section 2.2) and upper-echelons theories (Hambrick and Mason 1984) (see Section 2.3) as complementary theories for specific attributes of female directors.

Based on *stakeholder agency theory* (Hill and Jones 1992), emission-reduction targets are linked with conflicts of interest and information asymmetries (agency conflicts) between managers and stakeholders. Potential managerial opportunism refers to vague descriptions of climate targets and "low hanging fruit" goals (Mateo-Marquez et al. 2024). Stakeholders fear subjective and unambitious emission-reduction targets due to a higher risk of symbolic climate management und unethical sustainability behavior (Bendig et al. 2023). Effective board monitoring may decrease these agency conflicts (Hill and Jones 1992). Stakeholder agency theory assumes that stakeholders increasingly demand the inclusion of females in the board (stakeholder pressure), since board gender diversity reduces agency conflicts significantly (Banno et al. 2023). Female directors recognize stakeholder demands in reliable carbon disclosure more actively than their male colleagues (Velte 2025a). Literature also assumes that female board members are sympathetic, care about stakeholder interests in climate actions and fulfill an active monitoring function on these aspects (e.g., Banno et al. 2023). As a subpart of their monitoring function, female directors push top managers for ambitious corporate climate goals and prevent questionable climate targets. Consequently, in line with stakeholder agency theory (Hill and Jones 1992), we assume that female directors and SBT are positively related.

As many *empirical* studies have addressed the impact of female directors on carbon outputs, we concentrate on *European* studies for this review part. However, as already stressed, the link between female directors and SBT has been neglected so far. Thus, we rely on studies with a broader analysis on broader carbon issues. With a few exceptions (Gebhardt et al. 2024; Mardini and Lahyani 2024; Haque 2017), researchers have found that board gender diversity *increases* the level of carbon performance and reporting. Female directors decrease carbon emissions (as an inverse measure of carbon performance) in European cross-country settings (Velte 2024; Valls Martinez et al. 2022; Nuber and Velte 2021; Garcia Martin and Herrero 2020) and

country-specific studies (Oussii and Jeriji 2024; Muktadir-Al-Mukit and Bhaiyat 2024). Moreover, board gender diversity and carbon reporting are positively related in cross-country studies (Xhindole and Tarquinio 2024) and the United Kingdom (Al-Qahtani and Elgharbawy 2020; Tingbani et al. 2020; Haque 2017; Jizi 2017; Liao et al. 2015).

In line with stakeholder agency theory and empirical results, we assume that the ratio of female directors increases the probability of firms to include SBT (*hypothesis* H1):

H1. *Female directors and SBT are positively related.*

2.2 | Critical Mass of Female Directors and SBT

While H1 assumes a positive link between board gender diversity and SBT, female directors may only be successful in climate management if they reach a critical mass (Nuber and Velte 2021). These assumptions relate to the critical mass theory (Kanter 1977), whereas only a critical mass of female board directors influences their colleagues to include substantive climate actions and set ambitious emission reduction targets, such as SBT. In line with critical mass theory (Kanter 1977), we include a minimum quorum of at least 30% females on boards in line with prior studies (Velte 2024). Based on critical mass theory, we assume that a *critical mass of female directors* leads to increased board dynamics toward effective climate management, leading to a greater probability of recognizing SBT.

Prior empirical studies also recognized whether a critical mass of female directors improves the level of carbon performance and reporting. Most researchers found a positive relationship between a critical mass of female directors and carbon performance in cross-country settings (Gull et al. 2025; Peng et al. 2025; Haque et al. 2024; Velte 2024; Nuber and Velte 2021) and for the US capital market (Toukabri and Jilani 2023. Similar results occurred for the level of carbon reporting in international studies (Caby et al. 2024) and country-specific designs Lemma et al. 2023; Hollindale et al. 2019; Ben-Amar et al. 2017).

Based on critical mass theory (Kanter 1977) and empirical results, H1a assumes that a critical mass of female directors and corporate decisions to recognize SBT are positively connected.

H1a. *A critical mass of female directors and SBT are positively related.*

2.3 | Female CEOs and SBT

The relevance of top management team characteristics for corporate sustainability, e.g., CEO gender, is dominantly explained with upper-echelons theory (Hambrick and Mason 1984) in prior studies (Wang et al. 2024). Hambrick and Mason (1984) explicitly included demographic CEO attributes, such as sex, in their upper-echelons framework. The CEO is the most powerful member of the top management team with a significant impact on carbon reporting and performance (Caby et al. 2020, 2024). Upper-echelons theory assumes that group-related factors within the board of directors are of minor importance, but the role of the CEO is a crucial factor in establishing SBT and joining the SBTi (Hambrick and Mason 1984). Upper-echelons characteristics have a huge influence on strategic choices, e.g., product innovation, and firm performance (Hambrick and Mason 1984). As product innovation and SBT have many interrelations, CEO gender as a demographic upper-echelons characteristic leads to increased probability of recognizing SBT as ambitious climate management and strategic choices. Thus, based on upper-echelons theory, female CEOs set SBT as effective climate management.

Former *empirical* studies neglected the relationship between female CEOs and environmental (carbon) outputs. We only identified two international studies, stressing the positive impact of CEO gender on carbon reporting (Caby et al. 2024) and insignificant results (Caby et al. 2020). On a broader level, Bhaskar et al. (2023) and Wang et al. (2024) conducted meta-analyses on CEO characteristics and their contributions to corporate sustainability. Among others, the authors stressed the positive relationship between CEO gender and CSR outputs. In their literature review on the link between CEOs and environmental sustainability, Mahran and Elamer (2024) also highlighted the positive effect of female CEOs on environmental actions.

