Effects of Mandatory Carbon Reporting on Unrepresentative Environmental Disclosures

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Abstract

We study whether mandatory carbon reporting reduces the disclosure of favorable versus unfavorable environmental information (unrepresentative disclosure). Our setting is a regulation mandating firms to report carbon emissions, or mandatory carbon reporting (MCR). Measuring unrepresentative disclosure as the difference between how much a firm discloses and how much of the disclosure is indicative of the firm's overall environmental damage, we find that MCR leads to a decline in unrepresentative carbon disclosure, consistent with MCR requiring firms to disclose environmentally impactful carbon information that they did not report when disclosure was voluntary. We also find MCR curtails firms' unrepresentative disclosure of other, non-carbon environmental information disclosed voluntarily before and after MCR. Further analyses reveal worse carbon performers had higher levels of unrepresentative carbon disclosure prior to MCR, and their revealed poor carbon performance impels them to decrease unrepresentative non-carbon disclosure more after MCR. Firms experiencing a reduction in unrepresentative carbon disclosure around MCR also reduce their carbon emissions.

Keywords: *Unrepresentative disclosure, Mandatory ESG reporting, Greenhouse gas emissions, climate change, greenwashing*

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1. Introduction

This study examines the effects of mandated environmental, social and governance ("ESG") reporting on the disclosure of favorable versus unfavorable ESG information, or unrepresentative disclosure. Nearly 12,000 public companies disclosed ESG information in 2021, up from fewer than 100 firms in 1999 (Bloomberg 2022). Despite this dramatic increase, there are widespread concerns that the absence of ESG reporting requirements – particularly those that require standardized, timely, and comparable ESG metrics – permits companies to "greenwash" or provide disclosure that "misleads people into adopting overly positive beliefs" about a firm's ESG performance (Lyon and Montgomery 2015, p.225). In light of these concerns, regulators around the world have recently proposed mandated ESG reporting aimed at protecting investors from greenwashing.[1] Though prior research has examined the determinants of greenwashing and how it can manifest (see Christensen, Hail, and Leuz 2021 for a summary), less is known about whether mandated reporting curbs this type of disclosure behavior.

In 2012, the United Kingdom (UK) adopted Section 385 (2) of the Companies Act 2006 Regulations 2013. The act requires UK-incorporated companies listed on a major stock exchange to disclose two out of the three scopes of greenhouse gas emissions (GHG) in annual financial reports for fiscal years ending on or after September 30, 2013 (hereafter, mandatory carbon reporting or MCR).[2] The UK regulator's stated objective for MCR was to increase transparency on GHG (DEFRA 2012a).[3] Moreover, it can be inferred from the announcement of MCR by the

[1] The Securities and Exchange Commission (SEC) in the United States, along with securities regulators in Australia, Canada, Hong Kong, and Singapore, have released proposals for new regulatory requirements on ESG reporting to address greenwashing (Lee 2022; Mishra 2022; Jones 2022).

[2] MCR mandates "Scope 1" (direct or generated) emissions and "Scope 2" (indirect or purchased) emissions, but not "Scope 3" (supply-chain) emissions.

[3] Department for Environment, Food & Rural Affairs (DEFRA). 2012a. Leading Businesses to disclose greenhouse gas emissions. Accessible from: https://www.gov.uk/government/news/leading-businesses-to-disclose-greenhouse-gas-emissions

Deputy Prime Minister that MCR was regarded as a policy tool to mitigate greenwashing, as "…hiding your greenhouse gas emissions is a false economy" (Ibid). We use this setting to study the impact of mandated reporting on unrepresentative disclosure. Following prior research, we define unrepresentative disclosure as the disclosure of less harmful environmental impacts while not disclosing information that is more environmentally damaging (e.g. Marquis, Toffel, and Zhou 2016). Because firms' intentions are unobservable (does the disclosure of good versus bad news signify the lack of bad news, or does it signify that bad news is being withheld?) we adopt the view that unrepresentative disclosure "need not be deliberate" (Lyon and Montgomery 2015, p. 225); irrespective of intentions, so long as the firm disclosed its positive but not its negative information prior to mandated reporting, this constitutes unrepresentative disclosure.

Using data from Trucost Plc, we measure unrepresentative disclosure as the difference between how much disclosure is provided by the firm and how much of the firm's total estimated environmental damage is covered by that disclosure. The intuition is that a firm which discloses many of its benign indicators, but few if any of its more harmful ones, creates an impression of transparency that is not representative of its overall environmental damage (Marquis et al. 2016). We construct two measures of unrepresentative disclosure: (1) *unrepresentative carbon disclosure* which aims to reflect the extent to which carbon disclosures are less indicative of overall carbon damage, and (2) *unrepresentative non-carbon disclosure* which aims to reflect the extent to which non-carbon disclosures (e.g. water usage, waste, and non-carbon pollutants) – which UK firms are not mandated to disclose – are less indicative of overall non-carbon environmental harm.

Our empirical approach involves comparing changes in unrepresentative carbon and non-carbon disclosure for treatment (UK) firms from before to after MCR, to those of control (non-UK) firms unaffected by MCR. We account for flexible time and static firm-level differences

through the inclusion of year and firm fixed effects and time-varying controls. We validate the parallel trends assumption and use entropy-balancing to minimize differences across treatment and control firms along observable firm characteristics (Hainmueller 2012).

We document that UK firms experienced a decline in unrepresentative carbon disclosure (hereafter, UCD) after MCR came into effect. The estimate for the full sample indicates that UCD fell by 33% for UK firms, on average, while the estimate for the entropy-balanced specification is similar at 31%. Our results show that although the amount of disclosed carbon data *increased* after MCR (since a number of firms did not voluntarily disclose GHG prior to MCR), UCD *decreased* because UK firms were forced to disclose more of their overall carbon damage under MCR. We therefore infer that prior to MCR, UK firms did not disclose environmentally-impactful GHG data; after MCR, the requirement to disclose impactful GHG data led to a decline in UCD.

We then examine the effect of MCR on unrepresentative reporting of other, non-carbon environmental information disclosed voluntarily before and after MCR. We predict that, under MCR, heightened attention placed on environmental disclosures will discipline firms to provide more substantive information regarding their non-carbon environmental impacts. Consistent with our expectation, we find that UK firms decreased unrepresentative non-carbon disclosure (hereafter, UNCD) after MCR. The coefficient estimates on the full and entropy-balanced samples reveal that UNCD fell by 28% and 31% for UK firms, respectively. We find firms disclose *less* non-carbon environmental information after MCR, but what remains disclosed covers *more* of the firm's total non-carbon environmental damage, driving the overall decrease in UNCD.

Next, we examine whether carbon performance moderates the relationship between MCR and unrepresentative disclosure. Using a within-sector ranking of carbon performance revealed in the first year that MCR is in effect, we find that the worst carbon performer (relative to the best

one) experienced a decline in UCD of 56%. This suggests that poor carbon performers disclosed more benign and less harmful carbon impacts prior to mandated reporting. We also document that poor carbon performance is associated with larger reductions in UNCD after MCR. This is consistent with poor carbon performers' exposed UCD serving to undermine their voluntary environmental disclosures, leading to larger UNCD reductions after MCR.

Last, we find that affected firms experiencing a decline in *UCD* around MCR also decrease their GHG by, on average, 14.9%. Our interpretation is that firms which experienced a decline in *UCD* – indicating that their carbon disclosures became more representative of their overall carbon impacts after MCR – will face pressure from stakeholders who may view these firms as having used unrepresentative disclosure as a substitute for real efforts to reduce underlying carbon emissions. In turn, these firms make real efforts to reduce carbon emissions to maintain or restore reputation. However, because we cannot isolate these real effects from those of broader stakeholder pressures following increased transparency (e.g. Downar, Ernstberger, Reichelstein, Schwenen, and Zaklan 2021), our finding should be interpreted with this caveat in mind.

Our results are robust to additional tests: removing firms from countries with concurrent GHG regulations (e.g. cap-and-trade, carbon taxation, carbon reporting); estimating within-UK specifications that use UK firms on the Alternative Investment Market of the London Stock Exchange – which are not covered by MCR – as the control group; limiting our analyses to firms with third-party verified GHG; and excluding industries with high Scope 3 emissions, which are difficult to measure and more susceptible to measurement error (e.g. Griffin and Sun 2022). We further employ textual analysis to construct three alternative measures of greenwashing and continue to find support for a decline in these alternative measures of greenwashing. Specifically, we identify firms as greenwashing when they exhibit worse carbon performance relative to

industry peers yet provide narrative carbon disclosures that are (1) longer, (2) vaguer, and (3) and overly optimistic, in their responses to the Carbon Disclosure Project survey.

Our study falls within the stream of research on managerial disclosure decisions. Adding to research on the strategic and opportunistic motivations behind financial disclosures (e.g. Li 2008), accounting researchers have studied the credibility of ESG reporting (e.g. Matsumura, Prakash, and Vera-Muñoz 2022). Some recent work finds evidence of greenwashing among mutual funds (e.g. Kim and Yoon 2022) and firms (Huang and Lu 2022), while other research documents genuine motives among institutional investors that publicly request corporate climate change information (Cohen, Kadach, and Ormazabal 2022). Outside of accounting, scholars in environmental economics, strategy and organizational theory have modeled and empirically documented factors that exacerbate, and mitigate, greenwashing (e.g. Delmas and Burbano 2011). Though proposed theoretically (e.g. Lyon and Maxwell 2011) we are the first (to our knowledge) to empirically document that mandated reporting constrains unrepresentative reporting.

We also contribute to research on how mandatory ESG reporting shapes voluntary disclosures. Prior research finds that firms provide more voluntary environmental disclosures when they are mandated to report toxic emissions (e.g. Patten 2002), consistent with firms voluntarily disclosing more when they are mandated to divulge information that threatens their legitimacy. We differ from this work in that we focus on unrepresentative disclosure (rather than the level of disclosure) which factors-in the environmental-materiality of the disclosed information. We find that firms experience a decline in unrepresentative disclosure on the specific environmental outcomes required by the reporting mandate, but also reduce unrepresentative disclosure of *other* environmental outcomes that are not covered by the mandate.

Finally, we contribute to research on the real effects of mandatory ESG reporting (e.g. Downar et al. 2021). These papers document that ESG data disclosed under mandated reporting attracts stakeholder pressure to improve ESG outcomes (see Christensen et al. 2021 for a review), and improves firms' ability to benchmark ESG outcomes against peers (Tomar 2023). Our evidence suggests stakeholder pressure from mandated reporting may come not only from revealed performance, but also from revealed unrepresentative disclosure.

2. Institutional setting

Mandatory Carbon Reporting (MCR) was first proposed in the UK Climate Change Act of 2008 (the Act). As part of the Act, UK Parliament imposed a deadline of April 2012 on the UK government to pass regulation mandating the reporting of corporate greenhouse gas emissions, or explain to Parliament why it had not done so. In early 2012, the UK government released a report explaining that mandated reporting might impose an unnecessary regulatory burden on firms, essentially meeting the April 2012 deadline.[4] However, citing climate change concerns and low transparency on GHG, Deputy Prime Minister Nick Clegg announced on June 20, 2012 that publicly-traded UK-incorporated companies listed on a major stock exchange (i.e. the Main Market of the London Stock Exchange, an exchange in a European Economic Area state, the New York Stock Exchange, or Nasdaq) would be required report annual GHG for fiscal years ending on or after September 30, 2013 in the Directors' Report (the equivalent of SEC Form 10-K).[5] MCR mandates covered firms to report annual GHG in metric tons of carbon dioxide equivalent, along with a ratio expressing GHG in relation to the company's activities, such as sales or assets.

[4] See: https://www.gov.uk/government/publications/company-reporting-of-greenhouse-gas-emissions

[5] In the UK, Directors' Reports must be approved by the Board of Directors, reviewed by the auditor, and certified by the CFO and CEO; it is a criminal offense to report false, misleading, or deceptive information.

MCR's rules are formulated from the GHG Protocol Corporate Accounting and Reporting Standard ("GHG Protocol"), an internationally recognized framework for GHG (DEFRA 2012b).[6] After MCR was announced, the UK government issued reporting guidance specifying acceptable methodologies to measure GHG (e.g. Standard 14064-1 of the International Organization for Standardization), the reporting boundary (global GHG for the entire organization), the covered period (12-month period corresponding to the firm's fiscal year), the disclosure channel (within annual Directors' Reports) and assurance (recommended but not required).[7]

MCR requires companies report their direct (Scope 1) and indirect (Scope 2) GHG emissions. Direct emissions result from the combustion of fuels (in stationary buildings and equipment, in transportation vehicles, and in industrial processes). Indirect emissions result from purchased electricity, heat, steam, or cooling. Broadly speaking, Scope 1 and 2 emissions are considered to be straightforward to measure and report (e.g. Bolton and Kacperczyk 2021). For Scope 1 companies "need only activity data, such as the amount of distance travelled or fuel combusted" (GHG Protocol 2022) and then to convert these levels to carbon dioxide equivalents (CO2e) using emissions factors set by the Intergovernmental Panel on Climate Change.[8] Scope 2 calculations require activity data such as the number of kilowatt-hours of electricity consumed by the firm, which is converted into CO2e using emissions factors. In most developed countries, governmental environmental agencies publish the emissions content of every kilowatt-hour of

[6] GHG Protocol is the most widely adopted greenhouse gas accounting standard. It can be accessed here: https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf (GHG Protocol, 2004, A Corporate Accounting and Reporting Standard from the World Resources Institute and the World Business Council for Sustainable Development.

[7] See: Department for Environment, Food & Rural Affairs (DEFRA), 2012b, Environmental Reporting Guidelines: Mandatory Greenhouse Gas Emissions Reporting, from www.gov.uk/defra.

