

Differentiating the good from the bad – an investor perspective on the informative value of corporate climate disclosure

Lena Klaaßen,^{1*} Christian Lohmüller^{1,2}, Bjarne Steffen,^{1,3,4}

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Abstract

Investors are under increasing pressure to help mitigate climate change and reduce greenhouse gas emissions from their portfolios. However, previous evidence on whether companies that disclose corporate carbon measures subsequently show emissions reductions is controversial, making forward-looking assessments of future portfolio decarbonization difficult for investors. Building on common practices from public policy and transnational climate action, we hypothesize that a company must adopt a range of corporate climate measures from different complementary areas to successfully achieve emissions reductions. To test this hypothesis, this article draws on a CDP dataset of climate-related disclosure of 1,635 companies based in OECD countries from 2010 to 2021 and reporting for at least five years. By doing so, we also address the limitations of previous research, including small sample sizes and short observation periods. Consistent with previous studies, we find inconclusive results as to whether companies disclosing single corporate climate measures are associated with subsequent emission reductions. For companies that disclose a comprehensive corporate climate measure mix which includes measures from four complementary areas (targets, governance, implementation, as well as monitoring, reporting, and verification), we find subsequent absolute emission reductions. However, the effect is only robust to changes in the regression design for an especially stringent comprehensive measure mix including measures with comparatively low adoption, suggesting that it is not only the combination of complementary measures that matters but also the kind of measures included in the measure mix.

¹ Climate Finance and Policy Group, ETH Zurich, Switzerland

² TUM School of Life Sciences, Technical University of Munich, Germany

³ Institute for Science, Technology and Policy, ETH Zurich, Switzerland

⁴ Center for Energy and Environmental Policy Research, Massachusetts Institute of Technology, USA

*Correspondence: lena.klaassen@gess.ethz.ch

Introduction

Aligning financial flows with greenhouse gas (GHG) emission reduction targets is critical to mitigating climate change and achieving pathways to net zero (Klaaßen & Steffen, 2023). Over the past years, the private financial sector's response to pressures around climate change has emphasized the role of disclosure. Most prominently, this has led to the introduction of the recommendations of the Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD) in 2017 which meanwhile have been integrated in most sustainability reporting standards (IFRS, 2021) and the introduction of mandatory sustainability reporting, such as the Corporate Sustainability Reporting Directive (CSRD) entered into force in 2023 (European Commission, 2023). The fundamental idea of these disclosure standards and requirements is that investors may reallocate capital to reduce climate risk as well as portfolio emissions. To enable investors to effectively decarbonize their portfolio emissions, the disclosed information must be informative concerning a company's future GHG emissions. In light of the need for deep decarbonization across all sectors, there is an ultimate need for corporate emission reductions in order to prevent climate risk and unleash the potential of non-state climate action, including from companies, which has been identified to be significant in the fight against climate change (Hsu et al., 2019; Kuramochi et al., 2020). Particularly in Europe, regulatory requirements concerning climate action disclosure by companies – with the ultimate goal of facilitating the re-direction of capital in line with investors' climate concerns – are increasingly considered as part of public climate policymaking as well (Steffen, 2021; Steffen & Michaelowa, 2022).

However, the big question is whether disclosed corporate climate action is associated with subsequent emission reductions and thus may be a helpful predictor for investors to consider in a climate-conscious investment strategy. If disclosed mitigation measures have no effect on future emissions, expecting investor-led reallocation to companies that demonstrate greater mitigation effort is hopeless. In the sustainable finance literature, two major corporate sustainability disclosure views – that is, the legitimacy view and the management-oriented view – present contrasting theories on the effect of disclosed corporate climate measures. The legitimacy view suggests that disclosure is used to portray sustainable images or repair adverse images in order to obtain or maintain legitimacy but the disclosed climate measures are not linked to actual climate performance improvements (Castelo Branco & Lima Rodrigues, 2006; Cormier, Gordon, & Magnan, 2004). On the contrary, the management-oriented view argues that disclosed corporate climate measures can serve as a management tool to create organizational pressure and incentives which subsequently drives climate performance (Burritt & Schaltegger, 2010).

Despite past research on the link between corporate climate measures and emission reductions, the empirical evidence remains contested and inconclusive to fully support either the legitimacy view or the management-oriented view. However, existing research on this topic exhibits two shortcomings: First, sample sizes are often very small with only a few hundred companies and observation periods are typically short with less than five years impeding analyzing time-lagged effects. Second, the vast

majority of the studies investigate only the effect of single corporate climate measures in isolation, such as policies for emission reporting (Bauckloh, Klein, Pioch, & Schiemann, 2022; Downar, Ernstberger, Reichelstein, Schwenen, & Zaklan, 2021), setting of emission reduction targets (Dahlmann, Branicki, & Brammer, 2019) or establishing climate-related corporate governance (Le Luo & Tang, 2021; Moussa, Allam, Elbanna, & Bani-Mustafa, 2020). Only in few cases more than one type of corporate climate measure was analyzed, though these studies either aggregate measures together by using an aggregated disclosure score (Jiang, Fan, Zhu, & Xu, 2023; Qian & Schaltegger, 2017), or considered only a very small sample size of fewer than 500 observations (Doda, Gennaioli, Gouldson, Grover, & Sullivan, 2016). Consequently, we lack evidence of how a combination of different corporate climate measures could be an effective strategy for emission reduction.

Decades of experience with climate policy on a national and transnational level, however, showed that effective policy strategies require a mix of different policy instruments. Concerning national climate policy, the literature on policy mixes describes how different policies work in conjunction (Kern & Howlett, 2009; Rogge & Reichardt, 2016; Schmidt & Sewerin, 2019). Particularly, there is a need for coordination (e.g. via targets or overarching cap-and-trade systems), sector-specific measures, and continuous monitoring with potential adaption of measures. One example is the German climate law, introduced in 2019, which includes concrete targets, a dedicated governance structure to define responsibilities as well as a monitoring system (Umweltbundesamt, 2022). Concerning international climate policy, Michaelowa and Michaelowa (2017) argue that any transnational initiative requires mitigation targets, financial incentives, a baseline, as well as monitoring, reporting and verification (MRV) to have any plausible effect on climate change mitigation. The TCFD also draws on this logic and advises companies to disclose, information related to climate-related governance, strategy, risk management as well as metrics and targets (TCFD, 2017). However, there is no research investigating whether the disclosure of a comprehensive corporate climate measure mix spanning over multiple complementary areas is associated with improved climate performance.

To address this gap, this article investigates the link between the disclosure of corporate climate measures and subsequent GHG emission reductions in a ‘large-n’ analysis including the effect of installing a combination of corporate climate measures ranging across four key areas: targets, governance, implementation, as well as MRV. We build on a dataset of CDP (formerly: Carbon Disclosure Project) consisting of climate-related disclosure of 1,635 companies based in OECD (Company for Economic Co-operation and Development) countries from 2010-2021 and reporting for a minimum of 5 years.

The sections that follow discuss the related literature and the derived hypotheses (section 2), our methods and data (section 3), the descriptive results and our results from the regression analyses (section 4), and our discussion and conclusion (section 5).

Literature review and hypotheses development

Sustainability disclosure theory and related literature

The motivation of companies for disclosing sustainability-related information has been studied by sustainable finance literature and dates back to the early 2000s, with initial studies focusing on whether the act of disclosure indicates poor performance (legitimacy view) or good performance (management-oriented view) (Clarkson, Li, Richardson, & Vasvari, 2008; Patten, 2002). According to the legitimacy theory, organizations disclose sustainability information as a result of stakeholder and shareholder pressure, to obtain, maintain and repair their organization's legitimacy in society's perception (Castelo Branco & Lima Rodrigues, 2006; Cormier et al., 2004). Following the legitimacy theory, bad sustainability performance leads to greater external pressure, resulting in enhanced levels of sustainability disclosure. The management view, on the contrary, argues that organizations disclose sustainability information to communicate their need to improve sustainability performance. Here, sustainability disclosure is a valuable tool for companies to establish measurement and management practices that can help them reduce their sustainability impact (Burritt & Schaltegger, 2010).

In light of the imminent climate crises, recent research has increasingly focused on the specific case of climate-related disclosure with a forward-looking perspective that aims to understand the inverse relation, namely the effects of carbon measure disclosure on future performance to determine whether disclosure can be an indicator of poor (legitimacy view) or good (management-oriented view) future performance. However, existing evidence remains contradictory. Qian and Schaltegger (2017) and found a positive relationship between carbon disclosure and carbon performance, while Haque and Ntim (2020) found that companies adopting voluntary reporting guidelines, such as the guidelines from the Global Reporting Initiative (GRI), are more likely to implement carbon reduction measures but do not improve their carbon performance. Belkhir, Bernard, and Abdelgadir (2017) found no correlation between GRI reporting and a company's carbon emissions. In terms of mandatory carbon disclosure, Downar et al. (2021), Jouvenot and Krueger (2019), and Tomar (2023) found a positive relationship between mandatory reporting and emission reductions for absolute emissions as well as carbon intensity, while Bauckloh et al. (2022) found that companies affected by mandatory disclosure improved their carbon intensity significantly more than unaffected companies, but not their absolute carbon emissions.