Based on upper-echelons theory (Hambrick and Mason 1984) and prior research, we assume that female CEOs include SBT (H1b):

H1b. *Female CEOs and SBT are positively related.*

2.4 | Female Nonexecutive Directors and SBT

We have already stressed that the major function of the board of directors is decreasing agency conflicts between managers and stakeholders via effective monitoring in line with stakeholder agency theory (Hill and Jones 1992). There is a long consensus in the literature that effective monitoring requires an adequate ratio of board independence (e.g., Gull et al. 2025; Furtuna and Sönmez 2024). Women in board positions are assumed to be more independent than their male colleagues in view of the "old boys network" (Garcia-Sanchez et al. 2023). This assumption should be more probable within the group of nonexecutive directors compared with executive directors (Konadu et al. 2022). Executive directors, being internal to the firm, support the CEO in managing climate strategies, reporting systems, and processes effectively (Konadu et al. 2022). In this context, conflicts of interest will be higher for executive directors, as they may act opportunistically and avoid ambitious emission targets. Female nonexecutive directors can be classified as a catalyst for increased board independence and increased preference for objective emission targets (Garcia-Sanchez et al. 2023). Thus, according to stakeholder agency theory (Hill and Jones 1992), female nonexecutive directors are linked with an increased climate awareness and probability of corporate inclusion of SBT.

Empirical researchers often used female nonexecutive directors as a synonym for female board independence (e.g., Furtuna and Sönmez 2024). In line with CEO gender, we only identified a few studies on the impact of female nonexecutive directors on carbon outputs. Two international studies found a positive

relationship between female nonexecutives and carbon performance (Gull et al. 2025; Garcia-Sanchez et al. 2023), whereas a Turkish study stressed insignificant results (Furtuna and Sönmez 2024). Positive tendencies also related to overall ESG measures for European firms (Fernandez-Mendez et al. 2025).

In line with stakeholder agency theory and empirical results, we assume that female nonexecutive directors positively contribute to firms' sensibility to implement SBT (H1c):

H1c. *Female nonexecutive directors and SBT are positively related.*

2.5 | Female Directors in the Audit Committee and SBT

Audit committees are the most important board committee (Abbasi et al. 2024) and stress the need for an active monitoring function to support other board members. The traditional role of audit committees was focused on monitoring financial reports, management systems, and financial auditors (Haque et al. 2024). However, audit committees are also responsible for supervising carbon reports, carbon performance, and especially SBT (Velte 2025b). Information overload and conflicts of interest between managers and stakeholders can be decreased by an adequate representation of female directors in audit committees (Hill and Jones 1992). Monitoring the level of ambition for corporate climate transformation by the audit committee in line with stakeholder demands requires objective emission targets like SBT. Female members in the audit committees fulfill an active monitoring function of questioning vague emission reduction targets and pushing executive directors to implement SBT and joining the SBTi. Female members in the audit committee are independent, risk averse, and sensitive on climate management (Haque et al. 2024; Abbasi et al. 2024). Thus, stakeholder agency theory assumes that gender diversity in the audit committee leads to increased climate sensitivity and higher probability of corporate inclusion of SBT (Hill and Jones 1992).

Empirical research on the impact of audit committees on corporate sustainability has been growing during recent years. However, studies on gender diversity in the audit committee and carbon were neglected with a few exceptions (Velte 2025b). Based on UK firms, Abbasi et al. (2024) found that nonaccounting females in the audit committee improve the level of carbon reporting. However, Haque et al. (2024) stressed an insignificant impact of at least one female member in the audit committee on carbon performance for European firms. Relying on broader CSR issues, empirical research is more homogeneous: Female audit committee members improve CSR (environmental) reporting (e.g., Bravo and Reguera-Alvarado 2019; Appuhami and Tashakor 2017; Wang and Sun 2022) and CSR performance (Bose et al. 2022).

Based on stakeholder agency theory and prior studies, gender diversity in the audit committee leads to an increased probability of SBT (H1d):

H1d. *Female directors in the audit committee and SBT are positively related.*

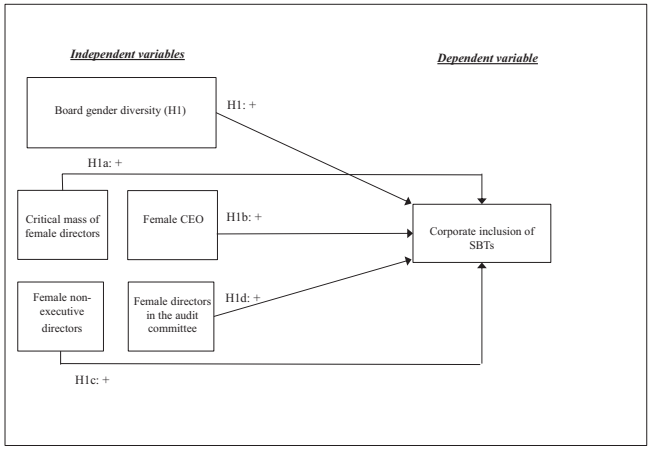

FIGURE 1 | Research framework.

Figure 1 gives an overview of the research framework.

