Mandatory Corporate Carbon Disclosure: Evidence from a Natural Experiment

by

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Abstract

We study the introduction of a unique law in the United Kingdom that mandates publicly listed firms to disclose their greenhouse gas emissions in a standardized way. Using a difference-in-differences framework, we provide evidence that firms respond to the disclosure regulation by reducing their emissions. Examining why firms reduce their emissions, we show that a mix of institutional investor, general stakeholder, and competitive pressure is likely to explain the reduction. We also study the financial effects of the regulation and find that firms disclosing low (high) emissions relative to industry peers exhibit positive (negative) abnormal returns.

The impact of firms on climate change is an increasingly relevant topic for institutional investors. For example, Christopher Hohn, founder of activist hedge fund TCI, announced recently that his fund plans to vote against directors of firms that fail to disclose their greenhouse gas emissions (see Financial Times 2019; Bloomberg 2020). In a similar spirit, Larry Fink stated in his annual letter to CEOs in January 2020 that the awareness of the investment risks posed by climate change was rapidly changing in the investment industry and that climate change had become a defining factor in companies' long-term prospects (Fink 2020).

Against this backdrop, an increasing number of investors have started analyzing the carbon (or greenhouse gas) footprints of their investment portfolios (Bolton and Kacperczyk 2019, 2020). To do so, they require accurate and comparable firm-level disclosures of greenhouse gas (GHG) emissions. Despite the growing importance and relevance of firm-level GHG emissions data, current GHG disclosure regimes are mostly voluntary and nonprescriptive. As a result, firm-level GHG disclosures remain largely non-standardized, inconsistent, and sparse. This has led many institutional investors to believe that current firm-level carbon disclosures are lacking both in terms of quantity and quality (Ilhan et al. 2019).

In this paper, we study the real and financial effects of the introduction of a unique GHG disclosure regulation in the United Kingdom (U.K.). In 2013, the U.K. introduced *The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013* (The Act), a law that requires all companies listed on the Main Market of the London Stock Exchange (LSE) to disclose their carbon emissions in a standardized way in their annual reports. We use the introduction of the law as laboratory setting to study whether *mandatory*, *prescriptive*, and *standardized* GHG emissions disclosure regulation affects corporate GHG emissions and whether investors recognize the potential financial costs associated with high levels of GHG emissions.

We provide evidence that the disclosure regulation led to a decrease in firm-level GHG emissions. Turning to the financial effects of the regulation, we find that firms disclosing high (low) levels of emissions relative to industry peers experience negative (positive) abnormal returns around the dates on which these firms first disclose emissions in their annual reports. We also study why firms reduce their GHG emissions and find that they do so primarily because of investor, general stakeholder, and competitive pressures.

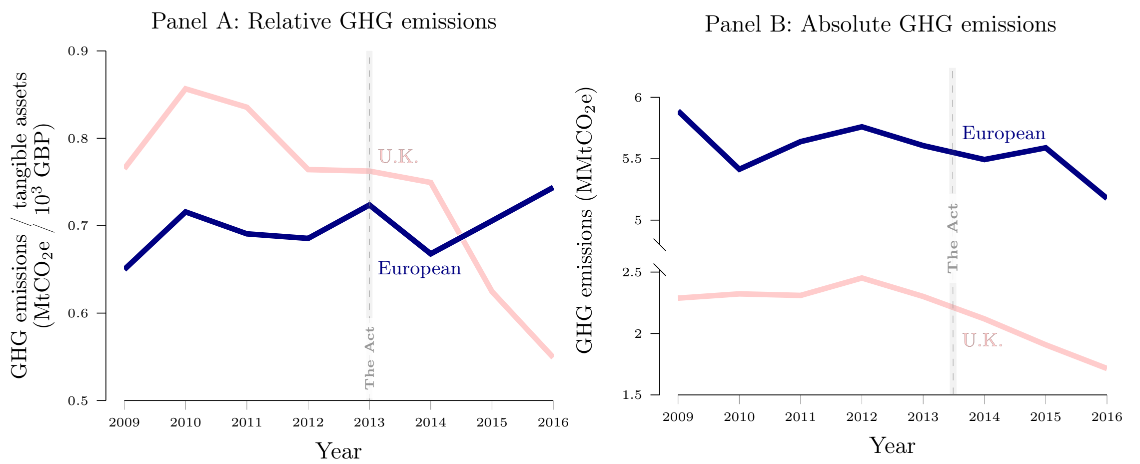

Figure 1. Average GHG emissions of U.K. and European firms around the regulation. Panel A shows relative GHG emissions. Panel B shows absolute GHG emissions. The gray dashed vertical line corresponds to the introduction of the regulation.

Figure 1 shows the effect of the disclosure regulation on GHG emissions and motivates our analysis: corporate GHG emissions decline more after the introduction of the regulation in the U.K. than in other European countries. Panel A plots *relative* GHG emissions, which we measure as the ratio of a firm's total GHG emissions over tangible assets. Panel B shows the evolution of *absolute* GHG emissions, which is measured as the logarithm of a firm's total GHG emissions.[1] In both panels, we compare the average firm from the U.K. with the average firm from other European countries. The dashed gray lines indicate the introduction of the regulation in 2013. Before the regulation, absolute and relative GHG emissions of U.K. and European firms follow similar trends. After the regulation, absolute and relative GHG emissions of U.K. firms decrease in comparison to the GHG emissions of comparable European firms. Comparing average GHG emissions before the regulation (2009 to 2012) and after the regulation takes effect (2013 to 2016), we find that the average U.K. firm reduced both relative and absolute GHG emissions by about 16.63% and 14.18%, respectively. In contrast, the average European firm increased its relative GHG emissions by 3.61% and reduced its absolute GHG emissions by only 3.69% over the same period.

A natural concern is that the greater post-regulatory reduction in GHG emissions observed for U.K. firms is not caused by the introduction of the regulation but by other factors. For instance, a greater reduction might be explained by differences in characteristics such as firm size, differences in industry composition across countries, or general time-trends in the levels of emissions. To rule out the possibility that the results are driven by observable differences in firm characteristics and to cleanly identify the effect of the regulation on GHG emissions, we estimate a difference-in-differences specification. We compare the change in GHG emissions between U.K. and European firms before and after the regulation, while at the same time controlling for industry, country, and other observable firm-level characteristics. In this framework,

[1] Companies typically measure several greenhouse gases, namely carbon dioxide (CO_2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6), and nitrogen triflouride (NF3). These greenhouse gases have different "Global Warming Potential'' (GWP), meaning that their climate impact differs. For example, carbon dioxide has a GWP of exactly 1. In contrast, the GWP of Methane exceeds 80. Because of the different global warming potentials, emissions are measured in metric tons of CO_2e ($MTCO_2e$), where CO_2e stands for "CO_2 equivalent". In a way "CO_2 equivalent" is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same GWP.

we confirm the univariate evidence presented in Figure 1 and find similar magnitudes, namely that—in comparison to firms located in other European countries—U.K. firms reduce both their absolute and relative GHG emissions by about 15% and 17%, respectively. Overall, our results suggest that firms respond to mandatory, prescriptive, and standardized disclosure regulation by reducing their GHG emissions.[2]

We then move on to asking the important question of *why* U.K. firms reduce their GHG emissions as a result of the regulation. To do so, we test three non-mutually exclusive hypotheses. We develop these hypotheses on the premise that the regulation increases transparency and facilitates the benchmarking of firms on the basis of their GHG emissions given that all firms disclose in a standardized way.

Our first hypothesis is that institutional investors invest less in firms with high GHG emissions. The idea is that the regulation makes it easier for institutional investors to identify firms with higher levels of GHG emissions relative to industry peers. Lower cost of discriminating between firms based on their disclosed GHG emissions then results in lower institutional ownership after the regulation, in particular for firms with high emissions. We find that following the regulation, institutional investors decrease their holdings in U.K. firms with high GHG emissions relative to those with low emissions. Thus, the prospect of lower institutional ownership is a mechanism that incentives managers to reduce GHG emissions.

Our second hypothesis is that high levels of GHG emissions may result in bad media coverage. Because the regulation increases the availability of GHG emissions information for U.K. firms, it might be easier be easier for stakeholders, including

[2] In ancillary analysis, we also examine whether the response of U.K firms varies according to observable and plausible cross-sectional characteristics. In this analysis, we find that firms with higher levels of GHG emissions prior to the regulation reduce their GHG emissions more strongly than firms with lower emission levels. The decrease in emissions is also stronger for larger firms, as measured by tangible assets and sales.

NGOs and the press, to identify firms with poor climate policies. To test this second hypothesis, we use a measure of firm-level controversies based on media coverage with respect to pollution, firm-level climate change impacts, and GHG emissions. We find that following the regulation the number of such controversies increases for U.K. firms with high emissions relative to U.K. firms with lower emissions. This increase in negative media coverage is likely to impact the reputation of high-emissions firms and thus to be another mechanism incentivizing managers to decrease GHG emissions.

The idea behind our third hypothesis is that managers learn from the GHG disclosures of peer firms. Depending on where their firms stand relative to peer firms, managers are more or less incentivized to decrease emissions at their firms. In other words, by observing the emissions of peer firms, managers are able to evaluate whether their firms have high or low levels of emissions relative to industry peers. If managers learn that their firm is a high emitter in their respective sector, the additional transparency resulting from the disclosure regulation should push managers to reduce GHG emissions. One implication of this mechanism is that disclosed emissions at the industry-level should become more concentrated following the disclosure regulation. To test this last hypothesis, we study whether within industry dispersion of GHG emissions changes following the introduction of the regulation and find a decrease in the dispersion of GHG emissions within industries.

To illustrate that the above three mechanisms are a direct result of the disclosure regulation, we test whether we can observe similar effects for European firms over the same period. Consistent with the idea that in the absence of mandatory, prescriptive, and standardized GHG emissions disclosure regulation we should not observe the above mechanisms, we do not find any of the above evidence for European firms.

Last but not least, we study the short-term stock price implications of the disclosure regulation. Since the previous analysis suggests that institutional investors divest from U.K. firms with high GHG emissions, it is likely that the regulation also had an impact on equity valuations. To study the valuation effects of the disclosure regulation, we perform an event study around the dates on which U.K. firms publish the first batch of annual reports containing GHG emissions data. When examining abnormal returns around these disclosure dates, we find that firms with lower emissions than their industry peers exhibit positive abnormal returns. In contrast, firms with higher emissions are subject to negative abnormal returns. The relation between abnormal returns and industry-adjusted GHG emissions is consistent with the view that standardized GHG emissions contain new information for investors and is priced when it is revealed through official disclosure forms (i.e., annual reports). We then check if a similar relation exists for firms from other European countries. Again, we do not find any evidence of a relation between abnormal returns and GHG emissions for European firms during the reporting season during which U.K. firms start disclosing GHG emissions through their annual reports.

Finance scholars have been late to join the debate on climate change. Diaz-Rainey, Robertson, and Wilson (2017) note that the three leading finance journals did not publish a single article related to climate finance between 1998 and 2015. However, there is now an emerging climate finance literature (see Hong, Karolyi, and Scheinkman 2020), to which our paper makes important and novel contributions. Using the U.S. and global cross section of stock returns, Bolton and Kacperczyk (2019, 2020) show that stocks with high GHG emissions earn higher risk adjusted returns, suggesting that investors require a risk premium for investing in firms with high GHG emissions. Ilhan, Sautner, and Vilkov (2020) provide evidence that climate policy uncertainty is reflected in option prices of high GHG emitting firms. Our paper differs from these papers in important respects. First, the analysis in these papers is based on voluntarily disclosed—and sometimes also estimated—GHG emissions, while our paper is the first to study standardized GHG data disclosed through official disclosure documents. Second, we focus on the short run equity valuation effects of *disclosing* standardized GHG emissions and also examine the real effects of mandatory and standardized GHG disclosure regulation.