[8] Global conversion factors are maintained by the Intergovernmental Panel on Climate Change (IPCC), the premier authority on scientific assessments of climate change. The GHG Protocol embeds the IPCC's factors into its calculation tools and spreadsheets for companies' ease of use. See Greenhouse Gas (GHG) Protocol Calculation Tools, 2022: https://ghgprotocol.org/calculationg-tools-faq.

electricity produced and transmitted for each grid region (Sundaram 2022). The GHG Protocol's website provides step-by-step guidance and tools which firms can use to calculate their GHG.

Two attributes in particular make MCR in the UK a desirable setting for our analyses. First, all listed UK-incorporated firms are covered by MCR, whereas other environmental regulations tend to cover specific industries (e.g. the European Union Emissions Trading Scheme; see Downar et al. 2021) or installations/facilities (e.g. the GHG reporting program in the United States; see Tomar 2023). Thus, our results are generalizable beyond particular industries and subsets of the firm that have typically been the focus of prior studies on mandated environmental reporting. Second, unlike other ESG disclosure mandates which are vague about the information to be reported (e.g. the EU Directive on non-financial reporting; see Fiechter, Hitz, and Lehmann 2022 and Grewal, Riedl, and Serafeim 2019), MCR is prescriptive about what has to be disclosed, how it must be disclosed, and where (Downar et al. 2021).[9] Reduced managerial discretion is precisely what we aim to exploit to understand whether mandated reporting curbs unrepresentative reporting,.

3. Literature review

An extensive prior literature examines the motivations behind managerial disclosure choices. Some studies find that non-GAAP earnings and qualitative information in 10-K filings are informative about core earnings and operations (e.g. Li, Lundholm, and Minnis 2013), while others document that tone and non-GAAP earnings are used by management to obfuscate financial performance (e.g. Huan, Teoh, and Zhang 2014). More recently, accounting researchers have taken interest in studying the determinants and consequences of ESG reporting (see the review papers by Christensen et al. 2021 and Grewal and Serafeim 2020). Concerns about greenwashing – defined as "communication that misleads people into holding overly positive beliefs about an

[9] Compliance with MCR is high; 90% in year one, 96% in year two, and 100% by year three, according to our data.

organization's environmental performance, practices, or products" (Lyon and Montgomery 2015, p. 225) – spurred a new line of inquiry into misleading ESG disclosures, with evidence suggesting that firms with poor ESG performance are more likely to provide voluntary ESG disclosures (Liu, Zhou, Yang, and Hoepner 2021), managers use greenwashing in conference calls and certain linguistic properties in corporate communications to conceal true ESG performance (e.g. Hail, Kim, and Zhang 2021), and the manner in which ESG information is presented can influence user perceptions of ESG (Cho, Pillips, Hageman, and Patten 2009). A related stream of work examines greenwashing among investors, finding that so-called "ESG" mutual funds do not, in actuality, improve fund-level ESG scores (Kim and Yoon 2022) and such funds hold firms with worse track records on labor and environmental laws (Raghunandan and Rajgopal 2022). By contrast, investor signatories to the Carbon Disclosure Project seem to be genuine (Cohen et al. 2022).[10]

Researchers have also studied how mandatory environmental reporting affects voluntary disclosures, documenting that mandated reporting is associated with more voluntary reporting. For example, Patten (2002) found that U.S. firms' voluntary environmental disclosures in the 10-K increased after firms were mandated to provide plant-level toxic emissions data to the U.S. government, which the government then published on a publicly-available website. In another study, Cowan and Deegan (2011) reported an increase in voluntary environmental disclosures in annual reports around the time that Australian firms were mandated to publicly report their toxic emissions as part of the National Pollutant Inventory program. Both studies conclude that when firms are mandated to provide information that threatens their legitimacy (e.g. Deegan 2019), they respond with increased voluntary environmental disclosures aimed at mitigating this threat.

[10] Papers in environmental economics and organizational theory have studied greenwashing, modeling greenwashing behaviours (e.g. Lyon and Maxwell 2011), deriving predictions for its drivers (e.g. Delmas and Burbano 2011), documenting firm and country factors that make it more or less likely (e.g. Marquis et al. 2016) and the consequences of greenwashing on customer satisfaction (Ioannou, Kassinis and Papagiannakis 2022).

Moreover, accounting studies examine the real effects of mandated ESG reporting. This literature looks at how mandated ESG reporting affects outcomes such as mine-safety violations (Christensen et al. 2017), payments to governments (Rauter 2020), pollutants (Chen, Hung, and Wang 2018), and greenhouse gas emissions (Downar et al. 2021, Jouvenot and Kreuger 2021, Tomar 2023), consistently finding that mandatory ESG reporting improves ESG outcomes by increasing the visibility of ESG to external stakeholders, which in turn puts pressure on firms to improve environmental outcomes, or by enabling comparisons across firms (Tomar 2023).

4. Hypotheses

4.1 Unrepresentative carbon disclosure

A priori it is unclear whether MCR will affect unrepresentative carbon disclosure (UCD). UCD is the extent to which a firm discloses carbon data that is less environmentally damaging – say, a particular scope of GHG that is relatively small – while not disclosing carbon data that is more indicative of the firm's true environmental harm. On the one hand, MCR could have no effect on – or even increase – UCD. For instance, firms that disclosed GHG prior to MCR will experience no change in UCD, because they will continue to disclose GHG mandatorily under MCR that they disclosed voluntarily beforehand. Another set of firms unlikely to be affected is small emitters, i.e. carbon is not an environmentally-material issue, because disclosing what is immaterial will not affect UCD, either. However, if firms have material Scope 3 GHG (which are not mandated under MCR) but immaterial Scope 1 and 2 GHG, MCR could cause UCD to *increase* because MCR will force transparency on Scopes 1 and 2 (which are immaterial), but not on what matters (Scope 3).[11]

[11] In some sectors, like automobile manufacturing, Scope 3 is the most important component of emissions (Bolton and Kacperczyk 2021). See Greenhouse Gas (GHG) Protocol Corporate Value Chain (scope 3) Accounting and Reporting Standard, 2006: http://ghgprotocol.org/standards/scope-3-standard

On the other hand, MCR could cause UCD to decrease. Firms may not have invested in the internal processes needed to collect and report GHG data when disclosing was optional, but are forced to once MCR is in effect. If the GHG impacts are environmentally important, this could result in a decline in UCD. It is also possible that firms knew their GHG figures but chose not to disclose them. One reason could be proprietary costs which, in our setting, include the carbon efficiency of firms' operations which could be utilized by competitors (Tomar 2023). Firms may also decide to withhold GHG data – or selectively disclose some, but not all, of their impacts – in order to avoid the revelation of information that attracts criticism, sanction or attack from regulators and other stakeholders (Li, Richardson, and Thornton 1997). Dye (198) predicts that non-disclosure of bad news is sustained due to investors' uncertainty regarding managers' information set, and Lyon and Maxwell (2011) extend Dye's (1985) model and predict that, because stakeholders may not infer from silence that managers are withholding bad news, firms suppress bad environmental outcomes in order to avoid negative stakeholder perceptions.

Regardless of why firms do not disclose information that is representative of their overall carbon impacts, they will be forced to do so under a mandatory reporting regime. In this case, unrepresentative disclosure will fall after MCR, revealing that disclosures were not representative of overall carbon impacts when disclosing was altogether voluntary. In sum, although there is tension, we expect UK firms did not disclose environmentally-relevant and substantive GHG data prior to MCR such that the requirement to disclose GHG under MCR reduces unrepresentative carbon disclosure. We therefore hypothesize:

Hypothesis 1: *Firms experience a decline in unrepresentative carbon disclosure as a result of mandatory carbon reporting.*

4.2 Unrepresentative non-carbon disclosure

We now turn to the question of whether MCR affects firms' unrepresentative non-carbon disclosure (UNCD), i.e. the disclosure of benign non-carbon environmental impacts whilst not disclosing more harmful ones. Here we are interested in whether MCR disciplines firms' *voluntary* environmental disclosures, and as such our focus is environmental impacts disclosed voluntarily (before and after MCR) which include the consumption of natural resources, waste, and non-carbon pollutants (see Appendix IV).[12]

Research on the real effects of ESG regulations shows that mandatory ESG reporting increases the salience of ESG data and heightens stakeholder attention to and awareness of ESG issues (Christensen et al. 2017; Chen et al. 2018). Concerning MCR specifically, the findings in Downar et al. (2021) and Jouvenot and Kreuger (2021) suggest that MCR's requirements on UK firms to disclose GHG in a standardized, comparable way within financial reports made GHG data more visible and useful to external stakeholders. Relatedly, the greenwashing literature finds that firms facing increased visibility are less likely to greenwash, because attention from regulators and the public makes firms more susceptible to scrutiny and accusations of falsely promoting themselves as environmentally responsible (Marquis et al. 2016; Lyon and Maxwell 2011). Under the watchful eyes of external stakeholders, firms are wary of attracting negative attention and being accused of greenwashing, which in turn curbs greenwashing (Lyon and Montgomery 2013).

Combining insights from the above streams of research, it follows that when MCR puts a "spotlight" to firms' carbon emissions, the heightened attention and scrutiny from external stakeholders will lead firms to be more transparent about their environmental impacts to avoid the appearance of greenwashing. We hypothesize that the increased visibility of environmental information under MCR increased the expected costs of UNCD, causing it to decline. In sum:

[12] UK firms are not mandated to disclose any of the non-carbon environmental indicators included in our measure of unrepresentative non-carbon disclosure (see section 6.2).

Hypothesis 2: *Mandatory carbon reporting reduces unrepresentative non-carbon disclosure.*

4.2 Carbon performance moderator

4.2.1 Carbon performance and unrepresentative carbon disclosure

Theoretical research predicts that the benefits of disclosing positive, but not negative, environmental information increase as relative performance worsens (e.g. Cho et al. 2015). Because stakeholders tend to compare the environmental outcomes of a firm to that of its peers (Tomar 2023), an environmental record that looks unfavorable in relation to a competitor will make the firm a target for stakeholder actions aimed at improving environmental outcomes (e.g. embarrassing them in the media, encouraging consumers to boycott them, regulatory threats, etc.). To avoid being targeted, firms can take actions to improve environmental outcomes, but doing so is costly, time-consuming, and uncertain.[13] Thus, firms with a low probability of producing positive environmental outcomes are more likely to selectively disclose good news and withhold bad news, because disclosing successes yields improvements in public perception and reputation, while withholding failures can prevent reputational harm (Lyon and Maxwell 2011). As noted in section 9 below, Trucost estimates are based on sector averages, allowing worse carbon performers in their sectors not to disclose and thus hide behind sector average carbon emissions. MCR unravels this partial disclosure equilibrium. This suggests that firms with worse carbon performance have higher levels of unrepresentative carbon disclosure.

Firms with worse carbon performance might not disclose their environmentally-impactful carbon data because they do not possess this information, and only learn of it (and are forced to disclose it) once mandated reporting is in effect. A central axiom in accounting is that "what gets measured, gets managed" (Drucker 1954) which suggests that the lack of private information on a

[13] Such uncertainties include whether a given activity will actually yield a positive environmental outcome.

performance outcome could impede the ability to improve that outcome (Kaplan and Anderson 2007). If firms with worse carbon performance reveal more environmental damage under MCR, this could be due to a lack of this information prior to MCR as opposed to having withheld it.

Accordingly, we expect worse carbon performers to have higher levels of unrepresentative carbon reporting prior to MCR, either because they withhold their true carbon impacts in order protect their reputations, or because they lack the information needed to improve carbon performance. Unrepresentative carbon disclosure will therefore decline to a greater extent after MCR for poor carbon performers, as withholding firms can no longer hide data on their true carbon impacts once MCR is in effect, while firms that did not know about their carbon impacts (and hence did not manage them) must now be transparent. Thus,

Hypothesis 3a: *There is a negative relationship between carbon performance and reductions in unrepresentative carbon disclosure after mandatory carbon reporting.*

4.2.2 Carbon performance and unrepresentative non-carbon disclosure

Although ESG disclosure regulations are on the rise, most ESG reporting still takes place voluntarily and without regulation, standardization and third-party audits (Christensen et al. 2021). Despite the unregulated nature of ESG data, prior research finds that claims expressed in sustainability reports are often viewed as credible signals to the market that companies proactively manage environmental and social issues (Malsch 2013). Theoretical research reasons that stakeholders tend to give firms "the benefit of the doubt" because when a firm has established legitimacy in the eyes of its stakeholders, meaning that it exhibits behaviors that are congruent with the most accepted norms of society, stakeholders are more likely to view the firm as acting in good faith when it discloses ESG information voluntarily (Cho et al. 2015).[14]

[14] The threat of reputational damage resulting from false or exaggerated claims also provides some assurance to users that firms will not use ESG reports to engage in excessive window-dressing (Malsch 2013).

Good faith has its limits, though, and is undermined when firms reveal information that calls into question the intent behind their voluntary disclosures. Theory suggests that mechanisms to expose the disclosure of positive but not negative aspects of environmental performance will be costly for firms, as stakeholders may view such disclosures as being intentionally misleading (Yang et al. 2020; Delmas and Burbano 2011; Cho et al. 2015). Lyon and Maxwell (2011) theorize that regulation could act as one such mechanism, requiring firms to disclose less-than-favorable information and revealing that disclosures were unrepresentative when reporting was voluntary.

