The Effect of Mandatory Carbon Disclosure Along Global Supply Chains

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May 2024

Abstract

We examine whether and how mandatory carbon disclosure affects the transmission of carbon emissions through a firm's global supply chain. Our analysis uses the 2013 UK carbon disclosure mandate that requires the reporting of Scopes 1 and 2 emissions (from firms' own activities and purchased energy) but not Scope 3 emissions (from firms' value chains). Using data from a major emissions data provider for the corporate sector, we find that affected UK firms exhibit an increase in Scope 3 emissions following the disclosure mandate. Additionally, foreign suppliers of the affected UK firms exhibit a greater increase in Scope 1 emissions relative to suppliers of non-UK firms. The effects are driven by foreign suppliers that do not voluntarily provide carbon disclosures. Consistent with supply-chain relations influencing the extent of carbon outsourcing following the mandate, further analyses reveal that the effect is stronger among foreign suppliers with greater proportions of UK customers, sharing similar functions in production networks, and having fewer environmental protection policies. Our findings highlight the importance of considering corporate supply chains when implementing mandatory carbon disclosures.

Acknowledgments: We appreciate comments from Mark Bradshaw, Mary Ellen Carter, Sandra Chamberland, Kevin Chen, Alper Darendeli, Amy Hutton, Kelvin Law, Kai Li, Kin Lo, Russell Lundholm, Guoman She, Lynn Wang, Xin Zheng, and seminar participants at Boston College, Fudan University, Hong Kong University of Science and Technology, Nanyang Technological University, University of British Columbia, University of Hong Kong, and Shanghai University of Finance and Economics.

1. Introduction

Climate change is a pressing global issue with far-reaching societal implications. To enhance investors' ability to assess climate-related risks, the US SEC has recently mandated climate-related disclosures, which require disclosures of Scope 1 emissions (direct emissions from production) and Scope 2 emissions (indirect emissions from consumption of purchased energy) by large public companies (SEC 2024). The SEC's mandate excludes disclosure of Scope 3 emissions (indirect emissions from upstream and downstream activities of a company's value chain), a particularly contentious issue among the business community (Rosenbaum 2021; Vanderford 2023).[1] Proponents argue that the disclosure of Scope 3 emissions is necessary to fully reveal companies' climate risks and address their full carbon footprints. Critics, however, argue that measuring and disclosing Scope 3 emissions is burdensome and costly and could expose proprietary information about companies' supply chains. Using the 2013 carbon disclosure mandate in the UK, we examine whether and how carbon disclosure regulation that does not mandate reporting of Scope 3 emissions affects the carbon footprints throughout firms' global supply chains.

In 2013, the UK enacted The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013. This act requires publicly listed UK companies to disclose the annual quantity of Scopes 1 and 2 emissions in their annual reports. The disclosure mandate increases the salience and comparability of Scopes 1 and 2 carbon emissions information and is commonly used in research to test the real effects of carbon disclosure regulations. Consistent with the notion that the availability of Scopes 1 and 2 emissions information helps stakeholders benchmark firms'

[1] We use the terms "carbon emissions" and "GHG emissions" interchangeably. The SEC initially proposed to require disclosure of Scope 3 emissions if these emissions are "material." This has sparked debate and raised concerns about potential compliance costs because Scope 3 emissions represent most of the carbon footprints for most companies. According to a 2021 report by the Carbon Disclosure Project (CDP), Scope 3 emissions are on average 11.4 times higher than the sum of Scopes 1 and 2 emissions (CDP 2021).

environmental externalities, Downar et al. (2021) focus on UK firms that operate plants under the EU Exchange Trading Systems and find decreases in their Scope 1 emissions following the mandate. Jouvenot and Krueger (2021) focus on voluntary carbon disclosers and broaden the investigation to include Scope 2 emissions (as a predicted consequence of the disclosure mandate) and Scope 3 emissions (as a placebo test). They conclude that the disclosure mandate leads to a decrease in Scopes 1 and 2 emissions, and has an insignificant effect on Scope 3 emissions.

To reduce the emissions that are required to be disclosed under the mandate (i.e., Scopes 1 and 2), firms can implement a range of strategies across their production resources and business segments. These strategies include, but are not limited to, reducing energy consumption, transitioning from carbon-intensive energy sources to renewable alternatives, investing in energy-efficient equipment, divesting pollutive assets, and/or shifting production to suppliers in unregulated areas. Unlike strategies such as energy savings and renewable alternatives, shifting emissions to new asset owners or suppliers reduces the firm's *reported* emissions but not the *actual* carbon emissions. Downar et al. (2021) and Jouvenot and Krueger (2021) suggest that the effect of the carbon disclosure mandate results from less energy consumption and greater investment in clean technologies, while Ecker and Keeve (2023) provide evidence consistent with asset divestments driving the decreases in Scopes 1 and 2 emissions.

Drawing upon the literature on carbon leakage (Bartram, Hou, and Kim 2022; Dai et al. 2024), we propose that the reduction in the reported Scopes 1 and 2 emissions may also be driven by emissions shifting to suppliers. Production outsourcing, which correlates with emissions outsourcing, is pervasive among UK firms prior to the disclosure mandate.[2] We argue that the

[2] In a report from UK's Energy and Climate Change Committee, the committee chair states "Successive governments have claimed to be cutting climate-changing emissions, but in fact a lot of pollution has simply been outsourced overseas."(https://committees.parliament.uk/work/2419/consumptionbased-emissions-reporting/news/178810/government-should-be-open-about-outsourced-emissions-according-to-committee/)

disclosure mandate, by enabling stakeholders to benchmark firms' emissions, may incentivize affected firms to further shift production abroad to cut reported emissions.[3] Thus, our first hypothesis predicts that Scope 3 emissions of affected UK firms increase following the UK carbon disclosure mandate.[4]

Several factors can work against our prediction. First, the increased monitoring of a firm's emissions following the disclosure mandate may transmit a positive effect along a firm's supply chain. Bolton and Kacperczyk (2021a) find that the UK carbon disclosure mandate improves disclosure practices of peer firms in countries with geographic and economic proximity to the UK. Second, the disclosure mandate may enhance firms' awareness of climate-related risks. Heightened awareness may encourage firms to monitor suppliers to improve environmental practices (Dai, Liang, and Ng 2021). Third, emissions shifting is more difficult across firms than within a firm (Ben-David et al. 2021). Suppliers may resist increases in their own emissions to avoid jeopardizing support from other stakeholders (e.g., regulators, employees, and investors).

If the affected UK firms outsource emissions to their suppliers, we also expect that Scope 1 emissions of their foreign suppliers ("exposed suppliers") should increase relative to suppliers that have only non-UK customers ("benchmark suppliers"). We focus on foreign suppliers because domestic suppliers are subject to the disclosure mandate. In addition, we expect that non-UK suppliers that do not provide carbon disclosures are more likely to receive the outsourced emissions because they are less subject to the public scrutiny of their emissions. Thus, our second

[3] For example, firms may outsource production and services rather than discontinue these activities, which are more harmful to profits. They may also sell gas power plants to suppliers, rather than retrofit these plants. We focus on emissions shifting to a firm's foreign suppliers rather than subsidiaries, because the reported Scope 1 emissions encompass a firm's global operations.

[4] Due to data availability, we examine only upstream Scope 3 emissions, which are associated with purchased materials. Throughout the paper, Scope 3 emissions refer to *upstream* Scope 3 emissions.

hypothesis predicts that exposed suppliers that do not provide carbon disclosures have an increase in Scope 1 emissions following the UK carbon disclosure mandate, relative to other suppliers.

Our emissions data come from S&P Trucost, a widely used commercial provider of corporate carbon emission data (Azar et al. 2021; Bolton and Kacperczyk 2021b; Cohen, Kadach, and Ormazabal 2023). Trucost collects carbon emissions from publicly available sources, such as annual financial reports, sustainability reports, corporate websites, and CDP surveys. If a covered firm does not publicly disclose its carbon emissions, Trucost estimates the emissions based on its environmentally extended input/output profiling model. It also conducts an annual engagement with covered companies to provide the opportunity to verify their environmental performance (Trucost 2020). Unlike Scopes 1 and 2 emissions, which are straightforward to measure, Scope 3 emissions are hard to measure and rarely disclosed by firms. Aswani et al. (2024) argue that the vendor-estimated emissions appear rather naïve because most of the variation is associated with firm size, growth, industry membership, and time. To address this concern, we include firm and year fixed effects that control for time-invariant firm characteristics and time-varying macro conditions. Our analysis of suppliers' emissions further mitigates this concern because Scope 1 emission data are less prone to vendor-estimation errors.[5]

We test our first hypothesis using a difference-in-differences research design that compares the changes in Scope 3 emissions among treatment firms with changes among two benchmark samples, during the five years before and after the enactment of the UK carbon disclosure mandate. Our treatment sample consists of UK firms mandatorily adopting the disclosure regulation. We

[5] Busch, Johnson, and Pioch (2020) find that Scope 1 data are highly consistent between data providers with an average correlation coefficient of 0.97. In contrast, Scope 3 data are less frequently provided by data providers and less consistently estimated. As noted in Cohen et al. (2023), it is unclear why Trucost would systematically overestimating or underestimating emissions. In the absence of intentional bias, the estimation error of Trucost should be randomly distributed around zero.

exclude voluntary disclosure firms in our main analyses because they are subject to self-selection and likely possess different incentives and strategies for carbon disclosures and reduction. Our two benchmark samples consist of: 1) firms that are incorporated in the European Economic Area (EEA) countries and listed in the same set of stock exchanges as the treatment firms, matched by an entropy balancing technique, which we term "EB benchmark firms," and 2) global non-UK firms that are propensity-score-matched (PSM) with the treatment firms, which we term "PSM benchmark firms." To ensure that our results are not driven by changes in the coverage of Trucost (Bolton and Kacperczyk 2021b), we use a balanced sample that requires each sample firm to have at least one year of observation in both the pre- and post-mandate periods.

We find that, relative to benchmark firms, treatment firms increase Scope 3 emissions following the UK carbon disclosure mandate. The result is robust to alternative event windows and regression specifications. Consistent with the parallel trends assumption, we find that the treatment firms begin to increase Scope 3 emissions relative to the benchmark firms after the mandate, and show similar trends in Scope 3 emissions before the mandate. We further find that treatment firms exhibit a decrease in Scope 1 emissions but little change in the total emissions, suggesting that the increase in Scope 3 emissions offsets the decrease in Scope 1 emissions.

We test our second hypothesis using a similar difference-in-differences design during the same event window. Consistent with our second hypothesis, we find that non-UK suppliers who have at least one UK customer and do not voluntarily provide emissions data ("exposed suppliers") have a greater increase in Scope 1 emissions than non-UK suppliers who do not have any UK customers ("benchmark suppliers") following the disclosure mandate.[6] The results hold for

[6] This analysis focuses on publicly listed suppliers due to the data availability of private firms. To the extent that affected UK firms are more likely to outsource emissions to private suppliers, we underestimate the impact of the carbon outsourcing.

alternative benchmark samples, event windows and standard error clustering schemes, and validate the parallel trends assumption.

Next, we explore factors that may impact customer firms' and suppliers' incentives, bargaining power, and opportunities. We expect that the documented effect on the customer firms' Scope 3 emissions is stronger among UK firms with higher emission intensity before the mandate, a higher proportion of private suppliers or foreign suppliers sharing similar functions in the firm's production network ("horizontally linked"), and weaker environmental protection policies. We reason that these firms face more pressure to reduce emissions, have greater power to influence suppliers' emissions decisions, and are less constrained to outsource emissions. Our findings confirm these expectations. Consistent with our expectation that the extent to which suppliers are willing to cooperate with the customers' carbon outsourcing depends on their bargaining power, we find that the effect on suppliers' Scope 1 emissions is more pronounced among foreign suppliers with a greater proportion of UK customers, smaller firm size, a higher proportion of horizontally linked UK customers, and fewer environmental protection policies.

Last, we examine asset divestments, a potential channel for UK firms to outsource emissions to other entities. We find that compared to benchmark firms, only the affected UK firms with a greater proportion of private suppliers or horizontally linked foreign suppliers experience an increase in the likelihood of asset divestments after the disclosure mandate. In additional analyses, we find little changes in the Scope 3 emissions of voluntary disclosers among the affected UK firms and the Scope 1 emissions of voluntary disclosers among the exposed suppliers.

We contribute to the literature in several ways. First, we document the effects of mandatory carbon disclosure on unreported emissions and provide policy implications. Studies suggest that firms improve environmental and social performance following sustainability disclosure

regulations (Christensen et al. 2017; Chen, Hung, and Wang 2018; Fiechter, Hitz, and Lehmann 2022; Tomar 2023). Unlike a broad sustainability disclosure mandate that lacks standardized reporting requirements, the UK carbon disclosure mandate requires specific emission measures to facilitate comparison and benchmarking. Prior studies show that this disclosure mandate reduces Scopes 1 and 2 emissions and provide important insights into potential mechanisms of the changes (Downar et al. 2021; Jouvenot and Krueger 2021; Ecker and Reeve 2023). We extend these studies by providing evidence that carbon outsourcing, an alternative strategy for reducing direct emissions, increases unreported Scope 3 emissions following the disclosure mandate and neutralizes the impact on firms' overall carbon footprints.[7]

Our findings speak to the importance of considering supply chains when designing and implementing carbon disclosure regulations. Given the urgency of climate risks, regulators worldwide are taking steps to require or encourage climate-related disclosures.[8] Our study reveals the cost of mandating only direct emissions in a world where regulators set the disclosure requirements in their own jurisdictions in isolation. We also show that voluntary carbon disclosures by foreign suppliers mitigate outsourcing activities. Thus, while mandating Scope 3 emission disclosure might be costly and involve high estimation risks, global cooperation in mandating disclosures of direct emissions for all corporations along the supply chains can serve as

[7] Prior studies are unable to provide such evidence due to the lack of Scope 3 emissions data. We tackle this challenge by using Trucost estimated Scope 3 emission data. Although the vendor-estimated Scope 3 emissions data can be noisy, they serve a crucial initial measure in assessing carbon footprints in firms' supply chains. Our study suggests several ways to mitigate the measurement errors and corroborate the inference (e.g., including firm fixed effects, using a balanced sample, and corroborating with Scope 1 emissions from suppliers).