Other papers in the climate finance literature have looked at the valuation and real effects of issuing green bonds.(see Baker et al. 2018; Tang and Zhang 2019; Zerbib 2019; Flammer 2020). Still other papers examine the extent to which asset prices reflect climate risk. For example, Painter (2019) shows that when counties issue long-term municipal bonds, the counties that are more likely to be affected by climate change exhibit higher financing costs in terms of both underwriting fees and initial yields. A series of papers studies the extent to which real estate prices reflect climate risk. Bernstein, Gustafson, and Lewis (2019) estimate that homes exposed to sea level rise sell for approximately 7% less than observably equivalent unexposed properties equidistant from the beach. Using a different identification strategy, Murfin and Spiegel (2020) find no evidence of sea level rise being priced in the real estate market. Baldauf, Garlappi, and Yanellis (2020) argue that the pricing of expected sea level rise in real estate markets depends crucially on the climate change beliefs of the local population and find that houses projected to be underwater in neighbourhoods in which the population are climate change believers sell at a discount when compared to houses in geographic areas populated predominantly by climate change deniers.

Another line of research focuses on the financial implications of other dimensions of climate risk. At the firm level, Addoum, Ng, and Ortiz-Bobea (2020) show that extreme temperatures can adversely affect corporate earnings. Pankratz, Bauer, and Derwall (2019) provide similar evidence showing that exposure to high temperatures reduces revenues and operating income. Kruttli, Tran, and Watugala (2019) show that extreme weather is reflected in stock and option market prices. Hong, Li, and Xu (2019) examine the relationship between equity valuations of food producers and drought risk and show that food producers have lower equity valuations when the countries in which they are headquartered have experienced prolonged spells of droughts.

Other research has focused more on investor beliefs regarding climate risks. For example, survey evidence in Krueger, Sautner, and Starks (2020) shows that institutional investors increasingly account for climate risk in their investment decision making. In a follow up paper focusing more on disclosure, Ilhan et al. (2019) point out that institutional investors regard current firm-level climate risk disclosures as being quantitatively and qualitatively insufficient. Ramelli et al. (2019) show that firms in carbon-intensive industries exhibit positive abnormal returns after Trump's election. Görgen et al. (2020) estimate a "carbon beta" that captures firm sensitivities to an unexpected transition process toward a green economy. Engle et al. (2020) construct a dynamic portfolio strategy that hedges climate change risks. Andersson, Bolton, and Samama (2016) propose a simple dynamic investment strategy allowing long-term passive investors to hedge climate risk without sacrificing financial returns. Using a cross-country setting De Haas and Popov (2019) show that firms in countries that are more credit-dependent have higher emissions.[3]

[3] Other studies have focused more generally on environmental pollution and policies. Such studies find, for example, that investors require higher expected returns for firms with high levels of pollution (Hsu, Li, and Tsou, 2019).

We contribute also to the economics and finance literature on (mandatory) disclosure (see, for example, Greenstone, Oyer, and Vissing-Jorgensen 2006; Goldstein and Yang 2017, 2019; Jayaraman and Wu 2019) as well as an existing accounting literature concerned with GHG emissions and their disclosure. Using a sample of S&P 500 firms, Prakash, Matsumura and Vera-Munoz (2014) show that firms that voluntarily disclose higher GHG emissions tend to have lower firm values. The few previous studies that examine the real effects of mandatory carbon emissions or environmental disclosure focus on some specific industries (Christensen et al. 2017; Downar et al. 2019), or measure carbon emissions at the city-level (Chen, Hung and Wang 2018). Importantly, prior studies on mandatory environmental disclosure focus mainly on regulations that do not require corporate disclosures to be standardized (e.g., Ioannou and Serafeim, 2017).[4] To the best of our knowledge, the real and financial effects of a mandatory, prescriptive, and standardized carbon reporting scheme for listed firms focusing only on carbon emissions are unknown.

Finally, our paper is also related to the literature examining channels that explain the increase in environmental performance under mandatory reporting schemes. For instance, Fiechter, Hitz, and Lehmann (2019) show that large firms listed on European stock exchanges required to prepare comprehensive non-financial reports on corporate social responsibility (CSR) increase their CSR activity because of anticipation of adverse stakeholder reactions. Tomar (2019) shows that the U.S. Greenhouse Gas Reporting Program that requires facilities to publicly disclose their

Firms with poor environmental policies also have higher cost of capital (e.g., Chava, 2014; Heinkel, Kraus, and Zechner, 2001). Dyck et al. (2019) provide evidence that institutional investors drive firms' environmental policies and Gibson et al. (2020) show evidence that European institutional investors are more interested in responsible investment.

[4] Christensen, Hail and Leuz (2019a, 2019b) provide a literature survey on the broader topic of CSR and Sustainability reporting from an accounting perspective.

emissions leads to a reduction in emissions because of a "benchmarking-learning" channel—namely, that facilities learn from their peers' disclosures and then adjust their levels of emissions. Our results complement this literature by showing how stakeholders use standardized corporate GHG emissions to push high polluting firms to reduce their emissions.

1. Background on The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013

On March 19, 2012, then Deputy Prime Minister Nick Clegg formally announced *The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013*, which came into effect on October 1, 2013. The regulation concerns all U.K. Quoted Companies. A U.K. Quoted Company is a publicly listed company that is U.K. incorporated and whose equity share capital is listed on the Main Market of the London Stock Exchange, on an exchange in a European Economic Area (EEA) state, or admitted to trading on the New York Stock Exchange or Nasdaq.[5]

The regulation requires firms to report both absolute and relative GHG emissions. Absolute emissions reflect the overall annual quantity of GHG emissions in metric tons of carbon dioxide equivalent ($MtCO_2e$) resulting from activities for which a company is responsible (including the combustion of fuel and the operation of any facility from the purchase of electricity, heat, steam, or cooling by the company for its use). A distinction is made between direct and indirect emissions. Direct GHG emissions are emissions from sources that are owned or controlled by the reporting entity. This component of emissions is typically referred to as Scope 1. Indirect GHG

[5] Very few U.K. Quoted Companies choose to list outside the U.K., which is why we concentrate our analysis on companies that have their share capital traded on the Main Market of the London Stock Exchange.

emissions are emissions resulting from activities of the reporting entity but occur at sources owned or controlled by another entity. Typically, a distinction is made between indirect emissions from the generation of purchased energy (Scope 2) and all indirect emissions not included in Scope 2 emissions that occur in the value chain (both upstream and downstream) of the reporting company. The latter component is referred to as Scope 3 emissions. The regulation requires disclosure of Scope 1 and Scope 2 but not Scope 3 emissions.[6]

Relative emissions are quantified as an intensity ratio that expresses the company's GHG emissions in terms of a quantifiable factor measuring the scale of the company's activities (e.g., sales or assets). Besides absolute and relative Scope 1 and Scope 2 emissions, firms must also report the methodologies used to calculate emission quantities and intensities.[7] All the disclosures must be included in the Directors' Report, which is a document limited companies are required to file at the end of the financial year under the requirements of U.K. company law. It is somewhat comparable to SEC Form 10-K in the United States.

What makes the U.K. GHG emissions disclosure regulation unique is that, in contrast to other disclosure regulations concerning non-financial information (e.g., the EU Directive on non-financial disclosures (Grewal, Riedl, and Serafeim 2019), the U.K. regulation is prescriptive about (1) what kind of information needs to be disclosed, (2) how this information needs to be presented, and (3) where the information needs to be disclosed. In other words, the regulation is mandatory, prescriptive, and standardized.

[6] The definitions of Scope 1, 2, and 3 emissions come from the GHG Protocol, which is an organization that provides standards, guidance, tools, and training for business and government to measure and manage emissions (see http://bit.ly/379czkh).

[7] The Act exempts certain firms from the reporting requirement, most notably small firms. Small firms are defined as firms that meet at least two of the following requirements: (i) Turnover lower than GBP 6.5m, (ii) balance sheet total lower than GBP 3.26m or, (iii) average number of employees lower than 50. Given that firms that list on LSE's main market are mostly large and mature, there are hardly any firms that come close to these thresholds.

In addition, it is the only instance of securities markets regulators making the disclosure of GHG emissions a listing requirement.

[Figure 2 about here.]

Figure 2 shows an example of GHG emissions disclosure by Unilever and Tesco, two U.K. quoted companies. Panel A displays GHG emissions disclosures for both firms before the regulation in 2012 and Panel B shows GHG emissions disclosures taken from the firms' Directors' Reports after the regulation came into force, that is in 2013. Panel A shows that, while one firm discloses a paragraph indicating its absolute reduction in emissions over the period 2008-2012, the other firm discloses year-on-year relative percentage reductions in GHG emissions from 2008 to 2012. For investors, the disclosed information (i.e., relative and absolute reductions) are not easily comparable across firms. For instance, based on the information displayed in Panel A, an investor cannot identify which firm has lower GHG emissions.

Panel B of Figure 2 shows how the information is disclosed under the new reporting requirement. The disclosed information is now much more comparable. In line with the requirements of the regulation both firms now report absolute levels and carbon intensities in terms of Scope 1 and Scope 2 emissions. An investor can now easily and quickly identify which of the firms is more carbon efficient. The example from Figure 2 already suggests that the regulation makes it easier to compare firm-level GHG emissions both in the time series and cross section.

Not only does the regulation make it easier to compare firms in terms of their GHG emissions, but the regulation also increases the availability of GHG emissions data. Evidence of an increase in the availability of GHG emissions data is provided in Figure 3.

[Figure 3 about here.]

The figure shows the availability of GHG emissions data at the firm-level in the U.K. compared to the rest of Europe. The pink and blue lines correspond to the percentage of U.K. and European firms that report their total GHG emissions. Before the regulation, that is to the left of the grey vertical line, U.K. and European disclosures follow similar trends. After the regulation, that is to the right of the grey vertical line, the disclosure rate for U.K. firms increases in comparison to the disclosure rate of European firms. We find that, by the end of 2016, about 98% of U.K. firms concerned by the regulation were compliant and reported their GHG emissions in their annual reports. In contrast, the disclosure rate for European firms—which by design were excluded from the regulation—was lower at 40%. According to the Sustainable Stock Exchanges Initiative (SEE 2018) the London Stock Exchange now exhibits the highest disclosure rate for GHG emissions among large stock exchanges.[8]

2. Data and Summary Statistics

2.1 Main Data

We collect accounting data in British Pound (GBP) from Worldscope Refinitiv (formerly Thomson Reuters). GHG emissions data, in metric tons of carbon dioxide equivalent ($MtCO_2e$), come from Refinitiv ESG (formerly Thomson Reuters Asset4)

[8] Large stock exchanges are defined by the Sustainable Stock Exchanges Initiative as stock exchanges with at least 100 listed companies with over $1 billion in sales. See http://bit.ly/35g8aKf.

and CDP (formerly the Carbon Disclosure Project). CDP is a not-for-profit organization that uses annual surveys to collect data on how firms manage climate-related issues. We merge GHG emissions data from Refinitiv ESG and CDP to obtain the largest possible sample of firms with available GHG emissions data.[9] We exclude firms with annual sales growth larger than 500% and firms with negative assets or sales. In order to be able to make meaningful comparisons over time, we further restrict our sample to firms that report GHG emissions in 2010. This restriction addresses two potential concerns. A first concern could be that our results are driven primarily by firms that only start disclosing their GHG emissions after the regulation came into effect.[10] The second concern is that U.K. firms that start reporting their GHG emissions after 2010 may already anticipate the introduction of the regulation. Our final sample covers 16 countries and runs from 2009 to 2016. To reduce the effect of outliers, we winsorize all ratio-based variables at the 1% level.

In later parts of the paper we also use institutional ownership as an outcome variable. The data used to construct this variable come from Factset (Ferreira and Matos 2008). As is customary when dealing with these data, we restrict holdings of institutional investors to non-voting depositary receipt (NVDRs), American depositary receipts (ADRs), depositary receipts (DRs)/certificates, global depositary receipts (GDRs), common/ordinary shares, alien/foreign shares, preferred shares and preferred equity. We also restrict the institutional ownership data to equity securities with

[9] Our results are identical when using emissions data only from Refinitiv ESG or only from CDP.
[10] After the regulation, many smaller U.K. firms that did not disclose prior to the regulation start disclosing their GHG emissions. These firms tend to have relatively low GHG emissions, mainly because of their smaller size. Thus, if we do not restrict our sample to firms that already report GHG emissions in 2010, the inclusion of these smaller first-time disclosers would mechanically make our results stronger.

available International Securities Identification Number (ISIN), as we need ISINs to match institutional ownership from Factset to accounting data from Worldscope.