3 | Data and Methodology

3.1 | Data and Sample

This study used listed firms headquartered in an EU member state and included in the CDP for the time frame between 2016 and 2021. The annual voluntary CDP questionnaire was dominantly used in empirical carbon research during the last decade (e.g., Busch and Lewandowski 2017). The business year 2016 is our starting point because the CDP included the question concerning SBT to the questionnaire in 2017, and the questionnaire always relates to the past year. We relied on EU-listed firms in view of the EU regulations on carbon reporting and performance in this time frame. The business year 2017 was the first year of the publication of a nonfinancial declaration in line with the NFRD. Starting in 2019, the ambitious EU Green Deal project and the related regulations (Taxonomy Regulative, CSRD, and CSDDD) set a focus on carbon reporting, climate transformation plans, and SBT. The United Kingdom as a former EU member state was also recognized in this study. In line with the CDP database, firm variables were collected from the LSEG (formerly: Refinitiv) and BoardEX databases. Our initial sample of publicly listed EU firms included 15,365 firms. We deleted 2887 firm-year observations from financial services firms due to their different capital structure and regulatory requirements. Furthermore, we excluded 10,462 observations from firms that are missing in any of the three databases (CDP, LSEG, and BoardEX). This led to an unbalanced panel of 336 firms and 2016 firm-year observations. Most firms were headquartered in the United Kingdom (28.3%), France (10.2%), and Germany (10.5%). Manufacturing firms were the most important industry in our sample (37.5%).

3.2 | Variables

3.2.1 | Dependent Variable: SBT

Our analysis addresses the research question of whether female directors improve the recognition of SBT. The dependent variable (*SBT*) is equal to one when a firm sets at least one science-based emission reduction target, approved by the SBTi, and zero

otherwise. We generated this variable from the CDP questionnaire (question C.4.1.a) in year t, which includes whether the corporate emission target is a SBT or not. Our dependent variable is commonly used in recent empirical research (e.g., Mateo-Marquez et al. 2024; Bendig et al. 2023).

3.2.2 | Independent Variables: Female Board Directors

We included five independent variables of female directors at different board levels. First, the ratio of female board directors (*FDB*), widely used in former studies (e.g., Caby et al. 2020, 2024), was included to test Hypothesis 1. Second, relying on Hypothesis 1a, a critical mass of board gender diversity (*CM*) is a dummy variable that equals 1 if at least 30% of the board directors are female. This variable was also used in former research (e.g., Velte 2024). Third, relying on Hypothesis 1b, we recognized a dummy variable that equals 1 if the firm has a female CEO or not (*FCEO*). This variable was also common in prior research (e.g., Caby et al. 2020, 2024). Fourth, the ratio of female nonexecutive board directors (*FNEX*) was recognized to test Hypothesis 1c in line with prior studies (e.g., Garcia-Sanchez et al. 2023; Furtuna and Sönmez 2024). Finally, the ratio of female directors in the audit committee (*FAUD*) is the fifth independent variable to test Hypothesis 1d, also well-known in other studies (e.g., Bose et al. 2022).

3.2.3 | Control Variables

In line with prior studies (Gull et al. 2025; Nuber and Velte 2021), we controlled for corporate governance and other firm-specific factors to decrease the risk of omitted variable bias in the link between female board directors and SBT. Corporate governance attributes are related to board affiliation (*BAF*), board independence (*BIND*), existence of sustainability board committees (*CSRC*), board size (*BSIZE*), board meeting frequency (*BMEET*), non-CEO duality (*CEOD*), sustainability-related executive compensation (*SREC*), and board expertise (*BEXP*) (Gull et al. 2025; Nuber and Velte 2021). Stakeholder agency theory (Hill and Jones 1992) assumes that these controls support the monitoring function of the board, leading to a higher probability of including SBT (Gull et al. 2025; Nuber and Velte 2021).

As other firm (financial) characteristics, we recognized firm size (*FSIZE*), accounting- and market-based financial performance (Return on Assets—*ROA*; Tobin's Q—*Q*), cash flow ratio (*CF*), and debt ratio (*DEBT*). Stakeholder agency theory (Hill and Jones 1992) assumes that higher financial performance, size, and liquidity are related to better corporate financial resources to rely on ambitious climate management, based on SBT. Finally, we included total emission intensity (*CARB*) and carbon-sensitive industries (*SENS*) to account for differences in high- versus low-emitting firms and industries. Higher carbon emissions and carbon-sensitive industries imply material carbon risks, which leads to greater awareness of top managers for effective carbon emission targets.

3.3 | Regression Models

Our sample of firms with a (non)inclusion of SBT is a subsample of firms that voluntarily respond to and publish their information in the CDP questionnaire. This leads to the risk of sample selection bias in empirical CDP research (e.g., Mateo-Marquez et al. 2024). To address this concern, we conducted the Heckman two-stage approach (Heckman 1979) to account for endogeneity in line with prior studies (e.g., Mateo-Marquez et al. 2024). In the first stage, we used a probit regression (Equation (1)), where CDP_{it} is a dummy variable equal to 1 if the firm responded to the CDP questionnaire and 0 otherwise. We chose a set of independent variables from prior studies (Mateo-Marquez et al. 2024) and increased our sample to recognize firms that did not participate in the CDP questionnaire during the time frame. Except for IND_CDP_{it-1}, measuring the industry average of CDP respondence, the other variables have been already introduced before as control variables.

$$CDP_{it} = \beta_0 + \beta_1{}^{*}IND\_CDP_{it-1} + \beta_2{}^{*}FSIZE_{it-1} + \beta_3{}^{*}ROA_{it-1} + \beta_4{}^{*}DEBT_{it-1} + \beta_5{}^{*}CF_{it-1+} + e_{it} \quad (1)$$