The effect of corporate climate measures

With the introduction of the recommendations of the Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD) in 2017, the disclosure of climate-related information beyond the mere reporting of carbon emissions has gained significant momentum. The TCFD recommends disclosure across four areas including governance, strategy, risk management, as well as metrics and targets, which have been integrated into most sustainability reporting standards (IFRS, 2021). This aligns with increasingly common practices from national and international climate policy, which require climate change mitigation efforts and policies to be backed by a set of measures aiming to ensure

progress towards the overall goal. One example is the German climate law, introduced in 2019, which includes concrete targets, a dedicated governance structure to define responsibilities as well as a monitoring system (Umweltbundesamt, 2022). Similarly, it is argued for transnational climate initiatives that there is a need for mitigation targets, financial incentives, a baseline, as well as monitoring, reporting and verification (MRV) to have any plausible effect on climate change mitigation (Michaelowa & Michaelowa, 2017).

While standards to report on climate measures within companies and beyond are maturing as just discussed, there is also a separate strand of research investigating the link between disclosed corporate climate measures falling into the proposed areas and subsequent emission reductions. Dahlmann et al. (2019) investigated the effects of emission reduction **targets** on subsequently reduced emissions but found no overall effect of setting GHG emission reduction targets on emissions reductions. Damert, Paul, and Baumgartner (2017) analyzed the effects of corporate climate strategy and reduction initiatives on a company's GHG emissions but also did not find a significant effect of these **implementation** tools on emission levels. Haque and Ntim (2020) found that **governance** tools, such as executive compensation is associated with reduced emission intensities, but no effect on absolute emission could be identified. Aslam, Rehman, and Asad (2020) investigate the effect of environmental audits and third-party verification which fall in the area of **MRV**. Still, the vast majority of studies are limited to investigating the effect of single corporate climate measures or a very narrow area of possible corporate climate measures. If there is a broader scope of disclosed corporate climate measures covered, they are usually represented by an aggregated disclosure score (Jiang et al., 2023; Qian & Schaltegger, 2017), disguising the effect of measures from specific areas. There is only one study by Doda et al. (2016) that builds on 23 disentangled corporate climate measures but finds only very limited evidence that these measures have an impact on a company's GHG emissions. However, the analysis is based on a relatively small data set of fewer than 500 companies with corporate climate measures data from 2010 and emissions data from 2009 and 2010. In this context, the authors acknowledge that it remains unclear whether their finding may be due to data limitations which also do not allow to analyze any implications of the future effect of corporate climate measures.

In light of the contested empirical evidence and the lack of investigation of the effect of a broader set of corporate climate measures on future climate performance, we propose the following two opposing hypotheses:

- **H1a:** In line with the legitimacy view, companies with corporate climate measures (i.e., related to targets, governance, implementation or MRV) exhibit GHG emission increases.
- **H1b:** In line with the management-oriented view, companies with corporate climate measures (i.e., related to targets, governance, implementation or MRV) exhibit GHG emission reductions.

The effect of corporate climate measure combinations

Although there is only fragmented empirical evidence on the effect of corporate climate measures on climate performance, there is a tendency toward results supporting the legitimacy view. At the same time, both, the TCFD framework as well as the above-described common practices from publicly and international climate policy suggest that a set of complementary measures is required to drive emission reductions. It also seems plausible that targets are most likely fulfilled through related implementation measures which need to be governed as well as monitored, reported and verified to track the process. Following this argumentation, installing corporate climate measures in a single area (e.g., targets) cannot prove successful if not accompanied by measures from other areas such as governance, implementation as well as MRV which therefore requires a ‘comprehensive measure mix’.

Following this argumentation, we propose the following hypotheses:

- **H2:** Companies with a comprehensive corporate climate measure mix (i.e., which includes measures from all key areas including targets, governance, implementation and MRV) exhibit GHG emission reductions.

Methods and data

Data and sample

We draw on a dataset of the CDP climate change and supply chain program public responses from 12,417 companies between 2010 and 2021 which we complement with financial and other company-specific data extracted from Refinitiv (formerly: Thomson Reuters Financial & Risk). We choose the CDP dataset since CDP (formerly: Climate Disclosure Project) constitutes the most extensive global database on corporate climate measures and GHG emissions data, spanning most regions and industries. CDP is an international non-profit organization initiated in 2000 by investors to collect corporate sustainability-related information. Today, it is considered the most comprehensive database for voluntarily reported climate-related information, with over 18,000 companies making up more than half of global market value disclosing to CDP. Investors constitute one of the main user groups with over 680 financial institutions with over US\$130 trillion in assets requesting information from their portfolio companies through CDP (CDP, 2022). Thus, the CDP database is also widely used in academic research in the area of sustainable finance (Fang, Tan, & Wirjanto, 2019; Kouloukoui, Marinho, Marcia Mara de Oliveira, Da Gomes, Kiperstok, & Torres, 2019; Tuhkanen & Vulturius, 2022).

We define the final sample for our analysis in three steps aiming to maximize its relevance to investors. First, we focus on companies based in OECD countries. Second, we limit the sample to the companies reporting GHG emission data (scope 1 and 2) for at least 5 years to be able to observe the potential effect of corporate climate measures on subsequent emission reductions for our sample companies over a longer time period. Third, we reduce the sample to companies that report an ISIN (International

Securities Identification Number) at least once between 2010 and 2021. This enables us to match the CDP data with company-specific data from Refinitiv. At the same time, companies reporting an ISIN are usually publicly traded, meaning that corporate climate measure disclosure can inform investment decisions on capital markets.

The resulting sample consists of 1,635 companies and 15,270 observations between 2010 and 2021. The sample is an unbalanced panel dataset as not every company reported to CDP every year, and not every observation contains data for every variable since some corporate climate measures have not existed in the early years (see Appendix: Table A.4). In 2018, a drop in the number of companies reporting publicly to CDP could be observed, which also exists in this sample. This drop occurred likely due to the structural changes CDP questionnaires underwent in 2018 when adapting reporting guidelines to TCFD recommendations. This change could have overwhelmed some companies and led them not to report in 2018 to avoid receiving a bad CDP score.

It is important to note that our sample does not constitute a random sample. While CDP invites most publicly traded and larger corporations to disclose, reporting is still voluntary, and some companies decide not to publish. Also, only companies reporting to CDP and disclosing at least five years of Scope 1 and Scope 2 location-based emissions are included. As of 2019, the sample's Scope 1 emissions (1.9bn metric tons CO₂-e) represent 5.2% of global emissions, while the sample's Scope 2 (location-based) emissions (0.4bn metric tons CO₂-e) account for another 1.1% of global emissions (Friedlingstein et al., 2019). Still, the sample is biased towards companies disclosing sustainability information comprehensively over a long time. While results may not be generalizable to companies not disclosing sustainability information, this paper focuses on informing climate-oriented investors who also need to base their assessment on voluntarily reported climate-related information for their assessment.

Variables and regression model

For the dependent variable, we are interested in the climate performance of a company. Similar to many studies in the field, we operationalize this variable as an outcome-based measure, absolute total emissions (scope 1 + scope 2 location-based), and as a process-based measure, emission intensity. Emission intensities are calculated by dividing absolute emissions (scope 1 + scope 2 location-based) by the company's total revenue, similar to previous studies in the field (Dahmann et al., 2019; Damert et al., 2017; Downar et al., 2021; Le Luo & Tang, 2022; Qian & Schaltegger, 2017). We do not use scope 2 market-based emissions as a dependent variable as they have only been introduced in 2016 and have been criticized for not reflecting real emission reduction as they largely rely on the purchase of renewable energy certificates (Bjørn, Lloyd, Brander, & Matthews, 2022). Also, we do not include Scope 3 emissions since companies have only limited direct influence on those emissions through corporate climate measures, and scope 3 emissions are subject to large inconsistencies and incompleteness (Busch, Johnson, & Pioch, 2022; Klaaßen & Stoll, 2021). We remove outliers from the emission data using the interquartile range (IQR) method. According to the method, values outside of

1.5 IQRs from the 1st and 3rd quartile are considered outliers. As emissions data is not comparable between companies of different sizes or operating in different sectors, outliers were identified by comparing emission intensities between companies of the same NAICS sector to account for size-specific and sector-specific differences to avoid removing especially small and large companies from the sample. Observations for which emission intensities were identified as outliers have also been removed from the sample with absolute emissions as the dependent variable.

