CLIMATE CHANGE AND FIRM VALUATION: EVIDENCE FROM A QUASI-NATURAL EXPERIMENT

First version: November 2014
This version: July 11, 2015

Philipp Krüger[1]

Abstract

In this article, I estimate the effect of mandatory greenhouse gas (GHG) emissions disclosure on corporate value. Using the introduction of mandatory GHG emissions disclosure requirements for firms listed on the Main Market of the London Stock Exchange as a source of exogenous variation in disclosure policies, I find that firms most heavily affected by the new regulation experience significantly positive valuation effects. Consistent with the notion that climate change is more relevant to larger firms and to firms belonging to carbon-intensive industries, the effect is strongest for the largest firms and for firms operating in the oil and gas and basic materials industries. Overall, the evidence shows that investors value increased transparency regarding corporate climate change risks positively. The results have important implications for security markets regulation in other jurisdictions, e.g., the United States.

JEL-Codes: D22, G18, G28, G38, K22, K32, L51, M48, Q52, Q54
Keywords: Mandatory disclosure regulation, greenhouse gas emissions, climate change, valuation

[1]Université de Genève, Swiss Finance Institute, Geneva School of Economics and Management (GSEM), Geneva Finance Research Institute (GFRI), Bd du Pont d'Arve 40, 1211 Geneva 4, Switzerland; philipp.krueger@unige.ch; Telephone: +41 (0)22 379 85 69. For comments and suggestions, I am grateful to Steven Tebbe (CDP) and seminar participants at the University of Piraeus, in particular Angelos Antzoulatos.

"I am looking at this through the lens of risk — climate change is not only a risk to the environment but it is the single biggest risk that exists to the economy today."[2]

Henry M. Paulson Jr. - Former Secretary of the Treasury

I Introduction

An organizing principle of securities market regulation is the view that mandatory reporting requirements of firm specific information allow capital markets to function more efficiently. Typically, financial information such as audited balance sheets as well as income and cash flow statements represent the cornerstone of such mandatory reporting requirements. In addition, security market regulators like the Securities and Exchange Commission (SEC) require publicly listed firms to include any information in their periodic regulatory filings (e.g., 10K's) that is deemed to be "material."[3] Overall, economists and law makers seem to be in agreement about the merits of mandating the disclosure of financial information: For instance, academic studies have shown that investors value mandatory disclosure of financial information at the firm level (see Greenstone, Oyer, and Vissing-Jorgensen (2006) or Ferrell (2007)), cross-country studies find that mandatory disclosure requirements are related with higher equity valuations (see La Porta, Lopez-de Silanes, Shleifer, and Vishny (2002)), and securities laws in the US mandate publicly listed firms to disclose financial information at least since the Securities Act of 1933.[4]

In contrast, there is much more debate on whether firms should also be required to disclose standardized non-financial information on, for instance, how they manage the risks and opportunities related to climate change.[5] This debate is set, however, against the backdrop of ever more anecdotal evidence suggesting that investors increasingly demand such information. For instance, *The Carbon Disclosure Project*[6] (CDP), an organization dedicated to collecting and disclosing corporate climate risk data of listed corporations worldwide, is supported by several hundreds of institutional investors representing a total of US$92 trillion in assets. In addition, shareholders increasingly engage with respect

[2]Quote from a panel discussion at the Clinton Global Initiative Annual Meeting in September 2014. See `http://goo.gl/5KnGP6`

[3]Information is regarded as being material if "a substantial likelihood that the disclosure of the omitted fact would have been viewed by the reasonable investor as having significantly altered the "total mix" of information made available. see (U.S. Supreme Court, TSC Indus. V. Northway, Inc., 426U.S. 438 (1976)) See: `http://goo.gl/OOYLpl`

[4]See, `http://www.sec.gov/about/laws/sa33.pdf`

[5]The SEC has so far shied away from mandating disclosure of climate change information and has only issued guidance as to how existing disclosure requirements apply to climate change matters (see SEC (2010)).

[6]see`https://www.cdp.net/en-US/Pages/About-Us.aspx`

to climate change: CERES,[7] an NGO concerned with corporate environmental conduct and raising awareness of environmental issues among institutional investors published a report[8] recently suggesting that mutual fund companies showed record high support for climate change related shareholder resolutions during the 2013 proxy season. In a similar vein, data from Institutional Shareholder Services (ISS)[9] shows that climate Change was one of the most common topics for shareholder proposals in the proxy season 2014. Using a sample of private shareholder engagements, Dimson, Karakas, and Li (2015) show that successful climate change related shareholder engagements generate positive risk adjusted abnormal returns for investors. Also, investors such as Yale's endowment fund, CALPERS, or Norges Bank Investment Management (NBIM), the arm of the Norwegian Central Bank responsible for managing the Government Pension Fund Global are nowadays pushing their managers and investee companies to evaluate their risk exposure to climate change. For example, Yale's chief investment officer David Swensen recently urged external managers to evaluate "the effects of climate change on the businesses in which they are or might be investing,"[10] and NBIM requires that the firms in which the Government Pension Fund Global invests "should disclose information on their climate change strategy, actions, and governance [and] manage risk associated with the causes and impacts of climate change."[11] Going further even, CALPERS CEO Anne Stausboll recently stressed the importance of mandatory corporate climate risk reporting.[12]

While such anecdotal evidence is interesting in its own right, it cannot sufficiently inform policy makers in their task of evaluating whether there is a case for taking regulatory steps aimed at increasing corporate transparency with respect to climate change risks. In other words, the question of whether mandating firms to disclose corporate climate risk information in regulatory disclosure forms is desirable from an economic efficiency perspective is ultimately an empirical question.

In this article, I examine whether investors attach financial value to *mandatory* corporate climate disclosures and estimate the impact of such information on firm-value (as measured by Tobin's q). More specifically, I exploit a recent regulatory change in the corporate reporting environment in the United Kingdom (UK) as a quasi-natural experiment. *The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013* (The Act), which was passed into law in July 2013, now requires every UK quoted company[13] to report comprehensive data on their GHG emissions in their annual reports.

[7] See `http://www.ceres.org/about-us/coalition`

[8] `http://goo.gl/nMaHKT`

[9] ISS is the worlds leading provider of corporate governance solutions for asset owners.

[10] see, `http://goo.gl/FlHpta`

[11] see `http://goo.gl/Uni5KL`

[12] See `http://goo.gl/1fZK4c` and `http://goo.gl/4ywBMH`

[13] A UK quoted company is a company that is incorporated in the UK with equity share capital being

The landmark introduction of this new law, which makes the UK the first country to introduce mandatory carbon reporting for publicly listed firms, provides an interesting and unique setting to study the valuation effects of mandatory corporate climate change information disclosure for several reasons: First, and most importantly, the legislation did not affect all UK quoted companies equally. This is because some of the concerned firms had already been publicly disclosing climate change related information on an annual basis before the time when the likelihood of mandatory disclosure regulation in the UK increased sharply in the year 2011. Arguably, such "early-reporters" face a smaller constraint by the new regulatory requirements than firms that did not report publicly or did not report at all prior to the regulation. Hence, the cross-sectional variation in the reporting status *before* the regulation allows sorting firms into control and treatment groups. Examining how much more, or less, firm value of firms that did not report *publicly* prior to the regulation (treatment group) changed after the regulation compared to firms that had already been reporting before the regulation (control group) provides important insights into the value effects, and thus the overall desirability of mandatory corporate climate change reporting.

Second, the institutional arrangements of the London Stock Exchange allow for a second way of testing if mandatory corporate climate change reporting is valued by investors. The London Stock Exchange maintains two separate secondary markets, i.e., the Main Market and AIM (formerly Alternative Investment Market). Both market segments have different listing requirements. Typically firms listed on LSE's Main Market are large and established. In contrast, smaller and growing firms choose to list on AIM because of the weaker regulatory requirements that govern AIM. The new climate change reporting requirement concerns only firms listed on the Main Market and exempts firms listed on AIM. Hence, firms incorporated in the UK and listed on AIM are unaffected by the regulation since the new law does not extend to this market segment. It follows that UK AIM firms can also serve as a control group in testing whether the mandatory carbon disclosure requirements had valuation effects.

Finally, the fact that the law was passed in a country which is part of Europe offers a third natural group of firms that can serve as a control group, namely size and industry matched firms listed in other European countries. Comparing the post-regulation valuation differences of both affected (i.e., UK firms that did not report publicly) and less affected UK firms (early reporting firms) to EU firms which were not subject to corporate climate change reporting regulation, also allows to gauge the effect of the new law on firm value.

listed on the Main Market of the London Stock Exchange, an European Economic Area State or admitted to trading on the New York Stock Exchange or Nasdaq.

In the tests, I rely on a difference-in-differences (DID) framework since the change in law provides a quasi-natural experiment in the sense that the event (change in reporting requirements) happens to be exogenous to the outcome (firm value). I show that UK quoted companies that did not report publicly on climate change issues prior to the new requirements experience highly significant valuation increases after the regulation relative to UK quoted companies that did disclose publicly. I document the same valuation increases when using alternative control groups such as firms listed on the AIM market segment or industry-size matched firms from other European countries. In contrast, "placebo" DID tests in which firms that were already reporting publicly before the regulation are compared to AIM firms or industry-size matched firms listed on other European stock exchanges show no evidence of significant valuation differences in the post-treatment period. This evidence is consistent with the view that investors highly value transparency with respect to corporate climate risk.

I also explore the time-series and cross-sectional variation of the valuation impact of mandatory climate change information disclosure. In terms of the time-series, I show that there are no valuation differences between control and treated firms prior to the time at which the likelihood of mandatory corporate carbon reporting increased sharply. This is crucially important for identification since it confirms that the parallel trends assumption is satisfied in the data and thus validates the DID approach. Cross-sectionally, I show that the valuation differences are strongest for the largest firms in a given industry, consistent with the intuitive notion that climate change is a more important issue for larger firms. I also show that the DID estimate is highest for oil and gas companies and firms belonging to the mining sector, highlighting the idea that investors value carbon transparency more in carbon intensive sectors with potentially stronger negative impacts on the climate. To validate my DID approach I also perform several placebo DID analyses in which, for instance, I look at a different time period and find that the average treatment effect estimated for the placebo DID is never statistically significant.

This paper is related to several different literatures. First of all, it relates to the literature on the valuation implications of mandatory reporting regulation (Greenstone, Oyer, and Vissing-Jorgensen (2006) or Ferrell (2007)) and corporate disclosure in general (see Leuz and Wysocki (2008)). Secondly, it contributes to literatures concerned with (asset) pricing implications of climate risk (see, e.g., Andersson, Bolton, and Samama (2014), Daniel, Litterman, and Wagner (2015), or Litterman (2013)), and the uncertainty about climate change parameters (see Freeman, Wagner, and Zeckhauser (2015)). It is also related to papers concerned with the financial effects of environmental regulation (see Porter and Van der Linde (1995), Palmer, Oates, and Portney (1995), or Ambec, Cohen, Elgie, and Lanoie (2013)). The paper also complements a recent paper in accounting

that examines the value effects of *voluntary* greenhouse gas emission disclosure (see Matsumura, Prakash, and Vera-Muñoz (2013)). Finally, the paper is also somewhat related to the literature examining how shocks to governance arrangements, e.g., the Sarbanes Oxley Act (see Chhaochharia and Grinstein (2007)) or quotas on board composition (see Ahern and Dittmar (2012)), affect firm value.

The rest of the paper is organized as follows. Section **II** provides background information on the *The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013*, the legislative change that is used to identify the effect of climate change information disclosure on firm value. Section **III** discusses mandatory GHG disclosure from an environmental and disclosure regulation perspective. Section **IV** provides background information on voluntary climate change reporting and the Carbon Disclosure Project, the organization that provided some of the data used in this paper. Section **V** outlines the sample construction and shows summary statistics of important variables. Section **VI** contains the empirical analysis and discusses the results while section **VII** presents robustness checks. Section **VIII** concludes. Finally, the Appendix C shows quantitative data on GHG emissions by industrial sector and Appendix D shows and discusses descriptive statistics on the beliefs of the corporate sector when it comes to climate change risks.

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

The main identification in this paper comes from the exogenous shock in climate change reporting induced by the passage of The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013, a law that now requires a subset of listed UK firms to publicly report on their GHG emissions. The provisions of the Act concerning the GHG reporting requirements can be found in Part 7 Disclosures Concerning GHG Emissions of The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013.[14] This section provides some background information on the Act.

[Table I about here.]

A. Major Events Leading to the Legislation

Table I shows a chronology of important events that ultimately led to the Act. Writing in The Guardian, Deputy Prime Minister Nick Clegg announced on June 19, 2012 that the UK government was going to pass legislation forcing UK quoted companies to publish

[14]The legislative text is available here `http://goo.gl/zaYLXU`.

full details on their GHG emissions in their annual reports.[15] Speaking at the United Nations Conference on Sustainable Development *Rio+20* two days later, the deputy prime minister reiterated the UK government's intent of mandating corporate GHG reporting.[16]

The announcement had followed a public consultation that lasted from May 11, 2011 to July 5, 2011 during which the Department of Environment, Food & Rural Affairs (DEFRA), the UK government department responsible for policy and regulations on environmental, food, and rural issues, had sought views on the question of whether regulations should be introduced to make it mandatory for some UK companies to report on their GHG emissions (see DEFRA (2011c)). This broad consultation of about two thousand stakeholders (e.g., individuals, companies, trade associations, not for profit organizations, campaigning organizations, investors, local authorities, regulators, investors and members of parliament), sought to clarify whether the UK government should continue to encourage measurement and reporting of GHG emissions on a voluntary basis, or whether mandatory regulation should be introduced. More specifically, respondents were asked to express their views on potential policy options and to choose their preferred one among (0) business as usual (no change to the current policy position), (1) enhanced voluntary reporting: increasing awareness of reporting guidance and outreach, (2) mandate GHG reporting under Companies Act[17] for all quoted companies, (3) mandate GHG reporting under Companies Act for all large companies, or (4) mandate GHG reporting for all companies meeting an energy use criteria.