[8] In June 2023, the International Sustainability Standard Board (ISSB) published an inaugural set of two standards, IFRS S1 (General Requirements for Disclosure of Sustainability-related Financial Information) and IFRS S2 (Climate-related Disclosures). On July 25 of the same year, International Organization of Securities Commissions (IOSCO) endorsed the ISSB standards and called on its 130 member jurisdictions, which regulate more than 95% of the world's financial markets, to consider ways in which they might adopt these standards.

an alternative way to curb carbon outsourcing (Bolton et al. 2021; Mahieux, Sapra, and Zhang 2023).

Second, our study complements the growing literature that examines the effect of sustainability information on supply-chain contracting. Darendeli et al. (2022) find that firms are less likely to contract with low-CSR suppliers after an exogenous change in CSR rating coverage that reveals their type. She (2022) documents that suppliers' human rights performance improves following the California mandate that requires firms to disclose their due diligence in ensuring suppliers' compliance with labor laws. Cho et al. (2023) show a reduction in suppliers' Scope 1 emissions after one of their major customers begins disclosing Scope 3 emissions. Lu et al. (2023) suggest that firms strategically select new suppliers from countries with opaque ESG reporting environments following the adoption of mandatory ESG disclosures worldwide. Our study differs by documenting the impact of mandating firms' carbon disclosures on the emission performance of their suppliers, and the specific mechanisms of this impact.

Finally, we add to the literature that examines carbon leakage in response to environmental regulations and policies. Most of these studies focus on within-firm carbon leakage and suggest that firms transfer emissions to unregulated facilities (Yang Muller, and Liang 2021; Bartram et al. 2022; Jiang 2023). The evidence on carbon leakage across firms, however, is relatively weak. Ben-David et al. (2021) find little evidence that carbon leakage occurs among firms' foreign suppliers. Using transaction-level import information for US firms, Dai et al. (2024) document a substitutional relationship between a firm's Scopes 1 and 3 emissions following shocks to regulatory stringency. Our study extends this literature by documenting that UK firms shift emissions following the carbon disclosure mandate and by demonstrating the changes in their suppliers' Scope 1 emissions.

2. Institutional background and hypothesis development

2.1 Institutional background

The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013 became effective on October 1, 2013. The act requires UK-incorporated companies listed on the Main Market of the London Stock Exchange, an exchange in an EEA country, the New York Stock Exchange, or Nasdaq to report carbon emissions for fiscal years ending on or after September 30, 2013 in the annual report (as part of the Directors' Report).[9] The affected firms are required to report annual carbon emissions in metric tonnes of carbon dioxide equivalent, along with a ratio expressing carbon emissions in relation to the company's activities, such as sales or assets.

The disclosure requirements are formulated using the GHG Protocol Corporate Accounting and Reporting Standard (GHG Protocol), an internationally recognized framework for reporting (DEFRA 2012a). The UK government further issued guidance specifying acceptable methodologies to measure carbon emissions (e.g., Standard 14064-1 of the International Organization for Standardization), the reporting boundary (global carbon emission for the entire organization), and the covered period (the 12 months corresponding to the firm's fiscal year). In addition, as part of the Directors' Report, the disclosures of carbon emissions must be approved by the board of directors and reviewed by auditors. These procedures safeguard the carbon disclosure quality (Downar et al. 2021; Jouvenot and Krueger 2021).

The disclosure mandate requires affected companies to report their Scopes 1 and 2 emissions but not Scope 3 emissions. Scope 1 emissions are the direct emissions generated by a firm from

[9] The disclosure mandate exempts small firms that meet at least two of the following criteria: 1) a turnover lower than GBP 6.5 million, 2) a balance sheet total lower than GBP 3.26 million, and 3) an average number of employees lower than 50. Since the companies listed on the main market of the London Stock Exchange are predominantly large and medium-sized companies, very few firms approach these thresholds.

owned or controlled sources, e.g., combustion of fuels in stationary buildings and equipment and vehicles. Scope 2 emissions relate to emissions generated from purchased electricity, heat, steam, or cooling that are consumed within the boundary of the firm. Scopes 1 and 2 emissions are straightforward to measure and report (Bolton and Kacperczyk 2021b; Lu, Serafeim, and Toffel 2022), because they can be determined by invoices for fuels consumed (for Scope 1) and electricity purchased (for Scope 2).[10] Appendix A presents excerpts from the annual report of one of our treatment firms, Norcros, following the adoption of the UK carbon disclosure mandate.

Scope 3 emissions cover the indirect emissions outside a firm's boundary, which mainly relate to the upstream and downstream emissions embodied in the goods and services in a firm's supply chain. According to the consultation report from the UK government (DEFRA 2012b), 86% (1,730) of the respondents support the mandatory inclusion of some Scope 3 emissions disclosure. However, more than 1,600 of the supporters are individuals, prompted by the Christian Aid campaign. Among institutions (e.g., companies, institutional investors, and trade associations), only 20% support the inclusion. The supporters note that Scope 3 disclosure is necessary to understand company activities and can prevent companies from reducing their emissions by outsourcing. Opponents of the Scope 3 disclosure, however, raise the following main concerns: 1) inconsistent methodologies, 2) collation costs, 3) inaccuracy, 4) difficulty in gathering information, and 5) double counting. In the end, the UK government decided not to require reporting of Scope 3 emissions because doing so could impose excessive costs on businesses.

Note that the likelihood of mandatory Scope 3 emission disclosure is low during our sample period, which ends in 2019 (five years after the disclosure mandate). In response to the passage of

[10] According to the GHG protocol, Scope 1 emissions are calculated based on the purchased quantities of commercial fuels using published emission factors, and Scope 2 primarily from metered electricity consumption and supplier-specific, local grid, or other published emission factors (GHG Protocol 2004).

IFRS S2 in June 2023, the UK government called for evidence on Scope 3 emissions in the UK reporting landscape in October 2023 (DESNZ 2023). Consistent with the low threat of Scope 3 disclosure, in additional analysis (untabulated) we find that less than 2% of the affected UK firms disclose Scope 3 emissions in the year prior to and the year following the disclosure mandate.

2.2 Hypothesis development

Studies suggest that the UK carbon disclosure mandate improves transparency and enhances stakeholder monitoring, thereby leading to a reduction in the reported emissions of the affected firms (Downar et al. 2021; Jouvenot and Krueger 2021). Testing the mechanisms through which Scopes 1 and 2 emissions reduce, they conclude that UK firms use less energy and invest in clean technologies after the UK mandate.

Decarbonization measures, however, can be costly (McKinsey & Company 2009). While firms have various options of cutting direct emissions, carbon outsourcing has been a popular choice due to cost considerations (Levinson 2023).[11] For example, firms may cut direct emissions by discontinuing the production of certain goods, but they will lose revenues associated with these goods. Instead, they can outsource the production to low-cost suppliers that are subject to less stringent environmental regulation and scrutiny. Consistent with this view, the literature that investigates carbon leakage suggests that local environmental transparency and/or enforcement regulations can lead to unintended consequences including carbon outsourcing and production allocation to unregulated areas (Bartram et al. 2022; Jiang 2023; Dai et al. 2024).

We posit that the increased stakeholder monitoring associated with the carbon disclosure mandate may motivate firms to outsource emissions to their suppliers in unregulated areas, leading to a diminished impact of the disclosure mandate on firms' total carbon footprints. Specifically,

[11] Also see "You've heard of Outsourced Jobs, but Outsourced Pollution? It is Real, and Tough to Tally Up" https://www.nytimes.com/2018/09/04/climate/outsourcing-carbon-emissions.html).

firms can strategically leverage their supply chain network and take advantage of the regulatory differences across countries to shift emissions abroad. This allows them to move emissions out of the radar of government regulations and stakeholder monitoring. While estimates of Scope 3 emissions may be available to market participants by subscribing to the data from ESG data providers, the information on these estimates can be difficult to access and understand. The market forces may only apply to benchmarking Scope 1 emissions because Scope 3 emissions are not under firms' control and are more difficult to interpret than Scope 1 emissions. By shifting the emissions from their own operations (Scope 1 emissions) to those of suppliers (Scope 3 emissions), firms can reduce the emissions that are required to be reported, but this comes at the expense of the undisclosed Scope 3 emissions. Consequently, our first hypothesis is as follows:

Hypothesis 1: Scope 3 emissions of UK customer firms increase following the UK carbon disclosure mandate.

There are also reasons why we may not find an increase in Scope 3 emissions in affected UK firms following the UK carbon disclosure mandate. First, the requirement to disclose carbon emissions may enhance firms' supply chains because stakeholder monitoring becomes more intensive. Bolton and Kacperczyk (2021a) document that the disclosure mandate spills over to emission reductions among peer firms in other countries. Second, the requirement may improve firms' awareness of climate-related risks and incentivize them to monitor their suppliers. Dai et al. (2021) suggest that socially responsible customers motivate comparable behaviors among their suppliers. Third, emissions shifting differs from the expense shifting documented in the literature (McVay 2006), because it involves changes in firms' operations and cooperation with other firms (i.e., suppliers). Thus, suppliers may be mindful about accepting the outsourcing of environmentally detrimental production that significantly increases their own emissions.

If the affected UK firms outsource emissions to their suppliers, Scope 1 emissions of their suppliers ("exposed suppliers") should increase relative to suppliers that have only non-UK customers ("benchmark suppliers"). We focus on a firm's suppliers rather than subsidiaries because the reported Scope 1 emissions encompass a firm's global operations. Our prediction pertains to the relative change in Scope 1 emissions of the exposed suppliers compared with the benchmark suppliers, because all non-UK suppliers, although not subject to mandatory carbon disclosures, face pressure from institutional investors and other stakeholders to cut Scope 1 emissions (Azar et al. 2021; Cohen et al. 2023). In addition, we expect that non-UK suppliers that do not provide carbon disclosures are more likely to receive the outsourced emissions. This is because firms self select into voluntarily disclosing Scope 1 emissions due to considerations of pressures from their stakeholders (e.g., regulators, employees, customers, and investors). Thus, non-UK suppliers that voluntarily disclose Scope 1 emissions would likely resist an increase in their emissions to avoid jeopardizing support from these stakeholders.

Our second hypothesis is as follows:

Hypothesis 2: Scope 1 emissions of exposed suppliers that do not provide carbon disclosures increase following the UK carbon disclosure mandate, relative to other suppliers.

We caution, however, that we cannot observe the amount of carbon outsourcing from each customer to its specific suppliers. There is also a lack of data on changes in emissions of private firms. The extent of carbon outsourcing depends on the incentives and bargaining power of UK customers and their suppliers. Recent studies suggest that firms tend to divest pollutive plants to private, non-ESG-rated, and with supply chain relationships or joint ventures (Duchin, Gao, and Xu 2022). To the extent that affected UK firms are more likely to outsource emissions to private suppliers, we may not be able to detect the changes in Scope 1 emissions among their public

suppliers. In additional analyses, we explore the factors that may affect the incentives, bargaining power, and opportunities of the customers and suppliers.

3. Tests of Hypothesis 1

3.1 Sample

The UK carbon disclosure mandate requires UK-incorporated companies whose equity shares are listed on the Main Market of the London Stock Exchange, an exchange in an EEA country, the New York Stock Exchange, or Nasdaq to disclose their Scopes 1 and 2 emissions for fiscal years ending on or after September 30, 2013. To test our first hypothesis regarding the impact of the disclosure mandate on affected UK firms' Scope 3 emissions, we focus on the last five years before ([-5, -1] years) and the first five years after ([1, 5] years) the disclosure mandate. The pre- and post- UK mandate periods consist of firm-years with fiscal years ending from September 30, 2008 to August 31, 2013 and from September 30, 2014 to August 31, 2019, respectively.

We start with the universe of firms in S&P's Global Vantage (non-U.S. firms) and Compustat (U.S. firms). We exclude firms that are not listed in the required stock exchanges, are in financial industries (NAICS2=52) or public administrations (NAICS2=92, 99), and have missing control variables. We then merge the data with Trucost to obtain emissions data. Because voluntary adopters may use different reporting methodologies before the mandate, and are often regarded as a non-random group subject to potential self-selection bias, we focus on firms that do not voluntarily report emissions data in our main analysis. To enhance the comparability of treatment and benchmark samples, we remove 1) treatment and benchmark firms that voluntarily disclose Scope 1 emissions for at least three years during the pre-UK mandate period, and 2) additional

firm-years with voluntary carbon emission disclosures.[12] Last, Trucost coverage vastly increased in 2015 (Bolton and Kacperczyk 2021b). To ensure that the changes in carbon emissions of treatment firms around the disclosure mandate are not due to changes in the sample composition over time, we require a sample firm to have at least one observation in each of the pre- and post-UK mandate period.

We include two benchmark samples to control for the impact of potentially confounding concurrent events. Our first benchmark sample, EB benchmark firms, consists of firms incorporated in the EEA countries and listed in the same set of stock exchanges as the treatment firms, matched by an entropy balancing technique.[13] We perform the entropy balancing year by year based on the first and second moments of the covariates and set the tolerance level at 0.01 (Hainmueller 2012; McMullin and Schonberger 2022). Our second benchmark sample, PSM benchmark firms, consists of global non-UK firms that are propensity-score-matched based on characteristics that typify the treatment firms. These procedures yield 229 treatment firms (2,011 firm-years), 271 EB benchmark firms (2,148 firm-years), and 229 PSM benchmark firms (1,836 firm-years). Table 1 Panel A describes the sample selection. We refer to the sample including the treatment firms and EB benchmark firms as the "EB sample" and the sample including treatment firms and PSM benchmark firms as the "PSM sample."