For the independent variables, we extract corporate climate measures from CDP adhering to the four key areas identified in the literature review: targets, governance, implementation and MRV. The CDP dataset covers a wide range of corporate climate measures. The questionnaires have been adapted annually between 2010 and 2021 to meet changing market needs and corporate climate change reporting trends. Generally, questionnaires have become more comprehensive, e.g., by including new corporate climate measures, such as the internal carbon price in 2015. Also, the questions have become more nuanced, e.g., from 2016 on, companies were asked if they had science-based targets, and from 2017 on, they had to declare if the Science-Based Targets initiative had approved those targets. An overview of areas covered in the CDP questionnaires between 2010 and 2021 is provided in the Appendix (Table A.4). Since most CDP questions changed multiple times between 2010 and 2021, we matched them thematically with similar questions in other years (see Appendix: section III). We focus on questions with binary or categorical answers since long, individual answers are unlikely to serve in large-n analyses conducted by investors to decide whether to include a company in a climate-oriented portfolio. This results in 13 corporate climate measures spread across the four key areas (see Table 1). We then operationalize the raw CDP data in three steps: First, the responses to all CDP questions belonging to the same corporate climate measures were collected across all years and CDP programs. Second, the responses were standardized since the answer options changed over the years. Third, the answers were operationalized for the statistical analysis by converting answers to a binary format (see Appendix: section III for a detailed overview).

Area	Corporate climate measure	Description	Available since year	# Observations
Targets	Absolute target	Company has at least one absolute emission reduction target.	2010	15,270
	Intensity target	Company has at least one emission intensity reduction target.	2010	15,270
	Science-based target	Company has at least one target approved as science-based by the Science-Based Targets initiative.	2017 ⁵	6,680

⁵ The question whether a company has a science-based targets was first introduced in 2016. In 2017, the question was specified to whether at least one target approved as science-based by the Science-Based Targets initiative. This led to a drastic drop of companies claiming to have a science-based target from 16% in 2016 to 7% 2017. Consequently, we only include *Science-based targets* as an independent variable from 2017 onwards.

Governance	Board-level oversight	The board or a committee appointed by the board is directly responsible for climate change in the company.	2010	15,270
	Incentives	Company provides incentives for the management of climate-related issues, including the attainment of targets.	2010	15,270
	Monetary incentives	Company provides monetary incentives for the management of climate-related issues, including the attainment of targets.	2010	15,270
	Internal carbon price	Company uses an internal price on carbon.	2015	9,462
Implementation	Mitigation initiatives	Company is implementing initiatives to reduce its GHG emissions.	2012	13,240
	Strategic integration	Company has integrated climate change into its business strategy.	2011	14,324
	Value-chain engagement	Company engages with at least one element of its value chain on GHG emissions and climate change strategies.	2013	12,060
Measurement, reporting, and verification (MRV)	Scope 1 verification	Reported Scope 1 emissions have been verified by third party.	2010	15,270
	Scope 2 verification	Reported Scope 2 emissions have been verified by third party.	2010	15,270
	Scope 3 disclosure	Company discloses Scope 3 emissions.	2010	15,270

Table 1: Overview of the corporate climate measures serving as independent variables as well as the earliest year available in our sample and the corresponding number of observations.

Figure 1 shows the correlation coefficient between the 13 independent variables. We see that the correlation is reasonably low except for the *Incentives* and the *Monetary incentives* as well as for *Scope 1 verification* and *Scope 2 verification*. From a corporate management perspective, this seems very plausible given that monetary incentives represent a specific kind of *Incentives* and scope 1 and scope 2 emissions are likely to be verified together. To avoid multicollinearity issues, we, therefore, exclude the variables *Incentives* and *Scope 2 verification* from the regression analyses, given that *Monetary incentives* are the more stringent measure and scope 1 emissions are more than four times higher in our sample compared to scope 2 emissions.



Figure 1: Correlation among corporate climate measures

We use a time-lagged fixed effects model to evaluate the link between corporate climate measures and GHG emissions. Previous studies suggest a time lag exists between adopting corporate climate measures and potential reductions in GHG emissions (Dahmann et al., 2019; Doda et al., 2016; Qian & Schaltegger, 2017). Following the findings of those studies, the model lagged the emission data by one year, so corporate climate measures of year t were regressed on emissions data of year $t+1$. To test H1a and H1b, we run multiple specifications regressing the independent variables separately as well as in combination. We regress each corporate climate measure separately as the vast majority of previous studies focused on investigating the effect of single corporate climate measures in isolation. Thus, we aim to establish benchmark specifications which come closest to previous model setups. To test H2, we regress a dummy which indicates whether a company discloses a comprehensive measure mix (i.e., at least one measure from each area). We also run an additional specification with a ‘comprehensive-stringent measure mix’ that only considers companies that introduced the measure from each area with the lowest adoption and a presence in CDP for at least 10 years. The rationale for the comprehensive-stringent measure mix is that corporate climate measures with comparatively low adoption (despite long presence in CDP) are likely associated with higher corporate effort and more structural change, which

speaks toward the management-oriented view suggesting corporate climate measures as a management tool driving emission reduction. In all specifications, we include the natural logarithm of revenue as a control for the company size as well as year-, region- and sector-fixed effects. This is in line with most previous studies which also include year-, region- and sector-fixed effects (Dahlmann et al., 2019) or only include sector- and time-fixed effects (Coen, Herman, & Pegram, 2022; Jiang et al., 2023; Le Luo & Tang, 2021; Moussa et al., 2020; Tang & Le Luo, 2014). There are also a few more recent studies, mostly focused on the effect of mandatory carbon disclosure, which resort to company- and year-fixed effect (Bauckloh et al., 2022; Downar et al., 2021; Le Luo & Tang, 2022). Thus, we conduct a robustness check including company- and year-fixed effects to test the validity of the results across specifications.

Results

Descriptive results

Figure 2 provides an overview of the development of the measure mix from 2010-2021. The number of disclosed existent measures has grown strongly over time given that more and more companies reported to CDP, the adoption rates of the single measures have risen and new measures were introduced. While corporate climate measures from the areas *targets*, *governance*, and *MRV* were already part of the mix in 2010, *implementation* measures entered the mix in 2011. Interestingly, we observe that some measures were adopted very quickly after their introduction to CDP (e.g., strategic integration) while others grow rather slowly (e.g., internal carbon price and science-based targets).

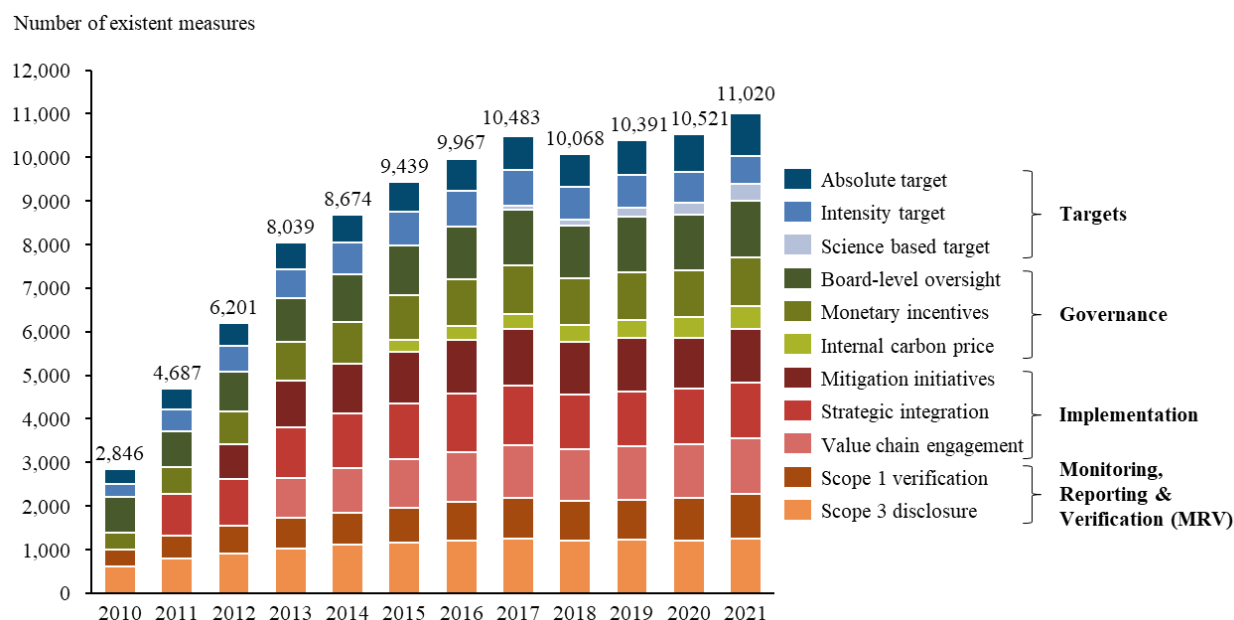


Figure 2: Evolution of existent corporate climate measure mix from 2010-2021.

Zooming in on the single corporate climate measures of the four complementary areas shown in Figure 3, we see that the adoption increased for all measures between 2010 and 2021. The identified corporate

climate measures can be categorized into three groups based on their adoption in 2021: very high adoption (over 90% of companies), high adoption (75%-89% of companies), and medium adoption (less than 50% of companies).