During the consultation period, respondents were also provided with an impact assessment (IA No.: DEFRA1334, see DEFRA (2011a)) published on January 17, 2011, which included background information on the different policy options, most notably detailed cost and benefit analyses for the different options. Preparing such impact assessments is common practice in the UK and the assessments are supposed to help policy-makers to understand the consequences of possible and actual government interventions in the public, private, and third sectors, but also as a tool to enable the government to weigh and present the relevant evidence on the positive and negative effects of such interventions. The public consultation orchestrated by DEFRA had been a direct result of The Climate Change Act 2008,[18] which made it the duty of the UK government to pass regulations by April 6, 2012 requiring the director's report[19] to include information about

[15] See `http://goo.gl/TdWlSF`

[16] See `http://goo.gl/tWrN4i` for a transcript of the speech by Nick Clegg at the RIO 20+ Summit.

[17] The Companies Act 2006 is an Act of the Parliament of the United Kingdom which forms the primary source of UK company law.

[18] The Climate Change Act 2008 is an Act of the Parliament of the United Kingdom. The Act makes it the duty of the Secretary of State to ensure that the net UK carbon account for all six Kyoto greenhouse gases for the year 2050 is at least 80% lower than the 1990 baseline, toward avoiding dangerous climate change. See, in particular, Section 85 of Climate Change Act 2008.

[19] A document produced by the board of directors under the requirements of UK company law, detailing

GHG emissions or to lay a report before parliament explaining why no such regulations had been made.

On August 31, 2011, DEFRA published a revised version of the initial impact assessment DEFRA1334 (see DEFRA (2011b)). Besides updated cost/benefit analyses and further background information on the different policy options, the new version now also included insights from the consultation process. Most importantly, the new version included information about DEFRA's preferred policy option, i.e., "mandatory GHG reporting under Companies Act 2006 for all quoted companies."[20] While this revised impact assessment was available to members of parliament and policy makers from August 31, 2011, it is unclear when exactly the content of the assessment became publicly available. If the document had not already been publicly available on August 31, 2011, i.e., the offical date of the report, there are several pieces of evidence suggesting that at least DEFRA's preferred policy recommendation became publicly available around that time: First, on September 15, 2011, *The Environmental Audit Committee*, a committee appointed by the House of Commons[21] to consider to what extent the policies and programmes of government departments and non-departmental public bodies contribute to environmental protection and sustainable development[22] published its *Seventh Report* titled *Carbon Budgets*.[23] Section 4 "The Carbon Plan" of the report contains explicit references not only to the DEFRA consultation process, but also to the preferred policy option from the revised impact assessment:

> "The Government consulted earlier this year on options to promote more widespread and consistent emissions reporting. [...] In order to aid transparency and illustrate the contributions that businesses are making, and need to make, to help tackle climate change, ***we recommend that the Government should introduce mandatory reporting by businesses at the earliest opportunity***."[24]

Second, around the completion of the DEFRA consultation in July 2011, several interest groups and companies that had participated in the consultation published their

the state of the company and its compliance with a set of financial, accounting and corporate social responsibility standards.

[20] See page 1 in DEFRA (2011b).

[21] The House of Commons is the lower house of the Parliament of the United Kingdom of Great Britain and Northern Ireland which, like the House of Lords (the upper house), meets in the Palace of Westminster.

[22] Other functions of the Environmental Audit Committee include to report to the House of Commons on environmental policies and to audit the performance of environmental policies against targets as may be set for them by Her Majesty's Ministers.

[23] See the report which was ordered by the House of Commons to be printed on September 14, 2011. (`http://goo.gl/Gjub4N`)

[24] `http://goo.gl/6SlSzg`

responses publicly. The majority of the organizations that spoke out publicly recommended mandatory disclosure. Institutions recommending mandatory disclosure included not only business lobbies such as The Confederation of British Industry (UK's premier business lobbying organization) or the Food and Drink Federation (Body representing the UK food and drink manufacturing industry), but also NGO's and companies such as the Climate Disclosure Project, Climate Disclosure Standards Group (consortium of global business and environmental NGOs.), the Aldersgate Group (a coalition of environment agencies, NGOs, think tanks and industry representatives), and Marks and Spencer's.

These two pieces of evidence suggest that an informed investor could have anticipated not only the course of action of the government regarding the policy matter at hand, but also the likely design of the regulation at the end of the summer of 2011 and thus almost a year before the official announcement by the government in June 2012.

Since the UK government missed the April 2012 deadline that was stipulated in the Climate Change Act 2008 for passing regulation on corporate GHG emission reporting, pursuant to Section 85 of the Climate Change Act 2008, the government laid a report before parliament on March 27, 2012 outlining why no regulations had been introduced so far (see DEFRA (2012a)). The report showed that ministers were still debating the different policy options and the responses from the public consultation and had not reached their final decision. The formal announcement then came on June 20, 2012 alongside the publication of a detailed report (see DEFRA (2012b), which provided detailed information on the outcomes and results form the public consultation. The first draft of the legislative text became publicly available on July 25, 2012 and a period of consultation for the first draft ended on October 17, 2012. The text was laid before parliament on June 10, 2013 and the House of Commons approved the bill on July 16, 2013. The act has come into effect on October 1, 2013.

B. Which Companies Are Concerned by the Act?

The Act concerns all UK quoted companies. A quoted company is defined in section 385(2) of the Companies Act 2006 as a company that is UK incorporated and whose equity share capital is listed on the Main Market of the London Stock Exchange or on an exchange in an European Economic Area (EEA)[25] state, or admitted to trading on the New York Stock Exchange or Nasdaq.

The Act exempts certain firms from the reporting requirement, most notably small firms that meet at least two of the following requirements: (i) Turnover lower than £6.5m, (ii) balance sheet total lower than £3.26m or, (iii) average number of employees lower

[25]The EEA is a free trade area in Europe. It is made up of 30 member countries, which includes EU and non-EU countries.

than 50.

C. What Needs to be Reported?

The legislation requires firms to report the annual quantity of emissions in metric tonnes of carbon dioxide equivalent (CO2e) 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 own use. This is what the GHG protocol refers to as Scope 1 and 2 emissions.[26] In addition, firms must report at least one ratio which expresses the company's total annual emissions in relation to a quantifiable factor associated with the company's activities (e.g. sales, assets, etc.). In other words, firms need to report both absolute (quantity) and relative emissions (intensity).

Besides these measures, firms must also report the methodologies used to calculate emissions intensity and quantities. Furthermore, not only emissions information for the current financial year need to be reported, but also emissions information as disclosed in the report for the preceding financial year. Firms are also required to state if the period for which GHG emissions are reported differs from the financial year of the company.

D. Where Will the Information Be Disclosed?

The Act adds the Strategic Report as a new section to the Directors' Report. The Directors' Report, a document prepared annually by the board of directors under the requirements of UK company law, is the UK equivalent of SEC Form 10-K in the United States. The purpose of the Directors' Report is to assess how the directors have performed in their duty to promote the success of the company. The information on GHG emissions will need to be disclosed in the Directors' Report.

III Economic Perspectives on Regulating GHG Emissions Disclosure

The Act contains two regulatory components and can be regarded as a hybrid type of regulation. First, the Act mandates the annual disclosure of a certain type of firm specific information, which represents a *reporting and disclosure regulation*. Second, the Act concerns an environmental externality (i.e., GHG emissions) and as such can also be regarded as an *environmental regulation*.

While the act directly regulates disclosure requirements by forcing firms to produce reliable and standardized information of their GHG emissions, the Act does not put a

[26] See subsection B of section **IV** for more details.

tax on emissions nor does it constrain the quantity of corporate GHG emissions. However, requiring the measurement and periodic disclosure of GHG emissions regulates the environmental externality related to carbon emissions *indirectly*. This is because mandating disclosure makes future regulation of GHG emissions (e.g., carbon tax) more likely and thus increases the expected cost of GHG emissions. Moreover, measurement and disclosure transforms GHG emissions into a potentially costly environmental liability because now a verifiable record of the quantity of emissions exists for individual firms. It follows, that firms emitting more are likely to face higher total regulatory costs, should such regulation be introduced in the future. This section explores economic perspectives on environmental and (financial) disclosure regulation to examine potential effects of the passage of mandatory GHG emissions disclosure.

A. Environmental Regulation

A.1. The Traditional View

Traditionally, regulation aimed at reducing the negative impact of firms on the environment is regarded as being costly to firms. This is because such regulatory actions force firms to allocate inputs (e.g., labor or capital) to complying with the regulation. Even though such regulation might generate environmental or other societal benefits, the internalization of the environmental externality reduces firms' options and thus, by definition, also reduce firms' profits. Accordingly, there is an important trade-off between the beneficial effects of a regulation and the private costs that are required to generate the desired benefits (see, for instance,Palmer, Oates, and Portney (1995)).

A.2. The Porter Hypothesis

In a controversial paper, Porter and Van der Linde (1995) challenge the traditional view and argue that properly designed environmental regulation does not necessarily have to be costly for firms. This is because if correctly designed, environmental regulation can trigger innovation that may partially or more than fully offset the costs of complying with the regulation. According to what has since become to be known as the Porter hypothesis, environmental regulation can thus be conducive to innovation that will add to profits, by for instance, bringing about improvements in energy or resource efficiency.

Porter and Van der Linde (1995) spell out several channels through which environmental regulation could positively impact business performance (see also Ambec, Cohen, Elgie, and Lanoie (2013)): First, regulation can signal about likely resource inefficiencies and potential technological improvements. Second, regulation focused on information gathering and disclosure can achieve major benefits by raising corporate awareness for po-

tentially financially material issues. Third, environmental regulation reduces uncertainty that environmentally oriented investments will be valuable. Finally, environmental regulation creates pressure that motivates innovation and progress. All in all, the Porter hypothesis suggests that well-designed environmental regulation can lead to Pareto improvements. It assumes implicitly however, that managers might not always be profit maximizing. The idea that there are no trade-offs for environmental regulation and the resulting corollary that environmental protection, if properly pursued, often presents free or even paid lunches has been one of the main criticisms of the Porter hypothesis (see Palmer, Oates, and Portney (1995)).

From an environmental regulation perspective, the Porter hypothesis suggests that mandating GHG disclosure could be value enhancing. In fact, the four channels through which environmental regulation would affect firm value seem to apply remarkably well to the case of GHG emissions. In contrast, the value implications are not clear from the traditional economic perspective on environmental regulation, since these very much depend on the trade-off between societal or firm-level benefits and costs.

B. Information Disclosure Regulation

As stated above, The Act is a hybrid type of regulation because it does not pursue improvements of the environment directly, but rather focuses on adapting securities market regulation by mandating changes to firms' reporting requirements. As a starting point, it is important to note that the literature on corporate information disclosure and the regulation thereof (see Leuz and Wysocki (2008) for an excellent review) focuses mainly on economic consequences of *financial* reporting and disclosure regulation. This is not surprising as financial information represents the cornerstone of the firm-specific information set available to investors and regulators. Typically, the literature distinguishes between mandatory and voluntary disclosure. The majority of research in economics, management, finance, accounting, and law focuses on voluntary disclosure and reporting choices. This is true for both academic work on financial information disclosure (see Leuz and Wysocki (2008)) and disclosure of climate change related information (see Matsumura, Prakash, and Vera-Muñoz (2013)) While such studies are informative about the private costs and benefits of voluntary disclosure, thus providing micro-foundations, analysis of voluntary disclosure choices cannot deliver insights about the overall economic desirability, economic efficiency, or aggregate outcomes of mandatory reporting and disclosure regulation. In the words of Leuz and Wysocki (2008) "debates about disclosure and financial reporting regulation often incorrectly point to firm-specific (net) benefits of voluntary disclosure choices rather than focus on the aggregate effects of regulation." In their parlance, aggregate effects are captured by market wide effects, which denote effects

that go beyond a single firm (e.g., a group of firms, an industry, etc.). Leuz and Wysocki (2008) also note that there is generally less evidence on these aggregate economic and social consequences of reporting and disclosure regulation. This is why the present paper focuses on exactly these aggregate effects.

B.1. Firm Specific Benefits of Financial Information Disclosure

Leuz and Wysocki (2008) identify several channels through which disclosure can generate firm specific benefits. First, disclosure can mitigate the adverse selection problem in stock markets, enhancing liquidity and also enhancing firm value (see also Verrecchia (2001)). Second, if disclosure leads to improved risk sharing in the sense of Merton (1987), it can also be beneficial for firm value. Finally, firm value can be impacted through the governance role of disclosure. Disclosure can change managerial behavior and actions, which can directly change the distribution of future cash flows (see, e.g., the framework presented in Shleifer and Wolfenzon (2002)). A similar taxonomy of the benefits of disclosure is provided by Bushman and Smith (2001), who identify three channels for disclosure to have firm-level benefits: (i) better identification of good versus bad projects by managers and investors (project identification), (ii) discipline on project selection and expropriation by managers (governance role of disclosure), and (iii) reduction in information asymmetries among investors.

B.2. Firm Specific Costs of Financial Information Disclosure

Information disclosure is costly to corporations. Firms have to set up systems and processes to collect, measure, prepare, certify and disseminate the information at hand. These costs are of direct nature and can involve both fixed (in the case of investing in reporting systems), or variable (in terms of paying for labor to run the systems) costs. Besides these straightforward direct costs of information disclosure, there are also indirect costs from disclosing information. For instance, publicly disclosed information that otherwise would have remained private can be used at the disadvantage of the disclosing entity by various stakeholders such as competitors, labor unions, creditors, banks, regulators, investors, etc.). In short, there are numerous direct and indirect costs to information disclosure.

C. Is Mandatory Disclosure Desirable from a Regulatory Perspective?

From an environmental regulation perspective, it is not clear whether mandatory GHG disclosure is economically beneficial. On the one hand, the traditional view on regulation suggests that the net benefits of regulation depend on the tradeoff between (societal)

benefits and regulatory costs. On the other hand, some have argued that environmental regulation can spur innovation and economic benefits that more than offset the regulatory costs.

In a similar vein, the literature on mandatory disclosure regulation also makes conflicting predictions about the overall desirability of mandatory disclosure. Leuz and Wysocki (2008) note that the costs and benefits of mandatory information disclosure are complex and argue that the net effect of disclosure regulation on a market or an economy is largely an empirical question. It is thus important to exploit the unique setting of the introduction of mandatory GHG Discloure in the UK to examine the net benefits of regulating GHG emissions disclosure.