Each of the two benchmarks has its advantages and limitations. The EB benchmark mitigates the potential confounding effect of other EU regulations such as the EU Emissions Trading Scheme (ETS). In particular, the implementation of the disclosure mandate happened in the same

[12] We define a firm-year as voluntary disclosure of Scope 1 emissions if Trucost item "di_319403_text" (i.e., Scope 1 carbon disclosure) states that the Scope 1 emission is: 1) "Exact Value from Annual Report/10K/Financial Accounts Disclosure," 2) "Exact Value from CDP," 3) "Exact Value from Environmental/CSR," or 4) "Exact Value from personal communication." Our results are qualitatively the same if we exclude the last category, which covers only four firm-years among our sample firm-years.

[13] The EEA countries include 27 EU countries and Iceland, Liechtenstein, and Norway (see https://www.gov.uk/eu-eea#:~:text=The%20European%20Economic%20Area%20(%20EEA,part%20of%20the%20single%20market).

year as the transition of the EU ETS to its third period from 2013 to 2020 (Downar et al. 2021). However, the small number of EAA firms in our sample precludes the use of the PSM procedure to identify comparable firms with the treatment firms. Thus, we use an entropy balancing technique, which eliminates differences in observable covariates across treatment and benchmark firms without reducing the sample size. While PSM procedure is able to identify from a larger pool of non-UK firms the benchmark sample that is more comparable to the treatment sample in firm characteristics, it may be potentially influenced by unspecified cross-country differences. Because of these advantages and limitations, we draw our conclusions based on the corroborating evidence from both benchmark samples.

Table 1 Panel B reports the sample distribution by event years. By construction, both treatment and benchmark samples display a comparable number of observations between pre- and post- UK mandate periods. Panel C reports the sample distribution by economy. Panel D presents the sample distribution by industry. It shows that the treatment sample and two benchmark samples are generally comparable in industry distribution, with manufacturing (NAICS2=31, 32, 33) and information (NAICS2=51) being the top two industry segments.

3.2 Descriptive statistics

Our emissions data come from S&P Trucost, which provides broad coverage and is widely used by international organizations (e.g., United Nations Environment Program Finance Initiative) and prior studies (Azar et al. 2021; Bolton and Kacperczyk 2021b; Cohen et al. 2023). Trucost collects corporate carbon emission data from publicly available sources including corporate financial and nonfinancial reports, company websites, and CDP surveys. If a firm does not disclose emissions data, Trucost uses an environmentally extended input–output (EEI-O) model to estimate environmental impacts for a company's own operations and across its global supply chain. The

model combines industry-specific environmental impact data with quantitative macroeconomic data on the flow of goods and services between different sectors in the economy. "Trucost then conducts an annual engagement with every company, providing the opportunity to verify environmental performance and provide additional information." (Trucost 2020, page 4). During our sample period, Scope 3 emissions are limited to the upstream emissions, which are estimated from the expenditures that a firm uses to purchase its inputs from all sectors.

Table 2 presents the descriptive statistics of the treatment and benchmark samples in the pre-UK mandate period and post-UK mandate period. Appendix B reports variable definitions and Appendix C reports the PSM estimation results. Because the distribution of emissions volumes is highly skewed, we use the natural logarithm of emissions in metric tons as the main measure in our regression and use the natural logarithm of emission intensity in a robustness check. We winsorize the raw value of emissions and all other continuous variables at the top and bottom 1% of their respective distributions to reduce the influence of extreme values. We report the pre-balancing statistics for the EB benchmark to illustrate the differences between treatment and benchmark firms before performing the entropy balancing. We find that the average Scope 3 emission volume increases for treatment firms, but decreases for EB benchmark firms and have little change for PSM benchmark firms. In contrast, both treatment firms and EB benchmark firms, but not PSM benchmark firms, experience a reduction in the average Scope 1 emission volume

3.3 Mandatory carbon disclosure and UK firms' Scope 3 emissions

We test our first hypothesis regarding the changes in Scope 3 emissions of the treatment firms using the following difference-in-differences regression models:

$$Ln(Scope3)_{i,t} = \beta_0 + \beta_1 Post_{i,t} \times Treat_i + \sum \beta_i Control\ Variables + Firm\ FE + Year\ FE + \varepsilon_{it}, \quad (1)$$

where *Ln(Scope3)* is the natural logarithm of Scope 3 emission volume. *Post* is a dummy variable indicating fiscal years ending on or after September 30, 2014. *Treat* is a dummy variable indicating treatment firms. We suppress the coefficient on *Treat* and *Post* because our model includes firm fixed effects and year fixed effects and there is no within-firm variation of *Treat* and no within-year variation of *Post*. Our first hypothesis predicts a positive coefficient on the interaction term *Post*×*Treat*. We include several variables used in prior studies to explain Scope 3 emissions, including Scope 1 emissions (*Ln(Scope1)*), firm size (*Ln(Assets)*), growth opportunities (*TobinQ*), leverage (*Leverage*), profitability (*ROA*), sales growth (*SaleGrow*), tangible assets (*Taingibility*), and R&D expenditures (*R&D*). We use robust standard errors clustered by firm to evaluate the significance of regression coefficients in all our analyses.

Table 3 Panel A presents the regression estimates. Columns (1)–(3) and (4)–(6) present changes in Scope 3 emissions following the disclosure mandate for the EB and PSM samples, respectively. Columns (1) and (4) report the baseline model where we include the main effects of *Post* and *Treat* and controls for industry fixed effects. Columns (2) and (5) report the full regression model including firm and year fixed effects. Consistent with our hypothesis, the coefficient on *Post*×*Treat* is significant and positive in these models, suggesting that treatment firms experience a greater increase in Scope 3 emissions than benchmark firms after the disclosure mandate. The effect is also economically significant. Columns (2) and (5) indicate that after controlling for firm characteristics, firm- and year- fixed effects, relative to changes in Scope 3 emissions in the benchmark firms in the EAA region or the global market, treatment firms experience an incremental increase in Scope 3 emissions by 15.3% and 12.2%, respectively.

Columns (3) and (6) assess the parallel trends assumption underlying our difference-in-differences regression estimation, i.e., without the treatment effects, the average change in the

Scope 3 emissions should have been the same for the treatment and benchmark groups. Following Bertrand and Mullainathan (2003), we replace the *Post* indicator with nine year indicators for *Year -5* to *Year -2* and *Year 1* to *Year 5*, with *Year -1* being the benchmark year. Columns (3) and (6) show that the coefficients on the interaction terms *Year Indicator*×*Treat* are all insignificantly different from zero during the pre-UK mandate period. This result indicates that there is no increasing trend with respect to Scope 3 emissions before the mandate. In contrast, the coefficients become significantly positive from *Year 2* and *Year 1* onward in Columns (3) and (6), respectively, suggesting that treatment firms experience larger increases in Scope 3 emissions than benchmark firms after the disclosure mandate. These results support the parallel trends assumption.

To corroborate our inference, we rerun our analysis using alternative emission measures. Columns (1) and (2) of Table 3 Panel B report changes in Scope 1 emissions after the disclosure mandate. Consistent with the findings in Downar et al. (2021) and Jouvenot and Krueger (2021), both columns show a significantly negative coefficient on *Post*×*Treat*, indicating that relative to benchmark firms, the treatment firms experience a greater decrease in Scopes 1 emissions after the mandate. Columns (3) and (4) use the total volume of carbon emissions as the dependent variable and report that the coefficient on *Post*×*Treat* is insignificant at conventional levels, suggesting that the decrease in Scope 1 emissions is offset by the increase in Scope 3 emissions in the treatment sample. Columns (5)–(6) and (7)–(8) present changes in the intensity of Scopes 3 and 1 emissions, respectively. We observe that treatment firms experience a significantly greater increase in Scope 3 emission intensity than benchmark firms in the EB sample, but a significantly greater decrease in Scope 1 emission intensity than benchmark firms in both the EB and PSM samples.

We also conduct a set of robustness tests. First, we examine changes in Scope 3 emissions during alternative event windows, including [-5, -1] versus [0, 4] and [-3, -1] versus [1, 3]. Second,

we adjust the standard errors using country clusters. Last, we conduct a placebo test by setting year 2010 as the pseudo carbon disclosure mandating year and 2007–2012 as the six-year pseudo-event window. We re-run the analysis for these tests and report the results in Panel C of Table 3. The panel shows that our findings in Table 3 Panel A continue to hold using the alternative sample periods and regression specifications, but not the placebo event window. Overall, these results suggest that UK firms subject to the disclosure mandate increase their Scope 3 emissions but reduce Scope 1 emissions, possibly due to outsourcing emissions to suppliers.

4. Tests of Hypothesis 2

4.1 Supplier sample and data

This section describes the procedures to build the supplier sample for testing our second hypothesis. We present the sample selection procedures in Table 4 Panel A. Similar to the sample selection for customer firms (discussed in Section 3.1), we start from the universe of firms in the Global Vantage and Compustat from 2008 to 2019. We then remove firms with missing industry identifications, firms in financial industries or public administration, firms without the required control variables, firms without Scope 1 emissions during the event window, and firms incorporated in the UK.

Next, we exclude firms that voluntarily disclose Scope 1 emissions every year during the [-2, 2] years, and additional firm years with voluntary Scope 1 disclosure during the [-5, 5] years around the UK carbon disclosure mandate. To mitigate the concern about the changes in the coverage of Trucost, we require a non-UK supplier to have at least one year of Scope 1 emission data both before and after the mandate. Finally, using the customer-supplier relationship information from the FactSet Revere Supply Chain databases, we remove non-UK suppliers that begin having UK customers only after *Year 2*, and partition the remaining non-UK suppliers into

exposed suppliers and benchmark suppliers. Our sample of exposed suppliers consist of 296 non-UK suppliers with at least one UK customer during the first three years since the disclosure mandate ([0, 2] years). Our sample of EB benchmark suppliers consists of 1,797 non-UK suppliers without any UK customers during the post-UK mandate period and is matched with the exposed suppliers using an entropy balancing technique. Similar to our analysis of UK customer firms, we also use a PSM procedure to identify 283 PSM benchmark suppliers (out of the full sample of 1,797 non-UK suppliers without any UK customers). Appendix C reports the PSM procedure.

Table 4 Panel B reports the non-UK suppliers by event years. Both the exposed and benchmark supplier samples display a balanced number of observations between pre- and post-mandate periods. Panel C presents the supplier distribution by economy. Panel D presents the supplier distribution by industry. We observe that exposed and benchmark suppliers are largely comparable in industry distribution and that manufacturing (NAICS2=31, 32, 33) and information (NAICS2=51) are the top two industry segments.

Table 5 presents the descriptive statistics of the exposed suppliers and benchmark suppliers in the pre- and post-UK disclosure mandate periods. Consistent with a global trend in reducing Scope 1 emissions, we find a decrease in the average Scope 1 emission volume and intensity for the EB benchmark suppliers, and the average Scope 1 emission intensity for the PSM benchmark suppliers.

4.2 Mandatory carbon disclosure and Scope 1 emissions of exposed non-UK suppliers

We test our second hypothesis by rerunning Equation (1) after replacing *Treat* with *Exposed_Suppliers,* an indicator variable for the exposed suppliers. Table 6 Panel A reports the regression results. Columns (1)–(3) and (4)–(6) present changes in Scope 1 emissions following the UK mandate for the EB and PSM supplier samples, respectively. Columns (1)–(2) and (4)–(5)

report a significantly positive coefficient on *Post×Exposed_Suppliers*, suggesting that exposed suppliers experience a greater increase in Scope 1 emissions than benchmark suppliers after the mandate. Columns (3) and (6) assess the parallel trends assumption. We replace the *Post* indicator with nine year indicators for *Year -5* to *Year -2* and *Year 1* to *Year 5*, with *Year -1* being the benchmark year. Columns (3) and (6) show that the coefficients on the interaction terms *Year Indicator×Exposed_Suppliers* are all insignificantly different from zero during the pre-UK mandate period. This result indicates that there is no increasing trend with respect to Scope 1 emissions before the mandate. In contrast, the coefficients become significantly positive from *Year 1* onward, suggesting that exposed suppliers experience larger increases in Scope 1 emissions than benchmark suppliers after the mandate. These results support the parallel trends assumption.

Table 6 Panel B reports changes in the total volume of carbon emissions and the intensity of Scope 1 emissions. Columns (1)–(2) use the logarithm value of the total volume of carbon emissions as the dependent variable and report a positive coefficient on *Post×Exposed_Suppliers* in both EB and PSM supplier samples (significant at 10% level). These results indicate that relative to benchmark suppliers, exposed suppliers experience a greater increase in total carbon emissions. Columns (3)–(4) show that exposed suppliers experience a greater increase in the intensity of Scope 1 emissions than benchmark suppliers in both EB and PSM supplier samples.

Table 6 Panel C reports the results of several robustness tests for our main result in Panel A, including 1) alternative event windows, [-5, -1] versus [0, 4] and [-3, -1] versus [1, 3]; 2) alternative stand errors clustering schemes at the country level; and 3) a placebo test that sets year 2010 as the pseudo carbon disclosure mandating year and 2007–2012 as the six-year pseudo-event window. Our findings continue to hold using the alternative sample periods and regression specifications, but not for the placebo test.

Overall, consistent with our hypotheses, we find that, compared to non-UK suppliers in the global market which do not have any UK customers, non-UK suppliers exposed to the UK carbon disclosure mandate increase their Scope 1 emissions after the disclosure mandate, possibly because of the carbon outsourcing from their UK customers.