Assuming H3a holds, we expect the unrepresentative carbon disclosure behaviors of poor carbon performers revealed when MCR comes into effect to undermine the good faith that supported these firms' voluntary environmental disclosures prior to MCR. This in turn will lead poor carbon performers to reduce unrepresentative non-carbon disclosure more than better carbon performers, as stakeholders will be less trusting of poor carbon performers' voluntary environmental disclosures. We therefore hypothesize:

Hypothesis 3b: *There is a negative relationship between carbon performance and reductions in unrepresentative non-carbon disclosure after mandatory carbon reporting.*

4.3 Unrepresentative carbon disclosure and carbon emissions

A central hypothesis of recent studies on the real effects of ESG disclosure (e.g. Christensen et al. 2017; Chen et al. 2018; Downar et al. 2021) is that mandated ESG reporting increases transparency on a particular ESG outcome and generates stakeholder pressure on management to improve this outcome. Importantly, the outcome, such as pollution, is viewed as a negative firm attribute by stakeholder groups such as customers, employees, and investors.[15] Separately, however, is the possibility that stakeholders view *unrepresentative disclosure* as unfavorable and, once mandated

[15] An outcome considered to be negative by investors is also central to Friedman and Heinle's (2016) model wherein investors exert pressure on management to improve sustainability practices.

reporting reveals that firms provided unrepresentative disclosure prior to mandated reporting, these firms will face stakeholder pressure to improve ESG outcomes. Stakeholders may skeptically view these firms as having used unrepresentative disclosure in the voluntary reporting regime as a substitute for real efforts to improve underlying ESG outcomes, and firms in turn will respond via real efforts to avoid further reputational harm. Thus, we predict:

> **Hypothesis 4:** *Firms that experience a decline in unrepresentative carbon disclosure around MCR also decrease their carbon emissions.*

5. Research Design

Our empirical strategy relies on the institutional fact that only firms incorporated in the UK and listed on the Main Market of the LSE, NYSE, or NASDAQ, are subject to MCR.[16] We use a difference-in-differences design to compare changes in unrepresentative disclosure for treatment and control firms from before to after MCR, and estimate the following model over 2004-2019:

$$Unrepresentative\ Disclosure_{it} = \alpha_i + \lambda_t + \beta_1\ Treat_i \times Post_t + \Sigma\beta_{it}\,\text{controls} + \varepsilon_{it} \quad (1)$$

where $Unrepresentative\ Disclosure_{it}$ is unrepresentative carbon disclosure (*UCD*) or unrepresentative non-carbon disclosure (*UNCD*) (defined in section 6.2), α_i refer to firm fixed effects that absorb all observed and unobserved time-invariant firm characteristics, and λ_t refer to year fixed effects that control for common macroeconomic shocks. We also include time-varying controls (assets, revenue, return-on-assets, and leverage) defined in Appendix I and cluster standard errors at the firm level.[17] Financial variables are from S&P Global and measured in USD.

[16] The legislation exempts certain (small) UK firms, specifically firms that meet at least two of the following requirements: (a) turnover lower than GBP 6.5m, (b) balance sheet total lower than GBP 3.26m, and (c) average number of employees lower than 50. Given that listed UK firms are mostly large, few come close to these thresholds.
[17] As disclosures are likely correlated within a firm over time, we adjust standard errors for within-firm clusters. However, we note in (untabulated) analyses that our findings are robust to alternative clustering, namely at the industry level (based Fama–French 48 industry groups) and country level.

The average treatment effect is the β_1 coefficient on the interaction *Treat* x *Post* which captures the change in *UCD* or *UNCD* for treatment firms after MCR comes into effect relative to the change for control firms. *Treat* is an indicator equal to one if the firm is covered by the regulation and *Post* is an indicator equal to one in the years that MCR is in effect. Because MCR first applies to fiscal years ending on or after September 30th 2013, *Post* equals 1 in 2013 for firms with fiscal year-ends after the 30th of September, but equals 0 in 2013 (and 1 in 2014) for firms with fiscal year-ends before the 30th of September. Thus, MCR's effect is staggered.[18]

5.1 Matching

An important assumption of model (1) is that *Treat* is uncorrelated with all unobservables (the error term, ε_{it}). However, there could be differences across treatment and control firms that bias the estimate of β_1. To address this concern we employ entropy balancing to minimize differences in observable characteristics across treatment and control firms (Hainmueller 2012).

To implement entropy balancing, we match our control variables (i.e. assets, revenue, return-on-assets, and leverage, as defined in Appendix I) across the treatment and control samples on the first (mean), second (variance), and third (skewness) moments. Through iterations, the algorithm searches for the set of weights for control observations such that the specified distributional properties of the treatment and post-weighted control observations are identical for all covariates. Appendix III tabulates the sample mean, variance, and skewness of the treatment and control samples before and after this process, showing that the three moments of the covariate distributions are balanced across the treatment and control firms after reweighting. The weights generated and assigned to each control observation are further incorporated in the regressions.[19]

5.2 Parallel Trends

[18] Accordingly, the coefficients on *Post* can be estimated in our regressions.
[19] In untabulated analyses we find that our results are robust to propensity score matching.

Another assumption of our difference-in-differences model is that the control sample's mean outcome changes are a valid counterfactual estimate for the treatment group's mean outcome changes, absent MCR. To validate this assumption, we plot treatment effects over time (see Figures 1a-1d in Appendix II) to ascertain whether the pre-period trends for *UCD* and *UNCD* – our dependent variables of interest – are similar for the two groups. Across both dependent variables, we find that the coefficients of *Treat* x *Post* are close to zero and statistically insignificant leading up to MCR in the full and entropy-balanced samples. The figures in Appendix II therefore do not indicate the existence of pre-trends that violate the parallel trends assumption.

6. Data and Sample

6.1 Sample construction

Table 1 outlines the sample construction. The initial sample includes all UK and non-UK firms in the Trucost Plc database from 2004 to 2019. Trucost (which has been part of S&P Global since 2016) provides corporate environmental data (e.g. carbon emissions, waste, water, pollutants, natural resources) for over 15,000 global firms. These data have been used in prior academic studies (e.g. Bolton and Kacperczyk 2021) and Trucost serves as a primary source for vendors that aggregate and disseminate data on corporate environmental outcomes, namely Bloomberg, MSCI KLD, Thomson Reuters ASSET4 and Sustainalytics.[20] Our initial sample consists of 204,768 firm-year observations (12,798 unique firms). After removing observations with missing data, we are left with 84,232 firm-year observations (12,722 unique firms).

6.2 Dependent variables

We measure unrepresentative disclosure using two variables: unrepresentative carbon disclosure (*UCD*) and unrepresentative non-carbon disclosure (*UNCD*). Broadly speaking, these variables

[20] For each of these data providers, a number of environmental data fields specify that the data comes from Trucost.

reflect the extent to which a firm discloses relatively benign impacts but not those more representative of overall environmental harm. Prior research classifies this as greenwashing (e.g. Delmas and Burbano 2011, Kim and Lyon 2011, Lyon and Maxwell 2011) "because it involves a company conveying…environmental information that creates a misleading impression of its overall environmental performance" (Marquis et al. 2016, p. 488).[21]

Appendix III describes the construction of our unrepresentative disclosure measures in detail. Following the approach in prior research (Marquis et al. 2016), *UCD* is equal to the *absolute carbon disclosure ratio* minus the *weighted carbon disclosure ratio*, from Trucost. *Absolute carbon disclosure ratio* is the fraction of the three GHG scopes (i.e. Scope 1, Scope 2 and Scope 3) that a firm discloses global quantitative figures for in publicly-available channels such as financial reports, regulatory filings, and websites. *Weighted carbon disclosure ratio* is the fraction of the firm's total estimated carbon damage (see below) disclosed by the firm. Therefore, *absolute carbon disclosure ratio* measures how much carbon information is disclosed, and *weighted carbon disclosure ratio* measures how much environmentally-important carbon information is disclosed.

Similarly, *UNCD* is the difference between the *absolute non-carbon disclosure ratio* and the *weighted non-carbon disclosure ratio*, where the absolute ratio is the proportion of the number of non-carbon environmental indicators identified by Trucost as relevant to a focal company (e.g. consumption of natural resources, waste, and non-carbon pollutants – see Appendix III) for which a firm publicly discloses global quantitative figures, and the weighted ratio measures how much of the firm's total estimated non-carbon environmental damage is disclosed by the firm (see below). Because the non-carbon environmental indicators included in our measure of *UNCD* are voluntary (i.e. they are not mandated by MCR or under another reporting requirement according to the UK

[21] Prior literature also calls this "selective disclosure" which we abstain from, because it connotes intent.

Government's Environmental Reporting Guidelines),[22] *UNCD* reflects environmental metrics over which managers have discretion to disclose, or not disclose, before and after MCR.

To estimate a firm's environmental damage, Trucost uses its proprietary Environmentally-Extended Input-Output (EEIO) model to estimate carbon emissions and other environmental impacts (further details on Trucost's methodology can be found in Appendix III).[23] First, a company's revenues are allocated to the subset of business activities in which it operated that year, based on segment data from the FactSet Fundamentals dataset, supply-chain data from FactSet Supply Chain Relationships, and other publicly-available information from financial reports and regulatory filings. Second, the company's total annual tonnage of emissions released (to air, land, and water) and resources consumed (such as metals, water, oil, natural gas) are estimated based on the company's revenues from each business activity. These calculations are based on resource-per-dollar factors derived from resource and pollution release and transfer registries and economic input–output models (which model trade between suppliers and customers). Third, the physical quantities are multiplied by environmental damage cost factors, which are drawn from academic research on the pricing of environmental externalities.

Trucost's environmental estimates have been used and validated in prior academic studies (e.g. Bolton and Kacperczyk 2021). In independent analysis we compare Trucost's Scope 1+2 GHG estimates for UK firms prior to MCR (in the last pre-period year) to these same firms' disclosed Scope 1+2 GHG data once MCR is in effect (in the first post-period year). We find that

[22] Chapters 1 and 2 of the Guidelines cover mandatory Scope 1 and 2 GHG reporting, while chapters 4-8 cover voluntary water, waste, resources, non-carbon pollutants, and biodiversity disclosures. See: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/850130/Env-reporting-guidance_inc_SECR_31March.pdf

[23] EEIO methodology, developed by the US Environmental Protection Agency, is widely used in academia and by government agencies, corporations, non-profits, and NGOs for calculating environmental impacts. See: https://www.epa.gov/land-research/us-environmentally-extended-input-output-useeio-models#:~:text=Developed%20by%20EPA%20researchers%20in,pollution%2C%20nutrients%2C%20and%20toxics.

the average difference between Trucost's estimates prior to MCR versus what firms report after MCR represents 3.6% of mean disclosed Scope1+2 GHG in the first post-period year. This error rate of 3.6% is reasonable and does not suggest material deficiencies in Trucost's estimation.[24] The equation for *Unrepresentative Carbon Disclosure (UCD)* is as follows:

$$\frac{\text{\# of disclosed global GHG Scopes}}{3} - \frac{\Sigma\,(\text{Scope 1–3 global GHG quantities } \mathbf{if\ disclosed} \times \$\text{ carbon damage cost factors})}{\Sigma\,(\text{Scope 1–3 global quantities} \times \$\text{ carbon damage cost factors})} \quad (2)$$

The equation for *Unrepresentative Non-Carbon Disclosure (UNCD)* is as follows:

$$\frac{\text{\# of disclosed global non carbon environmental indicators}}{\text{\# of relevant environmental indicators identified by Trucost}} - \frac{\Sigma\,(\text{Relevant non carbon global quantities } \mathbf{if\ disclosed} \times \$\text{ environmental damage cost factors})}{\Sigma\,(\text{Relevant non carbon global quantities} \times \$\text{ environmental damage cost factors})} \quad (3)$$

Both *UCD* and *UNCD* fall between -1 and +1.[25] Higher values indicate that the company disclosed more trivial indicators than important ones, and lower values indicate the opposite. Hence, a higher (lower) value is indicative of more (less) unrepresentative disclosure.

6.3 Descriptive statistics

Panel B of Table 1 presents summary statistics for the treatment and the control samples before entropy balancing. Treatment firms have lower *UCD* and *UNCD* compared to control firms – mean *UCD* (*UNCD*) for the treatment sample is -0.33 (-0.40), compared to -0.17 (-0.21) for the control sample.[26] Treatment firms are smaller than control firms, with treatment (control) firms having

[24] As noted by Busch, Johnson, and Pioch (2020, p. 360) Trucost estimates are based on sector averages, allowing worse carbon performers in their sectors not to disclose and thus hide behind sector average carbon emissions.
[25] Marquis et al (2016, endnote 5) notes *absolute disclosure ratio* minus *weighted disclosure ratio* means that unrepresentative disclosure will be 0 when *absolute disclosure ratio* equals *weighted disclosure ratio*, which occurs when the firm discloses nothing (both ratios equal 0), when the firm discloses everything (both ratios equal 1), or when the ratios have the exact same values. Each of these represents the lack of unrepresentative disclosure.
[26] For the pre-MCR period, the corresponding statistics for UCD (UNCD) are -0.27 (-0.31) for the treatment sample and -0.22 (-0.24) for the control sample.

mean total assets of $1.8 billion ($2.6 billion) and revenues of $977 million ($1.2 billion). Treatment firms are more profitable, having a mean return-on-assets of 0.88 compared to that of 0.74 for control firms. Treatment and control firms are similarly levered (0.87 for treatment and 0.88 for control). These differences illustrate the importance of controlling for firm characteristics in our models, as well as using an entropy-balanced sample. Panel C of Table 1 tabulates industry composition. Industrials has the highest representation, comprising 21.3% of the treatment sample and 18.4% of the control sample. This is followed by consumer discretionary (17.2% of treatment and 14.4% of control). For the remaining industries, no more than 15% comes from any given one. Panel D of Table 1 tabulates country representation. Nearly 60% of our control sample comes from the United States (24%), Japan (19%) and China (16 %).[27]

7. Results

7.1 Effect of MCR on unrepresentative carbon disclosure

Table 2 presents estimates of the effect of MCR on unrepresentative carbon disclosure. H1 predicts that firms' GHG disclosures were unrepresentative of their true carbon impacts prior to MCR, such that they experience a decline in *UCD* after MCR. We first disaggregate *UCD* into its components and examine the effect of MCR on *absolute carbon disclosure ratio* in column 1 and *weighted carbon disclosure ratio* in column 2 (because *UCD* is the difference between the two ratios). Column 1 shows that UK firms experience an increase, on average, in the *absolute carbon disclosure ratio* (coef. = 0.140, $p < 0.01$) which is unsurprising given MCR required GHG transparency among UK firms. However, in column 2 we see that UK firms also experience an increase in the *weighted carbon disclosure ratio* (coef. = 0.229, $p < 0.01$), revealing that carbon

[27] In robustness analyses (untabulated) we excluded firms from these countries and re-estimated our main models, and our inferences were unchanged.

data not reported prior to MCR is environmentally-material.