Five corporate climate measures were adopted by nearly all companies in 2021, with adoption rates exceeding 90%: *board-level oversight* (99%), *strategic integration* (98%), *value-chain engagement* (97%), *scope 3 disclosure* (95%), and *mitigation initiatives* (93%). High adoption rates (above 75% in 2021) were observed for *monetary incentives* (85%), *Scope 1 verification* (78%), and *absolute targets* (75%). Only three corporate climate measures were adopted by less than half of all sampled organizations in 2021: *intensity targets* (49%), *internal carbon price* (41%), and *science-based targets* (29%). While in 2010, *absolute and intensity targets* were adopted by a similar number of companies (37% vs. 31% respectively), *absolute targets* have become much more common over the years (75% in 2021), while *intensity targets* after reaching their maximum point in 2017 (58% adoption), decreased again until 2021 (49% adoption). Neither absolute nor intensity targets are adopted by a very high number of companies, but 95% of organizations had at least one type of emission reduction target in 2021. This inverse relationship is also reflected by the negative correlation coefficient (see Figure 1) indicating that companies tend to either have absolute or intensity targets. This is also specifically interesting as Dahlmann et al. (2019) have found that only absolute targets are associated with emission reductions while intensity targets are associated with higher emissions and are therefore rather an indicator for greenwashing. However, they only resort to absolute emissions as the dependent variable which may be one reason for the identified ineffectiveness of intensity targets. The low adoption of an *internal carbon price* and *science-based targets* are likely the result of their late introduction to CDP questionnaires in 2015 and 2017, but also the rather high implementation effort. Other measures that have been introduced during the last decade, such as mitigation initiatives, strategic integration, as well as value chain engagement reached a much higher adoption rate far more quickly.

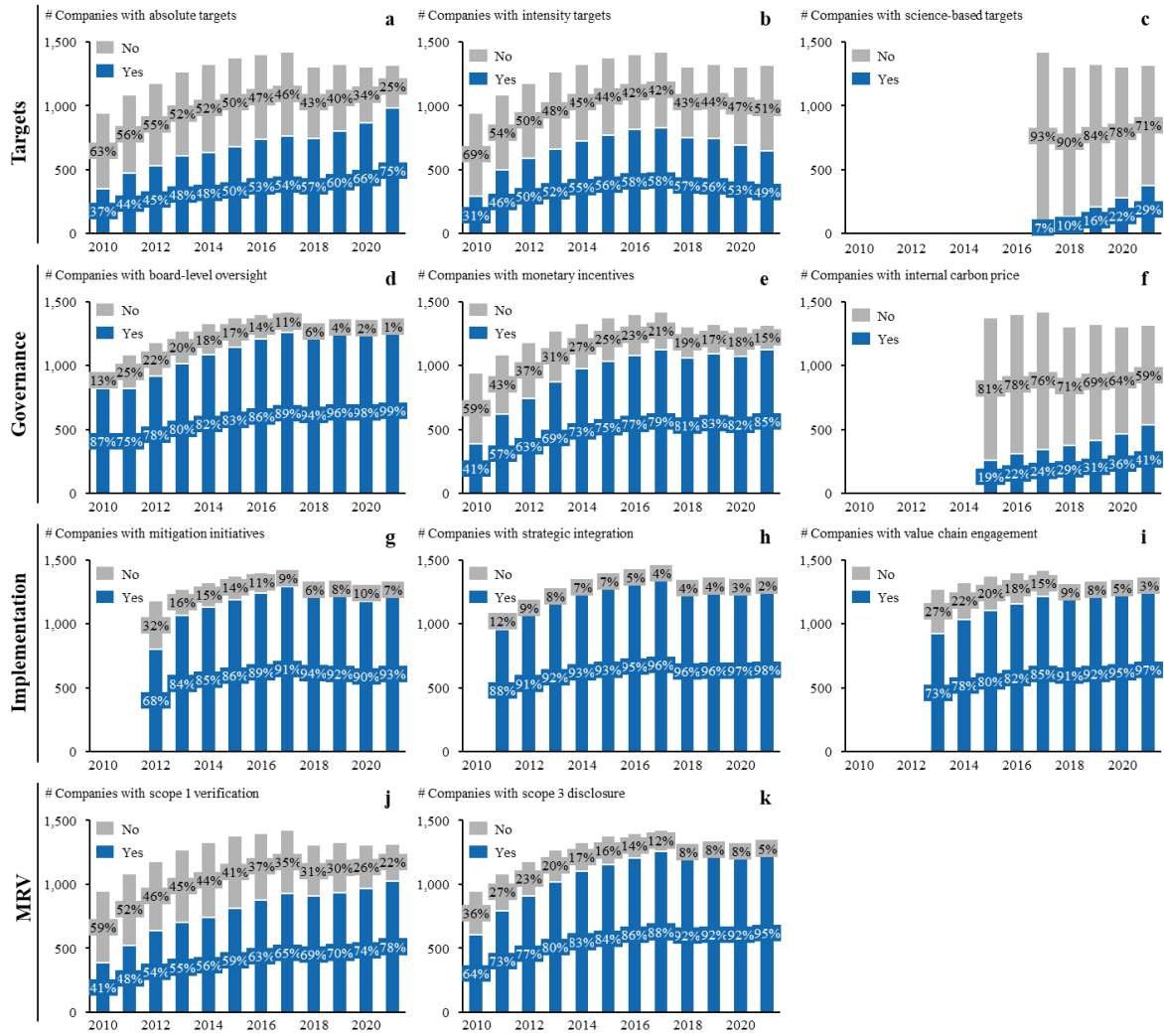


Figure 3: Overview of existence of the corporate climate measures over all observations and years.

Beyond the overall adoption of single corporate climate measures, we also aim to understand the adoption of comprehensive measure mixes. Therefore, Figure 4 shows the share of companies (in blue) that have adopted a comprehensive measure mix (panel a+b) or even a comprehensive-stringent measure mix (panel c+d). The comprehensive-stringent measure mix comprises of *absolute/intensity targets* for **targets**, *monetary incentives* for **governance**, *mitigation initiatives* for **implementation**, *scope 1 verification* for **MRV** given their comparatively low adoption despite their long presence in CDP. As absolute and intensity targets rather seem to pursue different goals and are used by different companies, we calculate two different shares for the comprehensive as well as for the comprehensive-stringent measure mix: For panels a + c, we only consider a mix to be comprehensive when including an absolute target, and for panels b + d, when including an intensity target.

We observe that in 2021, more than 70% of companies reporting to CDP adopted a corporate climate measure mix spanning across all four key areas rising from a level of just under 35% in 2011. Only considering selected measures with comparatively low adoption, the share still amounts to slightly over

55% in 2021 up from a level of less than 20% in 2012. When only considering intensity targets, the shares in 2021 are significantly lower representing the decline in intensity targets since 2017.

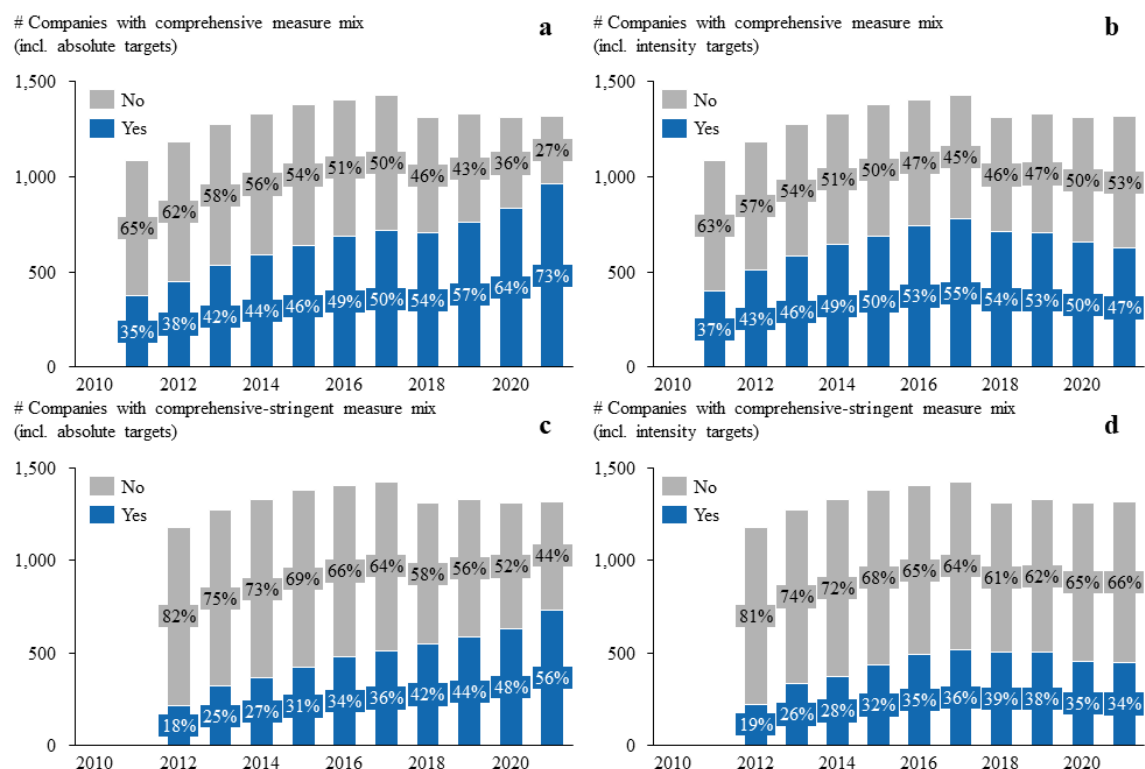


Figure 4: Number of companies with a comprehensive measure mix (a+b) and a comprehensive-stringent mix (c and d).