IV The Carbon Disclosure Project (CDP)

To evaluate the effect of mandatory GHG emissions disclosure on corporate value, I rely on data from the Carbon Disclosure Project. CDP is an independent not-for-profit organization backed by more than 767 institutional investors representing about US$92 trillion in assets. The Harvard Business Review has coined CDP "The Most Powerful Green NGO You've Never Heard Of."[27] Since 2003, CDP runs annual surveys asking publicly listed companies to report data and information to CDP on how they address climate change related issues. CDP maintains the by far most comprehensive database on corporate responses to climate change related issues.

[Table II about here.]

CDP requests information from companies in both emerging and developed markets. Table II provides a list of stock market indexes that make up the universe of firms that received information requests from CDP in 2013. Typically, CDP tries to contact the largest publicly-listed firms in international capital markets. For their 2013 survey, CDP requested information from 5,521 different firms worldwide. Table III displays the exact breakdown by country, showing that firms from the USA, United Kingdom, Japan, France, and South Korea make up roughly half of the firms contacted by CDP.

[Table III about here.]

Figure 1 shows a screenshot of the first page of the CDP 2013 information request. The first section of the request, parts of which are shown in the figure, contains mainly qualitative questions concerning the way climate change is integrated in the strategy or the corporate governance structures of the firm. The Appendix D contains more detailed

[27] See `http://blogs.hbr.org/2010/10/the-most-powerful-green-ngo/`

background information on the CDP request. Typically, the annual information request is sent out to corporations at the beginning of February of a given year. Corporations have to submit their response to CDP by the end of June. Submissions are made through an online response system.

[Figure 1 about here.]

A. The Response Permission

When submitting a response to CDP, the responding firm is asked to mark their response as either "Public" or "Private." This status is known as the "response permission." Private responses are made available to the requesting authority only. In the case of the *Investor CDP*,[28] the requesting authority are the signatory investors (i.e., those representing about US$92 trillion in assets) on behalf of which CDP sends out the information requests. Private responses are obviously also available to CDP itself. In contrast, public responses can also be accessed by the general public. Typically, public responses are made available through CDP's website in October of each year. Table IV provides a breakdown of the response permission for all firms contacted by CDP in 2013. In 2013, 33% of the contacted firms chose to make their responses available to the public while 9% made them available only to the requesting investors. Overall, 58 % of the contacted firms did not respond to the CDP request, and thus their response permission is "NA."

[Table IV about here.]

B. Measuring Corporate GHG Emissions: A Primer

An important element of the CDP request is data on the quantities of GHG emissions. Consistent with The Kyoto Protocol,[29] companies typically report data for six greenhouse gases, i.e., (1) carbon dioxide (CO2), (2) methane (CH4), (3) nitrous oxide (N2O), (4) hydrofluorocarbons (HFCs) and the two groups of gases (5) perfluorocarbons (PFCs), and (6) sulphur hexafluoride (SF6). These six greenhouse gases have different "Global Warming Potential" (GWP). As an example Nitrous oxide has a GWP 268 times that of CO2.[30] GWP is a relative measure of how much heat a GHG traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide (CO2e). This is

[28] There are also other requests, e.g., the CDP Supply Chain request. In the case of CDP Supply Chain it would be the procuring company (also known as a Supply Chain Member).

[29] See `http://unfccc.int/kyoto_protocol/items/2830.php`

[30] see `http://goo.gl/reUp0b`

why emissions are typically measured in metric tons of CO2e, where CO2e stands for "CO2 equivalent". This procedure allows to take into consideration that some gases have higher global warming potential (GWP) than others, and they are made comparable by rescaling all emissions into GWP in terms of CO2 emissions. See also the Appendix of Andersson, Bolton, and Samama (2014) for further information on the measurement of CO2 emissions.

There are several standards regarding the measurement of GHG emissions that are currently employed by organizations to understand, quantify, and manage GHG emissions. The Greenhouse Gas Protocol (GHG Protocol) is the most widely used one.[31] It makes a distinction between *direct* and *indirect* emissions. Direct GHG emissions are defined as emissions from sources that are owned or controlled by the reporting entity. In contrast, indirect GHG emissions are emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity.

The GHG Protocol further classifies a company's GHG emissions into three "scopes:"

- Scope 1 emissions are direct emissions from owned or controlled sources.
- 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.

While a few firms report emissions up to the level of Scope 3 to CDP, the majority of firms report only up to Scope 2. The Companies Act 2006 Regulations 2013 requires firms to disclose emissions up to Scope 2.

V Data and Summary Statistics

A. Data

A.1. Main Sample: UK Quoted Companies Listed on LSE's Main Market

To test the impact of the legislation on firm value, I construct a sample of firms that is affected by the regulation. I start with a list of all primary securities traded on the UK Main Market of the London Stock Exchange in June 2012.[32] The initial list of firms listed on the UK Main Market contains 1,038 different securities. I restrict the analysis to ordinary shares, which eliminates other types of securities, i.e., depository receipts, fixed

[31] `http://www.ghgprotocol.org/`

[32] The list is available here: `http://goo.gl/W6xUnY`

interest securities and warrants. This procedure reduces the list to 870 securities. I then eliminate equity investment instruments and nonequity investment instruments as well as REITs, which leaves 518 firms.[33] For 484 of these firms, I manage to match accounting and stock market data from Datastream and Worldscope in at least one year during the sample period, which runs from 2008 to 2014. I then match the response permission from CDP, and where available, greenhoue gas emissions data from CDP (Scope 1 and Scope 2). To be included in final LSE-Datastream-CDP sample, I require that accounting items (e.g., assets or liabilities) and stock market data (stock price and shares outstanding) for a given firm is available at least between 2009 and 2013. This procedure further reduces the number of firms to 419.

A.2. UK Firms Listed on LSE's AIM Market

In robustness checks, I also rely on a sample of firms listed on the Alternative Investment Market, which is the other secondary market operated by LSE. To identify firms listed on AIM, I use a combination of the Datastream variable "REMK"[34] and the abovementioned list of LSE quoted stocks listed on the London Stock Exchange. The final AIM sample contains 664 UK firms listed on AIM for which balance sheet and stock market data is available between at least 2009 and 2013.

A.3. Matched Firms from Other European Stock Exchanges

In another robustness check, I compare corporate valuation of UK quoted companies to size and industry matched firms listed on other European stock exchanges. To do so, I build a sample of all primary equity securities in Datastream that were listed at some point in Ireland, Belgium, Denmark, France, Germany, Italy, Luxembourg, Netherlands, Norway, Sweden, Switzerland, Austria, Portugal, Spain, and Finland (6,700 different firms). To retain a firm, I require that stock market and accounting data is available between 2009 and 2013. In total, this leaves me with 4,089 different firms between 2008 to 2014. I match on firm size (assets) and industry. I rely on stratified nearest neighbor matching without replacement: For each UK quoted company, I thus simply select the European firm from the same industry that is most similar in terms of asset size in 2010.

[Table V about here.]

[33] I eliminate these sectors by excluding firms with Industry Classification Benchmark (ICB) sub-sector codes 8995, 8985, 8671, 8672, 8674 or 8675.

[34] The Datastream variable REMK identifies AIM listed companies but only if they are active. I restrict myself to primary equity securities. To ensure that I do not miss dead firms that were listed on AIM at some point during the sample period, I also use the historic list of securities provided through the LSE website.

B. Summary Statistics

Table V shows basic summary statistics for the three samples. Panel A of Table V shows basic cross-sectional statistics for UK quoted companies. The average UK quoted company has a market capitalization of about £4 billion, 17,193 employees, and assets worth about £17 billion. The average firm is responsible for about 2.3 billion MTCO2e in Scope 1 and 735 million MTCO2e of Scope 2 emissions. Contrasting the mean and median emissions figures, it appears that the emissions distribution is highly skewed, with a few firms with extremely high emissions. Focusing on the sample of UK quoted firms, the Appendix C discusses descriptive statistics of GHG emissions by industrial sector.

Panel B shows statistics for firms listed on AIM. The summary statistics show that AIM firms are substantially smaller. Panel C shows descriptive statistics (expressed in £) of the size matched European Firms, which, when compared to UK quoted firms, have quite similar characteristics.

VI Does Mandatory GHG Disclosure Affect Firm Value?

The central idea I use to identify the impact of the legislation on firm valuation is the notion that the new reporting requirements did not affect all UK quoted companies equally. This is because some of the firms subjected to the new regulation had already been publicly disclosing corporate climate change related information on an annual basis when the likelihood of regulatory action increased sharply in 2011. To some extent, these firms were already quasi-compliant with the new requirements and should thus be affected differently by the new rules than firms that were not compliant. Hence, the cross-section of the pre-regulation reporting status allows to build two homogeneous groups of firms that were differentially affected by the change in the reporting rules. Examining the valuation differences between these groups allows to draw inferences about whether mandatory disclosure of corporate climate change information affects firm value.

[Table VI about here.]

To separate firms according to their pre-regulation reporting status, I rely on CDP's variable *response permission*. As explained in section **IV**, CDP records for each firm it contacts whether the firm responded publicly, privately, or did not respond at all. The response permission reported in CDP is thus "Public," "Private," or "NA."[35] Using the sample of UK quoted companies, Panel A of Table VI shows the number of firms per

[35]If a firm is not available in the CDP database but satisfies the sample selection criteria for Datastream, i.e., accounting and stock market data availability between 2009 and 2013, I set the response permission to "NA."

CDP response permission for each year between 2009 and 2014. In Panel B, I tabulate the fraction of sample firms per response permission by year. Several observations can be made: First, the number of public responses increases monotonically between 2009 and 2014. In a similar vein, the number of firms not replying to CDP decreases monotonically by about 27 % between 2009 and 2014 (from 232 in 2009 to 169 in 2014). Interestingly, the number of privately submitted responses increases between 2009 and 2010, but starts decreasing from 2011, the year in which the likelihood of mandatory GHG emissions increased sharply. Panel B of Table VI shows that in 2011, 164 (39%) of the sample firms responded publicly to CDP, 72 (17%) privately, and the remaining 182 (44%) firms did not respond at all to the CDP request in 2011. The distribution of response permission in the UK in 2011 is thus different from the distribution of response permission for all firms contacted by CDP in 2013 (see Table IV) in the sense that UK firms seem more responsive than all firms contacted by CDP, even before the legislation.

A. Baseline Analysis

I assign firms that did not report publicly to CDP in 2011 (response permission "Private" or "NA") to the treatment group, whereas firms with response permission "Public" are assigned to the control group. The idea is that firms that responded to CDP and made their responses public (response permission "Public") were already quasi-compliant with the new regulation and should thus be less or not affected by the new rules. In contrast, firms that chose to disclose their information only to the CDP (response permission "Private") or did not respond to the CDP request at all (permission "NA") should be more heavily affected by the new law. Since the latter firms will have to publicly disclose information that they chose to keep private or did not produce at all prior to the new requirements, these firms make up the treatment group. I code a dummy variable *Treat* that marks all firm-year observations corresponding to treated firms. Panel A of Table V shows that about 61 percent of all firm-year observations between 2008 and 2014 belong to treated firms.

To analyze whether the law affected the valuation of the two groups of firms differently, I rely on a DID approach. The DID approach gets its name from the fact that it compares the difference between two before-after differences. Essentially, DID analysis consists of comparing the pre-post difference in an outcome between a treatment and a control group. This approach has the advantage over simply comparing the outcome before and after the regulatory shock because there might be before-after differences in the outcome that are due to broader trends. This is why having a comparison group, unexposed (or less exposed) to the law, allows to capture this trend and thus better estimate a counterfactual. For an applied treatment of the DID framework see Remler and Van Ryzin (2014).

I measure corporate value using Tobin's q and start by estimating the following cross-sectional DID equation

$$q_{it} = \alpha_1 + \beta_1 Treat_i + \beta_2 After_t + \beta_3 Treat_i \times After_t + \eta_t + \epsilon_{it}, \quad (1)$$

where q_{it} is firm i's Tobin's q in year t and $Treat_i$ is a dummy variable marking all-firm year observations belonging to treated firms, i.e. firms that did not provide a public response to CDP in 2011. $After_t$ is a dummy variable marking all years of the post-regulation period (i.e., 2011 to 2014), η_t is a set of year dummies, and ϵ_{it} is an error term. Even though the law was publicly announced in 2012, I choose the before-treatment (pre-regulation) period to end in 2010, and the after-treatment (post-regulation) period to start in 2011. I do so because information circulated publicly as early as September 2011 that the most likely course of action of the government was to introduce mandatory GHG reporting (see the discussion of major events leading to the legislation in Section **II** and Table I for more details). In other words, even though no formal announcement was made in 2011, the probability of mandatory disclosure regulation increased sharply in 2011.

The coefficient of interest in equation (1) is β_3, which measures the DID, that is the difference in the before-after difference of Tobin's q between the treatment (not reporting publicly) and the control (reporting publicly) group. In contrast, β_1 measures the difference in Tobin's q between the treatment and control group during the pre-period and β_2 measures the difference in Tobin's q between the post- and pre-periods for the control group. Thus, focusing on the DID coefficient β_3 removes biases in post period comparisons between the treatment and control group that could be due to permanent differences between the control and treatment groups, as well as biases resulting from comparisons over time in the treatment group that could be the result of trends.

[Table VII about here.]