Columns 3 and 4 report estimates of the effect of MCR on *UCD*. The coefficients on *Treat* x *Post* are of interest, which capture changes in *UCD* from before to after MCR for UK firms relative to non-UK firms. In column 3, which uses the full sample, the coefficient estimate on *Treat* x *Post* is -0.088 (significant at the 1% level), indicating that UK firms experienced an on-average decline in *UCD* after MCR came into effect (the estimate of -0.088 is the difference between 0.140 and 0.229 from columns 1 and 2, respectively). The magnitude of the *UCD* decrease is around 33% of the pre-MCR sample mean of *UCD* for treatment firms (0.088/0.27). Column 4 presents results for the entropy-balanced sample, which provides a similar estimate of -0.084.

These results are consistent with H1 and suggest that UK firms did not, on average, disclose representative GHG data prior to MCR, such that MCR forced them to disclose GHG data that was more reflective of their true carbon impacts.[28] If UK firms had already disclosed what mattered, or MCR did not mandate the most consequential GHG scopes, these results would not manifest.[29] The result indicates that regulators "got it right" in mandating Scope 1 and 2 GHG, and firms did not disclose this environmentally-impactful information when disclosure was voluntary.

7.2 Effect of MCR on unrepresentative non-carbon disclosure

Table 3 reports the effect of MCR on *UNCD*. Because the non-carbon environmental indicators included in our measure of *UNCD* are voluntary (i.e. they are not mandated by MCR or by another reporting requirement), this test examines whether MCR disciplines firms' *voluntary* environmental disclosures. H2 predicts that MCR will attract increased scrutiny from external stakeholders and, wary of being accused of greenwashing and the ensuing reputational harm, firms

[28] In untabulated analyses we remove firms that did not disclose Scope 1 or 2 GHG prior to MCR, and we continue to find a negative treatment effect. Thus, our findings are not entirely attributable to firms that did not disclose GHG.
[29] We observe that only 12 UK firms began disclosing Scope 3 GHG after MCR, which suggests that the increase in the *weighted carbon disclosure ratio* is not driven by Scope 3 reporting after MCR.

will curb the unrepresentative disclosure of voluntary environmental data.

Again, we first tabulate the effect of MCR on the *absolute non-carbon disclosure ratio* and the *weighted non-carbon disclosure ratio* in columns 1 and 2, respectively, because *UNCD* is the difference between the two. The negative coefficient in column 1 (coef. = -0.015, $p < 0.01$) shows that treatment firms decreased the fraction of voluntarily disclosed non-carbon environmental indicators around MCR, while the nearly 5-times larger and positive coefficient in column 2 (coef. = 0.072, $p < 0.01$) shows that what remained voluntarily disclosed covers more of firms' environmental damage.

Hypothesis 2 is tested in columns 3 and 4 which use *UNCD* as the dependent variable. Consistent with H2, we document that MCR had a negative on-average effect on *UNCD*. The estimate in column 3 for the full sample reveals that UK firms decrease *UNCD* by 28% of its pre-MCR mean (0.087/0.31), and by 31% of its pre-MCR mean (0.095/0.31) in the entropy-balanced sample in column 2, both significant at the 1% level.[30] The results in Table 3 show that the decline in unrepresentative non-carbon disclosure was driven by less disclosure of benign, immaterial environmental data, and more disclosure of data that reflects firms' true environmental harm.

7.3 Carbon performance moderator

Next, we examine whether carbon performance moderates the relationship between MCR and unrepresentative disclosure. We reason that worse carbon performers provide less representative disclosures relative to better carbon performers. Hence, H3a predicts worse carbon performers, revealed by MCR, will experience larger reductions in *UCD* once MCR comes into effect and forces them to disclose their more impactful GHG. In turn, H3b predicts that when MCR exposes the greater extent of *UCD* among worse carbon performers, stakeholders will be more skeptical of

[30] In untabulated analyses, we test and do not find evidence that improvements in carbon performance after MCR drive our results (Downar et al. 2021).

these firms' unregulated environmental disclosures. Thus, worse carbon performers will provide more representative environmental disclosures after MCR, such that their *UNCD* will fall by more.

To test this, we calculate GHG intensity in the first year that MCR is in effect (either 2013 or 2014 depending on firms' fiscal year ends) by scaling GHG (the sum of Scope 1 and 2 GHG) by total revenues. We normalize GHG intensity within each country and sector (by subtracting the mean and dividing by the standard deviation) to create a ranking such that the worst (highest GHG-intensity) firm in each country-sector is assigned a value of 1 and the best (lowest GHG-intensity) firm in each country-sector is assigned a value of 0. This ranking is our measure of *carbon performance*; three characteristics of the ranking warrant explanation. First, the ranking is based on GHG intensity (rather than GHG level) to remove the differential impact of size, but untabulated analyses using GHG levels yield similar results. Second, we measure GHG intensity in first year of MCR because this allows us to rank all of the treatment firms, whereas using data prior to MCR limits the analysis to treatment firms that voluntarily disclose GHG in the pre-period. Third, a within country-sector ranking assumes that stakeholders benchmark the carbon performance of firms belonging to the same country and sector. While this basis of comparison is consistent with how extant research measures relative carbon performance (e.g. Tomar 2023), we acknowledge that other benchmarking groups are possible (e.g. industry, exchange-listing, etc.) In untabulated analyses we re-construct the ranking within treatment status and industry, and find similar results (within country and industry is infeasible as some countries have too few firms in each industry).

Table 4 reports the results. In columns 1 and 2, which use *UCD* as the dependent variable, the coefficient estimates of the triple interaction *Treat* x *Post* x *Carbon performance* are negative and significant at the 1% level. The coefficient on the interaction term in column 1 (coef. = -0.062, $p < 0.01$), which uses the full (unmatched) sample, suggests that after MCR the worst carbon

performer (relative to the best carbon performer) decreased unrepresentative carbon disclosure by 56% of the pre-MCR mean value for UK firms; the interpretation is similar for the estimate in column 2 that uses the entropy-balanced sample (coef. = -0.063, $p < 0.01$).[31] This confirms H3a, namely that worse carbon performers had less representative carbon disclosures prior to MCR.

Columns 3 and 4 use unrepresentative non-carbon disclosure as the dependent variable and also report negative coefficients on the triple interaction term (significant at the 10% level). The interpretation of the estimate from column 3 that uses the full sample (-0.029, $p < 0.10$) is that, for the worst carbon performer – relative to the best one – following MCR, *UNCD* decreased by 37% of the pre-MCR mean value for UK firms.[32] Again, the result for the entropy-balanced sample is very similar (coef. = -0.030, $p < 0.10$). Consistent with H3b, these results reveal worse carbon performance is associated with larger reductions in unrepresentative non-carbon reporting.

7.4 Unrepresentative carbon disclosure and carbon emissions

H4 predicts that stakeholders will view unrepresentative carbon disclosure, revealed under MCR, unfavorably, because firms may have used such disclosure in-lieu of real efforts to manage carbon emissions. Firms that experienced a decline in *UCD*, indicating that their carbon disclosures became more representative of their overall carbon impacts after MCR, will accordingly face stakeholder pressure and in turn make real efforts to reduce carbon emissions to maintain or restore reputation. To test H4, we create an indicator equal to 1 if a firm's mean *UCD* in the post-period is smaller than in the pre-period, denoting that the firm experienced a decrease in unrepresentative carbon disclosure after MCR (0 otherwise). We interact this term with our DID estimator, and regress the triple interaction term on firms' logged Scope 1+ 2 GHG.

Table 5 reports the results: the triple interaction term *Treat* X *Post* X *Unrepresentative*

[31] (-0.062 – 0.088) / -0.27 = -0.15 / -0.27 = 0.56 or 56%.
[32] (-0.029 – 0.087) / -0.31 = -0.116 / -0.31 = 0.37 or 37%

Carbon Disclosure Decrease is negative and significant at the 10% level, and indicates a decrease in Scope 1 and 2 GHG of 14.9% for treatment firms who experienced a decline in UCD relative to treatment firms that did not experience a decline in UCD, relative to the corresponding difference for control firms, from before to after MCR.[33] This provides some evidence of an association between a decline in *UCD* after MCR and Scope 1+2 GHG decreases around MCR. Columns 2 and 3 use logged Scope 3 GHG as the dependent variable to ascertain whether firms "shift" Scope 1+2 GHG to the supply chain rather than making real efforts to reduce them (column 2 uses Trucost's estimates when disclosure is not provided and column 3 uses only disclosed quantities), and the insignificant results do not indicate that this is the case.

These results lend some support for H4 that stakeholder pressure to improve ESG outcomes may come from firms' unrepresentative disclosures revealed under mandated reporting. However, we caution against a causal interpretation as these tests are cross-sectional and we cannot disentangle stakeholder pressure generated from revealed unrepresentative carbon disclosure from that of increased transparency more broadly (e.g. Downar et al. 2021). Thus, our results should be viewed as exploratory and suggestive of how mandatory reporting may restrict firms' ability to use unrepresentative reporting in place of real efforts to improve environmental performance.

8. Robustness Tests

8.1 Removing potential confounds

Because our analysis compares UK firms to non-UK firms, we search for concurrent regulations and events that could confound our inferences. In Appendix V, we summarize GHG regulations

[33] 14.9% = (1 - exp(−0.162)). Jouvenot and Krueger (2021) document a reduction in Scope 1 and 2 GHG of 16% following MCR. Downar et al. (2021) estimates an 8% reduction, but they focus on Scope 1 GHG which EU ETS firms already had to disclose to the EU ETS regulator before MCR. Thus, it is reasonable for our effect sizes to be larger, as we include Scope 2 GHG which UK firms were not already mandated to disclose.

around the world that passed during the sample period (e.g. mandated GHG reporting, carbon taxation, cap-and-trade schemes, etc.). It is unclear whether and how these mandates could confound our inferences; given MCR decreased the unrepresentative environmental disclosures of UK firms, it is possible that these mandates similarly affected the firms in these countries, such that including them would bias against our results.

In Panel A of Table 6, we exclude the 9 potentially confounded countries represented in our control sample (Australia, Bulgaria, Canada, Ireland, Japan, New Zealand, South Korea, Switzerland, and the United States), as well as firms regulated under the European Union's Emissions Trading Scheme (EU ETS), and continue to find a negative and significant on-average decline in *UCD* and *UNCD* for treated firms after MCR.[34] Thus, our inferences do not appear to be influenced by concurrent regulations implicating our control sample.

8.2 Within-UK analysis

Another threat to identification is whether the timing of MCR is non-random, such that it coincides with other forces that pressure UK firms to reduce unrepresentative reporting and simultaneously push UK regulators to adopt GHG policies; such forces could lead to the adoption of MCR *and* changes in firm disclosures. In other words, an omitted "UK-specific" factor may drive our results.

To address this concern, we conduct a within-UK analysis that employs entropy balancing to match UK firms listed on the Alternative Investment Market (AIM) of the London Stock Exchange (LSE) (which are not covered by MCR) and UK firms listed on the Main Market of the LSE (which are covered by MCR) in the same sector and along the same set of observable firm

[34] We identify firms regulated under the European Union Emissions Trading Scheme (EU ETS) using the Carbon Disclosure Project (CDP) (details on CDP are provided in section 8.4), which asks firms to self-identify their emissions trading schemes. This process yields 859 unique firms in the EU ETS (of which 192 are UK firms, which is only 5 fewer firms than identified by Downar et al. 2021, p. 1153).

characteristics controlled for in our analyses (i.e. *Assets, Revenue, ROA and Leverage)*.[35] AIM-listed UK firms comprise the control sample and listed UK firms comprise the treatment sample, reducing the likelihood that an omitted UK factor biases the results. Treatment effects plotted in event time (untabulated) do not indicate the existence of pre-trends. Panel B of Table 6 reports the results. The DID estimator on *UCD* is negative and significant (coef. = -0.096, $p < 0.05$), while also being negative and significant on *UNCD* (coef. = -0.088, $p < 0.05$). Thus, the results of our within-UK analysis confirm the inferences drawn from our main analysis, and indicate that MCR led to a reduction in unrepresentative carbon and non-carbon disclosure for the affected firms.