Regression results

Tables 2 and 3 show the results of the fixed effects regression model with sector-, region-, and time-fixed effects with absolute emissions and emissions intensity as the dependent variable, respectively. Specifications 1-10 provide the coefficients for regressing each corporate climate measure with the control variable and the fixed effects separately on GHG emissions. Absolute targets are only included if the dependent variable is absolute emissions and intensity targets if the dependent variable is emission intensity. Specifications 11 and 12 include all independent variables. We provide two specifications since including the existence of a science-based target and an internal carbon price strongly reduces the number of observations as they have been added to the CDP questionnaires later. We find *absolute targets* (Table 2, specification 1) and *board-level oversight* (specification 3) leading to lower absolute emissions on a 1% significance level in individual regressions. However, the effect disappears when additional independent variables are added (specifications 11 and 12). Additionally, we find a positive effect of internal carbon prices on a 1% significance level which is still present when adding other independent variables (specification 12) together with a negative effect for *strategic integration* and a positive effect for *scope 3 disclosure* on a 5% significance level. Revenue, the model's control variable is significantly correlated with higher absolute emissions ($p < 0.01$) over all specifications, reflecting that when a company makes more revenue, it also has higher absolute emissions. Looking at the effect

on emission intensities in Table 3, we find that most significant effects are associated with higher emission intensities (i.e., *board-level oversight* – specifications 3 and 11, *internal carbon price* – specifications 5 and 12, *mitigation initiatives* – specification 11, *strategic integration* – specification 7). We only find *scope 3 disclosure* (specification 10) and *intensity targets* (specification 12) to be significantly correlated with lower emission intensities. However, for both variables, the effect does not remain present over all specifications. When we explore more demanding specifications by including company-fixed effects instead of sector- and region-fixed effects (see Appendix: table A.1 and A.2), we find even fewer significant effects. This shows that the findings on the effect of single corporate climate measures remain rather inconclusive which is important to note given that the vast majority of previous studies, especially when analyzing the effect of voluntary reporting, did not control for company-specific omitted variable bias in their models. In total, there is no corporate climate measure that shows a significant correlation over all specifications when including company- and year-fixed effects. Based on the results, we can confirm neither H1a nor H1b as there is no clear indication of whether corporate climate measures are associated with subsequently higher or lower absolute emissions or emission intensities.

		Dependent variable:											
		Total emissions (scope 1+2) - lagged by 1 year [kt CO ₂ e]											
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Targets	Absolute target	-581.919*** (175.783)										-341.172* (182.377)	-169.049 (223.621)
	Science-based target		-394.414 (284.191)									-516.529* (294.937)	
Governance	Board-level oversight			-749.460*** (260.349)								-490.253* (284.816)	109.039 (449.245)
	Monetary incentives				98.191 (204.507)							-134.160 (238.134)	-224.004 (307.314)
	Internal carbon price					1,339.224*** (210.423)							1,205.842*** (242.060)
Implementation	Mitigation initiatives						-60.939 (269.853)					323.371 (304.563)	189.176 (417.062)
	Strategic integration							-468.754 (356.440)				-539.590 (400.812)	-1,147.631** (548.515)
	Value chain engagement								10.018 (250.460)			133.496 (268.029)	-241.774 (387.657)
MRV	Scope 1 verification									-357.156* (185.654)		-183.987 (203.794)	-406.470 (256.717)
	Scope 3 disclosure										365.740 (250.431)	360.169 (298.106)	848.380** (404.410)
Revenue (nat log)		2,075.421*** (64.022)	1,436.596*** (78.242)	2,058.795*** (63.503)	2,033.993*** (65.579)	1,473.914*** (67.994)	1,856.688*** (64.509)	1,962.477*** (64.471)	1,750.977*** (65.899)	2,078.575*** (66.013)	2,028.422*** (63.971)	1,798.814*** (69.465)	1,417.427*** (84.286)
Sector fixed effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations		9,315	3,533	9,315	9,315	5,329	7,951	8,697	7,133	9,315	9,315	7,133	3,533
R ²		0.328	0.370	0.327	0.327	0.355	0.329	0.325	0.333	0.327	0.327	0.335	0.376

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2: Effects of corporate climate measures on absolute emissions with sector-, region-, and time fixed effects.

		Dependent variable:											
		Total emissions intensity (Scope 1+2) - lagged by 1 year [t CO2e/thousands USD]											
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Targets	Intensity target	0.002 (0.009)										-0.013 (0.011)	-0.046*** (0.015)
	Science-based target		-0.012 (0.021)										-0.030 (0.021)
Governance	Board-level oversight			0.066*** (0.014)								0.050*** (0.017)	0.045 (0.033)
	Monetary incentives				0.008 (0.011)							0.006 (0.014)	-0.011 (0.022)
	Internal carbon price					0.088*** (0.014)							0.087*** (0.018)
Implementation	Mitigation initiatives						0.026* (0.015)					0.042** (0.018)	0.045 (0.030)
	Strategic integration							0.038** (0.019)				0.023 (0.024)	0.005 (0.040)
	Value chain engagement								0.015 (0.015)			0.010 (0.016)	-0.017 (0.028)
MRV	Scope 1 verification									-0.012 (0.010)		-0.015 (0.012)	-0.021 (0.018)
	Scope 3 disclosure										-0.030** (0.013)	-0.022 (0.018)	0.016 (0.029)
Revenue (nat log)		-0.009*** (0.003)	-0.015*** (0.006)	-0.011*** (0.003)	-0.010*** (0.004)	-0.017*** (0.005)	-0.009** (0.004)	-0.010*** (0.004)	-0.010*** (0.004)	-0.008** (0.004)	-0.008** (0.003)	-0.011** (0.004)	-0.019*** (0.006)
Sector fixed effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations		9,315	3,533	9,315	9,315	5,329	7,951	8,697	7,133	9,315	9,315	7,133	3,533
R ²		0.441	0.434	0.443	0.441	0.448	0.445	0.442	0.446	0.441	0.442	0.448	0.440
Note:										*p<0.1; **p<0.05; ***p<0.01			

Table 3: Effects of corporate climate measures on emission intensities with sector-, region-, and time-fixed effects.

To test whether companies that disclose a comprehensive corporate climate measure mix (i.e., measures from all four key areas – targets, governance, implementation and MRV) subsequently exhibit above-average carbon performance (hypothesis 2), we regress a dummy called *comprehensive measure mix* indicating the presence of a comprehensive mix on company' emissions while controlling for the company size and including sector-, region-, and time fixed effects (Table 4 – specification 1 and 2). If regressing on absolute emissions, only absolute targets count for the comprehensive mix; analogous for intensity targets and emission intensities – as described in the descriptive results section. We also regress the *comprehensive-stringent measure mix* (specifications 3 and 4) which only considers the measures with comparatively low adoption despite long presence in CDP as shown in Figure 3. We find both types of measure mixes to be significantly correlated with lower absolute emissions on the 5% level. For emission intensities, we do not find a significant effect. Also here, we include company-fixed effects instead of sector- and region-fixed effects as a robustness check (see Appendix: Table A.3) and find that the effect for the comprehensive measure mix turns insignificant while the correlation remains significant on the 5% significance level for the comprehensive-stringent measure mix. While we cannot confirm H2 as the comprehensive measure mix is not significant across all specifications, our results,

however, suggest that the combination of corporate climate measures is of relevance for reducing absolute emissions. Notably, it is not only the combination of measures from different areas in a comprehensive measure mix but also the kind of measures included in the mix which is of importance as shown by the comprehensive-stringent measure mix.

	<i>Dependent variable:</i>			
	Total emissions (scope 1+2) - lagged by 1 year [kt CO ₂ e] (1)	Total emissions intensity (Scope 1+2) - lagged by 1 year [t CO ₂ e/thousands USD] (2)	Total emissions (scope 1+2) - lagged by 1 year [kt CO ₂ e] (3)	Total emissions intensity (Scope 1+2) - lagged by 1 year [t CO ₂ e/thousands USD] (4)
Comprehensive measure mix (incl. absolute targets)	-415.709** (178.314)			
Comprehensive measure mix (incl. intensity targets)		-0.005 (0.010)		
Comprehensive-stringent measure mix (incl. absolute targets)			-548.679*** (186.070)	
Comprehensive-stringent measure mix (incl. intensity targets)				-0.012 (0.011)
Revenue (nat log)	1,977.359*** (64.744)	-0.008** (0.003)	1,906.960*** (66.475)	-0.008** (0.004)
Sector fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Observations	8,697	8,697	7,951	7,951
R ²	0.325	0.442	0.330	0.445
<i>Note:</i>				*p<0.1; **p<0.05; ***p<0.01

Table 4: The effect of a comprehensive measure mix and a comprehensive-stringent measure mix on emissions with sector-, region-, and time-fixed effects.