The results from estimating this standard DID equation are reported in column 1, Panel A, Table VII. Standard errors are clustered at the firm level. The coefficient estimate for β_3 is positive and statistically significant, suggesting that corporate value of treated firms (i.e., firms that did not respond publicly prior to 2011) increased more strongly than the value of firms that had already been reporting. In other words, a positive and significant coefficient is evidence in favor of the view that investors welcome the public provision of climate change information by firms that had not done so in the first place. To ensure that the the observed differences in Tobin's q reflect a treatment effect rather than underlying differences between the treatment and control groups in

terms of company size, I now include *ln(Assets)* as a control variable and estimate the following equation

$$q_{it} = \alpha_1 + \beta_1 Treat_i + \beta_2 After_t + \beta_3 After_t \times Treat_i + \beta_4 ln(Assets)_{it} + \epsilon_{it}. \quad (2)$$

Controlling for size also allows to account for the possibility that firm size is changing differently for the control and treatment group during the period of study. The results are reported in column 2, Panel A, Table VII and continue to show a significantly positive DID coefficient. Note that even though the size control is strongly statistically significant, neither the magnitude of the DID coefficient, nor the standard error change substantially. I choose not to use further control variables (e.g., capital expenditures, return on assets, profit margin, etc.) because these variables are likely to constitute "bad controls" in the sense of Angrist and Pischke (2008):

> *"Some variables are bad controls and should not be included in a regression model even when their inclusion might be expected to change the short regression coefficients. Bad controls are variables that are themselves outcome variables in the notional experiment at hand. That is, bad controls might just as well be dependent variables too. Good controls are variables that we can think of as having been fixed at the time the regressor of interest was determined."*

In column 3, I add industry–year fixed effects δ_{jt} in the spirit of Gormley and Matsa (2014) to the specification and estimate an equation that controls for yearly industry–specific shocks:

$$q_{ijt} = \alpha_1 + \beta_2 After_t + \beta_3 Treat_i \times After_t + \eta_t + \delta_{jt} + \epsilon_{it} \quad (3)$$

While the magnitude of the coefficient estimate drops slightly, the coefficient β_3 remains economically and statistically significant. In column 4, I include firm fixed-effects α_i to control for unobservable firm specific heterogeneity. Given that the treatment dummy has no within variation, I drop it from the equation and estimate the within transformation of the following fixed-effects specification

$$q_{it} = \alpha_i + \beta_2 After_t + \beta_3 Treat_i \times After_t + \eta_t + \epsilon_{it}. \quad (4)$$

With respect to the model controlling for industry shocks, the DID coefficient hardly changes in terms of size and precision of estimation. Finally, in column 5, I control for both firm- and industry-year fixed effects, that is,

$$q_{ijt} = \alpha_i + \beta_2 After_t + \beta_3 Treat_i \times After_t + \eta_t + \delta_{jt} + \epsilon_{it}. \quad (5)$$

In this specification, the DID coefficient estimate is only marginally significant and decreases in magnitude. There are several potential explanations for the marginal significant average treatment effect in model (5). First, it is known that even though fixed effects models are more robust in identifying coefficients consistently, this happens at an efficiency loss resulting in larger and thus more conservative standard errors.[36] Second, and most importantly, it is known that although fixed effects control for omitted variable bias, fixed effects are also notoriously susceptible to attenuation bias from measurement error.[37] If the treatment status (i.e., the pre-regulation reporting status) is measured with error, such measurement error would imply that fixed effects estimates obtained through within transformation of the model should produce smaller coefficient estimates than coefficients obtained from estimating the model as a pooled cross section.

To provide evidence consistent with this measurement error argument, I now perform the analysis for a subsample for which treatment status is likely to be more precisely measured. In doing so, I reestimate all five models restricting the sample to firms for which CDP reports the response permission in 2011. As explained in section **V**, I set the response permission to "NA" whenever a firm that is concerned by the regulation is not available in the CDP database. This is likely to introduce measurement error in the treatment dummy, because such an imputation of the pre-regulation status potentially introduces noise. In practice, this concerns 98 firms and I thus discard about 700 firm-year observations in the restricted estimation. Consistent with this measurement error view, Panel B, Table VII shows that all five DID coefficient estimates are higher compared to estimations using all sample firms.

B. Cross-sectional Variation in the DID Coefficient

In this section, I explore whether the relationship uncovered in Panel A and B of Table VII varies cross-sectionally along certain observable dimensions.

B.1. Firm Size

It seems plausible that the effect of the law should be strongest for the largest sample firms. One explanation for a high average treatment effect for the largest firms is closely related to the measurement error argument outlined in the previous section. It seems plausible that the response permission is most precisely measured for the largest sample

[36] See, for instance, the discussion on p771 of Cameron and Trivedi (2005).
[37] See, for instance, page 225 of Angrist and Pischke (2008).

firms, which would result in more consistent estimates of the average treatment effect. More importantly, however, the DID coefficient is also expected to be strongest for the largest firms because climate change issues are potentially more relevant for larger firms. One explanation for this is simply that emissions tend to increase with the scale of a firm's operations, making large firms more financially vulnerable to regulation aimed at reducing greenhouse gas emissions. Secondly, larger firms are also more likely to be adversely affected by climate change simply because more assets are exposed to the effects of climate risk (e.g., severe adverse weather events). Hence, I expect the GHG disclosure requirements to matter most for the largest firms (high average treatment effect). In Panel C, Table VII, I thus restrict the sample to the largest 50 percent of firms in each sector. I use market capitalization at the beginning of the year as the size measure and re-estimate all the previous specifications using the sample which contains only the largest firms. All specifications show higher DID coefficient estimates than those resulting from the whole sample (Panel A) and the sample restricted to firms for which CDP reports the response permission in 2011 (Panel B). Overall, this provides support in favor of the view that the valuation implications of the new reporting requirements are strongest for the largest firms.

B.2. Carbon Intensive Industries

I now explore another cross-sectional dimension along which the DID estimate could vary. As Appendix C shows, there is strong industry variation in GHG emissions. Hence, some sectors have a stronger climate impact. For instance, both the Oil and Gas and the Basic Materials sectors are subject to higher absolute (i.e., quantity; see Table C.I) and relative GHG emissions (i.e., intensity, see C.II) than other sectors. I thus expect that the average treatment effect is strongest in such carbon intensive sectors. To examine this hypothesis, I estimate a difference-in-difference-in-differences (DDD) equation in which the DID term is interacted with industry dummies. I use the ICB (Industry Classification Benchmark)[38] system to measure a firm's industry affiliation. ICB maintains four levels of granularity, i.e., 10 Industries, 19 Supersectors, 41 Sectors, and 114 Subsectors. Due to the relatively small size of the sample, I opt for the lowest level of granularity, i.e., ICB Industries. In addition, I require at least 50 firm-year observations per industry for the industry to be included in the estimation of the DDD equation. Unfortunately, regulated industries with relatively few firms such as the Utilities or the Telecommunications industries do not fulfill these criteria, and I drop them from the sample. In the case of the Utilities sector this is particularly unfortunate, since this sector is highly carbon intensive. Too low a number of observations, however, would not allow to identify the

[38] See `http://www.icbenchmark.com/`

average treatment effect per industry in a statistically meaningful way.

[Figure 2 about here.]

In estimating the DDD equation, I also restrict myself to a subsample of firms for which the CDP response permission has been only "Private" or "Public" throughout the sample period. I do so because dropping firms for which the response permission is "NA" reduces noise in measuring the reporting status. Figure 2 shows the DDD coefficient estimates for each industry alongside 95% confidence intervals. The coefficients are obtained from estimating a DDD specification that controls for size, industry-year shocks, firm fixed-effects, and obviously all additional base and interaction effects that result from interacting the treatment dummy, the post-period dummy, and all industry dummies.

Consistent with the view that the value implications of the regulation are stronger in more carbon intensive sectors, the DDD estimates are strongest in the basic materials (i.e., mining) as well as the oil and gas sector. While the point estimate of the average treatment effect is highest for the basic materials sector, it seems as if it is not as precisely estimated as the effect in the oil and gas sector (tighter confidence intervals).

B.3. Time-series Variation in the DID Coefficient

I now explore the time pattern that is the dynamics of the average treatment effect. This is crucially important for ensuring that the DID approach is valid. Instead of simply interacting the treatment dummy with the post-period dummy, I now interact the treatment dummy with every year dummy. I drop the dummy for 2008 (base year) and focus on the sample consisting of the largest firms.

[Figure VIII about here.]

The results are reported in Table VIII. In all five specifications, the interaction term between the treatment dummy and the year dummy is insignificant prior to 2011. This shows that there are no significant differences between the control and treatment groups in the pre-treatment period (i.e., 2008 to 2010). Insignificant differences between the treatment and control group in the pre-treatment period confirm that the identifying parallel trends assumption is satisfied in the data, which, in turn, validates the DID approach. In contrast, the yearly average treatment effects are highly significant starting in 2011. In terms of economic magnitude, the strongest effects are observed in the years in which the regulation was officially announced, that is 2012, and in which it was enacted, that is 2013. As outlined in section **II**, the likelihood of mandatory GHG reporting

regulation increased sharply in 2011, and the evidence suggests that investors anticipated the imminent changes in regulation. The significant average treatment effect in 2011 suggests that some of the valuation effects concerning non-compliant firms happened already before the official announcement, that is starting in 2011.

VII Robustness Checks

In this section I perform several robustness checks aimed at validating the results presented in the previous section. I perform a number of placebo tests and examine whether the results are sensitive to using different control groups.

A. Placebo Tests

A.1. Placebo Law Change in 2004

In Panel A and B of Table IX, I re-estimate the main specifications for the time period 2001–2007, assuming a change in reporting requirement had taken place in 2004. The dummy $Treat$ marks all firms that were not reporting publicly in 2011. Panel A shows DID estimates for all firms and Panel B limits the sample to the largest firms in each industry.

[Table IX about here.]

The DID coefficients are not significant neither for the whole sample, nor for the sample restricted to the largest firms. In fact, the average treatment effect in this Placebo DID is extremely close to zero in every single specification.

A.2. Pseudo Treatment

In Panel C, I construct a pseudo-treatment dummy by randomly separating firms into a treatment and control group. Given that about 60 percent of the firms in 2011 are treated firms (i.e., firms that report privately or do not report at all), I code a dummy variable that randomly marks 60 percent of the firms in 2011. I estimate all five specifications for the periods 2007 to 2014. Again, the average treatment effect is zero and insignificant in all five specifications.

B. Different Control Groups

In this subsection, Iexplore whether the results are sensitive to using alternative control groups.

B.1. Firms Listed on LSE's AIM Market Segment

I now exploit an institutional arrangement of the London Stock Exchange to form a second group of control firms. The London Stock Exchange maintains two separate secondary markets, i.e., the Main Market and AIM (formerly Alternative Investment Market). The GHG provisions of the Act apply only to UK quoted companies listed on the Main Market, but not to UK firms listed on AIM. Hence, firms incorporated in the UK and listed on the AIM are exempt from the regulation and can thus serve as a control group.

I start by conducting a "Pseudo-DID" by using firms that already responded publicly to the CDP request prior to the regulation as treated firms (i.e., the firms that served as the control group in the baseline analysis). Since these firms had already been reporting climate change related information in the pre-treatment period, they are less, if not, unaffected by the new requirements. This is why these firms served as the control group in the baseline analysis of the previous section. Conducting a DID analysis in which these firms are regarded as treated firms and compared to UK firms listed on AIM (control group), which are also unaffected by the regulation due to the way the change in law is designed, should not yield a statistically significant average treatment effect. Again, I reestimate all five specifications from the previous section. The results are reported in Panel A, Table X.

[Table X about here.]

Consistent with the view that firms that were already submitting public responses to the CDP prior to the regulation should not experience valuation effects with respect to AIM firms in the post-treatment period, the DID coefficient is insignificant in all five specification.

I now perform the true DID analysis by using as the treatment group the firms that did not report publicly prior to 2011, i.e., the treatment group from the baseline analysis of section **VI**. These firms differ from the control group (AIM listed firms) in the important respect that they are affected by the new regulation and will have to comply with it at some stage. Consistent with the view that investors value transparency with respect to climate change risks, the estimate of the DID coefficient is significantly positive in all five specifications (see Panel B, Table X). Statistical and economic significance are very similar to the baseline results.

The fact that magnitude and statistical significance of the average treatment effect in this section differs depending on whether the treatment group is made up of firms that did report (no significant DID coefficient for response permission "Public"; see Panel A, Table X) or did not report (significant DID coefficient for response permission "Private"

and "NA"; see Panel B, Table X) rules out the view that the statistical significant DID estimate for the analysis where less or not-compliant firms serve as the treatment group (see Panel B, Table X) is simply due to unobservable or observable differences between firms listed on AIM and LSE's Main Market. If the latter was true, one would expect significant DID estimates irrespective of the response permission, i.e., in both Panel A and B of Table X.

B.2. Size and Industry Matched Firms Listed on Other European Exchanges

In a final robustness check, I repeat the tests from the preceding subsection using set of firms as a control group, namely size and industry matched firms listed on other European stock exchanges (Ireland, Belgium, Denmark, France, Germany, Italy, Luxembourg, Netherlands, Norway, Sweden, Switzerland, Austria, Portugal, Spain, and Finland). I rely on stratified nearest neighbor matching without replacement, that is, for each UK quoted company, I simply match the European firm belonging to the same industry that is most similar to the UK firm in terms of assets in 2010. Again, I start by running a "placebo DID" in which treated firms are firms that are less or not affected by the regulation (i.e., firms with response permission "Public").

[Table XI about here.]

Akin to the results from the previous subsection, I find no significant DID coefficient when the treatment group is made up of firms that were already quasi-compliant with the law (see Panel A, Table XI), and the control group is made up of industry-size matched European firms. In other words, the average treatment effect is again insignificant in all five specifications.

In Panel B, I then move to comparing not-compliant firms (i.e., firms with response permission "Private" or "NA" in 2011) with their size and industry matched European peers. In stark contrast to the results in Panel A, firms that did not report publicly, or did not report to CDP at all in 2011, experience stronger value increases than the control firms (i.e., matched firms listed on other European stock exchanges) in the post-regulation period (see Panel B, Table XI). Estimates of the average treatment effects are highly significant in all specifications and again of very similar magnitude when compared to the baseline results (see Table VII) or to the results in which firms listed on AIM serve as the control group (see Panel B, Table X).

VIII Conclusion

In this article, I estimate the effect of mandatory GHG emissions disclosure on corporate value in a DID setting. Using the introduction of mandatory GHG emission dis-

closure requirements for firms listed on the Main Market of the London Stock Exchange as a source of exogenous variation in disclosure policies, I find that firms most heavily affected, that is firms not compliant with the new regulation, experience significantly positive valuation effects. The documented positive valuation effect is robust not only to controlling for both unobserved firm heterogeneity and industry-year shocks but also to a variety of placebo tests and to using different control groups such as, for instance, industry-size matched firms from other European countries.

Consistent with the notion that climate change is more relevant to larger firms and to firms belonging to carbon intensive industries, I show that the average treatment effect is highest for the largest sample firms and for firms operating in the oil and gas and the mining industries. Overall, the evidence suggests that investors value increased transparency regarding corporate climate change risks in particular when such increases in transparency concern large firms, or firms operating in carbon intensive sectors.[39].