Then, we measured the *inverse Mills ratio (IMR)* and included the estimated IMR from the first step as an additional control variable in the second stage as follows:

$$\begin{aligned} SBT_{it} = {} & \beta_0 + \beta_1{}^{*}FDB_{it-1} + \beta_2{}^{*}BAF_{it-1} + \beta_3{}^{*}BIND_{it-1} \\ & + \beta_4{}^{*}CSRC_{it-1} + \beta_5{}^{*}BSIZE_{it-1} + \beta_6{}^{*}BMEET_{it-1} + \beta_7{}^{*}CEOD_{it-1} \\ & + \beta_8{}^{*}SREC_{it-1} + \beta_9{}^{*}BEXP_{it-1} + \beta_{10}{}^{*}FSIZE_{it-1} + \beta_{11}{}^{*}ROA_{it-1} \\ & + \beta_{12}{}^{*}\,Q_{it-1} + \beta_{13}{}^{*}DEBT_{it-1} + \beta_{14}{}^{*}\,CF_{it-1} + \beta_{15}{}^{*}\,CARB_{it-1} \\ & + \beta_{16}{}^{*}\,SENS_{it} + \beta_{17}{}^{*}\,IMR_{it} + e_{it} \end{aligned} \quad (2)$$

As SBT, our dependent variable, is binary, *logistic regressions* were recognized in accordance with similar studies (e.g., Mateo-Marquez et al. 2024). To analyze the impact of female directors on SBT, we formulated five regression models. The regression models only differ in their modification of independent variables. We start with *FDB* as shown in Equation (2) and run separate regressions by replacing *FDB* with *CM*, *FCEO*, *FNEX*, and *FAUD* to account for multiple gender diversity characteristics. To decrease the effects of outliers, we winsorized all continuous variables at the bottom 1% and top 99% levels. Moreover, we included clusters by firm-year to estimate standard errors for coefficient significance. All independent variables were lagged by 1 year because the CDP questionnaire in year t relates to climate information related to year t-1.

4 | Results

4.1 | Descriptive Statistics and Correlation Analyses

Descriptive statistics and correlation analyses are reported in Tables 1 and 2. The descriptive statistics in Table 1 indicate a rather low number of firms with SBT (mean: 0.356). Moreover, the ratio of female board directors is rather moderate (mean: 24.234%). This also relates to the critical mass of female directors (mean: 0.206), a female CEO (mean: 0.143), female nonexecutives (mean: 0.315), and female directors in the audit committee (mean: 0.254).

TABLE 1 | Descriptive statistics.

	N	Mean	Median	Std. dev.	Min	Max
Dependent						
SBT	2016	0.356	0.000	0.654	0.000	1.000
Independent						
FDB	2016	24.234	22.056	14.232	0.000	72.000
CM	2016	0.206	0.000	0.143	0.000	1.000
FCEO	2016	0.143	0.000	0.243	0.000	1.000
FNEX	2016	0.315	0.000	0.523	0.000	60.000
FAUD	2016	0.254	0.000	0.353	0.000	40.000
Controls						
BAF	2016	0.769	0.700	0.623	0.000	3.000
BIND	2016	50.324	51.500	23.343	0.000	100.000
CSRC	2016	0.623	1.000	0.423	0.000	1.000
BSIZE	2016	9.564	9.000	3.545	4.000	21.000
BMEET	2016	8.345	8.000	3.212	1.000	31.000
CEOD	2016	0.202	0.000	0.398	0.000	1.000
SREC	2016	0.309	0.000	0.423	0.000	1.000
BEXP	2016	40.323	39.423	21.434	0.000	90.232
FSIZE	2016	21.323	20.398	1.434	15.343	24.323
ROA	2016	4.434	4.243	7.879	−2.323	28.232
Q	2016	1.987	1.698	3.176	0.434	60.389
DEBT	2016	0.512	0.550	0.154	0.034	1.767
CF	2016	14.656	13.000	10.767	−21.434	45.232
CARB	2016	354.343	40.989	1018.232	0.145	1687.872
SENS	2016	0.545	1.000	0.242	0.000	1.000

As our five independent variables are highly correlated to each other, as seen in Table 2, we conducted separate regression analyses for each variable. The other pairwise correlations suggest that there are no multicollinearity problems. The computed variance inflation factors (VIF) did not exceed 2.00 in any model, with a mean VIF below 1.65, and thus well-below critical thresholds.

4.2 | Regression Results

The basic regression results, based on second stage regressions of the Heckman two-stage approach, are shown in Table 3. The models relate to our five independent variables, whereas we used stepwise regression models (starting without controls and continuing with included control variables). Hypothesis 1 assumes that FDB has a positive effect on SBT. The regression analyses support this assumption as a significant and positive coefficient of female directors can be stated ($p < 0.05$). Hypotheses 1a–d also assume that CM, FCEO, FNEX, and FAUD have a positive impact on SBT. Our regression analyses indicate a significant and positive coefficient of these independent variables ($p < 0.05$). Thus, Hypotheses 1a, c, and d are supported. However, we stress an insignificant positive relationship between FCEO and SBT. Female CEOs do not seem to impact SBT significantly in a positive way in contrast to Hypothesis 1b.

4.3 | Additional Analyses

As additional analyses, we measured the influence of female directors on carbon emissions and assumed a negative relationship. We recognized the change of carbon (Scopes 1 and 2) emission intensity (*delta carbon*) between two business years. Carbon emissions may heavily depend on firm size, and the board of directors may influence the carbon intensity of its business rather than the sheer size of emissions. Therefore, we scaled carbon emissions to sales at the end of the year in line with prior research (e.g., Qian and Schaltegger 2017). Table 4 presents the regression results of our analyses, based on panel regressions with year, industry, and country fixed effects. In