8.3 Misrepresentation of GHG

MCR does not require GHG data to be independently verified or assured. It is therefore possible that firms' GHG data are not reliable and yet we document a decline in unrepresentative disclosure for these firms. To examine whether our results are driven by firms that misrepresent their GHG, we conduct two tests. For the first test, we identify a subsample of firms that have third-party assured Scope 1 and 2 GHG and re-run our analyses on this subsample.[36] For the second test, we focus on the subsample of UK and EU firms that are regulated under the EU ETS, because Scope 1 GHG data are audited by a third-party under the EU ETS system (Downar et al. 2021). Table 7 presents the results. Across both subsamples, we observe evidence consistent with our main inferences (for brevity we do not tabulate results for the entropy-balanced sample, but note that they are similar). Our results hold for firms that obtain third-party assurance over GHG.

8.4 Alternative dependent variables

We construct three alternative dependent variables to reflect other definitions of greenwashing in

[35] AIM is the London Stock Exchange's market for small and medium-size growth companies.

[36] We use data from the Carbon Disclosure Project (CDP) to identify firms that obtain assurance (details on CDP are provided in section 8.4). We use answers to the question "Please indicate the assurance status that applies to your reported Scope 1 and 2 emissions" and "Attach the assurance statement if applicable." It is generally understood that

prior research (see Lyon and Montgomery 2015 for a review). The first alternative measure is *DECOUPLING*, or symbolic management, which aims to reflect a disconnect between what is portrayed externally and what is achieved internally. In particular, firms may "decouple" their external appearance from their actual activities in order to achieve and maintain "legitimacy" in the eyes of stakeholders (e.g. Meyer and Rowan 1977). The second alternative measure is *VAGUENESS*, reflecting the use of language that is vague and non-specific, intended to deceive stakeholders (e.g. Wagner, Lutz, and Weitz 2009; Orazi and Chan 2020). The intuition is that vague claims can mislead users into believing the firm is "green" while detracting from the public's understanding of environmental issues (Lyon and Montgomery 2015).[37] The third alternative measure is *TONE*, which assesses the overall tone of the disclosure. Tone is an important impression management tool used by firms to influence stakeholders' perceptions. Poor CSR performing firms tend to exhibit a bias in their verbal tone by displaying greater optimism compared to good CSR performing firms (Cho, Roberts, and Patten 2010).

To construct these measures, we employ textual analysis of narrative climate change disclosures provided by firms in their voluntary Carbon Disclosure Project (CDP) survey responses. CDP is an annual survey which requests information on a wide set of environmental metrics from large companies on behalf of institutional investor signatories.[38] The CDP database provides information about climate change risks, opportunities, policies, and performance based on survey responses, and has been used in prior accounting research (e.g. Ioannou et al. 2016). In addition to a number of standardized questions, the CDP survey asks open-ended questions that are answered in a free text field. We use answers to three categories of questions. The first category

[37] U.S. Federal Trade Commission has cautioned firms not to "[make] general and vague environmental claims…as [they] cannot be easily substantiated and are open to different interpretations" (Orazi and Chan 2020, p. 109).
[38] Response rates are typically high; in 2021, 94% of the Global 500 responded to CDP.

is related to strategy: "*Please describe the process of how climate change is integrated into your business strategy and any outcomes of this process*" or "*Please explain why climate change is not integrated into your business strategy*" (depending on whether the firm answers yes or no to the preceding question "*Is climate change integrated into your business strategy?*"), which constitute the most substantial narrative responses in the CDP survey (Fabrizio and Kim 2019, p. 1214). The second category related to risk: "*Please describe your risks driven by changes in regulation*," "*Please describe your risks that are driven by change in physical climate parameters*," and "*Please describe your risks that are driven by changes in other climate-related developments*." We combine the answers to the three risk sub-questions. The third category is related to opportunities: "*Please describe your opportunities that are driven by changes in regulation*," "*Please describe the opportunities that are driven by changes in physical climate parameters*," and "*Please describe the opportunities that are driven by changes in other climate-related developments*." We combine the answers to the three opportunity sub-questions. The questions are worded consistently from 2010 in the CDP survey, so our sample period is from 2010 onwards for these analyses.

For each category of questions (strategy, risk, and opportunity), we calculate the length, tone, and specificity of the answers. Length is the total word count after removing stop words. Tone is calculated based on the dictionary of positive and negative words developed in Loughran and McDonald (2011), which has been widely used in ESG-related research (e.g., Sautner, van Lent, Vilkov, and Zhang 2023). Tone equals total positive words minus negative words divided by total words. Specificity of carbon disclosures equals total carbon-related words (based on our self-constructed dictionary; see Table 8) scaled by total word count. The mean of length, tone, and specificity of carbon disclosures are calculated by averaging across the three categories of questions. If the answer is missing for any question, the mean is calculated based on the other non-

missing questions. The mean of length, tone, and specificity are further ranked at the industry-year level. The carbon emission intensity (the total of scope one, scope two, and scope three emissions scaled by revenue) is also ranked at the industry-year level.

DECOUPLING equals one if a firm's carbon emission intensity ranks above the industry-year median and the length of answers to the three questions also ranks above the industry-year median (zero otherwise). *VAGUENESS* equals one if a firm's carbon emission intensity ranks above the industry-year median and the specificity of carbon-related disclosures ranks below the industry-year median (zero otherwise). *TONE* equals one if a firm's carbon emission intensity ranks above the industry-year median and the tone ranks above the industry-year median (zero otherwise). The intuition is that a firm is greenwashing when the firm is a worse carbon performer relative to its industry peers and the firm (1) provides longer disclosures, (2) provides disclosures that are less specific on carbon emissions, or (3) provide disclosures that are overly optimistic. The results are reported in Table 8 and reveal negative treatment effects across the three alternative measures in full and entropy-balanced samples (untabulated results do not indicate the existence of pre-trends).[39] Overall, the findings lend support for an on-average decline in alternative proxies for greenwashing after MCR for the affected firms.

8.5 Mitigating the impact of Scope 3 estimates

As explained in section 2, measuring Scope 1 and 2 is relatively straightforward.[40] By contrast, measuring Scope 3 is more complex, as Scope 3 requires a full value chain mapping of a firm's activities as well as data from members in the supply chain and estimates on how consumers use their products (Bolton and Kasperczyk 2021). Given the cost and difficulty involved, it is

[39] The coefficient on *TREAT×POST* for the entropy balanced sample is negative but not significant at conventional levels for the *GW_DECOUPLING* regression.

[40] Per Bolton and Kasperczyk (2021, p. 11): "Because they are easier to measure…data on scope 1 and scope 2 have been more systematically reported and accurately estimated."

reasonable that Trucost would also face difficulty estimating Scope 3.[41]

Since the denominator of the *weighted carbon disclosure ratio* includes Scope 3 estimates from Trucost, we evaluate whether measurement error relating to Scope 3 affects our inferences. Using three different sources of industry research on Scope 3 emissions – the CDP's Scope 3 technical note (CDP 2022),[42] the GHG Protocol's Scope 3 accounting standard (GHG Protocol 2014), and research on Scope 3 from Morgan Stanley Capital International (Baker 2020) – we identify six industry groups (Energy, Automobiles and Components, Utilities, Capital Goods, Materials, and Food, Beverage and Tobacco) that have the highest expected Scope 3 emissions.[43] We exclude these industries and re-run model (1), and find that our inferences are unchanged (untabulated); *Treat* x *Post* is negative and significant when regressed on *UCD* for the full and entropy-balanced samples. Given our inferences hold, this test helps mitigate the concern that Scope 3 measurement error systematically biases our results.

9. Discussion: Does Trucost data supplant the need for GHG reporting?

In section 6.2, we explained that Trucost's methodology for estimating firms' Scope 1 and 2 GHG appears to be reasonable, as estimates were within an error rate of 3.6% compared to firms' disclosed figures after mandated reporting. This raises the question of why mandatory carbon reporting was needed to reduce firms' unrepresentative environmental disclosures, given Trucost generates reasonable estimates of firms' environmental impacts in the absence of disclosure. In other words, our results point to "revealed" carbon impacts under MCR serving to curb

[41] As explained in section 6.2, we calculated, for the affected firms, an error rate of 3.6% between Trucost's estimated Scope 1+2 GHG compared to firms' disclosed data. An analogous comparison between estimates and actuals for Scope 3 is not possible, as, to our knowledge, there is no mandated Scope 3 reporting in any jurisdiction.

[42] Carbon Disclosure Project (CDP). 2022. CDP Technical Note: Relevance of Scope 3 Categories by Sector. Accessible from: https://cdn.cdp.net/cdp-production/cms/guidance_docs/pdfs/000/003/504/original/CDP-technical-note-scope-3-relevance-by-sector.pdf?1649687608

[43] In addition, we observe from our data that these industries have the highest Scope 3 quantity estimates per Trucost.

unrepresentative disclosure, but why did this not already take place prior to MCR? There are four potential explanations for why our results should manifest even with the existence of Trucost.

First, we do not expect perfect substitutability between estimates from a data provider and firm-reported information, even if the estimates are fairly good. Firm-reported information is more likely to increase accountability than data from a third-party provider, because third-party data can more easily be refuted, and stakeholders will thus have more success putting pressure on firms when the data comes from the firm itself. In support of this, a growing literature documents improvements in ESG outcomes after mandated reporting (e.g. Feichter et al. 2022), even though a number of data providers disseminate ratings and data on ESG outcomes (Christensen, Serafeim and Sikochi 2022). Second, we know from prior research that *how* and *where* information is presented matters (Christensen et al. 2017; Downar et al. 2021). Disclosures in the annual report are accessible and salient to a broad set of users, many of whom may not have access to, or the ability to process, additional data from third-party providers. Third, Trucost data only recently became available in commercial format (i.e. for sale) to investors, universities, and via platforms such as Bloomberg. Prior to 2014, Trucost data were used exclusively by governments and intergovernmental organizations for climate scenario and policymaking, as this was the original intended use of the data. As such, it is unlikely that a broad set of users had access to Trucost data in the years leading up to, and shortly after, MCR. Fourth, as noted by Busch et al. (2020), Trucost estimates are based on sector averages, allowing worse carbon performers to not disclose and hide behind sector average carbon emissions. MCR unravels this partial disclosure equilibrium.

10. Conclusion

We document the first empirical evidence (to our knowledge) on the effects of mandatory ESG reporting on unrepresentative disclosure, which prior research identifies as a form of

greenwashing. We use a setting in which firms are required to disclose GHG in financial reports (Mandatory Carbon Reporting, or MCR) and examine the implications for unrepresentative disclosure. Defining unrepresentative disclosure as the disclosure of benign environmental information while not disclosing environmental information that is more indicative of overall environmental damage, we document a decline in unrepresentative carbon disclosure for firms subject to MCR relative to unaffected firms. In robustness tests, we perform textual analyses on firms' voluntary carbon disclosures to construct alternative measures of greenwashing and continue to document a decrease around MCR for affected firms. We also find that MCR has a negative effect on firms' unrepresentative non-carbon disclosures, and that carbon performance moderates the relation between MCR and unrepresentative disclosure. Finally, we document an association between reductions in unrepresentative carbon disclosure and carbon emissions.

The practical implications of this study are significant. The U.S. SEC, and regulators in other jurisdictions including Australia, Canada, the European Union and Hong Kong, have either proposed or passed ESG reporting laws to address greenwashing; and yet, there is no empirical evidence on the matter. We document that not only did affected firms experience a decline in unrepresentative carbon disclosure after MCR, but affected firms also decreased unrepresentative reporting of other, non-mandated environmental disclosures. And, a decline in unrepresentative disclosure was associated with carbon emission reductions, suggesting that mandated reporting could help in the fight against climate change by limiting firms' use of greenwashing as a substitute for real environmental efforts.

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Appendix I: Variable Definitions

Variable	Definition/Calculation
Unrepresentative Carbon Disclosure (UCD)	*Absolute Carbon Disclosure Ratio* minus *Weighted Carbon Disclosure Ratio*. *Absolute Carbon Disclosure Ratio* is the proportion of the three carbon scopes (Scope 1, 2 and 3 greenhouse emissions) that a company publicly discloses in a given year. *Weighted Carbon Disclosure Ratio* weights each disclosed carbon scope by the contribution of each scope to total carbon damage. See Appendix IV for details.
Unrepresentative Non-Carbon Disclosure (UNCD)	*Absolute Non-Carbon Disclosure Ratio* minus *Weighted Non-Carbon Disclosure Ratio*. *Absolute Non-Carbon Disclosure Ratio* is the proportion of non-carbon indicators that a company publicly discloses in a given year. These non-carbon indicators belong to 10 broad categories: the consumption of various natural resources (biomass, metals, minerals, and water), landfill waste, recycled waste, waste incineration, and non-carbon pollutants (land, water, and air). *Weighted Non-Carbon Disclosure Ratio* weights each disclosed non-carbon indicator by the contribution of each indicator to total non-carbon environmental damage. See Appendix IV for details.
Treat	Equals one for UK public firms; zero otherwise.
Post	Equals one for financial years ending on or after the 30th of September 2013; zero otherwise.
Assets	Natural log of total assets.
Revenue	Natural log of total revenue.
ROA	Total revenue divided by total assets.
Leverage	Total debt divided by total equity.
Carbon Performance	Ranking of carbon performance based on GHG intensity (sum of Scope 1 and 2 GHG scaled by total revenues) in the first year that MCR is in effect. We normalize GHG intensity within each country-sector (by subtracting the mean and dividing by the standard deviation). The worst (highest GHG-intensity) firm in each country-sector is assigned a value of 1 and the best (lowest GHG-intensity) firm in each country-sector is assigned a value of 0.
GHG	Sum of Scope 1 and 2 GHG.
DECOUPLING	Indicator variable generated from textual analysis of answers to three categories of CDP survey questions: strategy, risk, and opportunity. *DECOUPLING* equals one if a firm's carbon emission intensity (the sum of scope one, scope two, and scope three emissions scaled by revenue) ranks above the industry year median and the length of answers to the three questions also ranks above the industry year median, and zero for all other firms.
VAGUENESS	Indicator variable generated from textual analysis of answers to three categories of CDP survey questions: strategy, risk, and opportunity. *VAGUENESS* equals one if a firm's carbon emission intensity ranks above the industry year median and the specificity of carbon-related disclosures ranks below the industry year median, and zero for all other firms.
TONE	Indicator variable generated from textual analysis of answers to three categories of CDP survey questions: strategy, risk, and opportunity. *TONE* equals one if a firm's carbon emission intensity ranks above the industry year median and the tone ranks above the industry year median, and zero for all other firms.