The analysis in the paper also provides a direct test and evidence in support of the controversial Porter hypothesis (see Porter and Van der Linde (1995)), which states that, if correctly designed, environmental regulation focused on transparency generates economic benefits that more than offset the costs. Overall, the results have important implications for security markets regulation in other jurisdictions, e.g., the United States, since they suggest that there might be case for mandating firms to report on climate risks.[40]

Finally the appendix of the paper also provides background information on corporate climate change risks by showing and discussing descriptive statistics on (i) GHG emissions by industrial sector and (ii) the beliefs of the corporate sector when it comes to climate change risks and.

[39]See the Appendix D for more information on the carbon intensity by industrial sector

[40]As per 2015, the SEC has only provided guidance as to how existing reporting requirements apply to climate change risks (See SEC (2010))

References

Ahern, Kenneth R, and Amy K Dittmar, 2012, The changing of the boards: The impact on firm valuation of mandated female board representation, *The Quarterly Journal of Economics* 127, 137–197.

Ambec, Stefan, Mark A Cohen, Stewart Elgie, and Paul Lanoie, 2013, The porter hypothesis at 20: can environmental regulation enhance innovation and competitiveness?, *Review of Environmental Economics and Policy* p. res016.

Andersson, Mats, Patrick Bolton, and Frédéric Samama, 2014, Hedging climate risk, Unpublished working paper. Columbia University.

Angrist, Joshua D, and Jörn-Steffen Pischke, 2008, *Mostly harmless econometrics: An empiricist's companion* (Princeton university press).

Bushman, Robert M, and Abbie J Smith, 2001, Financial accounting information and corporate governance, *Journal of accounting and Economics* 32, 237–333.

Cameron, A Colin, and Pravin K Trivedi, 2005, *Microeconometrics: methods and applications* (Cambridge university press).

Chhaochharia, Vidhi, and Yaniv Grinstein, 2007, Corporate governance and firm value: The impact of the 2002 governance rules, *the Journal of Finance* 62, 1789–1825.

Daniel, Kent D, Robert B Litterman, and Gernot Wagner, 2015, Applying asset pricing theory to calibrate the price of climate risk, Discussion paper, Working Paper Columbia University.

DEFRA, 2011a, Impact Assessment of options for company GHG reporting, Available at `http://www.legislation.gov.uk/ukia/2011/52/pdfs/ukia_20110052_en.pdf`. Accessed July 11, 2015.

——— , 2011b, Impact Assessment of options for company GHG reporting (revised version), Available at `http://goo.gl/pCxQ6y`. Accessed July 11, 2015.

——— , 2011c, Measuring and reporting of greenhouse gas emissions by UK companies: a consultation on options, Available at `http://goo.gl/uxhbwA`. Accessed July 11, 2015.

——— , 2012a, Company reporting of greenhouse gas emissions, Available at `http://goo.gl/huHn0B`. Accessed July 11, 2015.

——— , 2012b, Measuring and reporting of GHG emissions by UK companies', Available at `http://goo.gl/gahYnl`. Accessed July 11, 2015.

Dimson, Elroy, Oguzhan Karakas, and Xi Li, 2015, Active ownership, Unpublished working paper. London Business School, Boston College, and Temple University.

Ferrell, Allen, 2007, Mandatory disclosure and stock returns: Evidence from the over-the-counter market, *The Journal of Legal Studies* 36, 213–251.

Freeman, Mark C, Gernot Wagner, and Richard J Zeckhauser, 2015, Climate sensitivity uncertainty: When is good news bad?, Discussion paper, National Bureau of Economic Research.

Gormley, Todd A, and David A Matsa, 2014, Common errors: How to (and not to) control for unobserved heterogeneity, *Review of Financial Studies* 27, 617–661.

Greenstone, Michael, Paul Oyer, and Annette Vissing-Jorgensen, 2006, Mandated disclosure, stock returns, and the 1964 securities acts amendments, *The Quarterly Journal of Economics* 121, 399–460.

La Porta, Rafael, Florencio Lopez-de Silanes, Andrei Shleifer, and Robert Vishny, 2002, Investor protection and corporate valuation, *Journal of finance* pp. 1147–1170.

Leuz, Christian, and Peter D Wysocki, 2008, Economic consequences of financial reporting and disclosure regulation: A review and suggestions for future research, *Available at SSRN 1105398*.

Litterman, Bob, 2013, What is the right price for carbon emissions, *Regulation* 36, 38.

Matsumura, Ella Mae, Rachna Prakash, and Sandra C Vera-Muñoz, 2013, Firm-value effects of carbon emissions and carbon disclosures, *The Accounting Review* 89, 695–724.

Merton, Robert C, 1987, A simple model of capital market equilibrium with incomplete information, *The journal of finance* 42, 483–510.

Palmer, Karen, Wallace E Oates, and Paul R Portney, 1995, Tightening environmental standards: The benefit-cost or the no-cost paradigm?, *The Journal of Economic Perspectives* pp. 119–132.

Porter, Michael E, and Claas Van der Linde, 1995, Toward a new conception of the environment-competitiveness relationship, *The journal of economic perspectives* pp. 97–118.

Remler, Dahlia K, and Gregg G Van Ryzin, 2014, *Research methods in practice: Strategies for description and causation* (Sage Publications).

SEC, 2010, Commission Guidance Regarding Disclosure Related to Climate Change, Available at `http://www.sec.gov/rules/interp/2010/33-9106.pdf`. Accessed July 11, 2015.

Shleifer, Andrei, and Daniel Wolfenzon, 2002, Investor protection and equity markets, *Journal of Financial Economics* 66, 3–27.

Verrecchia, Robert E, 2001, Essays on disclosure, *Journal of accounting and economics* 32, 97–180.

A Figures

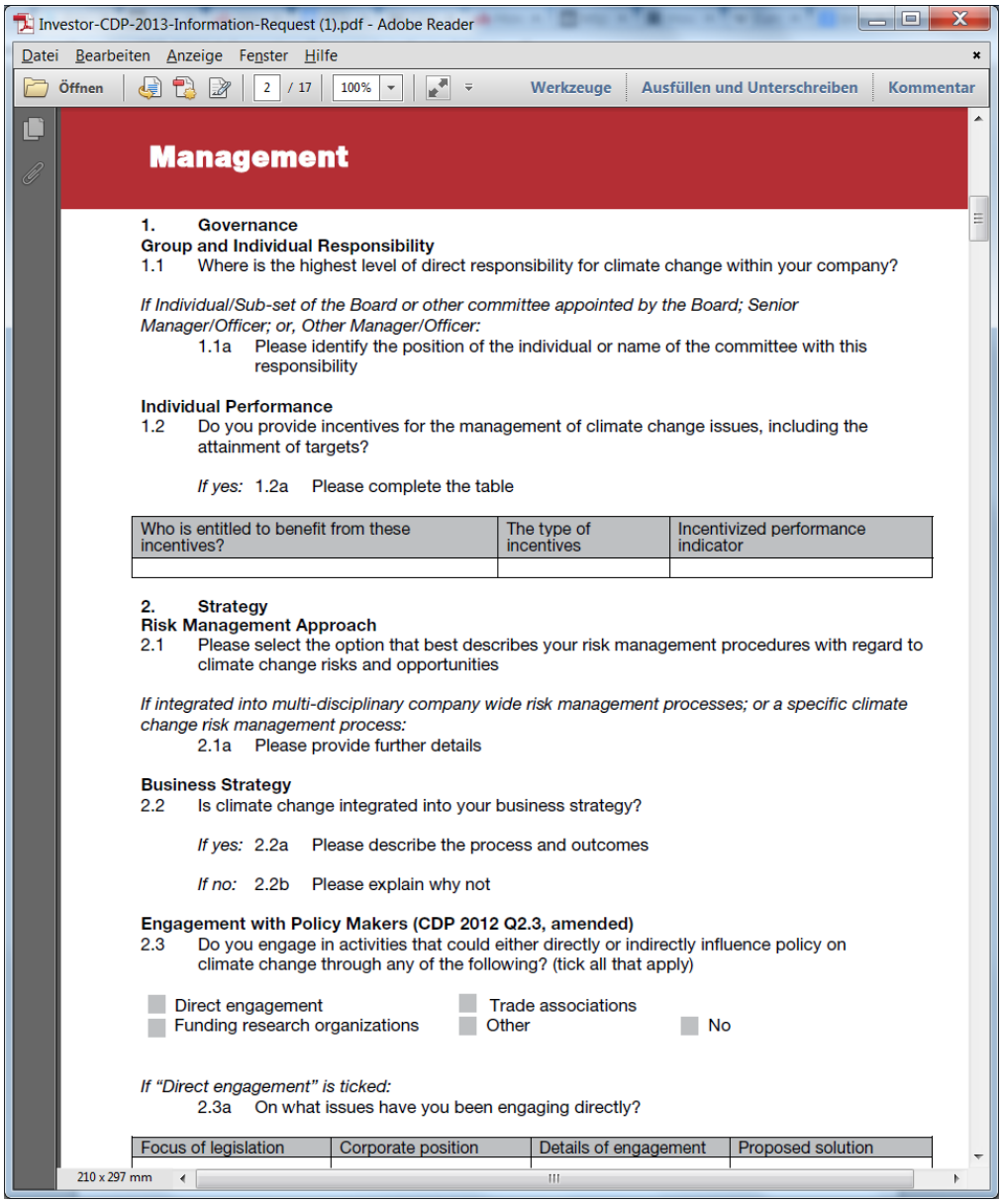

Figure 1. CDP Request This figure shows a screenshot of the first page of the questionnaire of the CDP Climate Change request.

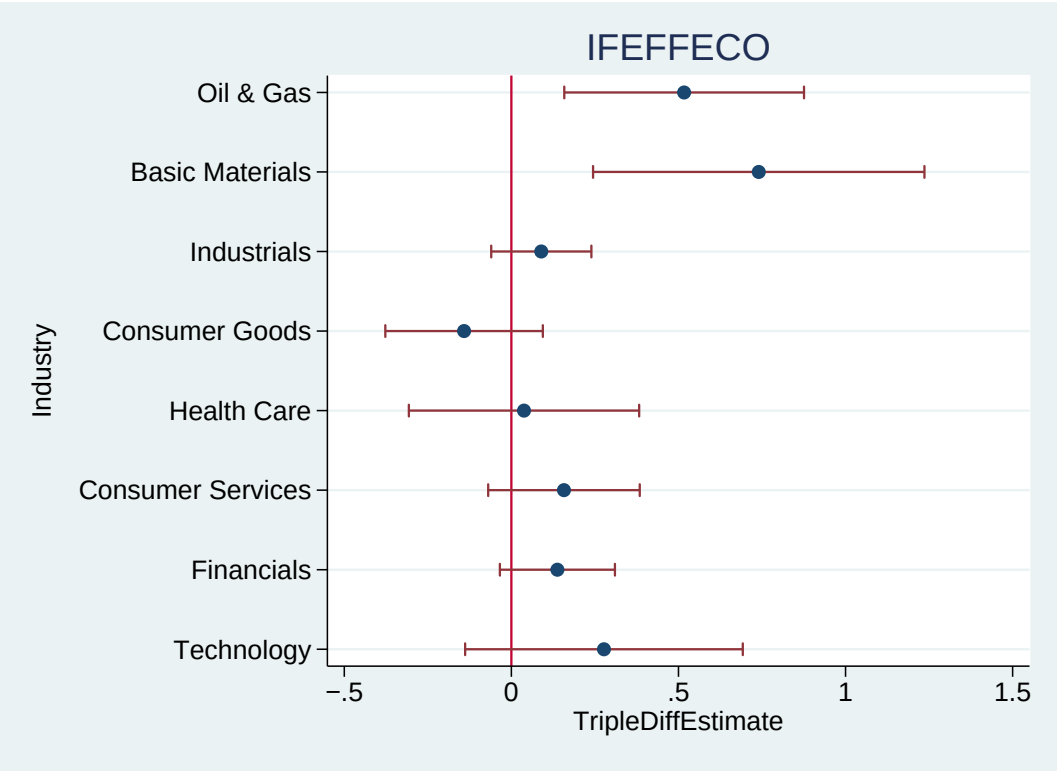

Figure 2. Difference-in-Difference-in-Differences (DDD) This figure shows DDD estimates alongside 95 percent confidence intervals. DDD estimates are esentially DID estimates by industry. I obtain the DDD coefficients by estimating an equation in which the DID term is interacted with industry dummies. The DDD specification controls for size, industry-year shocks, firm fixed-effects, and obviously all additional base and interaction effects that result from interacting the treatment dummy, the post-period dummy, and the industry dummies. The model estimation is restricted to the 50 percent largest firms.

B Tables

Table I
Important Events Leading to The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013

This table provides dates and descriptions of important events that eventually led to the passage of The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013.

Stage	Date	Comment
The Companies Act 2006	November 8, 2006	The Companies Act 2006 is an Act of the Parliament of the United Kingdom which forms the primary source of UK company law.
Climate Change Act 2008	November 26, 2008	The Climate Change Act 2008 (c 27) made it the duty of the Secretary of State to ensure that the net UK carbon account for all six Kyoto greenhouse gases for the year 2050 is at least 80% lower than the 1990 baseline, toward avoiding dangerous climate change. Section 85 of the Climate Change Act 2008 requires the Government to make regulations, under the Companies Act 2006, by 6 April 2012 requiring the directors report of a company to include information about GHG emissions as is specified in regulations, or to lay a report before Parliament explaining why no such regulations have been made.
First version of "Impact Assessment of Options for Company GHG Reporting (IA No: DEFRA1334)"	January 17, 2011	An impact assessment (IA) is a document that helps the policy-maker to fully think through and understand the consequences of possible and actual Government interventions in the public, private and third sectors; and a tool to enable the Government to weigh and present the relevant evidence on the positive and negative effects of such interventions.The first version of the IA DEFRA1334 presented cost/benefit analysis and background information on the four possible policy options, i.e., (0) Business as usual (no change to the current policy position), (1) Enhanced voluntary reporting: increasing awareness of reporting guidance and outreach; (2) Mandate GHG reporting under Companies Act for all quoted companies;(3) Mandate GHG reporting under Companies Act for all large companies;(4) Mandate GHG reporting for all companies meeting an energy use criteria.