Discussion and conclusion

In this article, we addressed the question of whether companies that disclose corporate climate measures exhibit subsequently lower GHG emissions and whether a comprehensive measure mix represented by the combination of corporate climate measures from complementary areas is associated with subsequent emissions reductions. The article contributes to the literature by presenting comprehensive corporate climate measure mixes as a novel approach to reconcile the contrasting legitimacy view and management-oriented view for which previous studies as well as our analyses show very mixed empirical evidence. Our empirical analysis shows initial evidence that a comprehensive measure mix is of relevance for reducing absolute emissions. This logic follows the “Anna-Karenina-principle” which states that a deficiency in any one of a number of factors dooms an endeavor to failure. Applied to the corporate climate measure context, this suggests that all areas of relevance must be covered to fulfill the intended outcome. Additionally, our empirical analyses also demonstrate that the specific measures in a mix are decisive for its effectiveness. We find that only companies that disclose a comprehensive-stringent measure mix exhibit lower absolute emissions robust to variations in the regression design. Notably, our results do not confirm that corporate climate measures or a specific measure mix are associated with lower emission intensities. Thus, our findings underline the importance of differentiating between emission intensity and absolute emission (Busch & Hoffmann, 2011).

For investors, our results clearly show that the mere fact that a company discloses corporate climate measures entails no warranty for future GHG emission reductions. The very high adoption rates of rather ‘low-effort’ may make it even more difficult to differentiate ‘the good from the bad’ from an outside-in perspective as these measures contribute to boosting aggregated disclosure scores. This makes it extremely hard for investors to build profound strategies to reduce financed emissions with a forward-looking perspective while diversifying their portfolio to sectors that are today still considered high-carbon sectors but are essential to decarbonize and require appropriate financing. However, our results show that a comprehensive-stringent measure mix which includes measures with comparatively low adoption rates may be a helpful indicator to identify potential portfolio companies which will reduce their absolute emissions. Having said that, there is a need for further research which includes more recently introduced measures in such a comprehensive-stringent measure mix that come with a high commitment for portfolio companies and a large degree of verifiability, such as science-based targets, which we could only analyze to a limited extent due to the short data availability period of fewer than five years.

For policymakers, our results may represent a starting point in the design of mandatory disclosure requirements. However, it should be kept in mind that only a certain type of companies participate in voluntary reporting and thus careful analyses are required to generalize insights to all companies potentially subject to mandatory reporting directives. In light of more mandatory reporting emerging, there is also a growing need to understand in which way the effect of voluntary reporting differs for mandatory reporting.

Appendix

I. Robustness checks

		Dependent variable:											
		Total emissions (scope 1+2) - lagged by 1 year [kt CO ₂ e]											
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Targets	Absolute target	-137.285*										-115.637	-382.132***
		(82.606)										(95.364)	(127.935)
Targets	Science-based target		-6.085										52.807
			(147.951)										(149.777)
Governance	Board-level oversight			-33.060								-62.163	106.637
				(106.261)								(122.146)	(181.605)
Governance	Monetary incentives				194.059**							28.460	115.801
					(95.962)							(120.739)	(157.672)
Governance	Internal carbon price					150.406							220.800
						(122.628)							(140.545)
Implementation	Mitigation initiatives						-96.050					4.993	-80.502
							(110.526)					(126.585)	(163.386)
Implementation	Strategic integration							217.979				212.253	-3.774
								(170.710)				(195.066)	(268.159)
Implementation	Value chain engagement								55.486			56.873	50.216
									(118.962)			(122.191)	(174.272)
MRV	Scope 1 verification									16.170		-46.564	-146.565
										(86.509)		(102.671)	(137.528)
MRV	Scope 3 disclosure										8.432	-81.007	115.480
											(114.867)	(149.561)	(203.827)
Revenue (nat log)		1,839.809***	1,655.039***	1,836.632***	1,825.959***	1,461.631***	1,710.342***	1,816.624***	1,649.015***	1,834.139***	1,834.549***	1,656.475***	1,629.995***
		(126.871)	(209.163)	(126.973)	(126.905)	(185.071)	(142.289)	(134.981)	(150.190)	(126.934)	(126.979)	(150.573)	(209.787)
Company fixed effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations		9,315	3,533	9,315	9,315	5,329	7,951	8,697	7,133	9,315	9,315	7,133	3,533
R ²		0.945	0.968	0.945	0.945	0.949	0.944	0.944	0.945	0.945	0.945	0.945	0.969

Note:

* p<0.1; ** p<0.05; *** p<0.01

Table A.1: Effects of corporate climate measures on absolute emissions with company- and time fixed effects.

		Dependent variable:											
		Total emissions intensity (Scope 1+2) - lagged by 1 year [t CO ₂ e/thousands USD]											
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Targets	Intensity target	-0.004 (0.005)										-0.003 (0.006)	-0.010 (0.008)
	Science-based target		0.009 (0.009)										0.007 (0.009)
Governance	Board-level oversight			-0.004 (0.006)								-0.003 (0.008)	0.006 (0.012)
	Monetary incentives				-0.004 (0.006)							-0.006 (0.008)	-0.004 (0.010)
	Internal carbon price					0.009 (0.008)							0.006 (0.009)
Implementation	Mitigation initiatives						-0.008 (0.007)					0.0003 (0.008)	0.006 (0.010)
	Strategic integration							0.007 (0.010)				0.003 (0.013)	0.005 (0.017)
	Value chain engagement								-0.002 (0.008)			0.001 (0.008)	0.009 (0.011)
MRV	Scope 1 verification									0.008 (0.005)		0.004 (0.007)	-0.021** (0.009)
	Scope 3 disclosure										-0.012* (0.007)	-0.021** (0.010)	-0.002 (0.013)
Revenue (nat log)		-0.035*** (0.008)	0.036*** (0.013)	-0.035*** (0.008)	-0.035*** (0.008)	0.027** (0.012)	-0.030*** (0.009)	-0.035*** (0.008)	-0.020** (0.010)	-0.035*** (0.008)	-0.034*** (0.008)	-0.019** (0.010)	0.036*** (0.013)
Company fixed effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations		9,315	3,533	9,315	9,315	5,329	7,951	8,697	7,133	9,315	9,315	7,133	3,533
R ²		0.944	0.978	0.944	0.944	0.961	0.947	0.945	0.947	0.944	0.944	0.947	0.978

Note:

*p<0.1; **p<0.05; ***p<0.01

Table A.2: Effects of corporate climate measures on emission intensities with company- and time-fixed effects.

		Dependent variable:			
		Total emissions (scope 1+2) - lagged by 1 year [kt CO ₂ e]	Total emissions intensity (Scope 1+2) - lagged by 1 year [t CO ₂ e/thousands USD]	Total emissions (scope 1+2) - lagged by 1 year [kt CO ₂ e]	Total emissions intensity (Scope 1+2) - lagged by 1 year [t CO ₂ e/thousands USD]
		(1)	(2)	(3)	(4)
Comprehensive measure mix (incl. absolute targets)		-124.810 (86.907)			
Comprehensive measure mix (incl. intensity targets)			-0.009* (0.005)		
Comprehensive-stringent measure mix (incl. absolute targets)				-190.989** (89.078)	
Comprehensive-stringent measure mix (incl. intensity targets)					-0.008 (0.005)
Revenue (nat log)		1,832.780*** (134.936)	-0.034*** (0.008)	1,715.962*** (142.270)	-0.030*** (0.009)
Company fixed effects		Yes	Yes	Yes	Yes
Time fixed effects		Yes	Yes	Yes	Yes
Observations		8,697	8,697	7,951	7,951
R ²		0.944	0.945	0.944	0.947

Note:

*p<0.1; **p<0.05; ***p<0.01

Table A.3: The effect of a comprehensive measure mix and a comprehensive-stringent measure mix on emissions with company- and time-fixed effects.

II. CDP Modules 2010-2021

	Year											
Module	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Introduction	X											
Governance	X											
Risks and opportunities	X											
Business strategy	X											
Targets and performance	X (“Targets and Initiatives” and “Emissions Performance”)						X					
Emissions methodology	X											
Emissions data	X											
Emissions breakdown	X											
Energy	X											
Additional metrics	-						X					
Verification	X											
Carbon pricing	-						X					
Engagement	X (“Engagement with policy makers” and “Communications”)						X (own category)					
Other land management impacts	-						X (only for specific sectors)					
Portfolio impact	-						X					
Signoff	-						X (own category)					

Table A.4: CDP modules between 2010 and 2021. X marks that a module existed in that year.

III. Extracted CDP questions and coding of answers

Absolute targets

CDP questions extracted

Variable	Years	CDP questions
absolute_target	2010	9.6. Please complete the table. (If you have a current emissions reduction target or have a recently completed target) 9.8.B C1. Target Type
absolute_target	2011-2013	3.1. Did you have an emissions reduction target that was active (ongoing or reached completion) in the reporting year?
absolute_target	2014 - 2015	CC3.1. Did you have an emissions reduction target that was active (ongoing or reached completion) in the reporting year?
absolute_target	2016	CC3.1. Did you have an emissions reduction or renewable energy consumption or production target that was active (ongoing or reached completion) in the reporting year?
absolute_target	2017	CC3.1 - Did you have an emissions reduction or renewable energy consumption or production target that was active (ongoing or reached completion) in the reporting year?
absolute_target	2018 - 2021	C4.1_Did you have an emissions target that was active in the reporting year?