TABLE 2 | Pairwise correlations.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
(1) SBT	1.00																			
(2) FDB	0.243**	1.00																		
(3) CM	0.257**	0.535***	1.00																	
(4) FCEO	0.154*	0.454***	0.323***	1.00																
(5) FNEX	0.278**	0.656***	0.234***	0.133**	1.00															
(6) FAUD	0.226*	0.544***	0.121**	0.232*	0.225*	1.00														
(7) BAF	0.152*	0.342	0.243	0.254	0.312*	0.231	1.00													
(8) BIND	0.178*	0.266**	0.313*	0.254*	0.232**	0.243*	0.312	1.00												
(9) CSRC	0.265*	0.354	0.213**	0.243*	0.254	0.215*	0.243	0.236*	1.00											
(10) BSIZE	0.253	0.254**	0.153**	0.235	0.143**	0.154*	0.143	0.243*	0.143	1.00										
(11) BMEET	0.298	0.343	0.313	0.254	0.253*	0.251*	0.234*	0.254*	0.221	0.023	1.00									
(12) CEOD	0.254*	0.214*	0.243*	0.154	0.221	0.198	0.211	0.154	0.143*	0.162	0.056	1.00								
(13) SREC	0.214*	0.323*	0.221*	0.198	0.124	0.241*	0.198*	0.243*	−0.090	0.154	0.098	0.143*	1.00							
(14) BEXP	0.221	0.214	0.198*	0.224*	0.156	0.114**	0.133	0.153*	−0.143	0.043*	0.042	0.154*	0.312*	1.00						
(15) FSIZE	0.365**	0.354**	0.156*	0.132*	0.198	0.154**	0.142	0.146*	−0.144	0.114*	0.013	0.087*	0.143	0.154	1.00					
(16) ROA	0.312*	0.313	0.265*	0.211*	0.254*	0.142**	0.113*	0.116	−0.091	0.067*	0.091	0.013	0.226	0.154	0.132	1.00				
(17) Q	0.266**	0.213*	0.261*	0.254*	0.193*	0.143	0.180*	0.251	0.134*	0.152*	0.112*	0.143	0.154	0.127	0.042	0.002	1.00			
(18) DEBT	−0.321	−0.221	−0.198	−0.243*	−0.298*	−0.154*	0.132*	0.143*	−0.034*	0.043	0.098*	0.224*	0.098	0.054	0.143	0.123	0.032	1.00		
(19) CF	0.212*	0.342	0.196	0.114*	0.132**	−0.132	0.232*	0.154	−0.164*	0.154*	0.154	0.023	0.143	0.315*	0.223	0.121	0.021	0.132	1.00	
(20) CARB	−0.024**	0.132*	0.132	−0.142	−0.134*	0.013	0.156*	0.089	0.154	0.231*	0.145	0.154	0.113	0.043	0.132	0.045	0.143	0.168	0.113	1.00
(21) SENS	−0.035**	0.012	0.154	0.135	0.154	0.113*	0.212*	0.143	0.093	0.152	0.108	0.143	0.054	0.146	0.005	0.023	0.132	0.043	0132	0.021

*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

TABLE 3 | Basic regressions (second stage regressions of the Heckman 2-stage model).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	(FDB)	(CM)	(FCEO)	(FNEX)	(FAUD)	(FDB)	(CM)	(FCEO)	(FNEX)	(FAUD)
FDB	0.00303**					0.00332**				
	(0.00232)					(0.00242)				
CM		0.00287**					0.00297**			
		(0.00224)					(0.00252)			
FCEO			0.00144					0.00154		
			(0.0320)					(0.0325)		
FNEX				0.00352**					0.00375**	
				(0.00207)					(0.00215)	
FAUD					0.00323**					0.00364**
					(0.00219)					(0.00226)
BAF						0.353***	0.323***	0.305***	0.312***	0.365***
						(0.0524)	(0.0504)	(0.0522)	(0.0535)	(0.0528)
BIND						0.0243***	0.0267***	0.0283***	0.0212***	0.0225***
						(0.00824)	(0.00865)	(0.00894)	(0.00824)	(0.00811)
CSRC						0.000442	0.000498	0.000496	0.000464	0.000402
						(0.000822)	(0.000735)	(0.000802)	(0.000836)	(0.000807)
BSIZE						0.043**	0.050**	0.045**	0.042**	0.049**
						(0.032)	(0.036)	(0.030)	(0.035)	(0.036)
BMEET						0.000554	0.00624	0.000574	0.00561	0.000546
						(0.00232)	(0.00241)	(0.000254)	(0.00224)	(0.000225)
CEOD						0.314***	0.304***	0.302***	0.331***	0.313***
						(0.0243)	(0.0266)	(0.0279)	(0.0253)	(0.0243)
SREC						0.221***	0.203***	0.253***	0.212***	0.223***
						(0.0312)	(0.0319)	(0.0302)	(0.0316)	(0.0313)

(Continues)

TABLE 3 | (Continued)