Finally, we obtain a measure of media-related GHG emissions controversies from RepRisk. Analysts at RepRisk collect negative news related to firms' environmental, social, and governance policies. The information is collected from media sources including newspapers, social media, online news, blogs and NGOs using artificial intelligence and human analysis in 20 languages. Based on RepRisk database, and for each firm from 2009 to 2015, we identify and count GHG emissions controversies. GHG emissions controversies are defined as controversies related to global pollution (including climate change and GHG emissions). We then sum the number of GHG emissions controversies for each firm in a given year and divide this sum by the total number of annual controversies. Total controversies are defined as any controversies related to environmental, governance, or social issues. Again, we restrict our sample to firms with available ISINs.

2.2 Treatment (U.K.) and Control (European) Group

To define a constant panel of U.K. firms affected by the regulation, we follow the requirements of the regulation and restrict our analysis to U.K. incorporated companies listed on the Main Market of the LSE. Because it is uncommon for large U.K. incorporated companies to choose stock exchanges other than the LSE for their primary listing, we focus on stocks listed on the LSE. We obtain a list of firms incorporated on the Main Market of the LSE from the website of the London Stock Exchange[11]. We merge the firms on this list with data from Refinitiv Worldscope,

[11] See https://bit.ly/3bsHvyg

Refinitiv ESG, and CDP. Using a variable from Refinitiv Worldscope indicating the listing venue, we carefully double-check if the U.K. firm is listed on the Main Market, and if not, exclude it from the analysis. We also exclude small firms which are exempted from the regulation and firms for which total GHG emissions are missing in 2010. We obtain a sample of 163 treated U.K. firms.

To form the control group, we construct a constant panel of firms listed on European stock exchanges outside of the United Kingdom. Mirroring the construction of the treatment group, we merge the Refinitiv Worldscope data with Refinitiv ESG, and CDP and again exclude firms for which total GHG emissions are missing in 2010. We obtain a control group of 356 European firms.

[Table 1 about here.]

In Table 1 Panel A, we examine the geographic distribution of control and treatment firms across different stock exchanges. The top three stock exchanges in terms of number of firms in the European control sample are Euronext Paris (18.16%), Deutsche Boerse AG (14.25%), and Nasdaq Stockholm AB (11.45%).

2.3 Summary Statistics

In Panel B of Table 1, we report summary statistics for U.K. and European firms before the introduction of the regulation. It shows that U.K. firms tend to be smaller in terms of assets and have lower total GHG emissions than European firms.

In Panel C of Table 1, we report summary statistics before the introduction of the regulation for U.K. firms only. We split the U.K. sample into U.K. firms with high and low GHG emissions. We define high-emissions U.K. firms as firms with GHG emissions above the median in a given year. Panel C shows that high- and low-emissions firms are different along various dimensions. First of all, they differ in terms of size as measured by *ln(Assets)*, which seems plausible given that larger firms typically generate more GHG emissions. In addition, high-emissions firms also have more tangible assets, which again seems plausible since firms that rely more heavily on tangible assets are also more likely to generate larger amounts of GHG emissions than firms with production processes more reliant on human capital or intangibles.

High- and low-emissions firms also differ in terms of some of the outcome variables we use later on to better understand why firms reduce their GHG emissions. More specifically, GHG emissions dispersion within industries, number of GHG emissions related controversies, and institutional ownership differs between high- and low-emissions firms.

Note that similar firm-characteristics in the pre-regulation period are not a necessary condition for the validity of our identification strategy. Instead, to validate our identification strategy, the average change in the outcome variable in both the treatment and control group should be the same in the pre-treatment period.

3. Does Mandatory Disclosure Lead to a Reduction in Firm-Level GHG Emissions?

3.1 Baseline Results

The ideal theoretical experiment to estimate the effect of the regulation on corporate GHG emissions would be to take two United Kingdoms, to expose one of them to the regulation and use the other one as a counterfactual. In practice, we approximate such an experimental design by comparing publicly listed U.K firms—the treatment group—to comparable listed companies in other European countries—the control group. We then use the introduction of the regulation as a quasi-natural experiment by comparing the changes in GHG emissions between U.K. and European firms before (2009-2012) and after (2013-2016) the regulation. Under the null hypothesis that the mandatory, prescriptive, and standardized GHG emission disclosure regulation has no impact, the change in GHG emissions between U.K. and European firms would be indistinguishable from zero. On the other hand, if the introduction of GHG emissions disclosure leads firms to reduce their GHG emissions, the change in GHG emissions between U.K and European firms should be negative. To examine this hypothesis, we estimate the following regression equation for firm *i*, in industry *j,* listed on stock exchange *s*, in year *t* :

$$
\begin{aligned}
ln(\text{GHG emissions})_{ijst} &= \beta_1 \text{ Treat}_i + \beta_2 \text{ After}_t + \beta_3 \text{ Treat}_i \times \text{ After}_t \\
&+ \beta_4 \ ln(\text{Assets})_{it} + \beta_5 \ ln(\text{Tangible Assets})_{it} + \alpha_t \\
&+ \eta_j + \phi_s + \varepsilon_{ijst}.
\end{aligned} \qquad (1)
$$

In this difference-in-difference equation, the dependent variable is the natural logarithm of the firm's Total GHG emissions (measured in $MtCO_2e$). *Treat* is a dummy indicating if the firm is a U.K. quoted company listed on the Main Market of the LSE. *After* is a dummy variable indicating the introduction of the regulation in 2013. The *After* dummy is equal to zero until 2012 and one thereafter. We control for firm size using the logarithm of total assets and for physical assets using the logarithm of tangible assets. α_t, η_j and ϕ_s are year, industry and stock exchange fixed effects, respectively. The year fixed effects, α_t, control for global trends in emissions common to all firms in our sample. The industry fixed effects, η_j , control for potential systematic differences in GHG emissions across industries. Industry fixed effects also address the concern that a subset of industries is driving our results. We define each firm's industry based on Fama–French 49 industry classification (Fama and French 1997). Finally, the stock-exchange fixed effects ϕ_s control for any time-invariant differences between countries such as differences in environmental policies, economic development, or cultural preferences. We cluster standard errors at the stock exchange-year level.

Note that the treatment dummy, *Treat*, is collinear with the stock-exchange fixed effects. In a similar spirit, the *After* dummy is collinear with the year fixed effects. Thus, both variables are absorbed in the estimation of equation (1) and what ultimately matters for our paper is the coefficient on the interaction between the *After* and the *Treat* dummies. In other words, the coefficient of interest in Equation (1) is β_3, which measures the change in absolute GHG emissions between U.K. and European firms following the introduction of the regulation. If the regulation has no impact on firm-level GHG emissions, β_3 should be insignificant. In contrast, if the regulation leads to a reduction in corporate GHG emissions, β_3 should be negative and significant.

[Table 2 about here.]

In Panel A of Table 2 we report the estimation results for specification (1). We use several variants of absolute GHG emissions as the dependent variable. In Column 1 of the table, we estimate β_3 to be -0.16. The estimate is highly statistically significant *(t-*stat*=-3.93)* and indicates that, following the regulation, U.K. firms reduce their absolute Total GHG emissions by [*exp*(-0.16)-1]×100= 14.8% in comparison to

European firms. This reduction in GHG emissions allows us to reject the hypothesis that the U.K. regulation—that is, mandatory, prescriptive, and standardized GHG emissions disclosure—has no impact on corporate GHG emissions.

In Columns 2—4 of Table 2 Panel A, we examine which component of total GHG emissions drives the reduction in emissions by splitting total GHG emissions into Scope 1, Scope 2, and Scope 3 emissions.[12] We find that the reduction in the absolute level of Total GHG emissions for U.K. firms is mainly explained by a decrease in Scope 2 emissions. Firms in the U.K. reduce their Scope 2 emissions by $[exp(-0.21)-1]\times 100=$ 18.94% in comparison to European firms (see Column 3, Table 2, Panel A). In contrast, Column 2, Panel A, Table 2 shows that they reduce their Scope 1 emissions by a lower $[exp(-0.08)-1]\times 100=$ 7.69% and do not reduce their Scope 3 emissions (Column 4). Notably, Scope 3 emissions are not required to be disclosed by the regulation. As such, the specification in Column 4 that uses Scope 3 emissions as dependent variable is akin to a placebo test. Taken together, the absence of an effect for Scope 3 emissions (Column 4) and the significant treatment effects for Total, Scope 1, and Scope 2 emissions (Columns 1 to 3) suggest that mandatory, prescriptive, and standardized GHG disclosure regulation at the firm-level results in a reduction of GHG emissions.

One potential concern with the previous analysis is that we focus on absolute emissions. For instance, U.K. firms may have lower absolute GHG emissions post regulation simply because they reduce their scale. To confirm that our results are not driven by firm size, we repeat the analysis by using relative instead of absolute emissions as the dependent variable (see Panel B of Table 2). While Specification (1)

[12] Scope 1 emissions are direct emissions from owned or controlled sources of the reporting company and Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions not included in Scope 2 that occur in the value chain of the reporting company, including both upstream and downstream emissions. Section 1 provides more background on GHG emissions measurement.

and the analysis in Table 1, Panel A already control for firm size, we believe that analyzing relative emissions has further merits given that relative emissions may be an indicator to measure the extent to which assets are run in a climate-efficient way. We measure relative emissions as the ratio of the firm's GHG emissions (in $MTCO_2e$) over tangible assets (in 10^3 GBP). Since firms' GHG emissions are normalized by tangible assets, we remove the tangible assets control variable from the specification. Hence our modified specification is similar to specification (1), except for changing the dependent variable and removing the logarithm of tangible assets as control.

Table 2, Panel B, shows the results using this modified specification. In line with the analysis using absolute emissions in Panel A, we find that U.K. firms reduce their total relative emissions by 17% in comparison to European firms after the regulation (see Column 1, Panel B, Table 2).[13] In contrast to the analysis for absolute emissions—in which the reduction was slightly less pronounced for Scope 1 emissions—the reduction in relative total GHG emissions is highly significant for both the reduction in relative Scope 1 (t-stat=-3.17) and Scope 2 (t-stat=-4.61) emissions. Following the introduction of the regulation, U.K. firms reduce their relative Scope 1 emissions by 11% and their relative Scope 2 emissions by 4% in comparison to European firms. The effect for relative Scope 3 emissions is not significant (Column 4).

3.2 Does the Treatment Effect Depend on the Level of GHG emissions?

The analysis in the previous section shows how the average U.K. firm responds to the disclosure regulation. It is plausible that the effect of the regulation varies according to observable cross-sectional characteristics, for example the level of GHG

[13] Given that the dependent variable in Panel B of Table 2 is no longer in logs, we can simply interpret the estimated coefficients in percentage terms.

emissions. To test this conjecture, we now analyze whether firms respond to the regulation differently conditional on the level of their GHG emissions. To do so, we form tercile groups by sorting U.K. and European firms each year according to their level of absolute and relative GHG emissions. We then estimate the same specifications as before, but restrict the sample to firms with low (Bottom tercile) and high (Top tercile) GHG emissions. We thus compare U.K. and European firms with the lowest and highest GHG emissions. We expect that U.K. firms with higher emissions react more strongly to the disclosure regulation.

[Table 3 about here.]

In Columns 1 and 2 of Table 3, we report the estimated treatment effects (that is the coefficient estimates for β_3) using absolute emissions as a dependent variable. In Columns 4 and 5 relative emissions serve as the dependent variable. Consistent with our conjecture, we find evidence suggesting a stronger decrease in GHG emissions for high- than for low-emitting U.K. firms. For example, Column 2 displays an estimated treatment effect of 0.12 (t-stat=1.85) for the absolute emissions of U.K. firms in the bottom tercile of the GHG emissions distribution. In contrast, in Column 3, we estimate a negative treatment effect of -0.21 (t-stat=-4.12) for firms with the highest GHG emissions. We obtain similar results for relative emissions in Columns 4 and 5 of Table 3: while the estimated treatment effect for the lowest emitting firms is only -0.01 (t-stat=-4.14), it is -0.32 (t-stat=-2.37) for the highest emitters.