Continued on next page

Table I – continued from previous page

Stage	Date	Comment
Start of the consultation by the Department for Environment, Food & Rural Affairs (DEFRA)	May 11, 2011	Public consultation seeking views on whether regulations should be introduced to make it mandatory for some UK companies to report on their GHG emissions or whether the Government should continue to encourage measuring and reporting of GHG emissions on a voluntary basis. A diverse range of respondents (e.g., NGO's, companies, individuals, Investors, regulators, trade associations/professional bodies, etc.) were asked to express their views on the five potential policy options that were outlined in the impact assessment and choose their preferred one.
End of DEFRA consultation	July 5, 2011	
Final version of Impact Assessment of Options for Company GHG Reporting (IA No: DEFRA1334)	August 31, 2011	The final version of the Impact Assesment is signed off by DEFRA and made available to ministers and to members of parliament. The final impact assessment includes a reference to the preferred policy "(2) Mandate GHG reporting under Companies Act for all quoted companies." Even though the impact assessment is dated 31 August 2011, it is unclear when exactly it became publicly available
Environmental Audit Committee publishes Seventh Report *Carbon Budgets*	September 14, 2011	Environmental Audit Committee publishes *Seventh Report Carbon Budgets*, in which an explicit statement to the preferred option of mandatory GHG reporting: "In order to aid transparency and illustrate the contributions that businesses are making, and need to make, to help tackle climate change, we recommend that the Government should introduce mandatory reporting by businesses at the earliest opportunity." The Environmental Audit Committee is appointed by the House of Commons to consider to what extent the policies and programmes of government departments and non-departmental public bodies contribute to environmental protection and sustainable development; to audit their performance against such targets as may be set for them by Her Majesty's Ministers; and to report thereon to the House.
Report to parliament "Company reporting of GHG emissions"	March 27, 2012	Report presented to Parliament pursuant to Section 85 of the Climate Change Act 2008 outlining why no regulations had been introduced so far.

Continued on next page

Table I – continued from previous page

Stage	Date	Comment
First announcement that the UK Government will make GHG disclosure mandatory for firms listed on the London Stock Exchange	June 19, 2012	Writing in The Guardian, Deputy Prime Minister Nick Clegg announce the UK's intent to pass legislation requiring UK quoted companies to disclose GHG emissions figures in their annual reports.
Plenary Adress RIO 20+	June 21, 2012	The intent of the UK government to make climate change related information disclosure mandatory was is reiterated in a keynote speech by UK's Deputy Prime Minister Nick Clegg at the United Nations Conference on Sustainable Development \textitRio+20.
Summary report of DEFRA consultation	July 2012	DEFRA publishes the report "Measuring and reporting of GHG emissions by UK companies" which provides detailed information on the outcome of the public consultation.
First draft of the regulations are published	July 25, 2012	The first draft of the legislative text concerning GHG disclosure under The Greenhouse Gas Emissions (Directors Reports) Regulations 2013 Act is published for consultation.
End of consultation	October 17, 2012	
Draft laid before parliament	June 10, 2013	
Revised draft	June 11, 2013	
Approved by the House of Commons	July 16, 2013	
The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013 takes effect	October 1, 2013	

Table II

The CDP Universe in 2013

This table shows a list of stock market indexes and descriptions of the universe of firms that received an information request from CDP in 2013.

800 of the largest global companies in developed countries based on market capitalization (FTSE All-World Developed - Large Cap)
800 of the largest and mid-sized companies in the Emerging Markets based on market capitalization (S&P/IFCI Large/Mid Emerging Market Index)
725 of the largest companies in the UK based on market capitalization (FTSE All-Share and FTSE Fledgling Index).
500 of the largest companies globally base d on market capitalization (Global 500)
500 of the largest companies in Japan based on market capitalization
500 of the largest companies in the USA based on market capitalization (S&P 500)
300 of the largest companies in Europe base d on market capitalization (FTSEurofirst 300 Eurozone)
260 of the largest companies in the Nordic region based on market capitalization
250 of the largest companies in France based on market capitalization (SBF 250)
250 of the largest companies in Germany an d Austria based on market capitalization
250 of the largest companies in Korea based on market capitalization, in partnership with the Korean Sustainability Investing Forum (KoSIF)
250 of the largest electric utilities globally based on market capitalization
200 of the largest companies in Australia and 50 of the largest companies in New Zealand based on market capitalization (ASX 200 & NZX 50), in cooperation with CDP's Investor Relations Partner -Australia/ New Zealand the Investor Group on Climate Change (IGCC)
200 of the largest companies in Canada based on market capitalization
200 of the largest companies in India based on market capitalization (BSE 200), in partnership with the Bombay Stock Exchange (BSE) and WWF India
180 of the largest companies issuing bonds (S&P CDS U.S. Investment Grade Index and Markit iBoxx USD Liquid Investment Grade Index)
170 of the largest companies in Asia ex-Japan, India, China and Korea (Asia ex-JICK)
150 of the largest companies in the Netherlands, Belgium and Luxembourg based on market capitalization
125 of the largest companies in Spain and Portugal based on market capitalization
100 of the largest companies in Brazil based on market capitalization (BM&FBOVESPA IBrX 100), in partnership with the Brazilian Association of Pension Funds - ABRAPP
100 of the largest companies in Central & Eastern Europe based on market capitalization
100 of the largest companies in China based on market capitalization
100 of the largest companies in Italy based on market capitalization
80 of the largest companies in Latin America based on market capitalization
100 of the largest companies in South Africa based on market capitalization (FTSE/JSE 100), in partnership with the National Business Initiative (NBI)
100 of the largest companies in Switzerland based on market capitalization (SPI Large & Mid Cap (SOCI))
100 of the largest companies in the transport sector globally based on market capitalization
100 of the largest companies in Turkey based on market capitalization (ISE 100), in partnership with Sabanci University Corporate Governance Forum
50 of the largest companies in Russia based on market capitalization (RTS Index)
30 of the largest companies in Ireland based on market capitalization

Table III

Number of Firms Targeted by CDP in 2013

This table reports the number of companies per country that have been contacted by the CDP in 2013.

Country	Firms	Country	Firms	Country	Firms
USA	1075	Malaysia	49	Slovenia	4
United Kingdom	708	New Zealand	46	Estonia	4
Japan	435	Portugal	40	Lithuania	4
France	246	Denmark	40	Romania	4
South Korea	231	Thailand	38	Croatia	4
Germany	225	Ireland	37	Slovakia	3
Canada	211	Austria	33	Pakistan	2
India	207	Indonesia	31	Iceland	2
Australia	184	Singapore	29	Guernsey	2
China	144	Chile	27	Liechtenstein	2
Brazil	115	Philippines	25	Cayman Islands	2
Turkey	110	Mexico	22	Vietnam	1
Switzerland	109	Hungary	14	Panama	1
South Africa	102	Colombia	13	Argentina	1
Italy	100	Peru	11	Belarus	1
Taiwan	99	Luxembourg	10	Mauritius	1
Netherlands	97	Czech Republic	10	Sri Lanka	1
Sweden	95	Bermuda	9	Netherlands Antilles	1
Spain	88	Channel Islands	8	Serbia	1
Hong Kong	88	Israel	7	Bahamas	1
Norway	63	Morocco	7	Qatar	1
Russia	59	Korea	7	Gibraltar	1
Poland	52	Egypt	6	Saudi Arabia	1
Belgium	52	Greece	5	Malta	1
Finland	50	United Arab Emirates	5	Cyprus	1

Table IV

CDP Response Permission (All Firms Targeted by CDP in 2013)

When submitting climate change related data to the CDP, firms are asked to mark their response as either "Public" or "Private". "Public" responses are accessible to the general public, while "Private" responses are available only to CDP and the investors on whose behalf CDP requests information from the firms. This status is known as the response permission. "NA" marks firms that did not respond to the CDP request. This table shows the distribution of response permission for all firms that CDP contacted in 2013.

	Number	Percent
Public	1,816	33
Private	500	9
NA	3,207	58
Total	5,523	100

Table V

Summary Statistics

This table reports summary statistics of firm-level variables. The sample period runs from 2008–2014. *Market cap* is Worldscope item *wc08001*. *Employees* is Worldscope item *wc07011*. *Assets* is item *wc02999*. *ln()* is the natural logarithm. 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) and winsorized at the 95 and 5 percent level. Financial variables are measured in British pounds. Scope 1 and Scope 2 emissions are measured in metric tonnes of CO2 equivalent (MTCO2e). For more information on emissions, see section **IV** and Appendix C. The variables are expressed in million units. *Treat* is a dummy variable marking all firm year observations of treated firms, i.e., firms that did not provide a public response to CDP in 2011. LSE stands for London Stock Exchange. SD displays the standard deviation, P25 the first and P75 the third quartile of the respective variable. Panel A shows the statistics for the main sample, i.e., UK quoted companies listed on LSE's Main Market. Panel B shows statistics for firms listed on LSE's other secondary market, i.e. the Alternative Investment Market. Panel C shows statistics for size and industry matched firms from other European countries.

Panel A: UK Quoted Companies Listed on LSE's Main Market						
	Mean	Median	SD	P25	P75	N
Market cap	4,172.02	467.74	13,872.95	116.56	1,819.18	2,918
Employees	17,193.34	2,791.00	52,375.92	719.00	11,441.00	2,623
Assets	17,155.13	586.36	118,359.13	165.83	2,452.10	2,710
ln(Assets)	13.42	13.28	2.28	12.02	14.71	2,710
Tobin's q	1.54	1.29	0.76	1.01	1.87	2,709
Scope 1 emissions	2,354.91	42.37	9,366.79	5.15	317.73	904
Scope 2 emissions	735.76	51.02	2,853.18	8.61	254.97	897
Treat	0.61	1.00	0.49	0.00	1.00	2,926
Panel B: UK Companies Listed on LSE's Alternative Investment Market						
			1			
	Mean	Median	SD	P25	P75	N
Market cap	120.57	15.58	1,141.48	5.33	44.96	3,979
Employees	326.67	80.00	820.53	24.00	269.00	3,483
Assets	333.76	20.55	4,159.67	6.10	61.22	3,989
ln(Assets)	9.88	9.93	1.86	8.72	11.02	3,989
Tobin's q	1.72	1.20	1.31	0.84	1.99	3,979
Panel C: Industry and Size Matched Firms Listed on Other European Exchanges						
	Mean	Median	SD	P25	P75	N
Market cap	3,801.09	436.78	11,464.95	102.37	1,818.68	2,647
Employees	18,245.40	2,539.50	48,362.47	602.00	11,880.00	2,550
Assets	17,521.92	802.47	105,957.43	163.77	3,852.22	2,652
ln(Assets)	13.63	13.60	2.45	12.01	15.16	2,652
Tobin's q	1.41	1.14	0.69	0.98	1.58	2,646

Table VI

CDP Response Permission by Year (UK Quoted Companies)

When submitting climate change related data/information to the CDP, the firms are asked to mark the response either as either "Public" or "Private". This status is known as the response permission. "Private" responses are made available only to the CDP and the institutions on whose behalf CDP is requesting information, while "Public" responses are also made available to the general public. "NA" marks firms that did not respond to the request of the CDP. Whenever a sample firm is not contacted by CDP, I set the response permission to "NA." Panel A tabulates the number of sample firms per response status against years. Panel B shows the relative distribution of response status by year.

Panel A: Number of Firms per Response Permission							
	2009	2010	2011	2012	2013	2014	Total
Public	130	159	164	174	181	206	1,014
Private	56	75	72	64	65	43	375
NA	232	184	182	180	172	169	1,119
Total	418	418	418	418	418	418	2,508
Panel B: Fraction of Firms per Response Permission							
	2009	2010	2011	2012	2013	2014	Total
Public	31.10	38.04	39.23	41.63	43.30	49.28	40.43
Private	13.40	17.94	17.22	15.31	15.55	10.29	14.95
NA	55.50	44.02	43.54	43.06	41.15	40.43	44.62
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table VII

Effect of The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013 on Tobin's *q*

This table shows DID estimates of the effect of The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013 on Tobin's q. The dependent variable is Tobin's q. The sample period is 2008 to 2014. *Treat* is a dummy variable marking all firm year observations of treated firms, i.e., firms that did not provide a public response to CDP in 2011. Accordingly, the control group is composed of all firms that did provide a public response to CDP in 2011. *After* is a dummy variable marking the post-regulation period, i.e., years 2011 to 2014. Panel A uses the whole sample. In Panel B, I restrict the regressions to a sample of firms for which the response permission in 2011 is either "Private" or "Public." Panel C estimates the relationship using only the 50 percent largest firms in each sector. The standard errors (in parentheses) are clustered at the firm level. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Panel A: All UK Quoted Companies Listed on LSE's Main Market in June 2012					
	(1)	(2)	(3)	(4)	(5)
ln(Assets)		-0.056***	-0.041**	-0.203***	-0.188***
		(0.016)	(0.019)	(0.065)	(0.061)
Treat	-0.152**	-0.295***	-0.265***		
	(0.064)	(0.076)	(0.077)		
After	0.374***	0.376***	0.513**	0.301***	0.008
	(0.057)	(0.057)	(0.237)	(0.041)	(0.119)
Treat × After	0.120***	0.115***	0.095**	0.091**	0.070*
	(0.045)	(0.044)	(0.045)	(0.043)	(0.042)
Observations	2,709	2,709	2,709	2,709	2,709
R^2	0.034	0.053	0.104	0.149	0.232
Year Fixed Effects	YES	YES	YES	YES	YES
Industry*Year Fixed Effects	NO	NO	YES	NO	YES
Firm Fixed Effects	NO	NO	NO	YES	YES
Panel B: UK Quoted Firms with Response Permission "Public" or "Private" in 2011					
	(1)	(2)	(3)	(4)	(5)
ln(Assets)		-0.118***	-0.097***	-0.241***	-0.199***
		(0.018)	(0.022)	(0.074)	(0.070)
Treat	-0.042	-0.242***	-0.205***		
	(0.074)	(0.075)	(0.076)		
After	0.422***	0.430***	0.006	0.346***	0.063
	(0.063)	(0.062)	(0.107)	(0.043)	(0.118)
Treat × After	0.147***	0.146***	0.117**	0.122***	0.092*
	(0.049)	(0.048)	(0.049)	(0.047)	(0.047)
Observations	2,068	2,068	2,068	2,068	2,068
R^2	0.038	0.106	0.154	0.173	0.267
Year Fixed Effects	YES	YES	YES	YES	YES
Industry*Year Fixed Effects	NO	NO	YES	NO	YES
Firm Fixed Effects	NO	NO	NO	YES	YES
Panel C: Sample Restricted to 50 Percent Largest UK Quoted Firms in Each Industry					
	(1)	(2)	(3)	(4)	(5)
ln(Assets)		-0.186***	-0.183***	-0.274***	-0.249***
		(0.023)	(0.031)	(0.083)	(0.083)
Treat	0.114	-0.178*	-0.122		
	(0.107)	(0.098)	(0.101)		
After	0.390***	0.423***	0.373	0.386***	0.018
	(0.081)	(0.078)	(0.399)	(0.055)	(0.161)
Treat × After	0.217***	0.225***	0.180***	0.220***	0.176***
	(0.064)	(0.062)	(0.061)	(0.062)	(0.060)
Observations	1,335	1,335	1,335	1,335	1,335
R^2	0.056	0.214	0.256	0.197	0.307
Year Fixed Effects	YES	YES	YES	YES	YES
Industry*Year Fixed Effects	NO	NO	YES	NO	YES
Firm Fixed Effects	NO	NO	NO	YES	YES