	(1) (FDB)	(2) (CM)	(3) (FCEO)	(4) (FNEX)	(5) (FAUD)	(6) (FDB)	(7) (CM)	(8) (FCEO)	(9) (FNEX)	(10) (FAUD)
BEXP						0.0615***	0.0646***	0.0651***	0.0691***	0.0643***
						(0.0125)	(0.0128)	(0.0153)	(0.0115)	(0.0143)
FSIZE						0.0423**	0.0455**	0.0402**	0.0398**	0.0442**
						(0.0435)	(0.0465)	(0.0442)	(0.0421)	(0.0402)
ROA						1.365**	1.354**	1.332**	1.382**	1.313**
						(0.367)	(0.332)	(0.314)	(0.341)	(0.324)
Q						1.466**	1.423**	1.442**	1.452**	1.423**
						(0.441)	(0.401)	(0.423)	(0.421)	(0.413)
DEBT						0.154	0.144	0.182	0.133	0.152
						(0.165)	(0.162)	(0.162)	(0.152)	(0.168)
CF						0.0052**	0.0049**	0.0055**	0.0051**	0.0048**
						(0.0032)	(0.0038)	(0.0035)	(0.0036)	(0.0038)
CARB						−0.243*	−0.223*	−0.294*	−0.251*	−0.233*
						(0.125)	(0.131)	(0.147)	(0.137)	(0.126)
SENS						−0.137**	−0.135**	−0.141**	−0.133**	−0.141**
						(0.0031)	(0.0029)	(0.0030)	(0.0021)	(0.0031)
IMR	0.00204	0.00221	0.00245	0.000208	0.00232	0.00214	0.00232	0.00254	0.000217	0.00243
	(0.000821)	(0.000853)	(0.000824)	(0.000823)	(0.000824)	(0.000843)	(0.000864)	(0.000836)	(0.000838)	(0.000842)
Constant	−5.175***	−5.265***	−5.232***	−5.326***	−5.243***	−5.312***	−5.465***	−5.253***	−5.425***	−5.353***
	(0.532)	(0.506)	(0.532)	(0.521)	(0.515)	(0.546)	(0.524)	(0.535)	(0.528)	(0.516)
Observations	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016
Pseudo R^2	0.264	0.259	0.207	0.245	0.265	0.281	0.275	0.223	0.295	0.287

Note: Robust standard errors in parentheses.
*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

TABLE 4 | Additional analyses (relationship between board gender diversity and carbon emissions).

Variables	(11) (FDB)	(12) (CM)	(13) (FCEO)	(14) (FNEX)	(15) (FAUD)
FDB	−0.00165** (0.00361)				
CM		−0.00153** (0.00325)			
FCEO			−0.00225 (0.0389)		
FNEX				−0.00135** (0.00331)	
FAUD					−0.00153** (0.00352)
Constant	−4.154*** (0.416)	−4.161*** (0.419)	−4.176*** (0.421)	−4.152*** (0.411)	−4.165*** (0.417)
Controls	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes
N	1957	1957	1957	1957	1957
R^2	0.256	0.246	0.251	0.249	0.242

Note: Robust standard errors in parentheses.
*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

line with our assumptions, board gender diversity and *delta carbon* are negatively and significantly related, except for female CEOs.

4.4 | Endogeneity Tests

Studies on the impact of female board directors on SBT are confronted with multiple endogeneity problems (Wintoki et al. 2012). In the basic regressions, we conducted logistic regression with a time lag of 1 year and the Heckman 2-stage approach (IMR) to reduce endogeneity risks, such as self-selection bias. However, there may be concerns of reversed causality between female directors and SBT in the model. Firms with SBT may be attractive for new female directors to enter the boards. Researchers have recommended advanced regression models, such as two-stage least squares with instrumental variables (2SLS/IV) to address these issues (Wintoki et al. 2012). In line with prior studies (e.g., de Abreu et al. 2023), we included the industry averages of our gender diversity variables as instrumental variables. In line with our basic regressions, the second stage coefficients for FDB, CM, FNEX, and FAUD in Table 5 are positively and significantly related to SBT ($p < 0.05$). FCEO and SBT are insignificantly related. Thus, Hypotheses 1, 1a, 1c, and 1d are supported. The post-testimation analysis confirmed the strength and relevance of the instruments.

4.5 | Channel Analysis

We conducted a channel analysis to address some preconditions, which may explain the assumed positive relationship between board gender diversity and SBT. We included the publication of CDP reports (CDP) and GRI reports (GRI) as dependent variables, which are used in prior research as dummy variables concerning the voluntary disclosure of carbon emissions and ambitious CSR reporting (Ben-Amar et al. 2017; Caby et al. 2024). Reporting on carbon and other CSR aspects is a major requirement of successful CSR (carbon) management and closer stakeholder relationships. We assume that firms' voluntary inclusion of SBT depends on prior learning effects with CSR (carbon) reporting. Logistic regression results are summarized in Table 6 and indicate that board gender diversity is positively linked with the publication of CDP and GRI reports as a potential channel for the future inclusion of SBT.

TABLE 5 | Endogeneity checks, based on 2SLS and instrumental variable.

Panel A: First stage of 2SLS					
Variables	**FDB**	**CM**	**FCEO**	**FNEX**	**FAUD**
FDB_industry	0.376** (0.0267)				
CM_industry		0.398** (0.0254)			
FCEO_industry			0.331** (0.0248)		
FNEX_industry				0.313** (0.0223)	
FAUC_industry					0.302** (0.0253)
Controls	YES	YES	YES	YES	YES
N	2016	2016	2016	2016	2016
Constant	−5.042*** (0.535)	−5.114*** (0.512)	−5.009*** (0.542)	−5.225*** (0.525)	−5.155*** (0.535)
Pseudo R^2	0.210	0.197	0.205	0.199	0.229
Panel B: Second stage of 2SLS					
Variables	**(16) (FDB)**	**(17) (CM)**	**(18) (FCEO)**	**(19) (FNEX)**	**(20) (FAUD)**
FDB	0.00265** (0.00276)				
CM		0.00287** (0.00281)			
FCEO			0.00198 (0.0338)		
FNEX				0.00269** (0.00264)	
FAUD					0.00277** (0.00267)
Controls	Yes	Yes	Yes	Yes	Yes
N	2016	2016	2016	2016	2016
Constant	−5.265*** (0.524)	−5.226*** (0.515)	−5.276*** (0.520)	−5.214*** (0.531)	−5.204*** (0.515)
Pseudo R^2	0.198	0.184	0.205	0.178	0.185

Note: Robust standard errors in parentheses.
*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

TABLE 6 | Channel analysis, based on the publication of CDP and GRI reports.