5. Incentives, Opportunities, and Bargaining Power in Supply Chains

5.1 Cross-sectional analyses of changes in customer firms' Scope 3 emissions

We argue that affected UK firms outsource emissions to unregulated parties, thereby resulting in an increase in their Scope 3 emissions. To corroborate our arguments, we test whether affected UK firms exhibit a greater increase in Scope 3 emissions when they have stronger incentives, greater bargaining power, or more opportunities to outsource emissions.

We first investigate customers' incentives to outsource emissions. Since the disclosure mandate improves information transparency and enhances market participants' ability to benchmark and discipline UK firms, we expect that affected UK firms with higher emission intensity before the mandate have greater incentives to outsource emissions afterward. To perform this test, we collect Scope 1 emission intensity of all the firms in a country-industry during the three years immediately before the disclosure mandate. We consider all firms in a country-industry because the market perception of a firm's efficiency and competitiveness in carbon emissions is determined by the firm's ranking out of all the firms in the market. We then rerun Equation (1) after classifying firms into high and low subgroups of emission intensity based on their country-industry median values.

The top rows of Table 7 Panel A report the results. We find that the coefficient on *Post*×*Treat* is significantly positive only among firms with high emission intensity in both the EB and PSM samples. The chi-squared test shows that differences in this coefficient between the two subgroups

are significant at the 1% level. This is consistent with our prediction that treatment firms with higher Scope 1 emission intensity before the disclosure mandate have greater incentives to outsource emissions after the mandate.

Second, we explore the variation in UK firms' bargaining positions that drive the emission decisions of their suppliers. We expect that affected UK firms have greater bargaining power when they have a higher proportion of private suppliers because these suppliers face lower market scrutiny and are more likely to cooperate with carbon outsourcing from their customers. We also expect that affected UK firms have greater bargaining power to foreign suppliers that are horizontally linked with UK firms due to the ease of production shifting (Bartram et al. 2022). To measure a firm's proportion of private or horizontally linked foreign suppliers, we collect from FactSet database the country and industry information on its suppliers during the three years immediately before the disclosure mandate.[14] We then calculate the ratio of the number of public suppliers to the total number of suppliers for each firm. We define that a firm and its foreign suppliers are horizontally linked if they share the same 3-digit SIC code (based on the SIC codes reported by FactSet), and calculate the ratio of the number of horizontally linked foreign suppliers to the total number of suppliers.[15] We then rerun Equation (1) after partitioning sample firms into high and low subgroups based on the country-industry median values of the respective ratios.

As shown in Table 7 Panel A, the coefficient on *Post*×*Treat* is significantly positive only among treatment firms with a high proportion of private suppliers, and the difference between the high and low subsamples is significant. We also find that the coefficient on *Post*×*Treat* is

[14] The sample size is smaller in this analysis because FactSet does not provide supplier information for 68 (out of 229) treatment firms, 55 (out of 271) EB benchmark firms, and 98 (out of 229) PSM benchmark firms.
[15] Unreported statistics show that the mean ratio of private suppliers to total suppliers is 16%, 11% and 16%, and the mean ratio of horizontally linked foreign suppliers to total suppliers is 10%, 12% and 14% for the treatment firms, EB benchmark firms, and PSM benchmark firms, respectively.

significantly more positive among treatment firms with a high proportion of horizontally linked foreign suppliers than among treatment firms with a low proportion of horizontally linked foreign suppliers. These findings are consistent with our expectation that affected UK firms with greater bargaining power against their suppliers are more likely to outsource emissions.

Last, we examine the role of firms' environmental protection policies before the disclosure mandate. We expect that affected UK firms with fewer environmental protection policies are more likely to outsource emissions, because their existing poor environmental protection practices may enable carbon outsourcing. To capture the stringency of a firm's environmental protection policies, we collect 33 items related to a firm's environmental policies and practices from Refinitiv (formerly Asset4) during the five years before the UK carbon disclosure mandate. Appendix D presents these items.[16] We then partition sample firms within each country-industry into high and low environmental protection policy groups, based on the country-industry median number of environmental protection policies.

The bottom rows of Table 7 Panel A show that the coefficient on *Post*×*Treat* is significantly positive only for treatment firms with fewer environment protection policies, and this coefficient is significantly more positive than treatment firms with more environmental protection policies. These findings are consistent with our expectation that firms with poor environmental policies yield more opportunities for carbon outsourcing.

Taken together, the results in Table 7 Panel A suggest that customer firms that have more incentives to outsource due to market pressure, greater bargaining power against their suppliers,

[16] Refinitive includes three categories in its environmental pillar: Emissions, Innovation, and Resource use. We obtain a firm's environmental policies and practices for 115 (out of 229) treatment firms, 163 (out of 271) EB benchmark firms, and 92 (out of 229) PSM benchmark firms, respectively.

and fewer governance constraints are more likely to outsource emissions after the UK carbon disclosure mandate.

5.2 Cross-sectional analyses of changes in foreign suppliers' Scope 1 emissions

In this section, we explore factors that affect the bargaining power of non-UK suppliers who are exposed to carbon outsourcing from their UK customers. We focus on suppliers' bargaining power because customers are a major stakeholder that drives suppliers' socially responsible behaviors (Dai et al. 2021). We expect that the suppliers with weaker bargaining power are more likely to cooperate with customers' carbon outsourcing activities. We argue that a supplier has a weaker bargaining power against the affected UK firms when it has: 1) a larger proportion of UK customers in its customer portfolio; 2) small firm size; 3) a greater proportion of horizontally linked UK customers; and 4) poor environmental protection policies.

To measure the proportion of UK customers out of an exposed supplier's customer portfolio, we identify its unique customers and the respective customer countries during the first three years since the supplier is exposed to the UK carbon disclosure mandate, i.e., [0, 2] period. The proportion is calculated as the ratio of the number of UK customers to the number of all customers. We partition exposed suppliers in each country-industry into high and low subsamples, based on the country-industry median value. Note that this measure is not available for benchmark suppliers, because by construction these suppliers do not have any UK customers during the post-mandate period. In regression analysis, we compare each subgroup of exposed suppliers with the full set of benchmark suppliers. To measure firm size, we calculate the mean value of total assets during the post-mandate period for each exposed and benchmark supplier, then partition all the sample suppliers into two groups based on the country-industry median value.

Table 7 Panel B reports the results conditional on the proportion of UK customers and supplier size. We find that in both the EB and PSM supplier samples, the coefficient on *POST*×*Exposed_Suppliers* is only significantly positive for exposed suppliers with a greater proportion of UK customers. The chi-square test further shows that the difference in this coefficient between the two subgroups is significant at the 1% level. This suggests that relative to benchmark suppliers that are immune to the UK carbon disclosure mandate, exposed suppliers with a greater proportion of UK customers experience a significant increase in the volume of Scope 1 emissions after the disclosure mandate. The finding is consistent with our expectation that their heavy reliance on UK economy weakens their bargaining power against carbon outsourcing from their UK customers.

Table 7 Panel B also shows that in both the EB and PSM supplier samples, the coefficient on *POST*×*Exposed_Suppliers* is only significantly positive for smaller exposed suppliers but not larger suppliers, and the difference in this coefficient between the two subgroups is significant at 10% level. This finding provides further evidence that foreign suppliers' bargaining power against UK customers plays an important role in their decisions to receive carbon outsourcing.

To measure the product similarity between an exposed non-UK supplier and its UK customers, we identify its unique UK customers that share the same 3-digit SIC codes during the first three years since the supplier is exposed to the UK carbon disclosure mandate, i.e., [0, 2] period. The proportion is calculated as the ratio of the number of UK customers with the same 3-digit SIC code to the number of all customers. We partition exposed suppliers in each country-industry into high and low subsamples, based on the country-industry median value. Because this measure is not available for benchmark suppliers, we include all benchmark firms in each subgroup.

Table 7 Panel B shows that the coefficient on *POST*×*Exposed_Suppliers* is significantly more positive among exposed suppliers with a high proportion of horizontally linked UK customers compared with the coefficient among exposed suppliers with a relatively small proportion of horizontally linked UK customers. This is consistent with our expectation that the product similarity between exposed suppliers and their UK customers lowers the costs of exposed suppliers to accept carbon outsourcing from their UK customers.

Last, we collect the number of environmental policies from Refinitiv (as listed in Appendix D) for our sample suppliers during the post-mandate period.[17] We then partition the sample suppliers within each country-industry into high and low environmental protection policy groups, based on the country-industry median value. We find that in both EB and PSM supplier samples, the coefficient on *POST*×*Exposed_Suppliers* is only significantly positive for exposed suppliers with limited environmental protection policies, and the coefficients are also significantly larger than the subgroup of exposed suppliers with more environmental protection policies. This finding is consistent with our expectation that the environmental protection practices of exposed suppliers affect their willingness to accept carbon outsourcing from UK customers.

In sum, the results in Table 7 Panel B suggest that the bargaining power of the exposed non-UK suppliers affects their decisions to accept carbon outsourcing from their UK customers after the disclosure mandate.

[17] We obtain the data for 125 (out of 296) exposed suppliers, 784 (out of 1,719) EB benchmark suppliers, and 127 (out of 283) PSM benchmark suppliers, respectively.

6. Additional Analyses on Divestures and Voluntary Carbon Disclosers

6.1 Divestment activities of UK firms

To provide additional evidence on the mechanisms of emissions outsourcing to their suppliers, we explore UK firms' divestment activities. Using the divesture deals from the Securities Data Company (SDC), we find that treatment firms experience an increase in divestment frequencies while the two benchmark samples experience a decrease in divestment frequencies after the disclosure mandate. Table 8 Panel A shows that treatment firms, EB benchmark firms and PSM benchmark firms conducted 156 versus 176, 197 versus 139, and 129 versus 90 divestment deals during pre- versus post-UK carbon disclosure mandate periods, respectively.

Next, we develop a dummy variable to indicate firm-years that have divestment activities and estimate if after controlling for firm characteristics, treatment firms experience a greater increase in the likelihood of asset divestments relative to benchmark firms after the disclosure mandate. Building on the cross-sectional results from Section 5.1, we further examine if the likelihood of divestments varies with a treatment firm's proportion of private suppliers or horizontally linked foreign suppliers.

Table 8 Panel B reports the regression results. The dependent variable is a dummy variable indicating firm-years with divestment activities. Columns (1) and (4) show that the coefficient on *Post×Treat* is insignificant at conventional levels, suggesting that relative to the two benchmark samples, treatment firms exhibit little change in the likelihood of divestment activities following the disclosure mandate. In contrast, Columns (2)–(3) and (5)–(6) report significantly positive coefficients on *Post×Treat×High_%Private_Suppliers* and *Post×Treat×High_%Horizontal_Suppliers,* suggesting that compared to benchmark firms, treatment firms with a higher percentage of private suppliers or foreign suppliers with similar production are significantly more likely to

divest assets after the disclosure mandate. These results corroborate our findings in Table 7 that affected UK firms with less visible suppliers or more horizontally linked foreign suppliers are more likely to outsource emissions.

6.2 Analysis of Voluntary Carbon Disclosers

Ex-ante, it is unclear whether the UK carbon disclosure mandate affects the carbon outsourcing of UK firms that already voluntarily disclose the emissions before the disclosure mandate. On the one hand, firms may choose to voluntarily disclose carbon emissions because they face a greater information demand from their stakeholders or they possess a stronger commitment to reduce carbon emissions. These firms therefore may be less likely to resort to carbon outsourcing to reduce Scope 1 emissions. On the other hand, as more UK firms are required to disclose carbon emissions after the disclosure mandate, market participants are able to obtain more information to reassess the competitiveness of voluntary disclosers against mandatory disclosers. This may motivate voluntary disclosers to further reduce their Scope 1 emissions via carbon outsourcing.

To answer this question, following the same data requirements as mandatory adoption firms and the definition of voluntary disclosure firms that we discuss in Section 3.1, we obtain 79 UK firms, 179 EB benchmark firms and 73 PSM benchmark firms that voluntarily disclose carbon emissions before the disclosure mandate. We rerun Equation (1) and report the results in Table 9. Columns (1) and (2) present the changes in Scope 3 emissions for the EB sample and the PSM sample, respectively. The coefficient on *Post*×*Treat* is insignificant at conventional levels in both

columns, indicating little evidence that voluntary carbon disclosers in the UK outsource emissions following the disclosure mandate.

We also consider the impact of the UK carbon disclosure mandate on the outsourcing risk to exposed non-UK suppliers that already voluntarily disclose Scope 1 emissions around the UK carbon disclosure mandate. Compared to exposed non-UK suppliers that do not disclose any carbon emission information, these suppliers are less likely to be subject to carbon outsourcing from their UK customers, because their voluntary disclosures expose them to greater market scrutiny which increases the costs of UK customers to outsource emissions to them. Therefore, we expect exposed non-UK suppliers that voluntarily disclose carbon emissions to experience little change in Scope 1 emissions after the UK carbon disclosure mandate.

Similarly, following the same data requirements as exposed suppliers without voluntary disclosures and the definition of voluntary disclosers that we discuss in Section 4.1, we obtain 207 exposed suppliers, 353 EB benchmark suppliers, and 145 PSM benchmark suppliers that voluntarily disclose carbon emissions before the disclosure mandate. We present the regression results in Columns (3)–(4) of Table 9. The coefficient on *POST×Exposed_Suppliers* is insignificantly different zero in both the EB and PSM supplier samples, suggesting that exposed suppliers that voluntarily disclose carbon emissions experience little changes in Scope 1 emissions after the UK carbon disclosure mandate. These results are consistent with our expectation that foreign suppliers' voluntary carbon disclosures mitigate carbon outsourcing by increasing UK customer firms' outsourcing costs. Collectively, these findings underscore the importance of global cooperation in mandating the disclosure of direct emissions for all corporations along the supply chain.