The difference-in-differences analysis in Columns 1 and 2 (and Columns 4 and 5) of Table 3 allow us to compare U.K. and European firms within a given tercile of

GHG emissions, but they prevent us from concluding decisively that U.K. firms in the top tercile reduce their emissions more strongly than U.K. firms in the bottom tercile.. To compare firms across the bottom and top terciles, we now estimate a triple-differences specification by adding to Specification (1) a *Top tercile* dummy and the respective interactions. The *Top tercile* dummy indicates if a firm falls in the top tercile of GHG emissions in a given year. More specifically, we estimate the following equation:

$$\begin{aligned} ln(\text{GHG emissions})_{\text{ijst}} = \; & \beta_1 \, \text{Treat}_{\text{i}} + \beta_2 \, \text{After}_{\text{t}} + \beta_3 \, \text{Treat}_{\text{i}} \times \text{After}_{\text{t}} \\ & + \beta_4 \, \text{Top tercile}_{\text{it}} + \beta_5 \, \text{Top tercile}_{\text{it}} \times \text{Treat}_{\text{i}} + \\ & \beta_6 \, \text{Top tercile}_{\text{it}} \times \text{After}_{\text{t}} \\ & + \beta_7 \, \text{Top tercile}_{\text{it}} \times \text{Treat}_{\text{i}} \times \text{After}_{\text{t}} \\ & + \beta_8 \, ln(\text{Assets})_{\text{it}} + \beta_9 \, ln(\text{Tangible Assets})_{\text{it}} \\ & + \alpha_{\text{t}} + \eta_{\text{j}} + \phi_s + \varepsilon_{\text{ijst}}, \end{aligned} \qquad (2)$$

The coefficient of interest in Specification (2) is the coefficient estimate on the triple interaction term, that is β_7. This coefficient estimates whether the difference in GHG emissions between U.K firms in the top tercile and U.K firms in the bottom tercile is significantly different relative to the difference in GHG emissions of European firms in the top and bottom terciles. When using relative emissions as a dependent variable, we again drop the logarithm of tangible assets as control variable and estimate a specification that is otherwise identical to Specification (2). Columns 3 and 6 of Table 3 report the estimates for β_7 for absolute and relative emissions. In our analysis, we find negative and significant estimates for β_7, suggesting that U.K. firms with the highest levels of absolute and relative emissions do indeed reduce their emissions more strongly following the regulation than U.K firms with the lowest levels of absolute or relative emissions.

[Table 4 about here.]

Next, we study whether our results on stronger reductions in emissions for high versus low emitting U.K. firms differ if we decompose total emissions in their Scope 1 and Scope 2 components. Similarly to the previous analysis, we now sort firms into low and high emitters based on the distribution of Scope 1 and Scope 2 emissions. We then analyze changes in absolute emissions in Columns 1 and 2 of Table 4 and relative emissions in Columns 3 and 4. We only report the treatment effects (i.e., the coefficients on the interaction terms between the treatment and after dummies). Generally speaking, we find that most treatment effects are stronger among high emissions firms, that is, in the respective top tercile. In other words, U.K. firms with the highest emissions tend to decrease their emissions while those with the lowest emissions tend to have insignificant (or sometimes positive treatment effects) decrease in their GHG emissions in comparison to European firms with the lowest emissions. Perhaps one exception is relative Scope 2 emissions, where low emissions U.K. firms also strongly decrease their GHG emission. The effects are sizeable. For example, Columns 2 shows that firms within the top tercile reduce their absolute Scope 1 emissions by [exp(-0.18)-1]×100= 16.47% and their Scope 2 emissions by an even stronger [exp(-0.24)-1]×100= 21.3 %—always relative to European

3.3 Examining Differences in the Treatment Effect Along Other Observable Cross-Sectional Dimensions

In Table 4 we also examine whether the treatment effect varies along other observable firm-characteristics. We choose two plausible firm-characteristics, namely tangible assets and sales. The idea behind differing treatment effects conditional on tangible assets is that firms with more tangible assets have higher emissions and a potentially more negative climate impact. Thus, such firms should decrease their emissions more strongly as a result of the regulation. The second conjecture based on firm size is that larger firms—as proxied by sales—should also decrease their emissions more strongly given that larger firms have a proportionally more negative impact on the climate.

As in the conditional analysis based on GHG emissions, we form terciles for U.K. and European firms each year according to firms' levels of tangible assets and sales. The *Top tercile* dummy now identifies firms with either the highest level of tangible assets or the highest level of sales. We use the same dependent variables, namely relative and absolute Total GHG emissions. Table 4 shows that changes in GHG emissions between U.K. and European firms within the top terciles are negative and significant: U.K. firms with the highest levels of tangible assets or sales reduce their emissions more than European firms with the highest levels of tangible assets or sales.

Overall the analysis in Tables 3 and 4 shows that the regulation mainly impacts big firms with high levels of relative emissions, absolute emissions, tangibles assets, and sales.

3.4 Controlling for Pre-Regulation Differences

A potential concern with our results is that they might be driven by pre-regulation differences between U.K. and European firms that are not addressed in our specifications. To address this concern, we examine in Figure 4 differences in GHG emissions between U.K. and European firms around the regulation. To do so, we use

Specification (1) but replace the *After* dummy with year dummies marking each year from 2009 to 2016. We use our modified specification to estimate changes in relative emissions by removing the logarithm of tangible assets as control variable from Specification (1). The point estimates in the figure correspond to the average difference in GHG emissions between U.K. and European firms in a given year relative to the year 2009. If the average differences in GHG emissions between U.K. and European firms would be diverging before the introduction of the regulation, it would mean that our specification is invalid. On the other hand, if average differences in GHG emissions between both groups become significant only from the date of the introduction of the regulation, it would suggest that our specification is valid—meaning that U.K. and European GHG emissions would have followed parallel trends absent of the regulation.

[Figure 4 about here.]

Figure 4 shows that, before the regulation, the estimated differences between U.K. and European firms are not statistically significant (for both absolute and relative GHG emissions). After the introduction of the regulation, however, the relative and absolute GHG emissions of U.K. firms drop significantly in comparison to the GHG emissions of European firms. Thus, Figure 4 supports the validity of our empirical design by providing evidence that the change in GHG emissions between U.K. and European firms would have been the same in the absence of the regulation.

4. Why Do Firms Reduce GHG Emissions as a Result of a Mandatory, Prescriptive, and Standardized GHG Emissions Disclosure Regulation?

The analysis up to this point shows that U.K. firms reduce their GHG emissions following the introduction of the regulation. While it is certainly important to know that GHG emissions fall as a result of the disclosure regulation, it is important to explain why U.K. firms reduce their GHG emissions. To address this question, we now examine three non-mutually exclusive hypotheses. We develop these three hypotheses based on the idea that U.K. corporate GHG emissions become more *salient* and more *comparable* after the regulation and that large U.K firms reduce their emissions more than small U.K. firms.

Our first hypothesis is that U.K. firms reduce their emissions because of institutional investors' preferences and pressures. The second hypothesis is that U.K. firms reduce their emissions because firms want to avoid bad media coverage related to GHG emissions. Finally, the third hypothesis is based on the idea that U.K. firms, by learning from their peers' GHG disclosures, reduce their GHG emissions to stay competitive.

To test these hypotheses, we rely on a subsample analysis. We split both the U.K and European samples into high- and low-emission firms. High- (low-) emissions firms are defined as firms above (below) the median of total GHG emissions in a given year. We then estimate Specification (1) by substituting the *Treat* dummy by a *Top dummy*. The *Top dummy* indicates if a firm belongs to the high emissions group in a given year. Because we analyze U.K. and European firms separately, we also remove the stock exchange fixed effects from the analysis. Effectively, in this section we are comparing high and low emissions firms before and after the regulation separately for the control and treatment group.

We begin by testing our first hypothesis, which is based on the idea of institutional investor pressure. The hypothesis is built on the now emerging evidence that institutional investors increasingly screen their portfolio firms on GHG emissions (Bolton and Kacperczyk 2019, 2020; Krueger et al. 2020). In our test, we estimate the change in a firm's institutional ownership between firms with high and low emissions. If institutional investors invest less in firms with high emissions, such firms should have an incentive to decrease their GHG emissions to remain attractive for institutional investors. In particular, if the regulation-induced reduction in greenhouse gas emissions that we document is driven by institutional owners, institutional ownership for U.K firms with high emissions should drop after the regulation in comparison to U.K firms with low emissions. Importantly, we should not observe such an effect in the control sample of European firms, mainly because these firms are not exposed to the regulation.

[Table 5 about here.]

The first column of Table 5, Panels A and B, show the results for U.K. and European firms, respectively. We find that while institutional ownership for high-emissions relative to low-emissions U.K. firms decreases by about 4 percentage points following the regulation (Table 5, Panel A, Column 1), there is no change in the difference in institutional ownership between high- and low-emissions European firms after the regulation (Panel B, Column 1). The negative and highly significant estimate for U.K. firms is consistent with the notion that—following the disclosure regulation—

institutional investors can better compare U.K. firms in terms of their GHG emissions and subsequently reallocate capital from high- to low-emissions firms. The reallocation, in turn, puts pressure on firms to reduce their emissions to remain attractive for institutional investment.

Next, we test our second hypothesis which is concerned with negative media coverage for high-emissions firms. If negative media coverage related to carbon emissions rises for U.K. firms with high emissions after the regulation, mainly because standardized information about firms' GHG emissions becomes more available, it may also provide incentives to firms to decrease their emissions to undo the negative impact on their reputation. We repeat the above analysis using the annual percentage of environmental controversies related to GHG emissions for each firm between 2009 and 2015 as a dependent variable. The annual percentage of GHG emissions controversies corresponds to the number of controversies related to "Global Pollution (Including Climate Change and GHG Emissions)" divided by the total number of controversies related to environmental, social or governance issues in a year, as defined by RepRisk. We normalize by the total number of controversies because larger firms are subject to more controversies and thereby ensure that any results would not be driven by firm size. If the documented reduction in GHG emissions is the result of bad media coverage for high-emissions firms, the percentage of GHG emission controversies should rise for high-emissions U.K firms in comparison to low-emissions U.K. firms, but no such effect should be visible for European firms.

Column 2, Panel A, Table 5 shows that the percentage of GHG emissions controversies for high-emissions U.K. firms increases by 41% relative to low-emissions U.K. firms. In contrast, Column 2, Panel B, Table 5 shows that the change in the percentage of GHG emissions controversies between high and low-emissions firms from other European countries is insignificant. Our analysis suggests that mandatory and *standardized* GHG emissions disclosure makes it easier to identify firms with GHG emissions related controversies, which in turn puts pressure on high-emissions U.K. firms to reduce their emissions.

If information on GHG emissions is easier to use and more salient—mainly because it becomes standardized under the regulation—it should also make it easier for managers to benchmark their firms with competitors in terms of GHG emissions. Hence, our last hypothesis is built on the idea that managers learn from peer disclosures. Because the regulation makes corporate GHG emissions publicly available and standardized, the decrease in GHG emissions for U.K. firms may be explained by managers taking measures that reduce emissions whenever these emissions are high relative to industry peers. In particular, if our results are driven by managers learning from each other's disclosures, then within-industry GHG emission dispersion should fall after the regulation. To test this hypothesis, we follow Tomar (2019) and use GHG emissions dispersion as a dependent variable. We use the standard deviation of GHG emissions within an industry to capture the idea that managers take measures that make their emissions more aligned with those of their peers.