Coding of answers

Standardized answer	Original answers
1	'Absolute target', 'Absolute and intensity targets', 'Both absolute and intensity targets', ' Absolute target', 'Absolute target; Intensity target', Both absolute and intensity targets',
0	Absence of any of the above answers

Intensity target

CDP questions extracted

Variable	Years	CDP questions
intensity_target	2010	9.6. Please complete the table. (If you have a current emissions reduction target or have a recently completed target) 9.8.B C1. Target Type
intensity_target	2011-2013	3.1. Did you have an emissions reduction target that was active (ongoing or reached completion) in the reporting year?

intensity_target	2014 - 2015	CC3.1. Did you have an emissions reduction target that was active (ongoing or reached completion) in the reporting year?
intensity_target	2016	CC3.1. Did you have an emissions reduction or renewable energy consumption or production target that was active (ongoing or reached completion) in the reporting year?
intensity_target	2017	CC3.1 - Did you have an emissions reduction or renewable energy consumption or production target that was active (ongoing or reached completion) in the reporting year?
intensity_target	2018 - 2021	C4.1_Did you have an emissions target that was active in the reporting year?

Coding of answers

Standardized answer	Original answers
1	'Intensity target', 'Absolute and intensity targets', 'Both absolute and intensity targets', 'Intensity target', 'Absolute target; Intensity target', 'Both absolute and intensity targets'
0	Absence of any of the above answers

Science-based target

CDP questions extracted

Variable	Years	CDP questions
science_based_target	2016	CC3.1a. Is this a science-based target?
science_based_target	2016	CC3.1b. Is this a science-based target?
science_based_target	2017	CC3.1a C8 - Please provide details of your absolute target - Is this a science-based target??
science_based_target	2017	CC3.1b C9 - Please provide details of your intensity target - Is this a science-based target?
science_based_target	2018 - 2019	C4.1a_C9_Provide details of your absolute emissions target(s) and progress made against those targets. - Is this a science-based target?
science_based_target	2018 - 2019	C4.1b_C10_Provide details of your emissions intensity target(s) and progress made against those target(s). - Is this a science-based target?
science_based_target	2020 - 2021	C4.1a_C14_Provide details of your absolute emissions target(s) and progress made against those targets. - Is this a science-based target?
science_based_target	2020 - 2021	C4.1b_C17_Provide details of your emissions intensity target(s) and progress made against those target(s). - Is this a science-based target?

science_based_target	2021	C4.2c_C5_Provide details of your net-zero target(s). - Is this a science-based target?
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Coding of answers

Standardized answer	Original answers
1	At least one target present with one of the following answers: 'Yes, this target has been approved as science-based by the Science-Based Targets initiative', 'Yes, and this target has been approved as science-based by the Science Based Targets initiative', 'Yes, this target has been approved as science-based by the Science Based Targets initiative', ' Yes, this target has been approved as science-based by the Science-Based Targets initiative ', ' Yes, this target has been approved as science-based by the Science Based Targets initiative '
0	Absence of any of the above answers; “science-based” according to company without approval by SBTi; in 2016 companies could not disclose if targets were approved by SBTi (leading to much more self-declared “science-based” targets), therefore, data from 2016 was not included in this variable

Board-level oversight

CDP questions extracted

Variable	Years	CDP questions
board_level_oversight	2010	1.1. Where is the highest level of responsibility for climate change within your company?
board_level_oversight	2011 - 2013	1.1. Where is the highest level of direct responsibility for climate change within your company?
board_level_oversight	2014 - 2016	CC1.1. Where is the highest level of direct responsibility for climate change within your organization?
board_level_oversight	2017	CC1.1 - Where is the highest level of direct responsibility for climate change within your organization?
board_level_oversight	2018 - 2021	C1.1_Is there board-level oversight of climate-related issues within your organization?

Coding of answers

Standardized answer	Original answers
1	'Yes', 'Board or individual/sub-set of the Board or other committee appointed by the Board', 'Individual/Sub-set of the Board or other committee appointed by the Board', ' Yes', 'Board committee or other executive body'
0	Absence of any of the above answers; responsibility for climate change by someone not on the board or directly appointed by the board

Incentives

CDP questions extracted

Variable	Years	CDP questions
incentives_existence	2010	1.4. Do you provide incentives for the management of climate change issues, including the attainment of greenhouse gas (GHG) targets?
incentives_existence	2011 - 2013	1.2. Do you provide incentives for the management of climate change issues, including the attainment of targets?
incentives_existence	2014 - 2016	CC1.2. Do you provide incentives for the management of climate change issues, including the attainment of targets?
incentives_existence	2017	CC1.2 - Do you provide incentives for the management of climate change issues, including the attainment of targets?
incentives_existence	2018 - 2019	C1.3_Do you provide incentives for the management of climate-related issues, including the attainment of targets?
incentives_existence	2020 - 2021	C1.3_C1_Do you provide incentives for the management of climate-related issues, including the attainment of targets? - Provide incentives for the management of climate-related issues

Coding of answers

Standardized answer	Original answers
1	'Yes', ' Yes'
0	Absence of any of the above answers.

Monetary incentives

CDP questions extracted

Variable	Years	CDP questions
monetary_incentives	2010	1.5C2. The type of incentives
monetary_incentives	2011	1.2aC2. The type of incentives
monetary_incentives	2012 - 2013	1.2a. The type of incentives
monetary_incentives	2014 - 2016	CC1.2a. The type of incentives
monetary_incentives	2017	CC1.2a C2 - Please provide further details on the incentives provided for the management of climate change issues - The type of incentives
monetary_incentives	2018	C1.3a_C2_Provide further details on the incentives provided for the management of climate-related issues. - Types of incentives

monetary_incentives	2019	C1.3a_C2_Provide further details on the incentives provided for the management of climate-related issues (do not include the names of individuals). - Types of incentives
monetary_incentives	2020 - 2021	C1.3a_C2_Provide further details on the incentives provided for the management of climate-related issues (do not include the names of individuals). - Type of incentive

Coding of answers

Standardized answer	Original answers
1	'Monetary reward', ' Monetary reward'
0	Absence of any of the above answers.

Internal carbon price

CDP questions extracted

Variable	Years	CDP questions
internal_carbon_price	2015 - 2016	CC2.2c. Does your company use an internal price of carbon?
internal_carbon_price	2017	CC2.2c - Does your company use an internal price on carbon
internal_carbon_price	2018 - 2021	C11.3_Does your organization use an internal price on carbon?

Coding of answers

Standardized answer	Original answers
1	'Yes', ' Yes'
0	Absence of any of the above answers.

Mitigation initiatives

CDP questions extracted

Variable	Years	CDP questions	Additional column
mitigation_initiatives	2012 - 2013	3.3a. Number of projects	3.3a. Please identify the total number of projects at each stage of development, and for those in the implementation stages, estimated CO2e savings 3.3a. Stage of development
mitigation_initiatives	2014 - 2016	CC3.3a. Number of projects	CC3.3a. Please identify the total number of projects at each stage of development, and for those in

			the implementation stages, the estimated CO2e savings CC3.3a. Stage of development
mitigation_initiatives	2017	CC3.3a C2 - Please identify the total number of projects at each stage of development, and for those in the implementation stages, the estimated CO2e savings - Number of projects	CC3.3a C1 - Please identify the total number of projects at each stage of development, and for those in the implementation stages, the estimated CO2e savings - Stage of development
mitigation_initiatives	2018	C4.3a_C1_Identify the total number of projects at each stage of development, and for those in the implementation stages, the estimated CO2e savings. - Number of projects	
mitigation_initiatives	2019	C4.3a_C1_Identify the total number of initiatives at each stage of development, and for those in the implementation stages, the estimated CO2e savings. - Number of initiatives	
mitigation_initiatives	2020 - 2021	C4.3a_C1_Identify the total number of initiatives at each stage of development, and for those in the implementation stages, the estimated CO2e savings. - Number of initiatives	

Coding of answers

Standardized answer	Original answers
1	If there was at least one initiative in the stages "To be implemented", "Implementation commenced", or "Implemented".
0	If there was no initiative in the above mentioned stages (the other existing stages are "Under investigation" and "Not to be implemented").

Strategic integration

CDP questions extracted

Variable	Years	CDP question
strategic_integration	2011 - 2013	2.2. Is climate change integrated into your business strategy?
strategic_integration	2014 - 2016	CC2.2. Is climate change integrated into your business strategy?
strategic_integration	2017	CC2.2 - Is climate change integrated into your business strategy?
strategic_integration	2018 - 2019	C3.1_Are climate-related issues integrated into your business strategy?
strategic_integration	2020 - 2021	C3.1_Have climate-related risks and opportunities influenced your organization's strategy and/or financial planning?