Appendix II: Parallel Trends

The figures below report coefficients and 95% confidence intervals of OLS regressions estimating the effect of Mandatory Carbon Reporting on *Unrepresentative Carbon Disclosure* (*UCD*) and *Unrepresentative Non-Carbon Disclosure* (*UNCD*) (defined in Appendix I) for treated UK firms and control non-UK firms. We estimate model (1) but replace *Treat* x *Post* with time dummy variables, each representing one time period relative to the year the mandate comes into effect (t=0). To account for the staggered implementation of MCR, t=0 refers to the year 2013 for firms with a fiscal year-end after September 30th, while t=0 refers to the year 2014 for firms with a fiscal year-end prior to September 30th. The indicator for year t=0 is the omitted benchmark period.

Figure 1a - Full sample – *UCD*

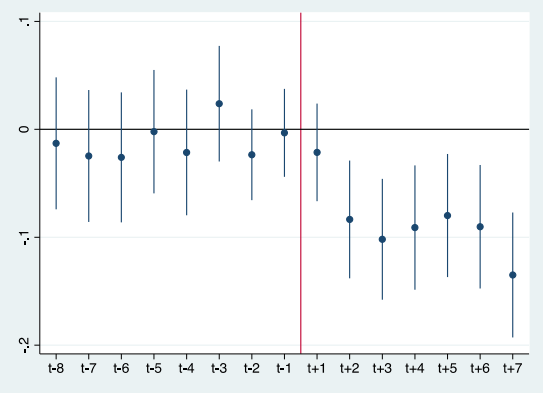


Figure 1b – Full sample – *UNCD*

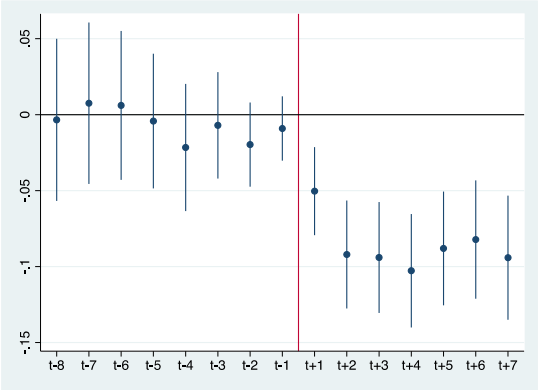


Figure 1c - Entropy-balanced sample – *UCD*

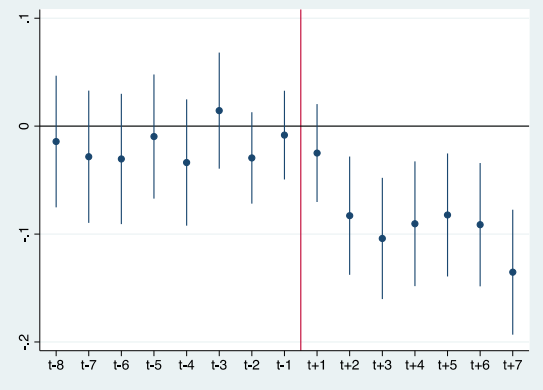
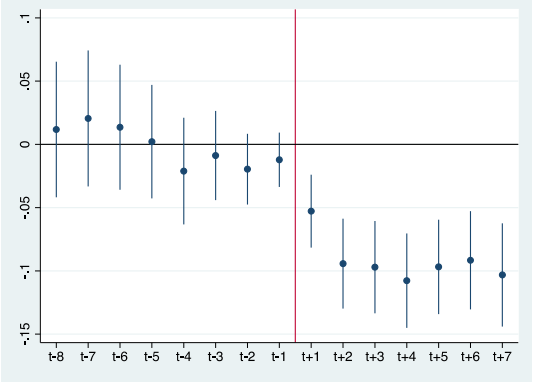


Figure 1d – Entropy-balanced sample – *UNCD*



APPENDIX III: Description of Trucost and *Unrepresentative Disclosure* variables

Trucost is a leading provider of carbon and environmental data and is considered to be "a pioneer in providing investment grade carbon and environmental data to investors, companies and governments."[44] Founded in 2000 and acquired by S&P in 2016, Trucost's data (which includes greenhouse gas emissions, water, waste, pollution and natural resources) covers over 15,000 companies representing 99% of global market capitalization.[45] Bloomberg and MSCI/KLD offer Trucost data as part of their ESG products, and large organizations (e.g. PUMA, NovoNordisk, Samsung) use Trucost for their climate-related financial disclosures (as recommended by the Financial Stability Board's Task Force for Climate-related Financial Disclosures (TCFD)). [46] National governments and intergovernmental organizations also rely on Trucost (original users of the data prior to its commercialization in 2014). For example, Trucost was commissioned by the United Nations and the World Business Council to assess environmental damage costs of the corporate sector, the World Bank to quantify the exposure of different regions to carbon costs, and governments in Brazil, China, India and the EU, to quantify the risks to national financial systems and inform climate policy.

Unrepresentative Carbon Disclosure

Unrepresentative Carbon Disclosure (*UCD*) is a measure of selective disclosure that is equal to *absolute carbon disclosure ratio* minus *weighted carbon disclosure ratio*.

Absolute carbon disclosure ratio is the fraction of carbon emission scopes that a company publicly discloses in a given year. Specifically:

1. There are three scopes of carbon emissions: Scope 1 emissions (direct emissions from sources owned by the company, e.g. emissions that result from the combustion of fuel to heat or power buildings), Scope 2 emissions (indirect emissions generated off-site, e.g. purchased electivity or heat), and upstream Scope 3 emissions (emissions caused by the company's suppliers.[47] The denominator of the *absolute carbon disclosure ratio* is therefore three.
2. Trucost uses the company's annual report, CSR report, CDP response, website, and other publicly-available data sources to determine whether the company disclosed global quantitative figures for each carbon emissions scope from step 1 in that year. The number of such disclosed carbon emissions scopes is the numerator of the *absolute carbon disclosure ratio.*
3. The number of disclosed carbon emissions scopes (from step 2) divided by three (step 1) is the *absolute carbon disclosure ratio*.

Weighted carbon disclosure ratio incorporates monetary values for GHG and calculates how much of a firm's total carbon damage is accounted for in its public disclosures. Specifically, Trucost uses its proprietary Environmentally-Extended Input-Output (EEIO) model to estimate carbon emissions and other environmental impacts.[48]

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[44] https://www.prnewswire.com/news-releases/sp-dow-jones-indices-acquires-trucost-300337852.html

[45] As evidence of Trucost's renown in the investment community, State Street partnered with Trucost in 2021 to provide Trucost's "highly-regarded climate data" to its clients holding assets totaling more than $40 trillion (USD) "to help them meet challenging global ESG regulatory guidelines and investor expectations." https://newsroom.statestreet.com/press-releases/press-release-details/2021/State-Street-and-SP-Global-Trucost-Announce-ESG-Strategic-Engagement/default.aspx

[46] https://www.spglobal.com/marketintelligence/en/documents/trucost_samsung_sdi_talking_points_final.pdf

[47] A description of Trucost's Scope 3 estimation methodology, which focuses only on suppliers, is accessible from: https://gabi.sphera.com/fileadmin/GaBi_Databases/Thinkstep_Trucost_NCA_factors_methodology_report.pdf

[48] EEIO methodology, developed by the US Environmental Protection Agency (EPA), is widely used in academia and by other government agencies, corporations, nonprofits, and nongovernmental organizations.

1. First obtain a detailed understanding of the company and its operations. Using segment-based revenues data (FactSet Fundamentals dataset), supply-chain data (FactSet Supply Chain Relationships), and other public information from financial reports and regulatory filings, Trucost classifies yearly revenues to various business activities and determines the extent of at-source emissions (purchased/generated by the firm) versus upstream/downstream emissions along the supply chain (e.g. transportation and distribution). Trucost has a set of approximately 500 business activities, which are more detailed and suited to environmental modeling than industries (e.g., American Electric Power Company has 3 primary GICS industries in Capital IQ vs 10 business activities per Trucost).
2. Using carbon emissions release and transfer registries – mainly regional, state, and national databases with inventories of emissions – Trucost estimates, for each business activity, how many tons of Scope 1, Scope 2 and Scope 3 carbon are emitted per dollar of activity.[49]
3. Trucost multiplies the carbon-per-dollar factors from step 2 by revenue in each business activity to obtain estimates of emissions released that year for each of a firm's business activities.[50]
4. The emissions quantities from step 3 are multiplied by carbon damage cost factors representing the societal or "social costs of carbon" (SCC). Trucost derives SCC from academic, government and industry research on the pricing of environmental externalities, and applies monetary values to GHG quantities representing the global average damages of a company's GHG.[51,52]
5. The numerator of *weighted carbon disclosure ratio* is the sum of the products of the emission quantities and cost factor of each disclosed carbon emissions scope, and the denominator is the firm's total carbon damage cost (step 4). This reflects the proportion of the firm's total carbon damage cost for which it disclosed quantitative emissions data.

Equation for *Unrepresentative Carbon Disclosure* (*UCD*):

$$\frac{\#\text{ of disclosed global GHG Scopes}}{3} - \frac{\Sigma\,(\text{Scope 1–3 global GHG quantities } \textbf{if disclosed} \times \$\text{ carbon damage cost factors})}{\Sigma\,(\text{Scope 1–3 global GHG quantities} \times \$\text{ carbon damage cost factors})}$$

https://www.epa.gov/land-research/us-environmentally-extended-input-output-useeio-models#:~:text=Developed%20by%20EPA%20researchers%20in,pollution%2C%20nutrients%2C%20and%20toxics.

[49] These registries include the Australian National Registry of Emissions Units, Canada's National Pollutant Release Inventory, the UK Environmental Accounts, Japan's Pollutant Release and Transfer Register, the European Union Emissions Trading Scheme Carbon Registry, South Africa's National Greenhouse Gas Inventory Management System, the Environmental Protection Act's Greenhouse Gas Reporting Program in the United States and the United States Energy Information Agency.

[50] Trucost engages annually with each firm that it covers. Companies can dispute any discrepancies. Third-party verified documentation is required to substantiate their claims. A company's own disclosed data is used without adjustment only if it is third-party verified and covers the firm's worldwide operations (i.e. global emissions). Refinements (if any) to the estimates that are deemed appropriate by Trucost and are supported by third-party verified documentation, are incorporated into the EEIO model and used in subsequent years' modeling (this process has been followed since 2007, which has allowed Trucost to improve its modeling over the past 15 years).

[51] Trucost uses separate damage cost factors for the firm's greenhouse gases (carbon dioxide, methane, nitrous oxide and fluorinated gases), as gases have different damage potential and time-horizons; methane, for example, is 25 times more potent at trapping atmospheric heat than carbon dioxide. See: https://www.epa.gov/ghgemissions/overview-greenhouse-gases

[52] Federal agencies, including the US EPA, use SCC to value the climate impacts of rulemakings and to measure, in dollars, the long-term damage of a ton of carbon dioxide equivalent (US EPA, 2022). The SCC aims to reflect the "full costs to society that a firm is responsible for. Companies pay fees for the energy and water they consume and the waste they dispose of, but natural and social capital costs reflect the true impact of these and other impacts that are currently externalized by the company" (Trucost 2015, p. 3). Trucost uses SCC based on the Interagency Working Group on Social Costs of Carbon (IWGSCC) because they "reflect the full global costs of the damage generated by GHG emissions over their lifetime, and…typically considered best practice" (Trucost 2015, p.17).

UCD Example:
Consider firm A which discloses scope 1 GHG emission and withholds scope 2 and scope 3 GHG emission prior to MCR. The estimated environmental cost associated with Firm A's GHG emission: $3M – scope 1; $5M – Scope 2; and $2M – Scope 3. Consider firm B which discloses scope 2 GHG emission and withholds scope 1 and scope 3 GHG emission prior to MCR. The estimated environmental cost associated with Firm B's GHG emission: $3M – scope 1; $5M – Scope 2; and $2M – Scope 3. For firm A, UCD equals 0.033 (1/3 – $3M/$10M). For firm B, UCD equals -0.167 (1/3 – $5M/$10M). Both firms disclose one GHG scope so absolute disclosure ratio is the same. As firm B disclosed the scope that is more environmentally impactful, Firm B's *UCD* score is lower.

2. Unrepresentative Non-Carbon Disclosure
Closely mirrors the construction and details described above for *UCD, Unrepresentative Non-Carbon Disclosure* (*UNCD*) is a measure of selective disclosure of non-carbon environmental information that is equal to *absolute non-carbon disclosure ratio* minus *weighted non-carbon disclosure ratio*.

As explained in the Online Appendix B to Marquis et al (2016), tracks more than 700 environmental indicators, with the vast majority being non-carbon indicators. The environmental indicators can be aggregated into the following ten broad categories: the consumption of various natural resources (biomass, metals, minerals, and water), landfill waste, recycled waste, waste incineration, and non-carbon pollutants (land, water, and air). Nevertheless, Trucost tracks disclosure by the company at the more detailed environmental indicator level. For a helpful example, see footnote 8 of Marquis et al (2016), where 20 environmental indicators are identified by Trucost as relevant to a focal company.