Column 3, Panel A, Table 5 shows the results for U.K. firms while Column 3 Panel B, displays the results for European firms. The dependent variable is the within-industry standard deviation of GHG emissions. For U.K. firms, we find a negative and highly significant effect on dispersion (*t*-stat=-4.30). In contrast, for European firms, we find no effect. The negative coefficient for U.K. firms indicates that GHG emissions dispersion for high-emission U.K. firms decreases more after the regulation than GHG emissions dispersion for low-emission U.K. firms. Importantly in these regressions we control for industry effects, which makes the evidence consistent with the idea that managers learn from their peer's disclosures and reduce their GHG emissions whenever they are high relative to industry peers.

Overall, our analysis is consistent with stakeholder pressures playing an important role in pushing firms to decrease GHG emissions. In Table 3, we observe that U.K. firms with the highest emissions reduce their emissions more than U.K. firms with the lowest emissions. This result suggests that U.K. firms with the highest emissions are subject to higher stakeholder pressures than other firms to decrease their GHG emissions. In Table 5, we show that U.K. firms with high emissions have lower institutional ownership than low emission firms after the regulation. In addition, high emission firms in the U.K. are subject to more negative media coverage related to GHG emissions after the introduction of the regulation. We also show that managers learn from industry peers' disclosures, resulting in lower within-industry dispersion of GHG emissions. Remarkably, we do not observe any of these three mechanisms for European firms with high GHG emissions, suggesting that mandatory, prescriptive, and standardize GHG disclosures are the cause of the reduction in GHG emissions for U.K. firms. To ensure the validity of the estimates of the regulation on institutional ownership, media coverage and within-industry variation in GHG emissions, we examine, in Figure 5, differences in these three variables between high- and low-emission U.K firms around the regulation. We interact the Top dummy with event-time dummies.

[Figure 5 about here.]

The figure shows that before the regulation takes effect, the differences in the outcome variables between high- and low-emissions firms are insignificant and only become significant after the regulation takes effect. Such evidence is consistent with the view that stakeholder pressures increase after the mandatory, prescriptive, and standardized corporate GHG emissions disclosure regulation takes effect. Further, because we find insignificant differences in the pre-regulation period, we believe that our identification strategy is valid.

5. Stock Market Response to the Regulation

In the previous section, we provided evidence suggesting that—after the disclosure regulation takes effect—institutional investors reallocate equity capital from U.K. firms with high emissions to U.K. firms with low emissions. Thus, one may wonder about the direct effects of the regulation on equity valuations. In this section, we examine how the stock market responds to the regulation. More specifically, we are interested in how investors react to first-time disclosures of standardized GHG emissions.

To do so, we hand-collect the standardized GHG emissions reported in the directors' reports of U.K. firms between 2013 and 2014. We focus on the years 2013 and 2014 because this period covers the first reporting season in which firms have to include the disclosures in their Directors' Reports. Specifically, we check whether total, direct, and indirect GHG emissions as well as intensity ratios are disclosed. If one component is missing, we exclude the firm from our sample because the firm is noncompliant with the regulation. If a firm is compliant with the regulation, we identify the date of the disclosure of the standardized GHG emissions. We assume that the date of disclosure corresponds to the date of the annual earnings announcement. To ensure that we use the correct annual earnings announcement date, we double-check for each firm that the date of approval of the annual financial statement which is typically reported at the same time as the directors' report, is prior to the annual earnings announcement date. We then merge disclosure dates with daily market adjusted returns. We compute daily market adjusted returns as the difference between daily stock returns and daily market returns. The daily market returns are the daily returns of the value-weighted MSCI Europe index in pounds.[14]

Under the null hypothesis that standardized GHG emissions do not contain new information for investors, we should see insignificant differences in market adjusted returns between firms that disclose high or low levels of GHG emissions. On the other hand, if standardized GHG emissions contain new information for investors, we should see that market adjusted returns depend on the disclosed levels of GHG emissions.

[Figure 6 about here.]

Figure 6 shows the results from testing the hypothesis that the disclosure of standardized GHG emissions contains new information for investors. The figure displays cumulative market adjusted returns for U.K. firms from ten event days prior to the first disclosure date to ten event days after the disclosure date for three event portfolios formed on conditional on *industry-adjusted* GHG emissions. We sort firms

[14] The MSCI Europe Index consists of the following European country indexes: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. Details are available at: https://bit.ly/2UnTmXW.

into terciles of industry-adjusted GHG emissions, which correspond to the firm's GHG emissions minus the average GHG emissions of its industry in a given year. The green, gray and brown lines show the cumulative market adjusted returns of firms that disclose low (bottom tercile), medium (medium tercile), and high (top tercile) industry-adjusted GHG emissions relative to their industry peers. The figure shows that the stock market response depends on the levels of disclosed GHG emissions. Before firms disclose their GHG emissions for the first time (to the left of the gray dashed line), the cumulative market adjusted returns for the three groups are similar before the event date. In contrast, after firms disclose their GHG emissions for the first time (to the right of the gray dashed line), the cumulative market adjusted returns for the three groups differ substantially: while firms disclosing low GHG emissions relative to industry peers exhibit positive and high cumulative market adjusted returns, firms with high industry adjusted GHG emissions exhibit negative cumulative market adjusted returns. Thus, Figure 6 suggests that investors pay attention to the levels of GHG emissions when these are disclosed in a standardized way. Importantly, firms with high emissions are punished while firms with low emissions are rewarded.

In Table 6, we examine the relation between cumulative market adjusted returns and disclosed GHG emissions more formally. More specifically, we regress the cumulative market adjusted returns on dummies indicating the terciles of industry-adjusted GHG emissions. We focus on the announcement returns in the event window just around the disclosure of GHG emissions and denote this variable as [-1,1]. If investors pay attention to the levels of standardized GHG emissions, the coefficients associated with the dummy variables indicating firms with medium and high industry adjusted GHG emissions should be negative. Negative coefficients would mean that firms with low GHG emissions relative to their industry peers exhibit significantly higher returns than firms with medium and high GHG emissions.

[Table 6 about here.]

In Column 1, Panel A, Table 6, we find negative coefficients associated with the medium and high dummies. Firms that disclose medium and high GHG emissions have market adjusted returns of about -1.4% and -2.5% in comparison to firms that disclose low GHG emissions. Thus, firms with low GHG emissions exhibit significantly higher market adjusted returns around the dates on which they disclose their standardized GHG emissions for the first time.

Since the disclosure dates coincide with annual earnings announcement dates, one may wonder whether disclosed GHG emissions are correlated with earnings surprises. To address this possibility, we directly control for earnings surprises in Column 2, Panel A, Table 6. To measure earnings surprises, we follow the literature (e.g., DellaVigna and Pollet 2009; Hartzmark and Shue 2018) and define earnings surprises as the difference between announced and expected earnings. To measure expected earnings, we use the analyst forecasts prior to the announcement. We then scale the difference between announced and expected earnings by the price of the firm 253 days before the earnings announcement. To mitigate the influence of outliers, we winsorize the earnings surprises at the 1st and 99th percentiles. After including earnings surprises as a control variable in Column 2, Panel A, Table 6 we continue to find negative and significant coefficients associated with the dummy variables *Medium* and *High*.

In Column 3, we include industry fixed effects to address the concern that our results may be explained by a specific subsample of industries. We find that the negative coefficients associated with the dummy variables *Medium* and *High* increase in both statistical and economic significance. Thus, the results in Panel A of Table 6 are in line with the effects observed in Figure 6—the lower the firm's disclosed industry-adjusted GHG emissions, the higher the increase in market adjusted returns.

In Columns 4—6, Panel A, Table 6 we repeat the above analysis using European instead of U.K. firms. While some European firms might disclose their GHG emissions in their annual reports—just as U.K. firms did before the introduction of the regulation—it is unlikely that they disclose their GHG emissions in a standardized way. More importantly, even if some European firms disclose their GHG emissions in their annual reports, it is highly unlikely that all European firms do so. Thus, if investors react to the disclosure of standardized GHG emissions of U.K. firms and not to a potential omitted variable correlated to the levels of GHG emissions, we should see insignificant differences in GHG emissions between European firms with low, medium and high GHG emissions. In Columns 4—6, Panel A, we find that the coefficients associated with the dummy variables *Medium* and *High* are insignificant. This result suggests that investors pay attention to the standardized GHG emissions of U.K. firms disclosed through annual reports and mitigates the concern that potential omitted variables bias our results.

In Panel B of Table 6, we examine the market adjusted returns for different event windows to test for the existence of a systematic trend prior to the disclosure dates. We do so by comparing the difference in returns between firms with high and low GHG emissions. In the absence of trends prior to the disclosure dates, we should see insignificant differences between firms with low and high GHG emissions.

Column 1 shows the absence of a systematic trend in cumulative market adjusted returns for U.K. firms prior to disclosure dates. We find insignificant coefficients for all time intervals but for the event window [-1, 1]. In Column 2, we repeat the analysis by examining different time intervals for the abnormal returns of European firms and do not find any evidence of significant event returns.

Overall, the results in Figure 6 and Table 6 provide evidence that investors take into account the standardized GHG emissions of U.K. firms and invest more in firms with low GHG emissions relative to their industry peers. The analysis also offers a placebo test by showing that investors do not take into account the non-standardized GHG emissions of European firms. The observed positive market adjusted returns for U.K. firms leaves open the question of why investors put a higher valuation on firms with lower GHG emissions.

6. Conclusion

In this paper, we exploit the introduction of a unique firm-level carbon disclosure law in the United Kingdom (U.K.) to estimate whether and why mandatory, prescriptive, and standardized disclosure regulation affects corporate greenhouse gas (GHG) emissions. We present causal evidence that following the introduction of a mandatory, prescriptive, and standardized disclosure scheme, firms reduce their absolute and relative GHG emissions. These reductions in GHG emissions are mainly driven by large firms with high levels of tangible assets and sales as well as firms with high GHG emissions.

We also study why firms decrease their emissions. We provide evidence consistent with the view that the reduction in GHG emissions is explained by stakeholder pressures. By comparing U.K. firms with high and low levels of GHG emissions after the introduction of the disclosure law, we show that U.K. firms with high GHG emissions see a decrease in their institutional ownership and an increase in negative media coverage. Further, we find evidence of managers learning from their peers' disclosures and show that within-industry GHG dispersion decrease for U.K firms in the post-regulation period.

Finally, we explore the effect of the regulation on equity valuations and find evidence that investors take into account the standardized GHG emissions of U.K. firms. When U.K. firms report their standardized GHG emissions under the regulation for the first time, high emissions firms experience decreases in their equity valuations relative to low emissions firms.

Given that limiting global warming below 2 °C requires a large and rapid decline in global GHG emissions, our results have important policy implications. Provided that our results are generalizable at a global scale, we show that mandatory, prescriptive and standardized carbon disclosures regulations can substantially reduce corporate GHG emissions and thus be used to achieve international climate targets. An important implication of our paper is that firm-level GHG disclosure regulation needs all three components, that is it should be mandatory, but also prescriptive and standardized. If the last two components are missing the disclosed information might only be of limited value to the various users of the information (e.g., managers, investors, regulators etc.).