Table VIII

Dynamics of the Effect of The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013 on Tobin's *q*

This table shows DID estimates of the effect of The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013 on Tobin's q for each year of the sample period. The dependent variable is Tobin's q. $Treat$ is a dummy variable marking all firm year observations of treated firms, i.e., firms that did not provide a public response to CDP in 2011. Accordingly, the control group is composed of all firms that did provide a public response to the CDP in 2011. $Year = t$ are year dummies. $Treat \times Year = t$ are interaction terms between the treatment dummy and the respective year dummies. The base category is 2008, which is why the year dummy and the interaction term for this year are dropped. Standard errors (in parentheses) are clustered at the firm level. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

	(1)	(2)	(3)	(4)	(5)
ln(Assets)		-0.186***	-0.183***	-0.273***	-0.249***
		(0.023)	(0.031)	(0.084)	(0.083)
Treat	0.061	-0.226**	-0.168		
	(0.111)	(0.101)	(0.105)		
Year = 2009	0.078*	0.086**	0.211	0.089**	0.118
	(0.041)	(0.040)	(0.255)	(0.039)	(0.228)
Year = 2010	0.203***	0.227***	0.246	0.238***	0.154
	(0.046)	(0.046)	(0.186)	(0.047)	(0.125)
Year = 2011	0.091*	0.127***	0.065	0.144***	-0.028
	(0.047)	(0.048)	(0.185)	(0.048)	(0.078)
Year = 2012	0.145***	0.187***	0.238	0.206***	0.144***
	(0.052)	(0.052)	(0.168)	(0.053)	(0.043)
Year = 2013	0.281***	0.328***	0.470**	0.350***	0.635**
	(0.059)	(0.059)	(0.188)	(0.060)	(0.268)
Year = 2014	0.361***	0.395***	0.158	0.481***	0.084
	(0.100)	(0.095)	(0.465)	(0.077)	(0.349)
Treat × Year = 2009	0.034	0.030	0.035	0.027	0.034
	(0.073)	(0.072)	(0.071)	(0.072)	(0.070)
Treat × Year = 2010	0.124	0.116	0.104	0.112	0.101
	(0.079)	(0.080)	(0.081)	(0.081)	(0.081)
Treat × Year = 2011	0.195***	0.194***	0.161**	0.194***	0.161**
	(0.073)	(0.073)	(0.079)	(0.074)	(0.079)
Treat × Year = 2012	0.298***	0.301***	0.256***	0.302***	0.257***
	(0.085)	(0.085)	(0.088)	(0.086)	(0.088)
Treat × Year = 2013	0.306***	0.314***	0.240**	0.317***	0.243**
	(0.102)	(0.101)	(0.102)	(0.101)	(0.102)
Treat × Year = 2014	0.292*	0.298**	0.279	0.229*	0.228*
	(0.154)	(0.146)	(0.170)	(0.124)	(0.132)
Observations	1,335	1,335	1,335	1,335	1,335
R^2	0.057	0.215	0.256	0.201	0.310
Year Fixed Effects	YES	YES	YES	YES	YES
Industry*Year Fixed Effects	NO	NO	YES	NO	YES
Firm Fixed Effects	NO	NO	NO	YES	YES

Table IX

Placebo Tests

This table shows several placebo tests. In Panel A and B, I reestimate the main specifications for the time period 2001–2007, assuming that a change in reporting requirement had taken place in 2004. Panel A shows DID estimates for all firms and Panel B limits the sample to the largest 50 percent of firms in each industry. In Panel C, I reestimate the main specifications for the time period 2008–2014 but instead of using CDP's pre-regulation response permission to assign firms to the control and treatment group, I use a pseudo treatment dummy which randomly assigns 60 percent of the sample firms in 2011 to the control group. The dependent variable in all regressions is Tobin's q. In Panels A and B, *Treat* is a dummy variable marking all firm year observations of treated firms, i.e., firms that did not provide a public response to CDP in 2011. Accordingly, the control group is composed of all firms that did provide a public response to the CDP in 2011. In Panel C, *Treat* is a dummy variable randomly marking 60 percent of the firms in 2011. In Panels A and B, *After* is a dummy variable marking years 2004–2007 and in Panel C years 2011–2014. The standard errors (in parentheses) are clustered at the firm level. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Panel A: Placebo Law Change in 2004 (All Firms)					
	(1)	(2)	(3)	(4)	(5)
ln(Assets)		0.050***	0.046***	0.002	0.005
		(0.005)	(0.005)	(0.016)	(0.017)
Treat	-0.095***	0.037*	0.022		
	(0.022)	(0.022)	(0.021)		
After	0.037***	0.012	-0.026	0.015	-0.023
	(0.010)	(0.011)	(0.035)	(0.010)	(0.032)
Treat × After	0.002	0.003	0.001	-0.001	-0.003
	(0.011)	(0.012)	(0.011)	(0.011)	(0.011)
Observations	2,571	2,571	2,571	2,571	2,571
R^2	0.049	0.241	0.328	0.021	0.071
Year Fixed Effects	YES	YES	YES	YES	YES
Industry*Year Fixed Effects	NO	NO	YES	NO	YES
Firm Fixed Effects	NO	NO	NO	YES	YES
Panel B: Placebo Law Change in 2004 (Largest Firms)					
	(1)	(2)	(3)	(4)	(5)
ln(Assets)		0.042***	0.033***	-0.010	-0.007
		(0.007)	(0.005)	(0.019)	(0.020)
Treat	-0.053*	0.032	0.011		
	(0.030)	(0.029)	(0.026)		
After	0.036***	0.015	-0.005	0.021**	0.019
	(0.011)	(0.013)	(0.070)	(0.010)	(0.039)
Treat × After	0.002	0.003	0.005	-0.002	-0.001
	(0.015)	(0.016)	(0.016)	(0.014)	(0.015)
Observations	1,351	1,351	1,351	1,351	1,351
R^2	0.019	0.173	0.382	0.024	0.077
Year Fixed Effects	YES	YES	YES	YES	YES
Industry*Year Fixed Effects	NO	NO	YES	NO	YES
Firm Fixed Effects	NO	NO	NO	YES	YES
Panel C: Random Treatment Dummy					
	(1)	(2)	(3)	(4)	(5)
ln(Assets)		-0.028**	-0.016	-0.210***	-0.193***
		(0.014)	(0.016)	(0.064)	(0.060)
Treat	0.061	0.064	0.041		
	(0.065)	(0.065)	(0.064)		
After	0.444***	0.440***	0.525**	0.354***	0.038
	(0.054)	(0.053)	(0.241)	(0.039)	(0.120)
Treat × After	-0.000	0.000	-0.004	0.009	0.004
	(0.047)	(0.046)	(0.043)	(0.044)	(0.041)
Observations	2,709	2,709	2,709	2,709	2,709
R^2	0.031	0.038	0.091	0.145	0.230

Table X

Effect of the The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013 on Tobin's q: Relative to AIM Listed UK firms

This table shows DID estimates of the effect of the The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013 on Tobin's q using an alternative control group. The control group in both Panel A and B is composed of firms listed on LSE's AIM market segment. Firms from this market segment are exempt from the disclosure regulation. The dependent variable is Tobin's q. In Panel A, $Treat$ is a dummy variable marking all firm-year observations of firms that provided a public response to CDP in 2011 ("Placebo DID"). These regressions are estimated using exclusively firm-year observations of firms with response permission "Public" in 2011 and firm-year observations of firms from the control group. In Panel B, $Treat$ is a dummy variable marking all firm-year observations of firms that did not provide a public response to CDP in 2011. These regressions are estimated using exclusively firm-year observations of firms with response permission "Private" or "NA" in 2011 and firm-year observations of firms belonging to the control group. $After$ is a dummy variable marking the post-treatment (2011–2014) period. Standard errors (in parentheses) are clustered at the firm level. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Panel A: CDP Response Permission - "Public"					
	(1)	(2)	(3)	(4)	(5)
ln(Assets)		-0.242***	-0.230***	-0.374***	-0.385***
		(0.019)	(0.019)	(0.042)	(0.043)
Treat	-0.093	1.160***	1.175***		
	(0.072)	(0.117)	(0.120)		
After	0.359***	0.420***	0.680*	0.290***	0.516***
	(0.078)	(0.076)	(0.366)	(0.049)	(0.174)
After × Treat	0.024	0.004	0.014	0.029	0.051
	(0.054)	(0.052)	(0.054)	(0.050)	(0.053)
Observations	5,035	5,035	5,035	5,035	5,035
R^2	0.007	0.143	0.208	0.104	0.138
Year Fixed Effects	YES	YES	YES	YES	YES
Industry*Year Fixed Effects	NO	NO	YES	NO	
Firm Fixed Effects	NO	NO	NO	YES	YES
Panel B: CDP Response Permission - "Private" or "NA"					
	(1)	(2)	(3)	(4)	(5)
ln(Assets)		-0.214***	-0.199***	-0.369***	-0.383***
		(0.018)	(0.019)	(0.041)	(0.041)
Treat	-0.243***	0.315***	0.357***		
	(0.069)	(0.082)	(0.084)		
After	0.373***	0.417***	0.687*	0.280***	0.580***
	(0.073)	(0.071)	(0.370)	(0.048)	(0.182)
After × Treat	0.157***	0.119**	0.126**	0.113**	0.128***
	(0.055)	(0.053)	(0.050)	(0.050)	(0.048)
Observations	5,624	5,624	5,624	5,624	5,624
R^2	0.013	0.118	0.171	0.106	0.145
Year Fixed Effects	YES	YES	YES	YES	YES
Industry*Year Fixed Effects	NO	NO	YES	NO	YES
Firm Fixed Effects	NO	NO	NO	YES	YES

Table XI

Effect of the The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013 on Tobin's *q*: Relative to European Size and Industry Matched Firms

This table shows DID estimates of the effect of the The Companies Act 2006 (Strategic Report and Directors Report) Regulations 2013 on Tobin's q using another alternative control group. The control group in both Panel A and B is composed of size and industry matched firms listed on other European exchanges. Matched firms from other European countries are obviously exempt from the UK disclosure regulation. The dependent variable is Tobin's q. In Panel A, $Treat$ is a dummy variable marking all firm-year observations of firms that provided a public response to CDP in 2011 ("Placebo DID"). These regressions are estimated using exclusively firm-year observations of firms with reporting permission "Public" in 2011 and their size-industry matched European peers. In Panel B, $Treat$ is a dummy variable marking all firm-year observations of firms that did not provide a public response to CDP in 2011. Again, these regressions are estimated using exclusively firm-year observations of firms with response permission "Private" or "NA" in 2011 and their size-industry matched European peers. $After$ is a dummy variable marking the post-treatment (2011–2014) period. Standard errors (in parentheses) are clustered at the firm level. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Panel A: CDP Response Permission - "Public"					
	(1)	(2)	(3)	(4)	(5)
ln(Assets)		-0.093***	-0.075***	-0.186***	-0.196***
		(0.016)	(0.017)	(0.065)	(0.069)
Treat	0.118*	0.094	0.100		
	(0.068)	(0.066)	(0.064)		
After	0.333***	0.326***	-0.425***	0.268***	0.136
	(0.071)	(0.072)	(0.154)	(0.036)	(0.129)
After × Treat	0.044	0.049	0.049	0.057	0.056
	(0.039)	(0.040)	(0.039)	(0.038)	(0.037)
Observations	2,094	2,094	2,094	2,094	2,094
R^2	0.031	0.099	0.175	0.120	0.199
Year Fixed Effects	YES	YES	YES	YES	YES
Industry*Year Fixed Effects	NO	NO	YES	NO	YES
Firm Fixed Effects	NO	NO	NO	YES	YES
Panel B: CDP Response Permission - "Private" or "NA"					
	(1)	(2)	(3)	(4)	(5)
ln(Assets)		-0.080***	-0.061***	-0.147***	-0.160***
		(0.014)	(0.015)	(0.047)	(0.045)
Treat	-0.021	-0.039	-0.035		
	(0.056)	(0.055)	(0.054)		
After	0.318***	0.320***	-0.047	0.237***	0.017
	(0.057)	(0.058)	(0.152)	(0.029)	(0.130)
After × Treat	0.182***	0.176***	0.177***	0.144***	0.142***
	(0.036)	(0.035)	(0.035)	(0.034)	(0.033)
Observations	3,394	3,394	3,394	3,394	3,394
R^2	0.029	0.077	0.130	0.126	0.180
Year Fixed Effects	YES	YES	YES	YES	YES
Industry*Year Fixed Effects	NO	NO	YES	NO	YES
Firm Fixed Effects	NO	NO	NO	YES	YES

C Appendix: GHG Emissions by Industry

A. Absolute GHG Emissions by Industrial Sector

Using the sample of all UK firms that reported to CDP at least once between between 2009 and 2014, this Appendix provides information on absolute GHG emissions by industrial sector. Absolute emissions are simply the total amount (in metric tons of CO2e) of emissions. In table C.I, I report summary statistics of absolute emissions broken down by industrial sector. Panel A reports total sum of emissions by industry, Panel B reports average emissions by industry, and Panel C reports median emissions. The unit of measurement is thousand metric tons of CO2e.