Absolute non-carbon disclosure ratio is the fraction of non-carbon environmental indicators that the company publicly discloses in a given year. Specifically:
1. The denominator of absolute non-carbon disclosure ratio is the number of non-carbon environmental indicators identified by Trucost as relevant to a focal company.[53]
2. Trucost uses the company's annual report, CSR report, CDP response, website, and other publicly-available data sources to determine whether the company disclosed global quantitative figures for each of the non-carbon environmental indicators from step 1 in that year. The number of disclosed environmental indicators is the numerator of the *absolute non-carbon disclosure ratio.*
3. The number of disclosed non-carbon environmental indicators (from step 2) divided by the number of non-carbon environmental indicators identified by Trucost as relevant to a focal company (step 1) is the *absolute non-carbon disclosure ratio*.

Weighted non-carbon disclosure ratio incorporates the materiality of non-carbon disclosures by using financial estimates of environmental harm relating to each non-carbon environmental indicator. Since the process and details are similar to what was described above for carbon greenwashing, we do not repeat the details here and instead highlight any notable differences:
1. (Step 2): Trucost estimates, for each business activity, the natural resources consumed, waste generated, or pollutants emitted for each non-carbon environmental indicator, relying on several release and transfer registries—national databases with inventories of natural resources, waste generation, and pollutants from various industries.

[53] According to the UK Government's Environmental Reporting Guidelines, UK firms are not mandated to disclose any of these non-carbon environmental indicators. See:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/850130/Env-reporting-guidance_inc_SECR_31March.pdf

2. (Step 3): Trucost multiplies the physical-units-per-dollar factors from step 2 by a company's revenues in each business activity to obtain estimate of resources consumed/waste generated/pollutants emitted by the company that year for each of its business activities.
3. (Step 4): The quantities from step 3 are multiplied by environmental cost damage factors, which are derived from academic, government and industry research on the cost of environmental externalities and aim to reflect the costs to society. For example, "Trucost's natural and social capital valuation of water quantifies the cost of water use to local communities by considering, among other factors, local water scarcity. Trucost's natural capital valuation of land use quantifies the local cost of environmental services that are lost when land is converted for business use" (Trucost 2015, p.5).
4. (Step 5): The numerator of weighted disclosure ratio is the sum of the products of the quantity and cost factor of each disclosed non-carbon environmental indicator, and the denominator is the firm's non-carbon environmental damage cost (step 4). This reflects the proportion of the firm's non-carbon environmental damage cost for which it disclosed quantitative figures.

Equation for *Unrepresentative Non-Carbon Disclosure* (*UNCD*):

$$\frac{\#\text{ of disclosed global non carbon environmental indicators}}{\#\text{ of non}-\text{carbon environmental indicators identified by Trucost}} - \frac{\Sigma\,(\text{Relevant non carbon global quantities } \textbf{if disclosed} \times \$\text{ environmental damage cost factors})}{\Sigma\,(\text{Relevant non carbon global quantities} \times \$\text{ environmental damage cost factors})}$$

UNCD Example

Firm A discloses 9 out of 10 relevant non-carbon environmental indicators. Estimated damage associated with Firm A's disclosed indicators is $10M (out of $100M total). Firm B discloses 1 out of 10 relevant non-carbon environmental indicators. Estimated damage associated with Firm B's disclosed indicators is $90M (out of $100M total). For firm A, UNCD equals 0.8 (9/10 – $10M/$100M). For firm B, UNCD equals -0.8 (1/10 – $90M/$100M). Firm A disclosed almost every environmental indicator, but what it did not disclose was the most impactful. Firm B only disclosed one environmental indicator, but this represented 90% of its total damage. Therefore, Firm B's *UNCD* score is lower.

APPENDIX IV: Entropy Balancing

Before entropy balancing

	Treat (N = 78,999)			Control (N = 5,233)		
	mean	variance	skewness	mean	variance	skewness
Assets	21.32	3.697	0.7539	21.70	3.70	0.2371
Revenue	20.70	3.321	0.1518	20.94	3.508	-0.1908
ROA	0.8793	0.5532	1.170	0.739	0.3634	1.323
Leverage	0.8714	2.864	3.20	0.8793	2.319	3.342

After entropy balancing

	Treat (N = 78,999)			Control (N = 5,233)		
	mean	variance	skewness	mean	variance	skewness
Assets	21.32	3.697	0.7539	21.32	3.698	0.7528
Revenue	20.70	3.321	0.1518	20.70	3.322	0.151
ROA	0.8793	0.5532	1.17	0.8792	0.553	1.17
Leverage	0.8714	2.864	3.20	0.8715	2.863	3.20

The tables above tabulate descriptive statistics for the treatment and control samples before and after employing entropy balancing. Variables are defined in Appendix I.

APPENDIX V: Carbon mandates around the world

This table summarizes carbon regulations that passed during our sample period (e.g. mandated GHG disclosure, carbon taxation, cap-and-trade schemes, etc.) and affect companies in our control sample. We identify these mandates using the database from the Grantham Research Institute on Climate Change and the Environment and the Sabin Center on Climate Change Law which includes more than 1,200 policies across 164 countries accounting for over 95% of global GHG (https://climate-laws.org/). In Section 8 we explain how we deal with these mandates in our analyses.

Country	Year law passed	Year law came into effect	Type of mandate	Firms affected	Description
Australia	2011	2012	Carbon tax	All organizations	On July 1, 2012, Australia introduced a carbon tax on organizations at $19.60 USD/ton of CO2. The tax was repealed two years later on July 17, 2014.
Australia	2007	2008	Emissions disclosure	Large emitters	Companies with emissions in excess of 125,000 tons of CO2 equivalent/annum are required to report energy usage and GHGE to the Government under the National Greenhouse and Energy Reporting Act.
Bulgaria	2015	2016	Carbon tax	Large emitters that operate in Bulgaria	Large companies with emissions in excess of 150,000 tons of CO2 equivalent/annum are subject to the country's carbon tax.
Canada	2003	2004	Emissions disclosure	Large emitters	Facilities that emit 10 kilotonnes or more of GHG per year are required to disclose to the Canadian Greenhouse Gas Reporting Program.
Chile	2015	2017	Carbon tax	Companies incorporated in Chile	Chile introduced a tax on CO2 emissions from fixed sources (boilers and turbines with a thermal power of 50MW of more).
Colombia	2016	2017	Carbon tax	All companies operating in Colombia	The law subjects Colombian companies to a carbon tax but allows corporate tax deductions from renewable energy sources.
Ireland	2008	2010	Carbon tax	All organizations	Ireland's carbon tax (€20/ton since 2012) covers fossil fuels consumed by homes, offices, vehicles and farms.
Japan	2008	2010	Cap-and-trade	Top 1,400 emitters	The scheme covers the top 1,400 emitters in Tokyo and requires these organizations to cut GHGE by 6%-8%, otherwise the firms must purchase emission allowances to cover excess emissions, or alternatively, invest in renewable energy certificates or offset credits. In the second phase of the scheme (2015-2019), target reductions were increased to 15%-17%.

Japan	2005	2006	Emissions disclosure	Large emitters	The Mandatory Greenhouse Gas Accounting and Reporting System requires large emitters to report GHGE to the Government.
New Zealand	2009	2010	Cap-and-trade	Certain sectors	NZ Emissions Trading Scheme covers forestry, energy, industry and waste. Covered firms must provide one emission unit for every two tons of CO2 equivalent emitted, or buy additional units from the Government.
Singapore	2016	2017	Mandated energy efficiency requirements	Large emitters in Singapore	Large energy consumers (organizations in the industrial and transport sectors that consume >54 terajoules of energy/annum) must monitor and report energy use and GHGE and submit energy efficiency improvement plans to the Government.
South Africa	2017	2018	Emissions disclosure	Large emitters	The National Greenhouse Gas Emission Reporting Regulation was introduced in South Africa to maintain a National Greenhouse Gas Inventory for large emitters.
South Korea	2009	2011	Emissions disclosure	Large emitters	South Korea's Basic Act on Low Carbon Green Growth includes mandatory rules that require energy-intensive companies to report emissions and energy consumption to the Government.
South Korea	2015	2016	Cap-and-trade	Certain sectors	South Korea's national Emissions Trading Scheme covers 525 entities from 23 sectors.
Switzerland	2006	2008	Emissions trading scheme	Large, energy-intensive entities	The Swiss ETS is mandatory for large, energy-intensive entities, while medium-sized entities can participate voluntarily. It covers about 10% of Switzerland's total GHGE.
United States	2008	2009	Emissions disclosure	Large emitters	Mandatory Reporting of Greenhouse Gases Rule covers large emitters of GHG in the United States. Facilities emitting at least 25,000 metric tons of CO2 equivalent/annum must disclose GHG data annually to the EPA.
European Union	2001	2005	Cap-and-trade	Power generators and manufacturing	The European Union Emissions Trading Scheme (EU ETS) operates in every EU nation and is the largest emissions trading scheme in the world. Covered firms are required to disclose facility-level Scope 1 GHG to the regulator.

Table 1 Sample Selection Procedure and Descriptive Statistics

Panel A: Sample Selection

	Firm-year observations
All observations obtained from Trucost for UK and non-UK firms in the years 2004 to 2019	204,768
Less: observations missing data for calculating required variables	(120,536)
	84,232

This panel presents the sample selection procedure.

Panel B: Descriptive Statistics – Full Sample

	Treat (N=5,233)			Control (N=78,999)			
Variable	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.	Diff (t-stat)
Unrepresentative Carbon Disclosure	-0.33	-0.33	0.36	-0.17	0.00	0.33	-33.19***
Unrepresentative Non-Carbon Disclosure	-0.40	-0.34	0.38	-0.21	0.00	0.35	-37.53***
Assets	21.32	21.07	1.92	21.71	21.64	1.92	-14.26***
Revenue	20.70	20.65	1.82	20.94	20.96	1.87	-8.95***
ROA	0.88	0.72	0.74	0.74	0.63	0.60	16.06***
Leverage	0.87	0.45	1.68	0.88	0.48	1.51	-0.29

This panel presents descriptive statistics of the variables (defined in Appendix I), for the treatment and control firms. Two-tailed t-tests are conducted for comparing the means of these variables between the treatment and control group.

Panel C: Industry Distribution – Full Sample

	Treat		Control	
	Freq.	Percent	Freq.	Percent
Communication Services	25	5.43	643	5.24
Consumer Discretionary	79	17.17	1,768	14.42
Consumer Staples	25	5.43	724	5.9
Energy	20	4.35	500	4.08
Financials	62	13.48	1,397	11.39
Health Care	24	5.22	1,202	9.8
Industrials	98	21.3	2,254	18.38
Information Technology	29	6.3	1,510	12.31
Materials	33	7.17	1,140	9.3
Real Estate	55	11.96	763	6.22
Utilities	10	2.17	361	2.94
Total	460	100.00	12,262	100.00

This panel presents the industry distribution.

Panel D: Country Distribution – Control Sample

Country Name	Freq.	Percent
Australia	393	3.21
Austria	39	0.32
Belgium	70	0.57
Bermuda	51	0.42
Bulgaria	3	0.02
Canada	414	3.38
China	1,988	16.21
Croatia	3	0.02
Cyprus	8	0.07
Czechia	6	0.05
Denmark	55	0.45
Estonia	2	0.02
Faroe Islands	1	0.01
Finland	66	0.54
France	271	2.21
Georgia	1	0.01
Germany	252	2.06
Gibraltar	1	0.01
Greece	36	0.29
Hong Kong	547	4.46
Hungary	6	0.05
India	558	4.55
Ireland	63	0.51
Italy	139	1.13
Japan	2,331	19.01
Kazakhstan	2	0.02
Liechtenstein	2	0.02
Lithuania	2	0.02
Luxembourg	38	0.31
Malta	6	0.05
Monaco	8	0.07
Netherlands	97	0.79
New Zealand	55	0.45
Norway	85	0.69
Poland	64	0.52
Portugal	16	0.13
Romania	8	0.07
Russia	59	0.48
Serbia	2	0.02
Slovenia	4	0.03
South Korea	958	7.81
Spain	94	0.77
Sweden	214	1.75
Switzerland	208	1.7
Turkey	90	0.73
USA	2,943	24.00
Ukraine	3	0.02
Total	12,262	100

Table 2: Effect of Mandatory Carbon Reporting on Unrepresentative Carbon Disclosure

	(1)	(2)	(3)	(4)
	Full sample	Full sample	Full sample	Entropy-balanced
	Dependent variable:			
VARIABLES	*Absolute Carbon Disclosure Ratio*	*Weighted Carbon Disclosure Ratio*	*UCD*	*UCD*
Treat × Post	**0.140*** **	**0.229*** **	**-0.088*** **	**-0.084*** **
	(11.844)	**(10.032)**	**(-3.976)**	**(-3.821)**
Post	-0.005	-0.011	0.006	-0.035
	(-0.706)	(-1.176)	(0.614)	(-1.420)
Assets	0.006	0.002	0.004	0.037**
	(1.055)	(0.233)	(0.476)	(2.084)
Revenue	-0.000	0.028***	-0.028***	-0.070***
	(-0.048)	(3.691)	(-4.551)	(-4.828)
ROA	-0.000	-0.001	0.015	0.053**
	(-0.007)	(-1.184)	(1.310)	(2.083)
Leverage	0.000	0.002	-0.001	-0.002
	(0.440)	(1.296)	(-0.964)	(-0.719)
Observations	84,232	84,232	84,232	84,232
Adjusted R^2	0.562	0.728	0.539	0.450
Firm FE, Year FE	Yes	Yes	Yes	Yes