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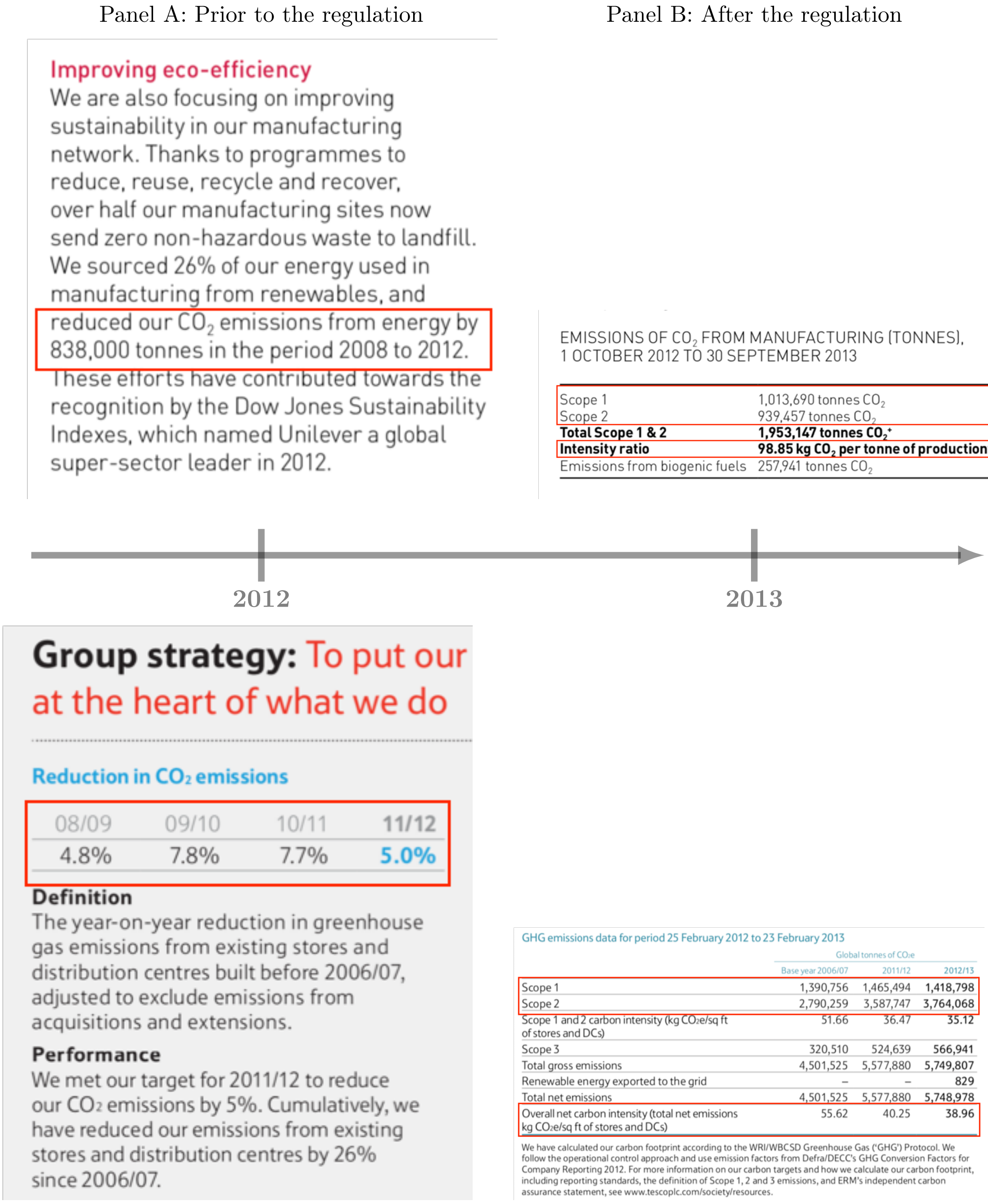

Panel A: Prior to the regulation

Panel B: After the regulation

Improving eco-efficiency
We are also focusing on improving sustainability in our manufacturing network. Thanks to programmes to reduce, reuse, recycle and recover, over half our manufacturing sites now send zero non-hazardous waste to landfill. We sourced 26% of our energy used in manufacturing from renewables, and reduced our CO_2 emissions from energy by 838,000 tonnes in the period 2008 to 2012. These efforts have contributed towards the recognition by the Dow Jones Sustainability Indexes, which named Unilever a global super-sector leader in 2012.

EMISSIONS OF CO_2 FROM MANUFACTURING (TONNES), 1 OCTOBER 2012 TO 30 SEPTEMBER 2013

Scope 1	1,013,690 tonnes CO_2
Scope 2	939,457 tonnes CO_2
Total Scope 1 & 2	**1,953,147 tonnes CO_2***
Intensity ratio	**98.85 kg CO_2 per tonne of production***
Emissions from biogenic fuels	257,941 tonnes CO_2

2012

2013

Group strategy: To put our at the heart of what we do

Reduction in CO_2 emissions

08/09	09/10	10/11	**11/12**
4.8%	7.8%	7.7%	**5.0%**

Definition
The year-on-year reduction in greenhouse gas emissions from existing stores and distribution centres built before 2006/07, adjusted to exclude emissions from acquisitions and extensions.

Performance
We met our target for 2011/12 to reduce our CO_2 emissions by 5%. Cumulatively, we have reduced our emissions from existing stores and distribution centres by 26% since 2006/07.

GHG emissions data for period 25 February 2012 to 23 February 2013

	Global tonnes of CO_2e		
	Base year 2006/07	2011/12	**2012/13**
Scope 1	1,390,756	1,465,494	**1,418,798**
Scope 2	2,790,259	3,587,747	**3,764,068**
Scope 1 and 2 carbon intensity (kg CO_2e/sq ft of stores and DCs)	51.66	36.47	**35.12**
Scope 3	320,510	524,639	**566,941**
Total gross emissions	4,501,525	5,577,880	**5,749,807**
Renewable energy exported to the grid	–	–	**829**
Total net emissions	4,501,525	5,577,880	**5,748,978**
Overall net carbon intensity (total net emissions kg CO_2e/sq ft of stores and DCs)	55.62	40.25	**38.96**

We have calculated our carbon footprint according to the WRI/WBCSD Greenhouse Gas ('GHG') Protocol. We follow the operational control approach and use emission factors from Defra/DECC's GHG Conversion Factors for Company Reporting 2012. For more information on our carbon targets and how we calculate our carbon footprint, including reporting standards, the definition of Scope 1, 2 and 3 emissions, and ERM's independent carbon assurance statement, see www.tescoplc.com/society/resources.

Figure 2. Example of GHG emissions disclosure from the directors' reports of two U.K. quoted companies before and after the regulation. This figure shows examples of GHG emission disclosures for two U.K. firms, Unilever (top) and Tesco (bottom), as reported in their Directors' report. Panel A shows GHG emissions disclosure prior to the regulation in 2012. Panel B shows GHG emissions disclosure after the regulation in 2013. Red rectangles show quantitative information on GHG emissions.

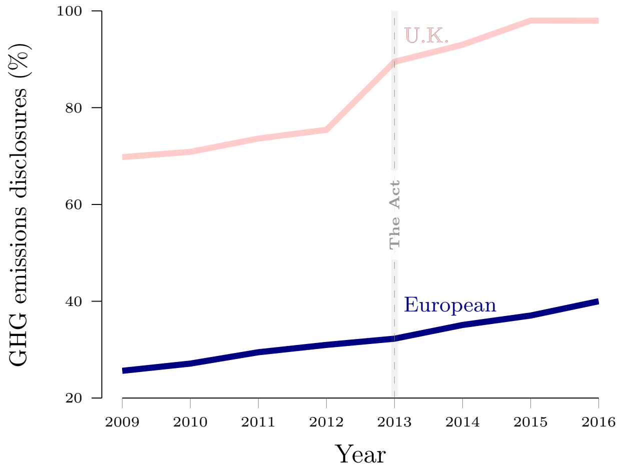

Figure 3. GHG emissions disclosure rates for U.K. and European firms around the regulation. This figure shows the share of U.K. and European firms with available GHG emissions data over the period 2009-2016. The sample corresponds to firms that were either included in Refinitiv ESG or that were contacted by CDP to participate in their survey in 2010. The pink line represents the share of U.K. firms disclosing their emissions. The blue line plots the corresponding number for European firms. The gray line indicates the year in which *The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013 (The Act)* came into force.

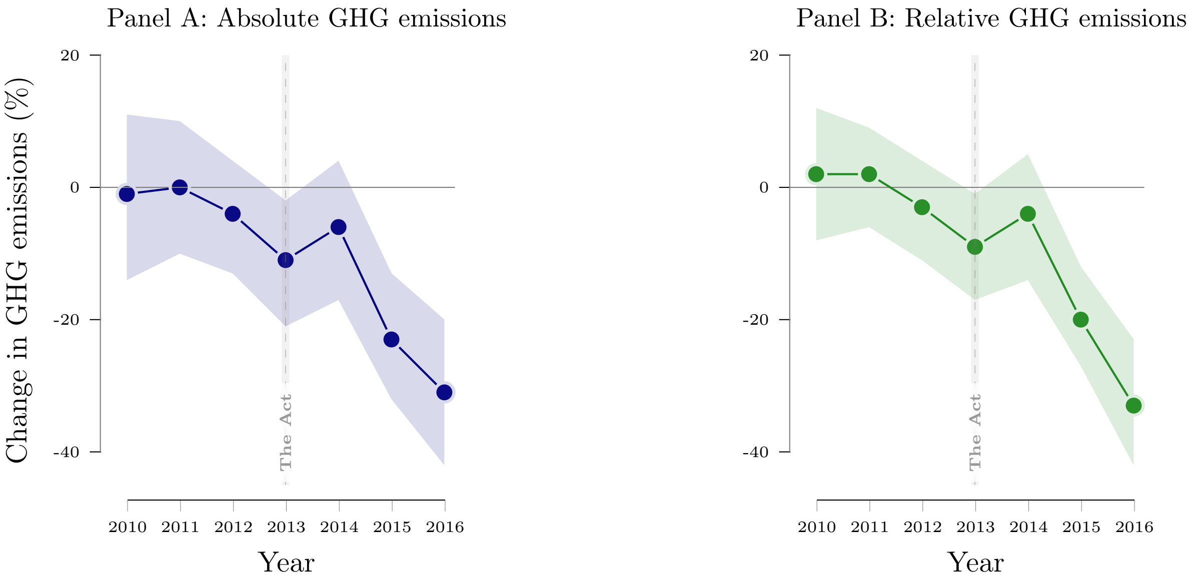

Figure 4. Absolute and relative GHG emissions for U.K. and European firms around the regulation. This figure shows the yearly average differences in GHG emissions between U.K. and European firms. Panel A shows differences in absolute GHG emissions. Panel B shows differences in relative GHG emissions. The gray line indicates the year in which *The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013* (The Act) came into force. The point estimates and 95% confidence intervals (shaded regions) are the coefficients of the interaction terms between the *Treat* dummy and annual event-time dummies around the regulation. The point estimates are relative to the year 2009.