7. Conclusion

We examine the effect of the UK mandatory carbon disclosure on firms' emissions along their global supply chains. The mandate requires firms to disclose carbon emissions from the activities they are responsible for (Scopes 1 and 2) but not other carbon emissions (Scope 3). Using a difference-in-differences design, we find that UK firms affected by the disclosure mandate reduce their Scope 1 emissions but increase their Scope 3 emissions, and the reduction in Scope 1 emissions is offset by the increase in Scope 3 emissions, leading to an insignificant change in total carbon emissions. The increase in Scope 3 emissions is greater among affected UK firms with higher Scope 1 emission intensity prior to the mandate, a higher proportion of private suppliers or foreign suppliers with similar production, and fewer environmental protection policies.

Consistent with the notion of carbon outsourcing, we further find that exposed non-UK suppliers of the affected UK firms have a greater increase in their Scope 1 emissions relative to the benchmark suppliers without UK customers after the disclosure mandate. The increase is more pronounced among exposed non-UK suppliers with a greater proportion of UK customers in their customer portfolios, a smaller size, a greater proportion of UK customers with similar production, and fewer environmental protection policies.

Overall, our study suggests that customers shift emissions to their global suppliers following the carbon disclosure regulation that excludes the reporting of Scope 3 emissions. These findings highlight the importance of considering corporate supply chains when implementing mandatory carbon disclosures and provide policy implications for the formation and design of global carbon disclosure standards. We caution that while Scope 3 emissions are relatively noisy and costly to measure, other mechanisms, such as improving supply chain transparency and coordination among global regulators on climate-related reporting policies, may be worth considering.

References

Aswani, J., A. Raghunandan, and S. Rajgopal. 2024. Are carbon emissions associated with stock returns? *Review of Finance* 28, 75–106.

Azar, J., M. Duro, I. Kadach, and G. Ormazabal. 2021. The Big Three and corporate carbon emissions around the world. *Journal of Financial Economics* 142, 674–696.

Bartram, S. M, K. Hou, and S. Kim. 2022. Real effects of climate policy: Financial constraints and spillovers. *Journal of Financial Economics* 143, 668–696.

Ben-David, I., Y. Jang, S. Kleimeier, and M. Viehs. 2021. Exporting pollution: where do multinational firms emit CO_2? *Economic Policy* 36, 377–437.

Bertrand, M., and S. Mullainathan. 2003. Enjoying the quiet life? Corporate governance and managerial preferences. *Journal of Political Economy* 111, 1043–1075.

Bolton, P. and M. Kacperczyk. 2021a. Signaling through carbon disclosure. Working paper. Columbia University.

Bolton, P. and M. Kacperczyk. 2021b. Do investors care about carbon risk? *Journal of Financial Economics* 142, 517–549.

Bolton, P., M. Kacperczyk, C. Leuz, G. Ormazabal, S. Reichelstein, and D. Schoenmaker. 2021. Mandatory corporate carbon disclosures and the path to net zero. *Management and Business Review* 1, 21–28.

Brav, A., W. Jiang, and H. Kim. 2010. Hedge fund activism: A review. *In Foundations and Trends in Finance* 4, 185–246.

Busch, T, M. Johnson, and T. Pioch. 2022. Corporate carbon performance data: Quo vadis? *Journal of Industrial Ecology* 26, 350–363.

CDP. 2021. Global supply chain report. Available at https://www.cdp.net/en/research/global-reports/transparency-to-transformation.

Chen, Y.C., M. Hung, and Y. Wang. 2018. The effect of mandatory CSR disclosure on firm profitability and social externalities: Evidence from China. *Journal of Accounting and Economics* 65, 169–190.

Cho, Y. J., J. Kim, H. Yang, and M. Yang, 2023. Corporate disclosures for green supply chains: Evidence from Scope 3 emissions disclosure. Working paper, Singapore Management University.

Christensen, H.B., E. Floyd, L.Y. Liu, and M. Maffett. 2017. The real effects of mandated information on social responsibility in financial reports: Evidence from mine-safety records. *Journal of Accounting and Economics* 64, 284–304.

Cohen, S., I. Kadach, G. Ormazabal. 2023. Institutional investors, climate disclosure, and carbon emissions. *Journal of Accounting and Economics* 76, 101640.

Dai, R., R. Duan, H. Liang, and L. Ng. 2024. Outsourcing climate change. Working paper. Available at SSRN 3765485.

Dai, R., H. Liang, and L. Ng. 2021. Socially responsible corporate customers. *Journal of Financial Economics* 142, 598–626.

Darendeli, A., P. Fiechter, J. Hitz, and N. Lehmann. 2022. The role of corporate social responsibility (CSR) information in supply-chain contracting: Evidence from the expansion of CSR rating coverage. *Journal of Accounting and Economics* 74, 101525.

DEFRA. 2012a. Environmental reporting guidelines: Mandatory greenhouse gas emissions reporting. Department for Environment, Food & Rural Affairs.

DEFRA. 2012b. Measuring and reporting of greenhouse gas emissions by UK companies: Summary of consultation responses. Department for Environment, Food & Rural Affairs June 2012.

DESNZ. 2023. Scope 3 emissions in the UK reporting landscape: Call for Evidence. Department for Energy Security & Net Zero. October 2023.

Downar, B., J. Ernstberger, S. Reichelstein, S. Schwenen, and A. Zaklan. 2021. The impact of carbon disclosure mandates on emissions and financial operating performance. *Review of Accounting Studies* 26, 1137–1175.

Duchin, R., J. Gao, and Q. Xu. 2022. Sustainability or greenwashing: Evidence from the asset market for industrial pollution. Working paper. Available at SSRN 4095885.

Dyck, A., K.V. Lins, L. Roth, and H. F. Wagner. 2019. Do institutional investors drive corporate social responsibility? International evidence. *Journal of Financial Economics* 131, 693–714.

Ecker, F. and T. Keeve. 2023. Managing corporate emission disclosures through divestitures. Working paper. Available at SSRN 4517339.

Fiechter, P., J.-M. Hitz, and N. Lehmann. 2022. Real effects of a widespread CSR reporting mandate: Evidence from the European Union's CSR directive. *Journal of Accounting Research* 60, 1499–1549.

Greenhouse Gas (GHG) Protocol. 2004. The Greenhouse Gas Protocol. Available at https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/Resources/A-corporate-reporting-and-accounting-standard-revised-edition.

Hainmueller, J. 2012. Entropy balancing for causal effects: A multivariate reweighting method to produce balanced samples in observational studies. *Political Analysis* 20, 25–46.

Jiang, Y. A. 2023. Does mandatory greenhouse gas reporting lead to pollution shifting within the firm? Available at SSRN 4400126.

Jouvenot, V., and P. Krueger. 2021. Mandatory corporate carbon disclosure: Evidence from a natural experiment. Available at SSRN 3434490.

Levinson, A. 2023. Are developed countries outsourcing pollution? *Journal of Economic Perspectives* 37, 87–110.

Lu, H., Q. Peng, J-E. Shin, and L. Yu. 2023. Migration of global supply chains: A real effect of mandatory ESG disclosure. Available at SSRN 4581611.

Lu, S., G. Serafeim, and M.W. Toffel. 2022. Driving decarbonization at BMW. Harvard Business School.

Machieux, L., H. Sapra, and G. Zhang. 2023. Climate-related disclosures: What are the economic trade-offs? Available at SSRN 4507526.

McKinsey & Company. 2009. Pathways to a low-carbon economy. McKinsey & Company.

McMullin, J., and B. Schonberger. 2022. When good balance goes bad: A discussion of common pitfalls when using entropy balancing. *Journal of Financial Reporting* 7, 167–196.

McVay, S. 2006. Earnings management using classification shifting: An examination of core earnings and special items. *The Accounting Review* 81, 501–531.

Rosenbaum, E. 2021. Climate experts are worried about the toughest carbon emissions for companies to capture. Available at https://www.cnbc.com/2021/08/18/apple-amazon-exxon-and-the-toughest-carbon-emissions-to-capture.html.

SEC. 2024. SEC Adopts Rules to Enhance and Standardize Climate-Related Disclosures for Investors. https://www.sec.gov/news/press-release/2024-31

She, G. 2022. The real effects of mandatory nonfinancial disclosure: Evidence from supply chain transparency. *The Accounting Review* 97, 399–425.

Tomar, S. 2023. Greenhouse gas disclosure and emissions benchmarking. *Journal of Accounting Research* 61, 451–492.

Trucost. 2020. Trucost Environmental Data Methodology Guide. S&P Global Market Intelligence.

Vanderford, R. 2023. SEC Chair Gensler Declines to Give Timeline for final Climate Disclosure Rule. *The Wall Street Journal*, September 12, 2023.

Yang, L., N. Z. Muller, and P. Liang. 2021. The real effects of mandatory CSR disclosure on emissions: Evidence from the greenhouse gas reporting program. NBER working paper.

Appendix A
Examples of Emission Disclosures Following the UK Carbon Disclosure Mandate

Norcros Plc Annual Report and Accounts 2014

Greenhouse gas emissions

The Board presents this report in order to meet the Company's obligation under the Companies Act 2006 (Strategic Report and Directors' Reports) Regulations 2013 to disclose the Group's worldwide emissions of the six Kyoto gases attributable to human activity measured in tonnes of carbon dioxide equivalent. As stated in the Corporate Responsibility Report on pages 26 and 27, the Company is committed to reducing and minimising its impact on the environment.

Global GHG emissions data for the year ended 31 March 2014	Tonnes of CO_2e 2014
Emissions from:	
Combustion of fuel and operation of facilities (Scope 1)	64,062
Electricity, heat, steam and cooling purchased for own use (Scope 2)	27,387
Total	**91,449**
Company's chosen intensity measurement[1]	**418.1**

[1] Emissions per £m of revenue.

We have reported on all of the emission sources, being Scope 1 and Scope 2 emissions. These are emissions from activities for which the Group is responsible, plus emissions resulting from the purchase of electricity, heat, steam or cooling by a business in the Group for its own use. This is the first year for which reporting is required. These sources use the same reporting boundary as for our consolidated financial statements. We do not have responsibility for any emission sources that are not included in our consolidated statement.

We have used the GHG Protocol Corporate Accounting and Reporting Standard (revised edition), data gathered to fulfil our requirements under the CRC Energy Efficiency scheme, and emission factors from the UK Government's GHG Conversion Factors for Company Reporting 2014. Where no more suitable data sources are available, we have used, where practicable, estimates based on the appropriate information that is available to the Group.

Appendix B
Variable Definitions

Post	An indicator variable equal to one for fiscal years ending on or after September 30, 2014, and zero otherwise.
Treat	An indicator variable equal to one for UK incorporated firms subject to the UK carbon disclosure mandate, and zero otherwise.
Exposed_Supplier	An indicator variable equal to one for non-UK incorporated firms with at least one UK customer during the first three years since the UK carbon disclosure mandate, and zero for non-UK firms without any UK customers during the post-mandate period.
Ln(Scope1)	The natural logarithm of Scope 1 emissions, where Scope 1 emissions are direct carbon emissions (in metric tons) that arise from sources controlled or owned by the firm.
Ln(Scope3)	The natural logarithm of upstream Scope 3 emissions, where upstream Scope 3 emissions are indirect carbon emissions (in metric tons) that mainly occur from the firm's suppliers.
Ln(Total)	The natural logarithm of the sum of Scopes 1, 2, and 3 emissions.
Ln(Insensity 1)	The natural logarithm of the ratio of the Scope 1 emission volume to total sales.
Ln(Insensity 3)	The natural logarithm of the ratio of the Scope 3 emission volume to total sales.
Ln(Assets)	The natural logarithm of book value of assets in millions of US dollars at the end of a fiscal year.
TobinQ	Total assets plus the market value of equity minus deferred taxes minus the book value of equity divided by total assets at the end of a fiscal year.
Leverage	Sum of long-term debt and short-term debt, divided by total assets at the end of a fiscal year.
ROA	Earnings before extraordinary items divided by the average total assets at the beginning and the end of a fiscal year.
SaleGrow	Annual percentage change in sales.
Tangibility	Net book value of property, plant, and equipment divided by total assets at the end of a fiscal year.
R&D	Annual R&D expenditure scaled by total assets at the end of a fiscal year, where missing values for R&D expenditure are replaced by zero.

Appendix C
Propensity Score Matching for Customers and Foreign Supplier Samples

Panel A: Logit regression used to compute the propensity score

Sample =	UK treatment firms versus global benchmark firms		Exposed non-UK suppliers versus global non-UK benchmark suppliers	
Dep Var =	***Prob (Treat=1)***		***Prob (Exposed_Supplier=1)***	
	Pre-match	Post-match	Pre-match	Post-match
	(1)	(2)	(3)	(4)
Ln(Scope1)	0.023	0.012	-0.128***	-0.088
	(0.052)	(0.073)	(0.045)	(0.067)
Ln(Assets)	-0.619***	0.062	0.492***	0.110
	(0.087)	(0.108)	(0.076)	(0.100)
TobinQ	0.002	-0.030	0.185***	-0.023
	(0.056)	(0.079)	(0.052)	(0.076)
Leverage	0.342	-0.116	0.162	-0.672
	(0.450)	(0.670)	(0.440)	(0.633)
ROA	0.085	-0.559	-2.517**	-1.075
	(1.058)	(1.604)	(1.028)	(1.439)
SaleGrow	-2.759***	-0.117	-0.769**	0.112
	(0.602)	(0.630)	(0.334)	(0.542)
Tangibility	-1.113**	-0.468	-0.743**	0.409
	(0.495)	(0.605)	(0.374)	(0.554)
R&D	1.288	-0.609	11.300***	0.095
	(2.363)	(3.012)	(2.268)	(2.815)
Industry FE	Yes	Yes	Yes	Yes
#Firms	2,914	458	2015	566
Pseudo R^2	0.14	0.02	0.11	0.01

Panel B: Statistics for the three-year mean value before the mandate for the PSM sample

	UK treatment firms versus global benchmark firms				Exposed non-UK suppliers versus global non-UK benchmark suppliers			
	Treatment (N=229)	Benchmark (N=229)	Diff	t-stats	Exposed (N=283)	Benchmark (N=283)	Diff	t-stats
Ln(Scope1)	9.814	9.761	0.053	0.80	10.980	10.992	-0.012	0.06
Ln(Assets)	6.812	6.741	0.071	0.58	8.009	7.960	0.049	0.42
TobinQ	2.154	2.330	-0.176	-0.25	2.046	2.127	-0.081	-0.52
Leverage	0.185	0.184	0.001	0.05	0.227	0.228	0.000	0.03
ROA	0.061	0.070	-0.009	-0.26	0.056	0.062	-0.006	-0.96
SaleGrow	0.090	0.099	-0.009	-0.56	0.140	0.141	0.000	0.02
Tangibility	0.244	0.258	-0.015	0.47	0.284	0.277	0.007	0.39
R&D	0.017	0.016	0.001	0.28	0.019	0.018	0.001	0.22

Panel A reports the results of the logistic regressions for the PSM method, using the average value of firm characteristics during [-3, -1] years. We use single nearest-neighbor propensity score matching without replacement within a caliper width of 0.05. Panel B compares the differences in firm characteristics between the matched samples.