Coding of answers

Standardized answer	Original answers
1	'Yes', ' Yes', 'Yes, and we have developed a low-carbon transition plan'
0	Absence of any of the above answers.

Value-chain engagement

CDP questions extracted

Variable	Years	CDP question
valuechain_engagement_binary	2013	14.4. Do you engage with any of the elements of your value chain on GHG emissions and climate change strategies? (Tick all that apply)
valuechain_engagement_binary	2014 - 2016	CC14.4. Do you engage with any of the elements of your value chain on GHG emissions and climate change strategies? (Tick all that apply)
valuechain_engagement_binary	2017	CC14.4 - Do you engage with any of the elements of your value chain on GHG emissions and climate change strategies? (Tick all that apply)
valuechain_engagement_binary	2018 - 2021	C12.1_Do you engage with your value chain on climate-related issues?

Coding of answers

Standardized answer	Original answers
1	'Yes, our suppliers', 'Yes, our customers', 'Yes, our suppliers; Yes, our customers', 'Yes, our customers; Yes, our suppliers', 'Yes, our suppliers; Yes, our customers; Yes, other partners in the value chain', 'Yes, other partners in the value chain; Yes, our customers; Yes, our suppliers', 'Yes,

	other partners in the value chain', ' Yes, our customers; Yes, our suppliers', ' Yes, other partners in the value chain; Yes, our customers; Yes, our suppliers', 'Yes, other partners in the value chain; Yes, our suppliers', 'Yes, our suppliers; Yes, other partners in the value chain', ' Yes, our suppliers', ' Yes, our customers', 'Yes, our customers; Yes, other partners in the value chain', 'Yes, other partners in the value chain; Yes, our customers', ' Yes, other partners in the value chain; Yes, our suppliers', ' Yes, other partners in the value chain', ' Yes, other partners in the value chain; Yes, our customers', 'Yes, other partners in the value chain; Yes, our customers; Yes, our investee companies; Yes, our suppliers', 'Yes, our customers; Yes, our investee companies; Yes, our suppliers', 'Yes, our investee companies; Yes, our suppliers', 'Yes, our investee companies', 'Yes, our customers; Yes, our investee companies', 'Yes, other partners in the value chain; Yes, our customers; Yes, our investee companies', 'Yes, other partners in the value chain; Yes, our investee companies', 'Yes, other partners in the value chain; Yes, our investee companies; Yes, our suppliers'
0	Absence of any of the above answers.

Scope 1 verification

CDP questions extracted

Variable	Years	CDP question
Scope1_verification_percentage	2010	20.1A. Please complete the following table indicating the percentage of reported emissions that have been verified/assured and attach the relevant statement. 20.1C1. Scope 1 (Q12.1)
Scope1_verification_percentage	2010	20.1A. Please complete the following table indicating the percentage of reported emissions that have been verified/assured and attach the relevant statement. 20.1. Scope 1
Scope1_verification_percentage	2011	8.6a. Please indicate the proportion of your Scope 1 emissions that are verified/assured
Scope1_verification_percentage	2012 - 2013	8.6a. Please indicate the proportion of your Scope 1 emissions that are verified/assured
Scope1_verification_percentage	2014 - 2016	CC8.6a. Proportion of reported Scope 1 emissions verified (%)

Scope1_verification_percentage	2017 - 2019	CC8.6a C7 - Please provide further details of the verification/assurance undertaken for your Scope 1 emissions, and attach the relevant statements - Proportion of reported Scope 1 emissions verified (%)
Scope1_verification_percentage	2020 - 2021	C10.1a_C7_Provide further details of the verification/assurance undertaken for your Scope 1 emissions, and attach the relevant statements. - Proportion of reported emissions verified (%)

Coding of answers

Standardized answer	Original answers
1	At least 50% of emissions have been verified.
0	Less than 50% of emissions have been verified. Comment: Most emissions verifications were either 0% or 100% (see Figure A.1), it would rarely make a difference if the threshold is at 20%, 40% or 60%.

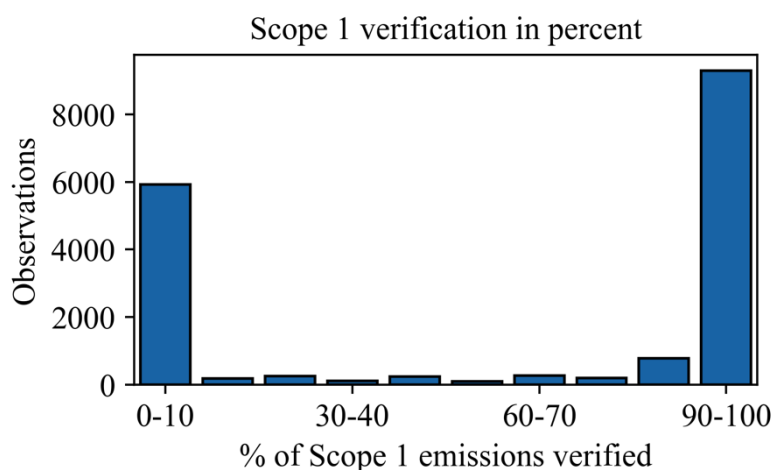


Figure A.1: Scope 1 verification [%] across all sampled observations.

Scope 2 verification

CDP questions extracted

Variable	Years	CDP question
Scope2_verification_percentage	2010	20.1C2. Scope 2 (Q13.1)
Scope2_verification_percentage	2011	8.7a. Please indicate the proportion of your Scope 2 emissions that are verified/assured

Scope2_verification_percentage	2012	8.7a. Please indicate the proportion of your Scope 2 emissions that are verified/assured
Scope2_verification_percentage	2013	8.7a. Please indicate the proportion of your Scope 2 emissions that are verified/assured
Scope2_verification_percentage	2014	CC8.7a. Proportion of Scope 2 emissions verified (%)
Scope2_verification_percentage	2015 - 2016	CC8.7a. Proportion of reported Scope 2 emissions verified (%)
Scope2_verification_percentage	2017 - 2019	CC8.7a C8 - Please provide further details of the verification/assurance undertaken for your location-based and/or market-based Scope 2 emissions, and attach the relevant statements - Proportion of reported Scope 2 emissions verified (%)
Scope2_verification_percentage	2020 - 2021	C10.1b_C8_Provide further details of the verification/assurance undertaken for your Scope 2 emissions and attach the relevant statements. - Proportion of reported emissions verified (%)

Coding of answers

Standardized answer	Original answers
1	At least 50% of emissions have been verified.
0	Less than 50% of emissions have been verified. Comment: Most emissions verifications were either 0% or 100% (see Figure A.1), it would rarely make a difference if the threshold is at 20%, 40% or 60%

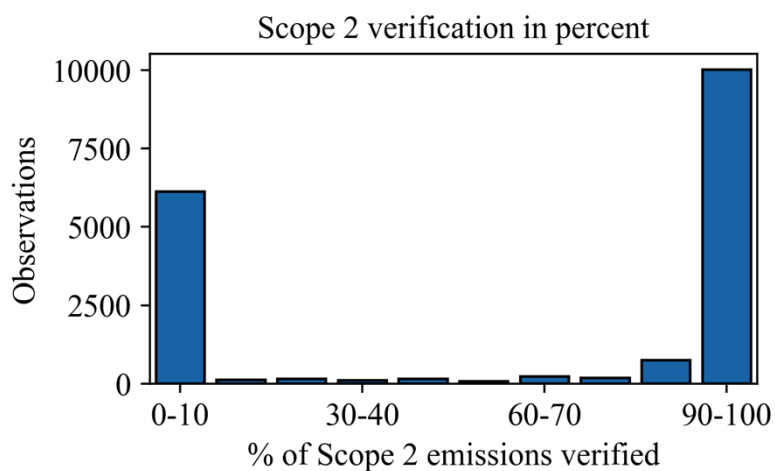


Figure A.2: Scope 2 verification [%] across all sampled observations.

Scope 3 disclosure

CDP questions extracted

Variable	Years	CDP question
Scope3_disclosure	2010	15.1C2. Metric tonnes of CO2-e
Scope3_disclosure	2011	15.1. metric tonnes CO2e
Scope3_disclosure	2012	15.1. metric tonnes CO2e
Scope3_disclosure	2013	14.1. metric tonnes CO2e
Scope3_disclosure	2014 - 2016	CC14.1. metric tonnes CO2e
Scope3_disclosure	2017	CC14.1 C3 - Please account for your organization's Scope 3 emissions, disclosing and explaining any exclusions - metric tonnes CO2e
Scope3_disclosure	2018 - 2019	C6.5_C2_Account for your organization's Scope 3 emissions, disclosing and explaining any exclusions. - Metric tonnes CO2e
Scope3_disclosure	2020 - 2021	C6.5_C2_Account for your organization's gross global Scope 3 emissions, disclosing and explaining any exclusions. - Metric tonnes CO2e

Coding of answers

Standardized answer	Original answers
1	Any amount of Scope 3 emissions [metric t CO2e] was disclosed.
0	No disclosure of any Scope 3 emissions.

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