This table presents regression results examining the effect of MCR on unrepresentative carbon disclosure. Variables are defined in Appendix I. Robust t-statistics clustered by firm in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Effect of Mandatory Carbon Reporting on Unrepresentative Non-Carbon Disclosure

	(1)	(2)	(3)	(4)
	Full sample	Full sample	Full	Entropy-balanced
	Dependent variable:			
VARIABLES	*Absolute Non-Carbon Disclosure Ratio*	*Weighted Non-Carbon Disclosure Ratio*	*UNCD*	*UNCD*
Treat × Post	**-0.015*** **	**0.072*** **	**-0.087*** **	**-0.095*** **
	(-2.711)	**(4.636)**	**(-5.539)**	**(-6.135)**
Post	0.004*	0.001	0.003	-0.004
	(1.670)	(0.197)	(0.401)	(-0.219)
Assets	0.0004	-0.002	0.002	0.017
	(0.201)	(-0.203)	(0.252)	(1.388)
Revenue	-0.000	0.011*	-0.012*	-0.035***
	(-0.542)	(1.700)	(-1.858)	(-2.827)
ROA	0.0007	-0.005	0.005	0.013
	(0.288)	(-0.441)	(0.497)	(0.717)
Leverage	-0.000	0.000	-0.000	-0.003
	(-0.185)	(0.173)	(-0.221)	(-1.247)
Observations	84,232	84,232	84,232	84,232
Adjusted R^2	0.403	0.746	0.709	0.713
Firm FE, Year FE	Yes	Yes	Yes	Yes

This table presents regression results examining the effect of MCR on unrepresentative non-carbon disclosure. Variables are defined in Appendix I. Robust t-statistics clustered by firm in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Carbon Performance Moderator

	(1)	(2)	(3)	(4)
	Full sample	Entropy-balanced	Full sample	Entropy-balanced
			Dependent variable:	
VARIABLES	*UCD*	*UCD*	*UNCD*	*UNCD*
Treat × Post × Carbon Performance	**-0.062*** **	**-0.063*** **	**-0.029***	**-0.030***
	(-3.064)	**(-3.195)**	**(-1.767)**	**(-1.798)**
Post	-0.006	-0.048**	-0.001	-0.011
	(-0.582)	(-1.963)	(-0.178)	(-0.694)
Treat × Post	-0.092***	-0.088***	-0.089***	-0.098***
	(-4.393)	(-4.243)	(-5.933)	(-6.542)
Post × Carbon Performance	0.001	0.000	-0.006	-0.006
	(0.153)	(0.075)	(-1.132)	(-1.045)
Assets	0.011	0.050***	0.006	0.023*
	(1.199)	(2.622)	(0.667)	(1.692)
Revenue	-0.040***	-0.086***	-0.019**	-0.042***
	(-4.930)	(-5.116)	(-2.188)	(-2.875)
ROA	0.021	0.063**	0.008	0.014
	(1.395)	(2.093)	(0.574)	(0.653)
Leverage	-0.002	-0.003	-0.000	-0.003
	(-0.974)	(-0.717)	(-0.256)	(-1.199)
Observations	50,934	50,934	50,934	50,934
Adjusted R^2	0.491	0.400	0.685	0.695
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

This table presents regression results examining whether carbon performance moderates the relationship between MCR and unrepresentative disclosure. *Carbon Performance* represents the ranking of carbon performance based on the normalized GHG intensity (sum of Scope 1 and 2 GHG scaled by total revenues) in the first year that MCR is in effect. The worst (highest GHG-intensity) firm in each country-sector is assigned a value of 1 and the best (lowest GHG-intensity) firm in each country-sector is assigned a value of 0. Variables are defined in Appendix I. Robust t-statistics clustered by firm in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Unrepresentative Carbon Disclosure and Carbon Emission

	(1)	(2)	(3)
	Full Sample	Full Sample	Disclosed Scope 3
		Dependent variable:	
VARIABLES	*log(Scope 1+2 GHG)*	*log(Scope 3 GHG)*	*log(Scope 3 GHG)*
Treat × Post × Unrepresentative Carbon Disclosure Decrease	**-0.162***	**-0.044**	**0.032**
	(-1.781)	**(-0.945)**	**(0.662)**
Treat × Post	-0.153***	-0.030	-0.027
	(-2.983)	(-1.035)	(-0.729)
Post × Unrepresentative Carbon Disclosure Decrease	0.021	0.070***	0.008
	(0.796)	(4.759)	(0.357)
Post	0.029	-0.023*	-0.012
	(1.506)	(-1.920)	(-0.608)
Assets	0.220***	0.198***	0.462***
	(5.955)	(6.044)	(7.527)
Revenue	0.712***	0.785***	0.420***
	(18.900)	(22.639)	(6.725)
ROA	0.109**	0.081**	0.289***
	(2.369)	(2.151)	(3.704)
Leverage	0.001	0.000	0.003
	(0.211)	(0.015)	(0.944)
Observations	84,234	84,234	7,237
Adjusted R^2	0.967	0.983	0.992
Firm FE	YES	YES	YES
Year FE	YES	YES	YES

This table reports the results of examining whether firms decrease GHG emissions following the decline in unrepresentative carbon disclosure. The dependent variable for column (1) regression is the log of the sum of scope one and scope two GHG emissions. Columns (2) and (3) use logged scope three GHG as the dependent variable. Regressions in column (1) and (2) are based on the full sample, while regression in column (3) is based on the sample of firms that disclosed scope 3 GHG emission. *Unrepresentative Carbon Disclosure Decrease* is an indicator variable that equals one if a firm's mean *UCD* in the post-period is smaller than in the pre-period, and zero otherwise. Variables are defined in Appendix I. Robust t-statistics clustered by firm in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Panel A: Removing Countries with Concurrent GHG Regulations

	(1)	(2)	(3)	(4)
	Full Sample	Entropy-balanced	Full Sample	Entropy-balanced
		Dependent variable:		
VARIABLES	*UCD*	*UCD*	*UNCD*	*UNCD*
Treat × Post	**-0.078*** **	**-0.078*** **	**-0.083*** **	**-0.095*** **
	(-3.430)	**(-3.491)**	**(-5.126)**	**(-5.861)**
Post	0.002	-0.050	0.012	-0.004
	(0.111)	(-1.619)	(1.178)	(-0.193)
Assets	0.015	0.044**	0.018**	0.023*
	(1.645)	(2.197)	(2.000)	(1.649)
Revenue	-0.034***	-0.077***	-0.015**	-0.039***
	(-4.441)	(-4.695)	(-2.017)	(-2.728)
ROA	0.022	0.059**	0.009	0.015
	(1.509)	(1.988)	(0.705)	(0.675)
Leverage	-0.001	-0.002	-0.001	-0.003
	(-0.650)	(-0.644)	(-0.683)	(-1.334)
Observations	50,623	50,623	50,623	50,623
Adjusted R^2	0.528	0.413	0.698	0.703
Firm FE , Year FE	Yes	Yes	Yes	Yes

This table presents regression results after removing countries with concurrent GHG Regulations and firms regulated under the European Union's Emissions Trading Scheme. Variables are defined in Appendix I. Robust t-statistics clustered by firm in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Panel B: Within-UK Analysis

	(1)	(2)
VARIABLES	Dependent variable: *UCD*	Dependent variable: *UNCD*
Treat × Post	**-0.096** **	**-0.088** **
	(-2.189)	**(-2.477)**
Post	0.007	0.020
	(0.164)	(0.613)
Assets	-0.019*	-0.007
	(-1.841)	(-0.618)
Revenue	-0.012	-0.009
	(-1.514)	(-0.905)
ROA	-0.052*	-0.018
	(-1.693)	(-0.678)
Leverage	-0.001*	-0.001
	(-1.766)	(-1.507)
Observations	7,952	7,952
Adjusted R^2	0.483	0.729
Firm FE, Year FE	Yes	Yes

This table presents the result of the within-UK analysis that employs entropy balancing to match UK firms listed on the Alternative Investment Market and UK firms listed on the Main Market of the LSE. Variables are defined in Appendix I. Robust t-statistics clustered by firm in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: GHG Assurance Protocol

	(1)	(2)	(3)	(4)
	Third-party assurance		EU ETS	
	Dependent variable:			
VARIABLES	*UCD*	*UNCD*	*UCD*	*UNCD*
Treat × Post	**-0.056*** **	**-0.041** **	**-0.075** **	**-0.061** **
	(-2.700)	**(-2.466)**	**(-2.112)**	**(-2.157)**
Post	-0.013	-0.008	-0.041	-0.006
	(-0.891)	(-0.727)	(-1.018)	(-0.189)
Assets	0.001	-0.039***	-0.035	-0.045*
	(0.047)	(-2.603)	(-1.063)	(-1.708)
Revenue	-0.004	0.026**	-0.045*	-0.029
	(-0.231)	(2.187)	(-1.667)	(-1.306)
ROA	-0.011	-0.020	-0.001	-0.008
	(-0.474)	(-0.950)	(-0.021)	(-0.240)
Leverage	0.003*	0.003	0.003	-0.001
	(1.702)	(1.441)	(0.637)	(-0.390)
Observations	18,777	18,777	7,874	7,874
Adjusted R^2	0.584	0.730	0.419	0.657
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

This table presents regression results based on the subsample of firms that have third-party assured Scope 1 and 2 GHG (column 1 and 2) and the subsample of UK and EU firms that are regulated under the EU ETS (column 3 and 4). Variables are defined in Appendix I. Robust t-statistics clustered by firm in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Alternate greenwashing dependent variables

	(1)	(2)	(3)	(4)	(5)	(6)
		Full sample			Entropy-balanced sample	
			Dependent variable:			
VARIABLES	*DECOUPLING*	*VAGUENESS*	*TONE*	*DECOUPLING*	*VAGUENESS*	*TONE*
Treat × Post	**-0.051***	**-0.077****	**-0.088*****	**-0.027**	**-0.060***	**-0.086*****
	(-1.875)	**(-2.517)**	**(-2.964)**	**(-1.029)**	**(-1.902)**	**(-2.842)**
Post	0.004	0.021	0.010	0.008	-0.002	0.033
	(0.176)	(0.813)	(0.426)	(0.332)	(-0.050)	(1.281)
Assets	0.041	0.094**	0.086**	0.047	0.088*	0.051
	(0.995)	(2.541)	(2.067)	(0.815)	(1.747)	(1.359)
Revenue	0.074**	0.019	0.041	0.015	-0.014	0.051
	(2.015)	(0.576)	(1.056)	(0.325)	(-0.363)	(1.371)
ROA	-0.003	0.104**	0.035	0.089	0.118**	-0.002
	(-0.058)	(2.074)	(0.619)	(1.174)	(2.282)	(-0.032)
Leverage	-0.007	-0.003	0.002	-0.001	-0.002	0.004
	(-1.557)	(-0.577)	(0.425)	(-0.116)	(-0.331)	(0.855)
Observations	9,888	9,888	9,888	9,888	9,888	9,888
Adjusted R^2	0.620	0.449	0.476	0.658	0.449	0.533
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

This table reports estimates from Eq. (1) with alternative measures of greenwashing as the dependent variable. Robust standard errors clustered by firm and t-statistics reported in parentheses; ***p<0.01, **p<0.05, *p<0.10. Variables are defined in Appendix I.

For *VAGUENESS*, we construct a dictionary of carbon-specific words that is contextual to answers to the CDP survey questions as below. Stop words are removed and trigrams are generated.
carbon, low_carbon, carbon_footprint, low_carbon_economy, carbon_intensity, reduce_carbon_footprint, carbon_neutral, carbon_tax, reducing_carbon_footprint, carbon_dioxide, carbon_intensive, low_carbon_technology, carbon_credit, carbon_disclosure, low_carbon_society, zero_carbon, carbon_constrained, decarbonization, lower_carbon_footprint, decarbonisation, carbon_free, carbon_sequestration, embodied_carbon, become_carbon_neutral, low_carbon_transition, carbon_offsetting, carbon_economy, emission_carbon_dioxide, carbon_footprinting, carbon_taxation, carbon_emitting, becoming_carbon_neutral, potential_carbon_tax, carbon_capture_sequestration, decarbonise, reduce_carbon_dioxide, carbon_sink, carbon_credentials, decarbonising, achieve_carbon_neutrality, introduction_carbon_tax, minimizing_carbon_footprint, calculation_carbon_footprint, achieve_carbon_neutral, carbon_footprint_calculator, reducing_carbon_dioxide, minimise_carbon_footprint, decarbonize, carbon_intense, decarbonized, achieving_carbon_neutrality, became_carbon_neutral, decarbonizing, smaller_carbon_footprint, greenhouse_gas_emission, greenhouse_gas, reduce_greenhouse_gas, reducing_greenhouse_gas, greenhouse_gas_reduction, greenhouse_gas_ghg, greenhouse_gas_inventory, greenhouse_gas_protocol, greenhouse_gas_emissions, greenhouse_gas_footprint, greenhouse_gas_intensity, greenhouse_effect, greenhouse_gas_reporting, mandatory_greenhouse_gas, greenhouse_gases, greenhouse_gas_regulation, ghg_emission, ghg, ghg_reduction, ghgs, ghg_inventory, ghg_emission_intensity, ghg_intensity, ghg_emission_inventory, ghg_emissions, ghg_accounting, ghg_emitting, mandatory_ghg, emission, co_emission, emissions_trading, emissions_trading_scheme, emissions_inventory, national_greenhouse, proposed_carbon_tax, tonne_carbon_dioxide, emission_per_square, emission_per_cent, hydrocarbon, pfc_emission, fugitive_emission