Appendix D
Measures of Environmental Policies and Practices

Item	Category	Title
1	Emissions	Biodiversity Impact Reduction
2	Emissions	Climate Change Commercial Risks Opportunities
3	Emissions	Emissions Trading
4	Emissions	Environmental Expenditures Investments
5	Emissions	Environmental Partnerships
6	Emissions	Environmental Restoration Initiatives
7	Emissions	e-Waste Reduction
8	Emissions	NOx and SOx Emissions Reduction
9	Emissions	Policy Emissions
10	Emissions	Staff Transportation Impact Reduction
11	Emissions	Targets Emissions
12	Emissions	VOC or Particulate Matter Emissions Reduction
13	Innovation	Environmental Assets Under Management
14	Innovation	Environmental Products
15	Innovation	Hybrid Vehicles
16	Innovation	Noise Reduction
17	Innovation	Renewable/Clean Energy Products
18	Innovation	Sustainable Building Products
19	Innovation	Water Technologies
20	Resource Use	Environmental Materials Sourcing
21	Resource Use	Environmental Supply Chain Management
22	Resource Use	Environmental Supply Chain Monitoring
23	Resource Use	Env Supply Chain Partnership Termination
24	Resource Use	Environment Management Team
25	Resource Use	Green Buildings
26	Resource Use	Land Environmental Impact Reduction
27	Resource Use	Policy Energy Efficiency
28	Resource Use	Policy Environmental Supply Chain
29	Resource Use	Policy Sustainable Packaging
30	Resource Use	Policy Water Efficiency
31	Resource Use	Targets Energy Efficiency
32	Resource Use	Targets Water Efficiency
33	Resource Use	Toxic Chemicals Reduction

Source: Refinitiv (Formerly Asset 4).

Table 1
Sample Distribution of Treatment and Benchmark Firms

Panel A: Sample selection procedure

	Treatment sample		Benchmark sample			
			EB benchmark		PSM benchmark	
	# Firms	#Firm-years	# Firms	#Firm-years	# Firms	#Firm-years
Global Vantage population, 2008-2019	**2,747**	**22,408**	**8,346**	**70,582**	**61,937**	**529,527**
-Not listed in required stock exchanges	(136)	(1,054)	(153)	(1,344)	(153)	(1,344)
-Missing NAICS2, financial firms (NAICS2=52), or public administration (NAICS2=92,99)	(649)	(5,528)	(1,064)	(9,570)	(7,898)	(69,556)
-Missing control variables for firm characteristics	(362)	(4,698)	(1,370)	(16,194)	(10,356)	(117,650)
-Missing emissions data during [-5,5] years	(1,092)	(7,651)	(4,338)	(35,886)	(30,217)	(280,091)
-Firms disclosing carbon emissions for at least three years during [-5, -1] years	(87)	(797)	(187)	(1,758)	(629)	(5,938)
-Additional firm-years with voluntary carbon emission disclosures	(2)	(97)	(4)	(566)	(12)	(2,660)
-Firms not present during both pre- and post-periods	(190)	(572)	(959)	(3,116)	(9,958)	(29,964)
-Benchmark firms not propensity-score-matched to the treatment firms					**(2,485)**	**(20,448)**
Final Sample	**229**	**2,011**	**271**	**2,148**	**229**	**1,836**

Panel B: Sample distribution by event year

		Benchmark sample	
Event year	**Treatment sample**	**EB benchmark**	**PSM benchmark**
-5 (Sept 2008 to Aug 2009)	194	195	137
-4 (Sept 2009 to Aug 2010)	201	203	151
-3 (Sept 2010 to Aug 2011)	205	214	171
-2 (Sept 2011 to Aug 2012)	196	233	191
-1 (Sept 2012 to Aug 2013)	195	261	216
Pre-UK mandate period	**991**	**1,106**	**866**
1 (Sept 2014 to Aug 2015)	226	233	202
2 (Sept 2015 to Aug 2016)	214	220	187
3 (Sept 2016 to Aug 2017)	202	210	200
4 (Sept 2017 to Aug 2018)	195	190	195
5 (Sept 2018 to Aug 2019)	183	189	186
Post-UK mandate period	**1,020**	**1,042**	**970**
Total	**2,011**	**2,148**	**1,836**

Table 1, Continued

Panel C: Sample distribution by economy

	EB sample		PSM sample	
	#Firms	#Firm-years	#Firms	#Firm-years
Treatment sample				
UK	**229**	**2011**	**229**	**2011**
Benchmark sample				
Austria	10	82	1	6
Belgium	10	95	1	10
Czech Republic	1	10		
Denmark	9	67	2	
Finland	8	66		
France	66	459	8	51
Germany	42	346	3	24
Greece	6	40		
Hungary	1	9		
Ireland	14	117	1	6
Italy	16	127	0	0
Luxembourg	6	50	1	10
Malta	1	6		
Netherlands	19	155	2	17
Norway	7	57	1	10
Poland	21	185	5	43
Portugal	2	20		
Spain	19	155	2	16
Sweden	13	102	3	25
Australia			26	195
Bermuda			4	31
Brazil			1	7
Canada			5	25
Cayman Island			11	96
China			9	77
Hong Kong			2	20
India			5	46
Indonesia			7	55
Israel			4	32
Japan			22	175
Jersey			1	10
Malaysia			3	25
Singapore			4	30
South Africa			13	97
South Korea			27	205
Switzerland			2	14
Taiwan			10	90
US			33	288
Others			10	100
Sub-Total	**271**	**2,148**	**229**	**1,836**
Total	**500**	**4,159**	**458**	**3,847**

Table 1, Continued

Panel D: Sample distribution by industry

NAICS2 - industry description	Treatment sample		Benchmark sample: EB benchmark		Benchmark sample: PSM benchmark	
	#Firm-years	%	#Firm-years	%	#Firm-years	%
11 - agriculture, forestry, fishing & hunting	30	1	12	1	0	0
21 - mining, quarrying, and oil land gas extraction	144	7	67	3	167	9
22 - utilities	26	1	83	4	10	1
23 - construction	74	4	118	5	35	2
31 - manufacturing-food, textile, apparel	100	5	181	8	162	9
32 - manufacturing-wood, paper, printing, petroleum, chemicals, plastics	200	10	271	13	179	10
33 - manufacturing-metals, machinery, computers, electrical, furniture	410	20	530	25	326	18
42 - wholesale trade	78	4	92	4	48	3
44 - retail trade-motor vehicles, furniture, electronics, food, gas	138	7	63	3	131	7
45 - retail trade-sporting goods, books, florists, office supplies, mail-order, vending	52	3	32	1	99	5
48 - transportation & warehousing-air transport, water transport, trucks, pipelines	44	2	42	2	45	2
49 - transportation & warehousing-post service, courier & express delivery service, local messengers, warehousing & storage	0	0	9	0	0	0
51 - information	214	11	373	17	183	10
53 - real estate & rental & leasing	57	3	0	0	54	3
54 - professional, scientific & technical services	189	9	129	6	152	8
56 - admin/support waste management/remediation services	101	5	56	3	79	4
62 - health care and social assistance	6	0	27	1	0	0
71 - arts, entertainment & recreation	38	2	26	1	41	2
72 - accommodation & food services	92	5	37	2	125	7
81 - other services (except public administration)	18	1	0	0	0	0
Total	**2,011**	**100**	**2,148**	**100**	**1,836**	**100**

Panel A presents sample selection procedures. Panels B, C, and D present the sample distribution by event year, economy, and industry, respectively.

Table 2
Descriptive Statistics for Treatment and Benchmark Firms

	Pre-UK mandate Period		Post-UK mandate Period		Difference
	Mean	**Median**	**Mean**	**Median**	**Mean, Post – Pre**
	(1)	(2)	(3)	(4)	(5)
	Treatment firms (N=2,011 firm-years)				
Ln(Scope3)	11.343	11.336	11.596	11.619	0.253***
Ln(Intensity3)	4.738	4.654	4.749	4.677	0.011
Ln(Scope1)	9.689	9.664	9.308	9.363	-0.381***
Ln(Intensity1)	3.098	2.887	2.474	2.343	-0.624***
Ln(Assets)	6.688	6.431	6.933	6.729	0.245***
TobinQ	1.914	1.411	3.104	2.101	1.189***
Leverage	0.195	0.169	0.206	0.193	0.012
ROA	0.056	0.056	0.045	0.047	-0.011***
SaleGrow	0.079	0.058	0.063	0.046	-0.016
Tangibility	0.245	0.192	0.238	0.162	-0.007
R&D	0.019	0.000	0.018	0.000	-0.001
	EB benchmark firms (N=2,148 firm-years, before balancing the covariates)				
Ln(Scope3)	12.761	12.703	12.464	12.471	-0.297***
Ln(Intensity3)	4.910	4.812	4.865	4.787	-0.046
Ln(Scope1)	10.917	10.683	10.573	10.243	-0.344***
Ln(Intensity1)	3.074	2.942	2.990	2.840	-0.084
Ln(Assets)	8.115	8.042	7.851	7.814	-0.264***
TobinQ	2.527	1.772	3.817	2.763	1.290***
Leverage	0.243	0.235	0.228	0.213	-0.016**
ROA	0.049	0.044	0.040	0.041	-0.009***
SaleGrow	0.063	0.052	0.043	0.037	-0.020***
Tangibility	0.237	0.205	0.232	0.189	-0.004
R&D	0.017	0.000	0.018	0.000	0.002
	PSM benchmark firms ((N=1,836 firm-years)				
Ln(Scope3)	11.368	11.332	11.321	11.361	-0.048
Ln(Intensity3)	4.799	4.645	4.741	4.584	-0.057
Ln(Scope1)	9.855	9.681	9.746	9.447	-0.109
Ln(Intensity1)	3.294	3.162	3.175	2.852	-0.120
Ln(Assets)	6.825	6.786	6.929	6.870	0.105
TobinQ	2.068	1.517	2.780	1.792	0.712***
Leverage	0.191	0.153	0.217	0.182	0.026***
ROA	0.066	0.059	0.049	0.052	-0.018***
SaleGrow	0.095	0.065	0.072	0.047	-0.023*
Tangibility	0.278	0.217	0.268	0.225	-0.010
R&D	0.019	0.000	0.019	0.000	0.001

This table presents carbon emissions and firm characteristics of treatment and benchmark firms, respectively. See Appendix B for variable definitions.

Table 3
Mandatory Carbon Disclosure and Scope 3 Emissions of Customer Firms

Panel A: Main analysis

Dep Var =				***Ln(Scope 3)***		
Sample =		**EB sample**			**PSM sample**	
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Treat	**0.292*** **	**0.153** **		**0.274*** **	**0.122*** **	
	(0.090)	**(0.060)**		**(0.060)**	**(0.040)**	
Post	-0.044			-0.010		
	(0.076)			(0.037)		
Treat	0.037			0.170**		
	(0.100)			(0.068)		
Year -5 × Treat			-0.030			-0.025
			(0.048)			(0.041)
Year -4 × Treat			-0.068			-0.014
			(0.059)			(0.039)
Year -3 × Treat			-0.048			-0.035
			(0.051)			(0.032)
Year -2 ×Treat			-0.111			-0.007
			(0.079)			(0.025)
Year 1 ×Treat			0.054			**0.102*** **
			(0.033)			**(0.038)**
Year 2 × Treat			**0.127*** **			**0.137*** **
			(0.037)			**(0.041)**
Year 3 × Treat			**0.142*** **			**0.108** **
			(0.049)			**(0.046)**
Year 4 × Treat			**0.165** **			**0.087***
			(0.078)			**(0.050)**
Year 5 ×Treat			0.031			**0.098***
			(0.055)			**(0.057)**
Ln(Scope1)	0.355***	0.119***	0.119***	0.368***	0.158***	0.158***
	(0.035)	(0.031)	(0.031)	(0.025)	(0.033)	(0.033)
Ln(Assets)	0.567***	0.725***	0.725***	0.559***	0.658***	0.658***
	(0.057)	(0.059)	(0.059)	(0.033)	(0.054)	(0.054)
TobinQ	-0.006	0.025***	0.025***	-0.004	0.021***	0.020***
	(0.012)	(0.006)	(0.006)	(0.013)	(0.006)	(0.006)
Leverage	-0.151	-0.382**	-0.382**	-0.313*	-0.021	-0.019
	(0.261)	(0.158)	(0.158)	(0.182)	(0.115)	(0.115)
ROA	1.191***	0.072	0.081	1.118***	0.105	0.104
	(0.355)	(0.206)	(0.210)	(0.237)	(0.141)	(0.142)
SaleGrow	-0.281*	0.121**	0.123**	-0.070	0.190***	0.190***
	(0.151)	(0.054)	(0.054)	(0.068)	(0.048)	(0.048)
Tangibility	-0.132	0.325	0.332	-0.278	0.375	0.372
	(0.255)	(0.587)	(0.585)	(0.193)	(0.322)	(0.321)
R&D	-4.097***	1.267*	1.282*	-3.244***	0.913*	0.912*
	(0.786)	(0.729)	(0.736)	(0.674)	(0.513)	(0.518)
Industry FE	Yes	No	No	Yes	No	No
Firm FE, Year FE	No	Yes	Yes	No	Yes	Yes
#Firm-years	4,159	4,159	4,159	3,847	3,847	3,847
Adj. R^2	0.85	0.98	0.98	0.83	0.97	0.97