Panel A: CDP	**(21)**	**(22)**	**(23)**	**(24)**	**(25)**
Variables	**(FDB)**	**(CM)**	**(FCEO)**	**(FNEX)**	**(FAUD)**
FDB	0.00147* (0.00236)				
CM		0.00132* (0.00242)			
FCEO			0.00167 (0.0145)		
FNEX				0.00127** (0.00203)	
FAUD					0.00196** (0.00246)
Controls	Yes	Yes	Yes	Yes	Yes
N	1967	1967	1967	1967	1967
Constant	−5.265*** (0.524)	−5.226*** (0.515)	−5.276*** (0.520)	−5.214*** (0.531)	−5.204*** (0.515)
Pseudo R^2	0.198	0.184	0.205	0.178	0.185
Panel B: GRI	**(21)**	**(22)**	**(23)**	**(24)**	**(25)**
Variables	**(FDB)**	**(CM)**	**(FCEO)**	**(FNEX)**	**(FAUD)**
FDB	0.00167** (0.00210)				
CM		0.00147** (0.00238)			
FCEO			0.00159 (0.0133)		
FNEX				0.00189** (0.00254)	
FAUD					0.00153** (0.00221)
Controls	YES	YES	YES	YES	YES
N	1959	1959	1959	1959	1959
Constant	−5.024*** (0.476)	−5.121*** (0.463)	−5.065*** (0.476)	−5.132*** (0.468)	−5.164*** (0.465)
Pseudo R^2	0.184	0.178	0.187	0.189	0.192

Note: Robust standard errors in parentheses.
*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

5 | Conclusion and Discussion

Empirical research on SBT has recently concentrated on the consequences of SBT for firms, such as financial performance (e.g., Ben-Amar et al. 2024) and environmental (carbon) performance (e.g., Li et al. 2025). While we stress an increased research activity on the link between board gender diversity and carbon outcomes (Velte 2025a), to the best of our knowledge, this study addresses the link between female board directors and SBT at different board levels (gender diversity heterogeneity) for the first time. Based on 2016 observations from 336 firms with headquarters in a European Union (EU) member state and included in the CDP database, we find a positive impact of the ratio and critical mass of female directors, female nonexecutives, and women in the audit committee on SBT. However, female CEOs and SBT show insignificant results. We concluded a complementary role between the representation of females on the board, especially via active monitoring, and effective carbon management through SBT.

Our research results are in line with Mateo-Marquez et al. (2024), stressing the positive impact of board-level supervision of climate-related issues on SBT, and prior studies on the positive impact of female directors on carbon outputs (Velte 2025a). The positive impact of board gender diversity on SBT may be explained by personality traits of female directors, assuming a greater awareness of climate issues due to gender-specific socialization, which emphasizes altruism, benevolence, and universalism (Glass et al. 2016; Liu 2018; Nadeem et al. 2020). Gender diverse boards are more likely to respond adequately to stakeholder concerns, leading to an increased voluntary recognition of SBT. Insignificant results on female CEOs and SBT may relate to their reduced number and their limited impact. The positive effects of female nonexecutive directors and female members in the audit committee can be explained by higher rates of independence of female directors in comparison with their male colleagues ("old-boys-network"), leading to higher degrees of monitoring in line with stakeholder interests (Glass et al. 2016). As the voluntary recognition of SBTs requires increased board resources and skills, we recognized the voluntary external publication of a CDP report as a major channel of the link between female directors and SBT. The positive link between board gender diversity and external transparency of CDP reporting stresses the existence of learning effects with climate reports before the later inclusion of SBT.

We motivate future researchers to conduct additional studies on other determinants of SBT to guide managers and regulatory bodies alike. We assume an increased empirical research activity on SBT due to various regulations on carbon management and reporting in many countries (e.g., the EU).

5.1 | Theoretical Implications

This study mainly contributes to the theoretical foundation of board gender diversity and corporate climate transformation. In line with stakeholder agency theory (Hill and Jones 1992), the recognition of female boards decreases conflicts of interest and information asymmetries between managers and stakeholders. Except for female CEOs, the ratio and critical mass of female board directors, the ratio of female nonexecutives and members in the audit committee positively and significantly contribute to effective carbon management, based on SBT. These results highlight the active monitoring function of female directors, which goes hand in hand with increased independence and climate-related sensitivity of female board members (Caby et al. 2020, 2024).

Female boards include climate demands of stakeholders in carbon strategies and disclosure more actively than their male colleagues (Garcia-Sanchez et al. 2025; Bergmann et al. 2025). Literature also assumes that female board members are sympathetic, care about stakeholder interests in climate actions, and fulfill an active monitoring function on these aspects (Velte 2024; Tingbani et al. 2020). Board gender diversity as a major element of sustainable corporate governance and SBT represent complementary practices, which are highly demanded by stakeholders (Hill and Jones 1992).

We make major contributions to prior research. To the best of our knowledge, we conducted the first study on the link between female board directors and SBT at different board levels (full board, CEO, audit committees, and nonexecutive directors). As empirical research on SBT has concentrated on firms' (non)financial consequences of SBT (e.g., Ben-Amar et al. 2024; Bendig et al. 2023; Bingler et al. 2024), we know very little about corporate governance drivers of the voluntary management decision to include SBT. In this way, we addressed recent calls for conducting empirical research on SBT (Bendig et al. 2023). Furthermore, we contributed to an increased number of studies, which found a positive impact of female directors on carbon outputs on the European capital market (e.g., Valls Martinez et al. 2022; Nuber and Velte 2021; Xhindole and Tarquinio 2024), while a focus on SBT was not set and gender diversity heterogeneity was ignored.