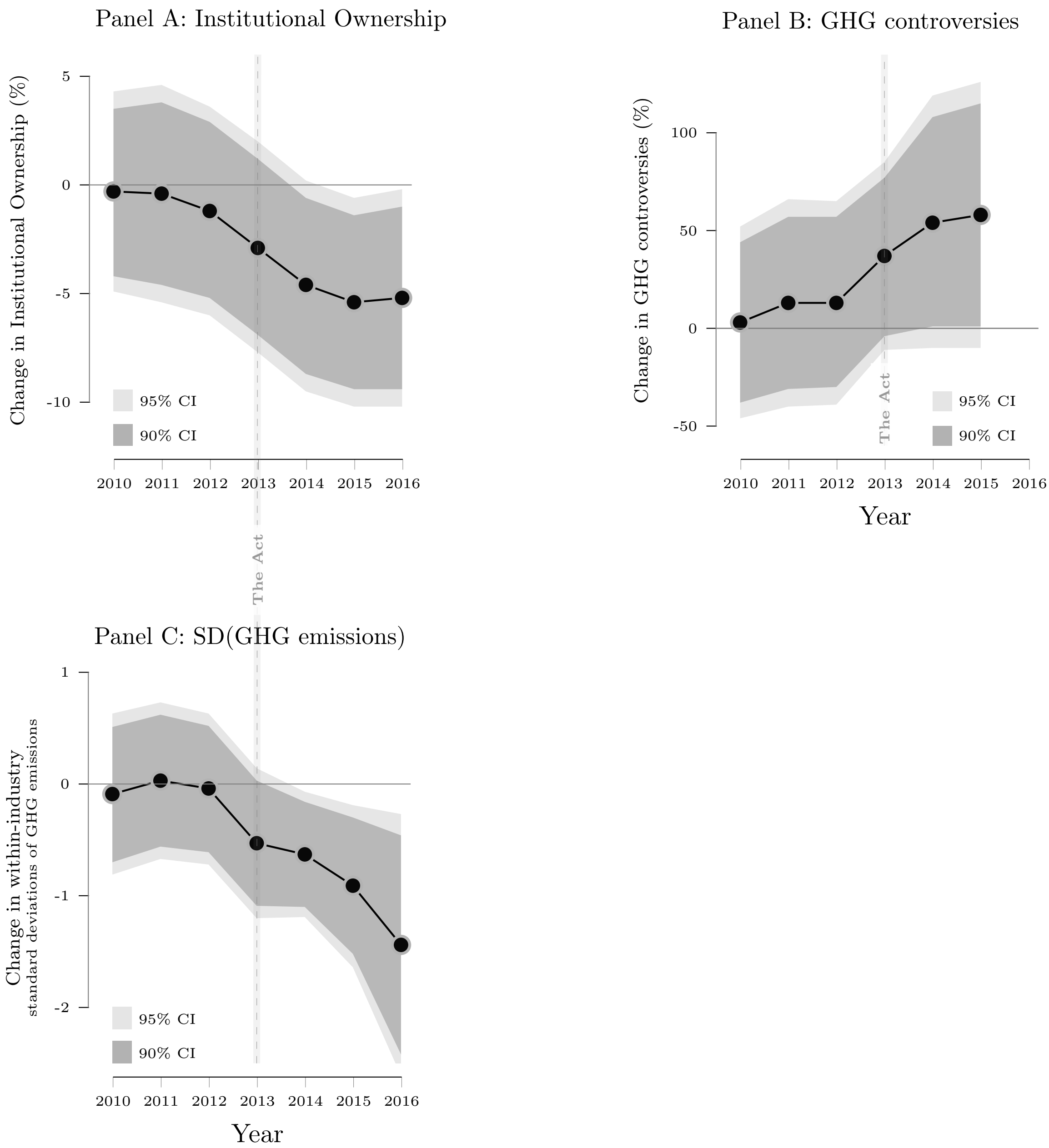

Figure 5. Institutional ownership, GHG emission controversies and within-industry GHG emissions dispersion for U.K. firms with high and low emissions. This figure shows the yearly average differences in institutional ownership, GHG emission controversies, and GHG emissions dispersion between U.K. firms with high and low GHG emissions. High and low correspond to firms with Total GHG emissions above and below the median level of Total GHG emissions in a given year. In Panel A, the dependent variable is fraction of a firm's equity held by institutional investors. In Panel B, the dependent variable is the firm's percentage of controversies related to GHG emissions. In Panel C the dependent variables are within-industry standard deviation of GHG emissions. The point estimates and the 90% and 95% confidence intervals (shaded regions) result from estimating the coefficients of the interaction between the Treat dummy and annual event-time dummies around the regulation. The point estimates are relative to the year 2009.

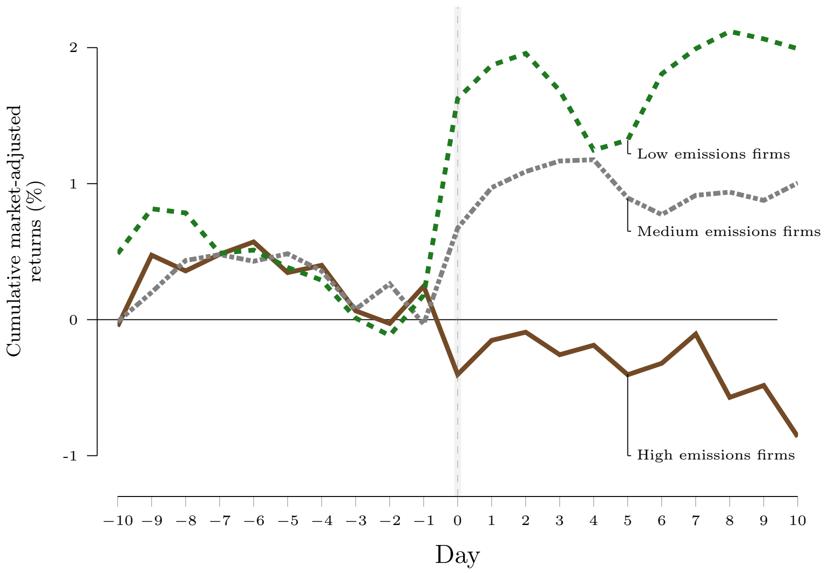

Figure 6. Event study around first-time disclosure. This figure shows the cumulative daily market-adjusted returns of U.K. firms by terciles of industry-adjusted GHG emissions around the disclosure dates of the standardized GHG emissions. Market-adjusted returns correspond to the difference between daily stock returns and daily returns of the value-weighted MSCI Europe index in pounds. Industry-adjusted GHG emissions correspond to the firm' GHG emissions minus the average GHG emissions of its industry in a given year. The gray dashed line indicates disclosure dates.

Table 1
Summary Statistics

This table presents information on the sample firms and summary statistics for the main variables used in our analysis. The sample period is 2009 to 2016. Panel A provides information on the geographical location of the stock exchanges on which the U.K. and European sample firms are listed in 2010. Panel B examines firm characteristics of U.K. and European firms prior to the regulation. Panel C examines firm characteristics of U.K. firms with high and low levels of GHG emissions prior to the regulation. High and low correspond to firms with Total GHG emissions above and below the median level of Total GHG emissions in a given year. *ln(Assets)* is the logarithm of the firm's total assets ($Worldscope$ item $wc02999$). *Tobin's q* is defined as (Market cap + Book value of total liabilities)/(Book value of common equity + Book value of total liabilities)= $(wc08001 + wc03351)/(wc03501 + wc03351)$. *Investment* is capital expenditures over total assets ($wc04601/wc02999$). *Leverage* is total debt over total assets ($wc03255/wc02999$). *ln(Tangible assets)* is the logarithm of the firm's net property plant and equipment ($wc02501$). *ln(Total GHG emissions)* is the logarithm of the firm's Total GHG emissions, in metric tons of carbon dioxide equivalent (in $MtCO_2$; when available $RefinitivESG$ item $enerdp023$, otherwise the sum of the firm's Scope 1 and Scope 2 GHG emissions from CDP). *Total GHG emissions/tangible assets* is Total GHG emissions over tangible assets. Financial data are in thousands of British Pounds (10^3 GBP). *Institutional ownership* is the firm's percentage of institutional ownership. *GHG controversies* is the firm's number of controversies related to GHG emissions over the firm's total number of environmental, social and governance controversies. *SD(GHG)* is within-industry standard deviation of GHG emissions. The column $Diff.$ in Panel B reports the average difference in the respective variable between European and U.K. firms for a given firm characteristic. In Panel C, the column $Diff.$ reports the average difference in the respective variable between U.K. firms with high and low GHG emissions. We calculate p-values using a two-sided t-test. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Geographic distribution

Control firms (Europe)			Treatment firms (U.K.)		
Stock exchange	Obs.	%	Stock exchange	Obs.	%
Euronext Paris	65	18.16	London Stock Exchange	163	100
Deutsche Boerse AG	51	14.25			
Nasdaq Stockholm AB	41	11.45			
Six Swiss Exchange	35	9.78			
BME - Bolsas Y Mercados Espanoles	31	8.66			
Borsa Italiana S.P.A.	24	6.7			
Euronext Amsterdam	21	5.87			
Nasdaq Helsinki Ltd	21	5.87			
Nasdaq Copenhagen A/S	19	5.31			
Euronext Brussels	15	4.19			
Oslo Bors ASA	15	4.19			
Wiener Boerse AG	9	2.51			
Euronext Lisbon	7	1.96			
Irish Stock Exchange - All Market	3	0.84			
Luxembourg Stock Exchange	1	0.28			

(Continued)

Table 1—*Continued*

Panel B: Pre-regulation Summary Statistics for U.K. and E.U firms

	Control firms (Europe)						Treatment firms (U.K.)						Diff.
	Obs.	Mean	SD	p25	Median	p75	Obs.	Mean	SD	p25	Median	p75	U.K.-Eur.
ln(Assets)	1,374	16.20	1.85	14.87	15.86	17.41	622	15.07	1.81	13.79	14.82	15.93	-1.13***
ln(Tangible assets)	1,369	14.13	1.82	12.90	14.26	15.43	622	12.91	2.23	11.66	12.88	14.56	-1.22***
Leverage	1,374	0.27	0.17	0.15	0.25	0.38	622	0.24	0.17	0.11	0.22	0.33	-0.03
Tobin's q	1,373	1.49	0.87	1.00	1.17	1.60	621	1.63	0.87	1.04	1.32	1.95	0.14
Investment	1,371	0.04	0.04	0.02	0.03	0.05	622	0.04	0.04	0.01	0.03	0.06	0.00
ln(Total GHG emissions)	1,374	12.54	2.57	10.91	12.33	14.19	622	11.73	2.50	10.10	11.64	13.29	-0.82***
ln(Scope 1)	1,237	11.54	3.12	9.55	11.23	13.64	552	10.67	3.03	8.64	10.65	12.53	-0.87**
ln(Scope 2)	1,212	11.61	2.21	10.23	11.70	13.05	540	10.89	2.31	9.17	10.86	12.45	-0.72**
ln(Scope 3)	943	11.52	3.34	9.29	10.99	13.64	373	10.01	3.29	7.93	9.54	11.27	-1.51***
Total GHG emissions/tangible assets	1,369	0.69	1.31	0.08	0.22	0.61	622	0.81	1.61	0.16	0.32	0.67	0.12
Scope 1/tangible assets	1,243	0.48	1.10	0.01	0.07	0.39	558	0.49	1.14	0.03	0.10	0.38	0.01
Scope 2/tangible assets	1,220	0.18	0.28	0.04	0.10	0.20	548	0.25	0.35	0.07	0.15	0.29	0.07*
Scope 3/tangible assets	948	1.10	3.27	0.01	0.06	0.40	379	1.46	5.42	0.01	0.05	0.16	0.36

Panel C: Pre-regulation Summary Statistics for U.K. firms

	Low-emissions firms (U.K.)						High-emissions firms (U.K.)						Diff.
	Obs.	Mean	SD	p25	Median	p75	Obs.	Mean	SD	p25	Median	p75	High-Low
ln(Assets)	312	14.26	1.55	13.16	13.92	14.89	310	15.88	1.69	14.67	15.51	16.92	1.62***
ln(Tangible assets)	312	11.47	1.81	10.08	11.68	12.52	310	14.36	1.59	13.22	14.15	15.35	2.89***
ln(Total GHG emissions)	312	9.78	1.42	8.96	10.11	10.87	310	13.69	1.68	12.24	13.29	14.73	3.91***
ln(Scope 1)	270	8.37	1.87	7.40	8.61	9.71	282	12.88	2.16	11.53	12.49	14.03	4.51***
ln(Scope 2)	270	9.27	1.35	8.33	9.30	10.44	270	12.51	1.89	11.47	12.45	13.63	3.25***
ln(Scope 3)	182	8.14	1.90	6.97	8.21	9.21	191	11.80	3.34	9.67	10.89	12.83	3.66***
Total GHG emissions/tangible assets	312	0.53	1.25	0.13	0.24	0.42	310	1.08	1.87	0.22	0.46	1.04	0.55*
Scope 1/tangible assets	276	0.27	0.75	0.01	0.05	0.15	282	0.69	1.40	0.07	0.22	0.73	0.42*
Scope 2/tangible assets	275	0.23	0.34	0.06	0.14	0.28	273	0.27	0.36	0.07	0.16	0.29	0.04
Scope 3/tangible assets	186	0.92	4.75	0.01	0.05	0.10	193	1.97	5.95	0.01	0.06	0.21	1.05
Institutional ownership (%)	208	38.93	11.43	31.09	39.40	46.90	176	35.81	9.84	31.57	37.18	41.97	-3.12
GHG controversies (%)	289	2.10	27.62	0.00	0.00	0.00	288	44.62	130.61	0.00	0.00	0.00	0.43***
SD(GHG)	299	0.59	2.53	0.02	0.11	0.41	281	5.69	8.76	0.46	1.55	3.71	5.10***