Table 3, Continued

Panel B: Alternative emissions measures

Dep Var =	**Ln(Scope1)**		**Ln(Total)**		**Ln(Intensity3)**		**Ln(Intensity1)**	
Sample =	**EB sample**	**PSM sample**	**EB sample**	**PSM sample**	**EB sample**	**PSM sample**	**EB sample**	**PSM sample**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post × Treat	**-0.410*** **	**-0.463*** **	0.056	-0.004	**0.114** **	0.020	**-0.414*** **	**-0.475*** **
	(0.116)	**(0.113)**	(0.064)	(0.051)	**(0.055)**	(0.017)	**(0.110)**	**(0.103)**
Ln(Intensity1)					0.039**	0.020*		
					(0.016)	(0.011)		
Firm Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
#Firm-years	4,159	3,847	4,159	3,847	4,159	3,847	4,159	3,847
Adj. R^2	0.93	0.91	0.97	0.97	0.96	0.98	0.88	0.87

Panel C: Robustness tests

Dep Var =	***Ln(Scope 3)***							
	Alternative event windows				**Alternative specifications**		**Placebo tests**	
Specifications	**[-5,-1] vs. [0,4]**		**[-3,-1] vs. [1,3]**		**Country cluster**		**(2007-2012)**	
Sample =	**EB sample**	**PSM sample**	**EB sample**	**PSM sample**	**EB sample**	**PSM sample**	**EB sample**	**PSM sample**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post × Treat	**0.149*** **	**0.096*** **	**0.149*** **	**0.131*** **	**0.153*** **	**0.122*** **	0.022	-0.024
	(0.052)	**(0.033)**	**(0.042)**	**(0.039)**	**(0.048)**	**(0.032)**	(0.023)	(0.028)
Firm Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
#Firm-years	4,413	3,956	2,567	2,190	4,159	3,847	3,021	2,666
Adj. R^2	0.98	0.98	0.99	0.98	0.98	0.97	0.99	0.99

This table presents the regression results of the impact of the UK carbon disclosure mandate on firms' Scope 3 emissions. Panel A presents the results for changes in Scope 3 emissions following the disclosure mandate. Panel B presents the results for changes in alternative emission measures. Panel C reports the robustness checks. *Post* is an indicator variable equal to one for fiscal years ending on or after September 30, 2014. *Treat* is an indicator variable equal to one for UK firms that are required to report Scopes 1 and 2 emissions under the mandate. See Appendix B for definitions of other variables. Robust standard errors, in parentheses, are clustered at the firm level. ***, **, * represent the significance at 1%, 5% and 10% two-tailed level, respectively.

Table 4
Sample Distribution of Non-UK Suppliers

Panel A: Sample selection for non-UK suppliers

	#Firms	#Firm-years
Global Vantage population, 2008-2019	**64,684**	**551,935**
-Missing NAICS2, financial firms (NAICS2=52) or public administration (NAICS2=92,99)	(8,607)	(75,640)
-Missing control variables for firm characteristics	(10,768)	(123,042)
-Missing emissions data during [-5, 5] years	(31,443)	(288,638)
-Firms incorporated in the UK	(568)	(3,827)
-Firm-years voluntarily disclosing Scope 1 emissions	(1,350)	(12,345)
-Firms not present during both pre- and post- periods	(9,725)	(29,494)
-Suppliers without UK customers during [0, 2] but with UK customers during [3, 5]	(208)	(1,811)
Non-UK supplier sample, including	**2015**	**17,138**
Exposed suppliers: non-UK suppliers with at least one UK customer	**296**	**2,353**
EB benchmark suppliers: Non-UK suppliers without any UK customer	**1,719**	**14,603**
-Benchmark suppliers not propensity-score-matched to the exposed suppliers	(1,436)	(12,119)
PSM benchmark suppliers	**283**	**2,484**

Panel B: Non-UK suppliers by event year

		Benchmark suppliers	
Event year	**Exposed suppliers**	**EB benchmark**	**PSM benchmark**
-5 (Sept 2008 to Aug 2009)	228	1,138	206
-4 (Sept 2009 to Aug 2010)	239	1,208	217
-3 (Sept 2010 to Aug 2011)	248	1,372	241
-2 (Sept 2011 to Aug 2012)	270	1,515	259
-1 (Sept 2012 to Aug 2013)	287	1,648	274
Pre-UK mandate period	**1,272**	**6,881**	**1,197**
1 (Sept 2014 to Aug 2015)	287	1,589	270
2 (Sept 2015 to Aug 2016)	274	1,580	264
3 (Sept 2016 to Aug 2017)	253	1,582	262
4 (Sept 2017 to Aug 2018)	229	1,516	252
5 (Sept 2018 to Aug 2019)	220	1,455	239
Post-UK mandate period	**1,263**	**7,722**	**1,287**
Total	**2,535**	**14,603**	**2,484**

Table 4, Continued

Panel C: Non-UK suppliers by economy

	Exposed suppliers		Benchmark Suppliers			
			EB benchmark		PSM benchmark	
	#Firms	#Firm-years	#Firms	#Firm-years	#Firms	#Firm-years
	(1)	(2)	(3)	(4)	(5)	(6)
Australia	13	106	94	751	11	89
Austria	3	26	2	18	1	10
Belgium	1	10	7	62	2	16
Bermuda	5	44	4	39	2	19
Brazil	3	23	26	218	4	39
Canada	6	54	28	225	5	40
Chile	7	64	8	75	0	0
China	7	61	215	1,807	39	340
Denmark	1	10	3	24	1	8
Egypt	2	16	10	90	1	9
France	10	81	24	175	4	28
Germany	11	100	24	201	2	17
Greece	1	7	4	29	0	0
Hong Kong	2	18	68	584	7	58
India	11	95	74	664	16	150
Indonesia	4	37	27	235	3	23
Ireland	5	41	6	54	3	30
Israel	5	46	11	90	2	20
Italy	1	8	13	113	3	24
Japan	19	158	227	1,857	41	352
Luxembourg	2	20	0	0	0	0
Malaysia	8	70	25	226	6	50
Mexico	1	7	20	161	4	33
Morocco	1	10	5	46	0	0
Netherlands	5	49	8	60	3	19
New Zealand	1	7	8	55	1	6
Norway	2	15	1	10	0	0
Peru	2	20	7	68	3	30
Philippines	1	10	10	95	0	0
Poland	6	51	12	108	1	10
Russia	5	41	17	149	3	27
Singapore	4	38	16	136	3	27
South Africa	4	33	26	192	3	20
South Korea	9	78	212	1,718	15	120
Spain	1	8	10	88	3	29
Sweden	2	16	5	46	0	0
Switzerland	9	76	14	126	3	27
Taiwan	6	56	114	1,052	18	172
Thailand	1	5	23	210	2	20
Turkey	3	23	9	78	2	20
US	106	897	259	2,306	60	545
Others	0	0	43	362	6	57
Total	**296**	**2,535**	**1,719**	**14,603**	**283**	**2,484**

Table 4, Continued

Panel D: Distribution of Non-UK suppliers by industry

NAICS2 - industry description	Exposed suppliers		Benchmark suppliers: EB benchmark		Benchmark suppliers: PSM benchmark	
	#Firm-years	%	#Firm-years	%	#Firm-years	%
11 - agriculture, forestry, fishing & hunting	0	0	122	1	0	0
21 - mining, quarrying, and oil land gas extraction	249	10	1,068	7	295	12
22 - utilities	71	3	770	5	35	1
23 - construction	90	4	419	3	69	3
31 - manufacturing-food, textile, apparel	94	4	1,304	9	81	3
32 - manufacturing-wood, paper, printing, petroleum, chemicals, plastics	275	11	2,185	15	234	9
33 - manufacturing-metals, machinery, computers, electrical, furniture	739	29	3,528	24	764	31
42 - wholesale trade	99	4	460	3	85	3
44 - retail trade-motor vehicles, furniture, electronics, food, gas	15	1	646	4	15	1
45 - retail trade-sporting goods, books, florists, office supplies, mail-order, vending	35	1	496	3	50	2
48 - transportation & warehousing-air transport, water transport, trucks, pipelines	104	4	740	5	106	4
49 - transportation & warehousing-post service, courier & express delivery service, local messengers, warehousing & storage	0	0	37	0	0	0
51 - information	413	16	1,225	8	408	16
53 - real estate & rental & leasing	50	2	205	1	34	1
54 - professional, scientific & technical services	232	9	345	2	216	9
56 - admin/support waste management/remediation services	29	1	231	2	56	2
61 - educational services	10	0	114	1	16	1
62 - health care and social assistance	0	0	209	1	0	0
71 - arts, entertainment & recreation	6	0	152	1	10	0
72 - accommodation & food services	16	1	308	2	10	0
81 - other services (except public administration)	8	0	39	0	0	0
Total	**2,535**	**100**	**14,603**	**100**	**2,484**	**100**

Panel A presents sample selection procedures for the non-UK suppliers. Panels B, C, and D present the sample distribution by event year, economy, and industry, respectively.

Table 5
Descriptive Statistics for Non-UK Suppliers

	Pre-UK mandate period		Post- UK mandate period		Difference
	Mean	**Median**	**Mean**	**Median**	**Mean, Post – Pre**
	(1)	(2)	(3)	(4)	(5)
			Exposed suppliers (N=2,535)		
Ln(Scope1)	10.942	10.716	10.999	10.703	0.058
Ln(Intensity1)	3.308	2.955	3.273	2.858	-0.035
Ln(Assets)	8.038	8.035	8.226	8.289	0.188***
TobinQ	2.006	1.479	2.415	1.576	0.409***
Leverage	0.224	0.204	0.259	0.248	0.035***
ROA	0.052	0.052	0.033	0.039	-0.019***
SaleGrow	0.097	0.080	0.054	0.044	-0.043***
Tangibility	0.271	0.192	0.277	0.194	0.006
R&D	0.021	0.000	0.023	0.001	0.001
	EB benchmark suppliers (N=14,603, before balancing the covariates)				
Ln(Scope1)	11.270	10.997	11.198	10.949	-0.071*
Ln(Intensity1)	3.938	3.429	3.775	3.275	-0.163***
Ln(Assets)	7.656	7.694	7.850	7.871	0.194***
TobinQ	1.953	1.388	2.224	1.493	0.271***
Leverage	0.229	0.215	0.240	0.224	0.011***
ROA	0.063	0.054	0.047	0.043	-0.016***
SaleGrow	0.128	0.085	0.062	0.046	-0.066***
Tangibility	0.345	0.316	0.326	0.291	-0.019***
R&D	0.010	0.000	0.012	0.000	0.002***
			PSM benchmark suppliers (N=2,484)		
Ln(Scope1)	11.078	10.726	10.923	10.732	-0.155
Ln(Intensity1)	3.466	3.133	3.260	2.962	-0.206***
Ln(Assets)	7.981	8.003	8.172	8.175	0.191***
TobinQ	2.097	1.457	2.352	1.601	0.254***
Leverage	0.226	0.211	0.258	0.236	0.031***
ROA	0.062	0.052	0.042	0.040	-0.020***
SaleGrow	0.100	0.079	0.063	0.050	-0.037***
Tangibility	0.283	0.221	0.273	0.204	-0.010
R&D	0.019	0.000	0.020	0.001	0.002

This table presents carbon emissions and firm characteristics of treatment and benchmark non-UK suppliers, respectively. See Appendix B for variable definitions.