5.2 | Practical Implications

Our research has many implications for firms, managers, and stakeholders. Managers should be more sensitive in the implementation of gender diversity at different board levels and carbon management to promote the connectivity between corporate governance and sustainability (Banno et al. 2023). If firms successfully implement a critical mass of female directors, female nonexecutive directors, and female audit committees, together with SBT, it leads to better stakeholder reputation and overall firm performance (Nuber and Velte 2021; Valls Martinez et al. 2022). These managerial implications are especially important for EU-listed firms due to carbon regulations of the EU Green Deal Project and mandatory board gender quotas in future years. Consequently, the sustainability report in line with the CSRD and ESRS should include an explicit description of the connectivity between board gender diversity and corporate carbon targets. Firms, which rely on stricter carbon regulations to increase their carbon performance, must change their boards in line with the climate expectations of their stakeholders. Our study contributes to the controversial discussions on greenwashing as firms should rely on SBT to signal increased objectivity and effectiveness of their climate goals to the public.

5.3 | Limitations and Research Recommendations

Our study is a useful starting point for future research on the impact of sustainable corporate governance on SBT. First, future researchers should evaluate the relationship between climate-related board expertise (e.g., Chief Sustainability Officers or sustainability board committees), other aspects of board diversity (e.g., cultural or educational background), climate-related executive compensation, and sustainability-related (institutional) ownership and SBT. We assume a positive impact of these firm attributes on firms' awareness of SBT.

Second, as our study focused on committed and set SBT, future studies should explicitly analyze possible drivers of the successful *realization* of SBT over time. Normally, there is a huge gap in business practice between announced and realized emission targets, which can be used for self-impression management and greenwashing practices (Bendig et al. 2023). The differentiation between climate talk and walk should be focused on in future studies on SBT.

Third, our sample of firms was restricted on the *CDP database*. As the CSRD and the ESRS request firms to report on their (non)reliance on SBT in future years as part of the mandatory sustainability report, researchers should conduct automated text analyses on published climate reports, such as descriptions on emission reduction targets. We also expect that the CDP may be consolidated with the International Sustainability Standards Board (ISSB) as part of the recent process of global harmonization of sustainability reporting. Thus, future researchers should compare the ambitiousness of corporate climate efforts between EU firms and other regimes (e.g., The USA).

Fourth, while we included specific advanced regression methods to address endogeneity concerns (Heckman 2-stage and 2SLS/IV), the difference-in-difference (DiD) method has become widespread in empirical economics (e.g., Chen et al. 2025). The DiD, as a quasi-experimental research design, is a useful strategy for studying causal relationships. We note that DiD approaches in prior research on board gender diversity are few (e.g., Chen et al. 2025). In view of the increased regulatory initiatives on board gender quotas, future research designs should recognize regulatory shocks, such as the introduction of the EU directive on mandatory gender quotas, for DiD analyses.

Finally, we stress the low ratio of firms with a critical mass of female directors, a female CEO, nonexecutive directors, and audit committee members. While some EU member states have implemented national rules on board gender diversity, the inclusion of female directors was not mandatory on an EU level during the analyzed time frame. While we included several robust measures to recognize endogeneity concerns, such as self-selection bias, reversed causality, and omitted variable bias, our results might be driven by other factors than board gender diversity. The EU Directive on gender quotas of 2022 mandates large EU-listed companies to have at least 40% of their nonexecutive directors or 33% of all director positions (executive and nonexecutive) held by the underrepresented sex by June 30, 2026. Thus, a critical mass of female directors is recognized by the EU Directive. Consequently, we expect increased levels of female directors in the future and increased research activities. However, the selection of a female CEO and female members in the audit committees remains an option for listed firms.

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Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Appendix A

Variable Definitions

Variable name	Definition	Data source
Dependent variables		
SBT	Dummy variable indicating if at least one emission reduction target has been validated by the science-based targets initiative (SBTi) in any year = 1, 0 otherwise.	CDP
Independent variables		
FDB	Ratio of female board members in %	LSEG
CM	Dummy variable indicating if a critical mass of female directors of least 30% is on the board = 1, 0 otherwise	LSEG
FCEO	Dummy variable indicating if a female CEO is existent = 1, 0 otherwise	BoardEX
FNEX	Ratio of female nonexecutive board members in %	LSEG
FAUD	Ratio of female members in the audit committee in %	BoardEX
Control variables		
BAF	Average number of other corporate affiliations for the board members	
BIND	Percentage of independent board members in %	LSEG
CSRC	Dummy variable indicating if a sustainability board committee is existent = 1, 0 otherwise	LSEG
BSIZE	Number of board members	LSEG
BMEET	Number of board meetings	LSEG
CEOD	Dummy variable indicating if the CEO is not the (ex-) board chair = 1, 0 otherwise	LSEG
SREC	Dummy variable indicating whether senior executive compensation is linked to sustainability or CSR-related incentives = 1, 0 otherwise	LSEG
BEXP	Percentage of board members with either industry or financial skills in %	LSEG
FSIZE	Log of total assets	LSEG
ROA	Return on assets in %	LSEG
Q	Tobin's Q = (market value of equity + liabilities)/book value of equity + liabilities	LSEG
DEBT	Total debt/total assets	LSEG
CF	(Net cash flows/sales) in %	LSEG
CARB	Total estimated CO2e emissions by revenues (tCO2/EUR mn)	LSEG
SENS	Dummy variable indicating whether the firm belongs to a carbon-intensive industry (materials, energy, or utilities) = 1, otherwise 0	LSEG
IMR	Inverse Mills Ratio	—