Table 2
Corporate GHG Emissions in Response to the Disclosure Regulation

This table examines whether the regulation impacts the GHG emissions of U.K firms relative to European firms using difference-in-differences specifications. Panel A examines the change in absolute GHG emissions between U.K. and European firms using specification (1). Absolute GHG emissions correspond to the logarithm of the firm's GHG emissions (in $MtCO_2e$). Panel B examines the change in relative GHG emissions between U.K. and European firms. Relative GHG emissions are measured as GHG emissions scaled by the firm's tangible assets (metric tons of carbon dioxide equivalent ($MtCO_2e$) per 10^3 GBP). In Panel B, we estimate specification (1) except that we remove the logarithm of tangible assets as a control variable. We refer to the specification used in Panel B as our modified specification. In column (1), the dependent variable is Total GHG emissions. In columns (2)-(4), we look at the different components of Total GHG emissions, namely Scope 1, Scope 2, and Scope 3 emissions. *Scope 1* emissions are direct emissions from owned or controlled sources of the reporting company and *Scope 2* emissions are indirect emissions from the generation of purchased energy. *Scope 3* emissions are all indirect emissions not included in Scope 2 that occur in the value chain of the reporting company, including both upstream and downstream emissions. $Treat$ is a dummy indicating if the company is a U.K. quoted company listed on the Main Market of the LSE. $After$ a is dummy variable that is set to zero until 2012 and one thereafter. All other variables are defined in Table 1. t-statistics are in parentheses and standard errors are clustered at the stock exchange-year level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Absolute GHG Emissions

	Total Emissions (1)	Scope 1 (2)	Scope 2 (3)	Scope 3 (4)
Treat × After	-0.16***	-0.08*	-0.21***	0.10
	(-3.93)	(-1.72)	(-5.01)	(0.98)
ln(Assets)	0.50***	0.48***	0.57***	0.89***
	(13.24)	(10.04)	(14.17)	(13.26)
ln(Tangibles)	0.55***	0.63***	0.41***	0.22***
	(14.45)	(14.04)	(11.51)	(4.65)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stock Exchange FE	Yes	Yes	Yes	Yes
Observations	3,977	3,672	3,634	2,472
Adj. R^2	0.800	0.778	0.712	0.598

Panel B: Relative GHG Emissions

	Total Emissions (1)	Scope 1 (2)	Scope 2 (3)	Scope 3 (4)
Treat × After	-0.17***	-0.11***	-0.04***	-0.40
	(-3.66)	(-3.17)	(-4.61)	(-1.58)
ln(Assets)	0.05***	0.08***	-0.01***	0.37***
	(2.45)	(4.18)	(-3.64)	(6.61)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stock Exchange FE	Yes	Yes	Yes	Yes
Observations	3,977	3,700	3,666	2,489
Adj. R^2	0.192	0.223	0.231	0.164

Table 3
Impact of the Disclosure Regulation on Firms With the Highest and Lowest Levels of GHG Emissions

This table examines whether the impact of the regulation differs between firms with the highest and lowest levels of GHG emissions. We code tercile dummies based on the levels of Total GHG emissions. *TopTercile* and *Bottomtercile* correspond to U.K. or European firms in the top and bottom terciles in terms of Total GHG emissions in a given year. In columns (1) to (3), we examines the change in absolute GHG emissions between U.K. and European firms. Absolute GHG emissions correspond to the logarithm of the firm's Total GHG emissions (in $MtCO_2e$). In columns (1) and (2), we estimate the changes in absolute GHG emissions separately for high and low emissions firms. Column 3 tests whether the change in absolute Total GHG emissions is different between the top and bottom U.K. terciles in comparison to European firms using specification (2). In columns (4) through (6) we repeat the same analysis using relative GHG emissions as a dependent variable. Relative Total GHG emissions are measured as GHG emissions scaled by the firm's tangible assets (metric tons of carbon dioxide equivalent ($MtCO_2e$) per 10^3 GBP). All other variables are defined in Table 1. t-statistics are in parentheses and standard errors are clustered at the stock exchange-year level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Absolute GHG Emissions			**Relative GHG Emissions**		
	Bottom Tercile	Top Tercile	Top v Bottom	Bottom Tercile	Top Tercile	Top v Bottom
	(1)	(2)	(3)	(4)	(5)	(6)
Treat × After	0.12*	-0.21***	0.08	-0.01***	-0.32**	-0.03
	(1.85)	(-4.12)	(1.09)	(-4.14)	(-2.37)	(-0.70)
Top tercile			3.04***			1.58***
			(26.69)			(13.72)
Treat × Top tercile			-0.60***			0.31***
			(-5.18)			(3.04)
After × Top tercile			0.19**			0.11
			(2.27)			(1.33)
Treat × After × Top tercile			-0.27**			-0.39**
			(-2.30)			(-2.34)
ln(Assets)	0.34***	0.83***	0.44***	0.00	-0.03	-0.01
	(12.29)	(11.19)	(20.02)	(1.13)	(-0.65)	(-0.53)
ln(Tangibles)	0.22***	0.06	0.24***			
	(7.88)	(0.82)	(9.58)			
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Stock Exchange FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,326	1,323	2,649	1,330	1,317	2,649
Adj. R^2	0.471	0.723	0.906	0.501	0.152	0.330

Table 4
Impact of the Disclosure Regulation Conditional on Levels of GHG Emissions, Asset Tangibility, and Sales

This table examines whether the impact of the regulation on GHG emissions varies along plausible cross-sectional dimensions. The column *Terciles* indicates the cross-sectional firm-characteristics we use to split the sample. We form terciles by sorting U.K. and European firms each year according to their levels of Total GHG emissions, their sales, and their tangible assets. *Bottom* and Top correspond to firms in the bottom and top terciles of the respective firm-level variable. The column *Dep. Variable* shows the dependent variable used in the regression. In columns (1) and (2), we examine the impact of the regulation on absolute GHG emissions within the bottom and top tercile of the respective cross-sectional characteristic. We use the logarithm of GHG emissions as the dependent variable. In columns (3) and (4), we examine the impact of the regulation on relative GHG emissions, within the bottom and top terciles, respectively. Relative emissions are calculated as absolute GHG emissions divided by the firm's tangible assets. We use specification (1) in columns (1) and (2) and our modified specification in columns (3) and (4). In our modified specification we remove the logarithm of tangible assets as control variable. We report only the treatment effects, that is the interaction term between the $Treat$ and $After$ dummies. All other variables are defined in Table 1. t-statistics are in parentheses and standard errors are clustered at the stock exchange-year level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

		Absolute GHG Emissions		Relative GHG Emissions	
Terciles	Dep. Variable	Bottom tercile (1)	Top tercile (2)	Bottom tercile (3)	Top tercile (4)
By Total GHG Emissions	Scope 1	0.11	-0.18***	-0.00	-0.30***
		(1.40)	(-3.45)	(-0.54)	(-2.82)
	Scope 2	0.16*	-0.24***	-0.01***	-0.04*
		(1.82)	(-3.17)	(-4.70)	(-1.96)
By Sales	Total GHG Emissions	-0.16**	-0.24***	-0.04	-0.14**
		(-2.25)	(-4.41)	(-0.49)	(-3.18)
By Tangible Assets	Total GHG Emissions	0.00	-0.30***	-0.08	-0.36***
		(0.06)	(-4.51)	(-1.14)	(-4.60)

Table 5
Stakeholder Pressures in Response to the Disclosure Regulation

This table examines whether stakeholder pressures explain the decrease in GHG emissions for U.K. firms using difference-in-differences specifications. We use a subsample analysis by comparing firms with high and low levels of GHG emissions. *High* and *low* correspond to firms with Total GHG emissions above and below the median level of Total GHG emissions in a given year. In Panel A we explore whether stakeholder pressures explain the decrease in GHG emissions for U.K. firms only. In Panel B we test the absence of change in stakeholder pressures for European firms only. In column (1), the dependent variable is the firm's percentage of institutional ownership. In column(2), the dependent variable is the firm's percentage of controversies related to GHG emissions. The dependent variables in columns (3) and (4) are within-industry standard deviations of GHG emissions and within-industry 80th-20th percentile differences in GHG emissions. We use specification (1) in each column, except that we substitute the *Treat* dummy by a *Top* dummy, change the dependent variable and remove country fixed effects. *Top* is a dummy variable indicating if a firm belongs to the high or low-emission group in a given year. All other variables are defined in Table 1. *t*-statistics are in parentheses and standard errors are clustered at the stock exchange-year level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: High vs Low-Emissions U.K. Firms

	Inst. Own. (1)	GHG cont. (2)	SD(GHG) (3)
Top	0.01	-0.31*	0.41*
	(1.14)	(-2.41)	(2.23)
After × Top	-0.04***	0.41***	-0.85***
	(-8.26)	(5.95)	(-4.30)
ln(Assets)	-0.02***	0.12**	0.02
	(-6.86)	(2.50)	(1.50)
ln(Tangibles)	0.01**	0.02	-0.02
	(2.88)	(0.45)	(-1.36)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	781	976	1,174
Adj. R^2	0.491	0.214	0.985

Panel B: High vs Low-Emissions European Firms

	Inst. Own. (1)	GHG cont. (2)	SD(GHG) (3)
Top	0.02**	-0.34**	0.21*
	(2.08)	(-2.23)	(1.85)
After × Top	-0.02	0.29	-0.26
	(-1.33)	(1.40)	(-1.40)
ln(Assets)	0.04***	0.43***	0.03
	(12.02)	(5.67)	(1.15)
ln(Tangibles)	-0.03***	-0.02	-0.01
	(-8.77)	(-0.51)	(-0.59)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	1,954	2,180	2,668
Adj. R^2	0.262	0.129	0.985

Table 6
Event Study

This table examines the cumulative market adjusted returns around annual earnings announcements of firms in 2013 or 2014 conditional on the disclosed level of industry-adjusted GHG emissions. The analyzed earnings announcements correspond to the first time disclosures of standardized GHG emissions for U.K. firms. Panel A shows the cumulative market adjusted returns of firms for the three-day event window around the first time disclosure, which is denoted by [-1,1]. Columns (1)-(3) show the returns of U.K. firms. Columns (4)-(6) show the returns of European firms. For European Firms, we use earnings announcement dates during the same reporting season. Dependent variables are regressed on dummy variables indicating terciles of industry adjusted GHG emissions. *Medium* and *High* are dummy variables indicating whether the levels of GHG emissions of firms lie in the medium and top terciles, respectively. In columns (2) and (5), we add the earnings surprise as a control variable. In columns (3) and (6), we control for earnings surprise and include industry fixed effects. Panel B shows the difference in cumulative market adjusted returns between firms in the top and bottom terciles in terms of GHG emissions for different event windows before and after the event date. In these regressions, we control for earnings surprise and include industry fixed effects in all specifications. t-statistics are in parentheses and standard errors are clustered at the industry level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Cumulative Market Adjusted Returns $[-1, 1]$

	U.K. Firms			European Firms		
	(1)	(2)	(3)	(4)	(5)	(6)
Medium	-0.0143*	-0.0155**	-0.0242**	0.00157	0.00189	0.000772
	(-1.88)	(-2.11)	(-2.06)	(0.24)	(0.27)	(0.09)
High	-0.0245**	-0.0254*	-0.0528***	0.00101	-0.000611	-0.0046
	(-2.07)	(-2.03)	(-3.44)	(0.15)	(-0.08)	(-0.50)
Earnings surprise	No	Yes	Yes	No	Yes	Yes
Industry FE	No	No	Yes	No	No	Yes
Observations	131	125	125	367	342	342
Adj. R^2	0.012	0.013	0.127	-0.005	-0.008	0.011

Panel B: High vs Low-Emissions Firms

	U.K. firms (Firms = 77)	European firms (Firms =224)
	(1)	(2)
$[-75, -50]$	0.0239	-0.00297
	(1.02)	(-0.23)
$[-50, -25]$	0.0231	-0.0201
	(0.83)	(-1.24)
$[-25, -10]$	0.0131	0.00967
	(0.2)	(0.91)
$[-10, -2]$	0.0331	0.0123
	(1.28)	(1.08)
$[-1, 1]$	-0.0572***	-0.00995
	(-3.02)	(-0.84)
$[2, 10]$	-0.035	0.000731
	(-1.67)	(0.09)
$[10, 25]$	-0.00693	-0.00916
	(-0.21)	(-0.97)
Earnings surprise	Yes	Yes
Industry FE	Yes	Yes