Table 6
Mandatory Carbon Disclosure and Scope 1 Emissions of Non-UK Suppliers

Panel A: Main analysis

Dep Var=	*Ln(Scope1)*					
Sample=	**EB supplier sample**			**PSM supplier sample**		
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Exposed_Suppliers	**0.131****	**0.119*****		**0.193*****	**0.167*****	
	(0.051)	**(0.039)**		**(0.065)**	**(0.053)**	
Post	-0.209***			-0.247***		
	(0.032)			(0.051)		
Exposed_Suppliers	-0.180**			-0.200		
	(0.086)			(0.131)		
Year -5 × Exposed_Suppliers			-0.018			-0.001
			(0.051)			(0.072)
Year -4 × Exposed_Suppliers			-0.004			-0.009
			(0.045)			(0.061)
Year -3 × Exposed_Suppliers			-0.017			-0.039
			(0.033)			(0.042)
Year -2 × Exposed_Suppliers			-0.015			0.008
			(0.027)			(0.033)
Year 1 × Exposed_Suppliers			**0.056***			**0.071***
			(0.032)			**(0.038)**
Year 2 × Exposed_Suppliers			**0.073***			**0.091****
			(0.037)			**(0.046)**
Year 3 × Exposed_Suppliers			**0.101****			**0.136****
			(0.044)			**(0.067)**
Year 4 × Exposed_Suppliers			**0.175*****			**0.273*****
			(0.056)			**(0.088)**
Year 5 × Exposed_Suppliers			**0.174****			**0.263*****
			(0.072)			**(0.096)**
Ln(Assets)	0.954***	0.726***	0.728***	1.000***	0.733***	0.735***
	(0.038)	(0.038)	(0.038)	(0.050)	(0.056)	(0.055)
TobinQ	-0.037*	0.009	0.009	-0.051*	-0.007	-0.007
	(0.020)	(0.010)	(0.010)	(0.029)	(0.013)	(0.013)
Leverage	0.205	0.193	0.190	-0.300	0.095	0.085
	(0.230)	(0.122)	(0.122)	(0.307)	(0.177)	(0.177)
ROA	1.548***	0.625***	0.616***	1.888***	0.569**	0.556**
	(0.351)	(0.187)	(0.187)	(0.466)	(0.248)	(0.249)
SaleGrow	-0.043	0.230***	0.229***	0.070	0.301***	0.299***
	(0.079)	(0.036)	(0.036)	(0.104)	(0.061)	(0.062)
Tangibility	2.552***	0.177	0.173	2.271***	0.291	0.296
	(0.241)	(0.191)	(0.192)	(0.327)	(0.255)	(0.256)
R&D	-1.175	2.752***	2.768***	-0.118	1.353	1.382
	(1.229)	(0.817)	(0.825)	(1.523)	(1.276)	(1.282)
Country FE, Industry FE	Yes	No	No	Yes	No	No
Firm FE, Year FE	No	Yes	Yes	No	Yes	Yes
# Firm-years	17,138	17,138	17,138	4,916	4,916	4,916
Adj. R^2	0.71	0.96	0.96	0.72	0.96	0.96

Table 6, Continued

Panel B: Alternative emissions measures

Dep Var=	*Ln(Total)*		*Ln(Intensity 1)*	
Sample=	**EB supplier sample**	**PSM supplier sample**	**EB supplier sample**	**PSM supplier sample**
	(1)	(2)	(3)	(4)
Post × Exposed_Suppliers	**0.040***	**0.062***	**0.109*****	**0.142*****
	(0.023)	**(0.033)**	**(0.036)**	**(0.047)**
Firm Characteristics	Yes	Yes	Yes	Yes
Firm FE, Year FE	Yes	Yes	Yes	Yes
# Firm-years	17,138	4,916	17,138	4,916
Adj. R^2	0.98	0.98	0.95	0.94

Panel C: Robustness tests

Dep Var =	*Ln(Scope 1)*							
Specifications =	**Alternative event windows**				**Alternative specifications**		**Placebo tests**	
	[-5,-1] vs. [0,4]		**[-3,-1] vs. [1,3]**		**Country cluster**		**(2007-2012)**	
Supplier sample =	**EB**	**PSM**	**EB**	**PSM**	**EB**	**PSM**	**EB**	**PSM**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post × Exposed_Suppliers	**0.088*****	**0.072***	**0.086*****	0.034	**0.119*****	**0.167*****	-0.012	-0.067
	(0.032)	**(0.040)**	**(0.033)**	(0.046)	**(0.033)**	**(0.052)**	(0.040)	(0.051)
Firm Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE, Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Firm-years	17,389	5,064	10,768	3,062	17,138	4,916	13,089	3,101
Adj. R^2	0.97	0.97	0.98	0.98	0.96	0.96	0.97	0.97

This table presents the regression results of Scope 1 emissions of non-UK suppliers following the UK carbon disclosure mandate. Panel A presents the results for changes in Scope 1 emissions of exposed and benchmark non-UK suppliers following the disclosure mandate. Panel B presents the results using alternative emission measures. Panel C reports additional robustness checks. *Post* is an indicator variable equal to one for fiscal years ending on or after September 30, 2014. *Exposed Supplier* is an indicator variable equal to one for non-UK suppliers with at least one UK customer during the first three years since the UK disclosure mandate. See Appendix B for definitions of other variables. Robust standard errors, in parentheses, are clustered at the firm level. ***, **, * represent the significance at 1%, 5% and 10% two-tailed level, respectively.

Table 7
Analysis Conditional on Incentives, Bargaining Power, Opportunities

Panel A: Cross-sectional analyses of customer firms' changes in Scope 3 emissions

Dep Var =	***Ln(Scope 3)***			
Sample =	**EB sample**		**PSM sample**	
	(1)	(2)	(3)	(4)
	Intensity of Scope 1 emissions before the mandate			
	High	Low	High	Low
Post × Treat	**0.271*** **	-0.025	**0.249*** **	0.013
	(0.090)	(0.048)	**(0.066)**	(0.044)
Difference	***0.296****		***0.236****	
(chi-square)	***(8.54)***		***(8.89)***	
#Firm-years	2,260	1,899	1,953	1,894
Adj. R^2	0.98	0.99	0.97	0.98
	Percentage of private suppliers			
	High	Low	High	Low
Post × Treat	**0.372*** **	0.018	**0.238*** **	-0.010
	(0.113)	(0.039)	**(0.065)**	(0.048)
Difference	***0.354****		***0.248****	
(chi-square)	***(8.93)***		***(9.60)***	
#Firm-years	1,478	1,647	1,233	1,262
Adj. R^2	0.97	0.99	0.98	0.98
	Percentage of horizontally linked foreign suppliers			
	High	Low	High	Low
Post × Treat	**0.374*** **	**0.100***	**0.188*** **	0.034
	(0.116)	**(0.057)**	**(0.065)**	(0.052)
Difference	***0.274****		***0.154****	
(chi-square)	***(4.56)***		***(3.51)***	
#Firm-years	1,265	1,860	942	1,553
Adj. R^2	0.98	0.99	0.98	0.98
	#Environmental management policies			
	High	Low	High	Low
Post × Treat	0.038	**0.212*** **	0.067	**0.149*** **
	(0.044)	**(0.066)**	(0.056)	**(0.058)**
Difference	***-0.174****		***-0.082****	
(chi-square)	***(4.91)***		***(2.91)***	
#Firm-years	1,460	878	869	879
Adj. R^2	0.99	0.98	0.98	0.98

Table 7, Continued

Panel B: Cross-sectional analyses of changes in non-UK suppliers' Scope 1 emissions

Dep Var =	*Ln(Scope 1)*			
Sample =	**EB supplier sample**		**PSM supplier sample**	
	(1)	(2)	(3)	(4)
	Supplier's reliance on UK customers (%UK Customers)			
	High	Low	High	Low
Post × Exposed_Suppliers	**0.205*** **	0.018	**0.230*** **	0.027
	(0.053)	(0.044)	**(0.059)**	(0.049)
Difference	***0.187*** **		***0.203*** **	
(chi-square)	***(9.05)***		***(10.15)***	
#Firm-years	15,984	15,757	5,132	4,902
Adj. R^2	0.96	0.96	0.96	0.96
	Supplier firm size (total assets)			
	Small	Large	Small	Large
Post × Exposed_Suppliers	**0.189*** **	0.054	**0.255*** **	0.080
	(0.059)	(0.051)	**(0.074)**	(0.075)
Difference	***0.135****		***0.175****	
(chi-square)	***(2.97)***		***(2.81)***	
#Firm-years	9,399	7,739	2,429	2,487
Adj. R^2	0.96	0.96	0.95	0.95
	Percentage of horizontally linked UK customers			
	High	Low	High	Low
Post × Exposed_Suppliers	**0.216*** **	**0.100** **	**0.263*** **	**0.114** **
	(0.081)	**(0.042)**	**(0.088)**	**(0.047)**
Difference	***0.116****		***0.149****	
(chi-square)	***(3.73)***		***(2.83)***	
#Firm-years	15,004	16,737	4,172	5,862
Adj. R^2	0.96	0.97	0.96	0.96
	#Environmental management policies			
	High	Low	High	Low
Post × Exposed_Suppliers	0.061	**0.299*** **	0.270*	**0.458*** **
	(0.071)	**(0.088)**	(0.156)	**(0.136)**
Difference	***-0.238****		***-0.188****	
(chi-square)	***(4.83)***		***(2.79)***	
#Firm-years	4,258	3,643	1,107	1,072
Adj. R^2	0.96	0.96	0.94	0.96

This table reports analyses conditional on customer firms' and suppliers' incentives, opportunities, and bargaining power. Panel A presents the cross-sectional results of customer firms' Scope 3 emissions following the mandate. Panel B presents the cross-sectional results of Scope 1 emissions of exposed suppliers following the mandate. *Post* is an indicator variable equal to one for fiscal years ending on or after September 30, 2014. *Treat* is an indicator variable set to one for UK firms. *Exposed Supplier* is an indicator variable set to one for non-UK suppliers with at least one UK customer during the first three years since the mandate. All the regressions control for firm- and year- fixed effects. Robust standard errors, in parentheses, are clustered at firm levels. ***, **, * represent the significance at 1%, 5% and 10% two-tailed level, respectively.

Table 8
Divestment Activities of Customers after the UK Disclosure Mandate

Panel A: Frequency of divestments

Sample =	**Treatment firms**		**EB benchmark firms**		**PSM benchmark firms**	
Period =	Pre	Post	Pre	Post	Pre	Post
#Divestments	156	176	197	139	126	90

Panel B: Regression analysis of changes in the likelihood of divestment

Dep Var =	***Prob (Divest=1)***					
Sample =		**EB Sample**			**PSM Sample**	
Factor =1, if variables		High % of private suppliers=1	High % of horizontal foreign suppliers=1		High % of private suppliers=1	High % of horizontal foreign suppliers=1
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Treat × Factor		**0.085***	**0.117*****		**0.119*****	**0.053****
		(0.046)	**(0.044)**		**(0.043)**	**(0.021)**
Post × Factor		-0.021	-0.048		-0.054**	0.020
		(0.034)	(0.033)		(0.027)	(0.028)
Post × Treat	0.008	-0.022	-0.032	-0.009	-0.051*	-0.026
	(0.020)	(0.034)	(0.031)	(0.018)	(0.028)	(0.028)
Ln(Assets)	0.016	0.007	0.006	-0.013	-0.005	-0.009
	(0.020)	(0.021)	(0.021)	(0.017)	(0.021)	(0.021)
TobinQ	-0.001	-0.002	-0.002	0.002	0.001	0.001
	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Leverage	0.070	0.055	0.061	0.052	0.037	0.039
	(0.065)	(0.078)	(0.078)	(0.058)	(0.073)	(0.074)
ROA	-0.040	-0.031	-0.011	-0.064	-0.019	-0.017
	(0.097)	(0.110)	(0.111)	(0.079)	(0.094)	(0.094)
SaleGrow	-0.134***	-0.132***	-0.135***	-0.073***	-0.063**	-0.065**
	(0.035)	(0.040)	(0.040)	(0.026)	(0.029)	(0.029)
Tangibility	-0.260**	-0.270**	-0.273**	-0.176**	-0.175*	-0.194**
	(0.101)	(0.108)	(0.108)	(0.077)	(0.091)	(0.089)
R&D	-0.420	-0.663	-0.645	-0.130	-0.069	-0.053
	(0.450)	(0.497)	(0.500)	(0.259)	(0.308)	(0.305)
Firm FE, Year FE	Yes	Yes	Yes	Yes	Yes	Yes
#Firm-Years	4,159	3,125	3,125	3,847	2,495	2,495
Adj. R^2	0.29	0.29	0.29	0.25	0.26	0.26

This table presents changes in the likelihood of divestment activities of treatment and benchmark customers following the UK carbon disclosure mandate. Panel A reports the descriptive statistics on divestment. Panel B reports the regression results. The dependent variable, *Divest*, is a dummy variable set to one if a customer-year experienced a divestment, and zero otherwise. *Post* is an indicator variable set to one for fiscal years ending on or after September 30, 2014. *Treat* is an indicator variable set to one for UK firms. Robust standard errors, in parentheses, are clustered at firm levels. ***, **, * represent the significance at 1%, 5% and 10% two-tailed level, respectively.

Table 9
Carbon Emissions of Voluntary Disclosers after the UK Disclosure Mandate

Dep Var =	***Ln(Scope 3)***		***Ln(Scope 1)***	
Business Status =	**Customers**		**Non-UK Suppliers**	
Sample =	**EB sample**	**PSM sample**	**EB supplier sample**	**PSM supplier sample**
	(1)	(2)	(3)	(4)
Post × Treat	-0.027	-0.072		
	(0.067)	(0.061)		
Post × Exposed_Suppliers			-0.023	0.017
			(0.057)	(0.059)
Ln(Scope1)	0.104***	0.089***		
	(0.025)	(0.029)		
Ln(Assets)	0.824***	0.787***	0.595***	0.634***
	(0.142)	(0.096)	(0.068)	(0.077)
TobinQ	0.018**	0.002	-0.006	-0.008
	(0.008)	(0.010)	(0.012)	(0.015)
Leverage	-0.559***	-0.540***	0.088	-0.040
	(0.161)	(0.161)	(0.220)	(0.219)
ROA	0.434*	0.544*	-0.078	-0.008
	(0.241)	(0.282)	(0.350)	(0.242)
SaleGrow	0.189***	0.302***	0.131*	0.052
	(0.066)	(0.094)	(0.070)	(0.065)
Tangibility	1.028**	0.662**	0.293	-0.094
	(0.459)	(0.289)	(0.299)	(0.302)
R&D	3.432**	2.671	8.640***	5.900***
	(1.341)	(1.792)	(2.197)	(2.241)
Firm FE, Year FE	Yes	Yes	Yes	Yes
#Firm-years	2,185	1,370	5,099	2,647
Adj. R^2	0.99	0.98	0.98	0.98

This table presents changes in carbon emissions following the UK carbon disclosure mandate for firms that voluntarily disclose Scope 1 emissions before the mandate. Columns (1)–(2) report the results for changes in Scope 3 emissions of treatment and benchmark customers following the mandate. Columns (3)–(4) report the results for changes in Scope 1 emissions of exposed and benchmark suppliers following the mandate. *Post* is an indicator variable set to one for fiscal years ending on or after September 30, 2014. *Treat* is an indicator variable set to one for UK firms. *Exposed_Supplier* is an indicator variable set to one for non-UK suppliers with at least one UK customer during the first three years since the carbon disclosure mandate. See Appendix B for definitions of other variables. Robust standard errors, in parentheses, are clustered at firm levels. ***, **, * represent the significance at 1%, 5% and 10% two-tailed level, respectively.