[Table C.I about here.]

Panel A in table C.I shows that the sector with the highest Scope 1 (i.e., direct) emissions between 2009 and 2013 is the oil and gas industry. In total, sample firms belonging to this sector were responsible for Scope 1 emissions corresponding to about 587 million metric tons of CO2e. Panel B shows that with mean firm-level emissions of 13 million metric tons of CO2e, firms from the oil and gas industry also reported the highest Scope 1 emissions on average. In contrast, median Scope 1 emissions are not the highest in the oil and gas sector (see Panel C). In fact, when looking at the median, both the basic materials and utilities sectors appear to generate higher Scope 1 emissions through their operations: 201 thousand metric tons of CO2e (MTCO2e) for Oil and Gas firms, versus 2.487 million MTCO2e for firms belonging to the basic materials sector and 7.739 million MTCO2e for firms belonging to the utilities sector. There several potential explanations for this pattern: it seems as if the absolute emissions distribution is skewed with a few, probably large firms in the oil and gas industry, being responsible for the majority of the GHG emissions. A second reason for this big difference between mean and median emissions is likely to be due to the granularity of the industry classification. While integrated oil and gas firms are responsible for extremely high emissions, firms offering oil equipment and services are likely to cause much lower emissions. Since both kinds of firms are subsumed in the oil and gas industry, high intra-industry variation is likely to be a result.

After the Oil and Gas sector, the Basic Materials and Utilities sectors reported second and third highest total Scope 1 emissions (345, respectively 260 million MTCO2e). When looking at mean firm-level Scope 1 emissions, the Utilities sector recorded slightly higher emissions than the Basic Materials sector (9.3 versus 9.1 million metric tons of CO2e). Within the basic materials sector, above all mining firms are responsible for the high Scope 1 emissions, whereas conventional electricity, gas distribution and multi-utility

firms are most responsible for emissions in the utility sector. Interestingly, the divergence of median and mean firm-level Scope 1 emissions for the basic materials and the utility sector is much lower than for the oil and gas sector. This suggests that there is less intra-industry variation in terms of absolute emissions in these sectors. In other words, it appears that utility and basic materials are much more homogeneous in terms of their carbon emissions.

When it comes to Scope 2 or indirect emissions, often due to energy use, the basic materials sector stands out as being responsible for the highest Scope 2 emissions no matter if total, mean, or median emissions are considered. This is due to the fact that mining activities are quite energy intensive. Second and third regarding mean Scope 2 or indirect emissions are the oil and gas and the telecommunications sector. The latter is a heavy consumer of energy explaining the relatively high average Scope 2 emissions.

When looking at total emissions (sum of Scope 1 and Scope 2), firms from the oil and gas and basic materials sectors appear to be responsible for the largest amount of carbon emissions (652 and 567 million MTCO2e), followed by the utilities sector (277 million MTCO2e). When the measure is average total firm-level emissions, a similar ordering ensues: the average oil and gas firm reports about 16 million MTCO2e, the average basic materials firm about 15 million MTCO2e and the average utilities firm about 9 million MTCO2e.

It can also be seen in table C.I that the financial sector was responsible for relatively low Scope 1 and Scope 2 emissions. This is not surprising, since Scope 1 and 2 emissions do not include what is often referred to as "financed emissions", i.e., carbon that results from financing and investment decisions. It seems quite obvious that the relevant emission metric for financial firms is Scope 3, since the financial sector has an impact on climate change primarily through its financing and investment decisions.

B. Relative Emissions: Intensity

Absolute emissions, such as those discussed in the previous subsection do not account for scale issues, that is to say that carbon emissions tend to increase with the size of the operations of a company. This is why I also calculate relative emissions, or emissions intensity for the sample of UK firms. The idea behind measuring relative emissions is to calculate a ratio which expresses the company's annual emissions in relation to a quantifiable factor associated with the company's activities. In other words, emission intensity allows to make statements as to whether a firm's assets are used carbon efficiently.

Table C.II shows median relative carbon emission or carbon intensity by industrial sector.

[Table C.II about here.]

I report three different relative emissions measures, namely emissions normalized by total assets (Panel A), total sales (Panel B), and tangible assets (Panel C). All three measures show that the Utilities sector is the most carbon intensive sector when Scope 1 emissions are considered. The second and third most emission intensive sectors are the Basic Materials sector and the Oil and gas sector.

When considering Scope 2, the Basic Materials sector is the most carbon intensive sector, which is due to the high energy use of mining activities. When looking at total emissions (Scope 1 and Scope 2 combined), the sectors with the highest carbon intensities are basic materials, utilities, and oil and gas. In conclusion, both absolute and relative emissions highlight the same sectors as being carbon intensive.

Table C.I

Absolute Emissions by Industrial Sector

This table reports descriptive statistics of annual absolute GHG emissions by industrial sector. The unit of measurement is thousand Metric Tons of CO2e (MTCO2e). CO2e stands for Carbon dioxide equivalent and allows to take into consideration that some greenhouse gases have higher global warming potential (GWP) than others. Rescaling greenhouse gases in CO2e makes them comparable in terms of their impact on climate change. Scope 1 are direct emissions from sources that are owned or controlled by the reporting firm. Scope 2 emissions are indirect emissions which result as a consequence of the activities of the reporting firm, but occur at sources owned or controlled by another entity (e.g., energy use). Combined is simply the sum of the two. Panel A reports the sum of emissions, Panel B reports the emissions of the average firm, and Panel C reports the median emissions by industrial sector.

Industry	**Scope 1**	**Scope 2**	**Combined**
Panel A: Total Sum Emissions			
Oil and Gas	587,704.334	75,352.642	652,566.392
Basic Materials	345,283.959	222,502.438	567,603.531
Industrials	127,792.332	31,512.452	159,114.596
Consumer Goods	34,267.252	27,121.276	61,388.527
Health Care	5,813.456	5,398.883	11,212.338
Consumer Service	129,074.403	45,184.939	168,813.556
Telecommunications	2,291.706	12,488.350	14,771.400
Utilities	260,606.765	16,747.982	277,354.751
Financials	1,305.887	12,240.207	13,539.718
Technology	15.578	224.713	240.291
Total	1494155.671	448,773.881	1926605.101
Panel B: Mean Emissions			
Oil and Gas	13,356.917	1,883.816	16,314.160
Basic Materials	9,086.420	6,013.579	15,340.636
Industrials	779.222	190.985	976.163
Consumer Goods	496.627	393.062	889.689
Health Care	252.759	234.734	487.493
Consumer Service	963.242	342.310	1,278.891
Telecommunications	134.806	657.282	868.906
Utilities	9,307.384	598.142	9,905.527
Financials	14.673	136.002	152.132
Technology	0.974	14.045	15.018
Total	2,402.180	724.998	3,137.793
Panel C: Median Emissions			
Oil and Gas	201.106	18.221	211.111
Basic Materials	2,487.478	1,447.991	5,596.809
Industrials	35.029	32.861	66.590
Consumer Goods	31.774	49.312	75.911
Health Care	26.123	37.890	70.843
Consumer Service	53.279	118.778	179.423
Telecommunications	19.547	126.689	188.267
Utilities	7,739.463	354.589	8,172.049
Financials	2.944	8.224	14.480
Technology	0.545	10.595	11.089
Total	41.837	51.016	130.406

Table C.II

Median Emission Intensity by Industrial Sector

This table reports industry specific medians of three different emission intensity measures. Emission intensities are calculated as the ratio between GHG emissions and a quantifiable factor associated with the company's activities. I use assets (Panel A), sales (Panel B), and tangible assets (Panel C) to scale GHG emissions. The unit of carbon intensity is thousand metric tons CO2e per Million GBP of assets. Direct emissions (Scope 1) are emissions from sources that are owned or controlled by the reporting entity. In contrast, Indirect emissions (Scope 2) are emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity. Indirect emissions are often due to energy use.)

Industry	**Scope 1**	**Scope 2**	**Combined**
Panel A: Scaled By Total Assets			
Oil and Gas	0.141	0.007	0.167
Basic Materials	0.198	0.220	0.464
Industrials	0.027	0.023	0.052
Consumer Goods	0.014	0.023	0.030
Health Care	0.006	0.010	0.020
Consumer Service	0.019	0.036	0.079
Telecommunications	0.008	0.054	0.062
Utilities	0.255	0.038	0.272
Financials	0.000	0.001	0.001
Technology	0.001	0.009	0.009
Total	0.016	0.019	0.049
Panel B: Scaled by Total Sales			
Oil and Gas	0.259	0.007	0.296
Basic Materials	0.335	0.310	1.012
Industrials	0.019	0.018	0.042
Consumer Goods	0.016	0.021	0.048
Health Care	0.010	0.021	0.031
Consumer Service	0.022	0.032	0.068
Telecommunications	0.008	0.046	0.058
Utilities	0.583	0.101	0.665
Financials	0.001	0.004	0.006
Technology	0.001	0.017	0.018
Total	0.016	0.021	0.046
Panel C: Scaled by Plant, Property and Equipment			
Oil and Gas	0.433	0.055	0.485
Basic Materials	0.343	0.344	0.766
Industrials	0.207	0.206	0.466
Consumer Goods	0.220	0.226	0.412
Health Care	0.066	0.091	0.166
Consumer Service	0.061	0.140	0.225
Telecommunications	0.014	0.107	0.131
Utilities	0.441	0.048	0.490
Financials	0.014	0.135	0.180
Technology	0.015	0.180	0.192
Total	0.109	0.157	0.350

D Appendix: CDP Information Request and Corporate Beliefs of Climate Change Risks

This appendix provides further background information on the questionnaire CDP uses to request climate change related information from publicly listed firms. The section also shows and discusses descriptive statistics on the beliefs of the corporate sector when it comes to climate change risks

A. Structure of the Information Request

The information requested through the CDP questionnaire[41] can be roughly grouped into the following three blocks:

1. Management
   (a) Governance
   (b) Strategy
   (c) Targets and Initiatives
   (d) Communications
2. Risks & Opportunities
3. Emissions
   (a) Emissions Methodology
   (b) Emissions Data
   (c) Energy

A.1. Management

The first block of questions is mainly concerned with how firms manage climate change related issues. For instance, questions in this block regard governance issues such as the highest hierarchical level at which climate change is discussed within an organization. Strategic aspects such as whether climate change concerns are anchored in the firm's strategy or whether the firm engages with policy makers on climate change are also considered in this block.

The targets and initiatives subsection asks questions related to whether firms have absolute (total quantity of emissions) or relative (intensity, e.g., emissions per sales)

[41] The questionnaire CDP used in 2013 can be downloaded here: `http://goo.gl/tf2oKN`

targets. Finally, the communications subsection gives information about whether the firm has published information on the company's response to climate change in places other than the CDP questionnaire.

A.2. Risks & Opportunities

The risks and opportunities block of the questionnaire tries to elicit the corporate sector's beliefs about corporate climate change risks and opportunities. In other words, questions in this section try to map out the beliefs of the corporate sector when it comes to corporate climate risks and opportunities. In the questionnaire, responding companies are asked to indicate whether they see corporate climate change related risks and opportunities mainly due to changes in one or more of the following three aspects:

1. Regulation
2. Physical climate parameters
3. Other climate-related developments

Respondents are further asked to qualify their responses within these three risk and opportunity classes with respect to the following dimensions:

1. **Driver**
   (a) Risks driven by changes in regulation: e.g., Cap and trade schemes; Carbon taxes; Emission reporting obligations; Fuel/energy taxes and regulations; General environmental regulations; International agreements; Lack of regulation; Product efficiency regulations and standards.
   (b) Risks driven by changes in physical climate parameters: e.g., Change in temperature extremes; change in precipitation extremes and drought; Tropical cyclones
   (c) Risks driven by changes in other climate-related developments: e.g., changing consumer behavior, Reputation, Uncertainty in market signals
2. **Potential Impact**, e.g., Inability to do business; Increased capital cost; Increased operational cost; Reduced demand for goods/services; Reduced stock price (market valuation); Reduction in capital availability; Reduction/disruption in production capability
3. **Time frame**, e.g., 1–5 years; 6–10 years; >10 years; Current
4. **Nature of impact**, e.g., Direct; Indirect (Client); Indirect (Supply chain)

5. **Likelihood**, e.g., Exceptionally unlikely; Very unlikely; Unlikely; About as likely as not; More likely than not; Likely; Very likely; Virtually certain

6. **Magnitude of impact**, e.g., High; Medium-high; Medium; Low-medium; Low

[Table D.I about here.]

In Table D.I, I tabulate the regulatory risks that the respondents to CDP identified in 2013. Panel A shows the distribution of the main regulatory risk drivers. The most commonly identified regulatory risk were carbon taxes (14.1 percent), while fuel/energy taxes and regulations (13 percent) came second, followed by cap and trade schemes (12.7 percent). When asked about the potential impact such changes in climate change regulation might have on the firms, almost 65 percent of the responses identified increased operational costs as the most likely impact (see Panel B, Table D.I). The second most common reply regarding the impact of changes in climate change related regulation was increased capital cost (9.95 percent) or reduced demand for goods/services (9.73 percent). The majority of corporations regard the impact of risks related to climate change regulation as being direct (81.61 percent), as opposed to being indirect through supply chains or clients (see Panel C). Regarding the time frame after which these risks are thought to become material, there seems to be the view that regulatory climate change risks are already relevant today, or will become so in the near future: 46 percent of the reported regulatory risk drivers were identified as materializing within the next 1-5 years and 33 percent of the risks were seen as being relevant already today (see Panel D). The majority of the corporate sector regards regulatory climate change risks as either Virtually certain (26.75 percent), Likely (18.5 percent) or Very likely (17.22 percent). Hence, almost two thirds of the regulatory climate change risks are regarded as being highly certain to impact corporations in one way or another. Quite interestingly, the magnitude of the identified regulatory climate change related risks were perceived as being of only Medium (25 percent), Low (25.08 percent), or Medium-low (19.7 percent) impact. It seems thus as if corporate sector sees climate change related regulation as a virtual certainty, but regards the real financial impact of such regulation as being only of limited nature.

[Table D.II about here.]

Table D.II repeats the previous exercise for risks due to changes in physical climate parameters. Interestingly, physical risks related to climate change were identified less often by the corporate sector than regulatory risks: while regulatory risk drivers got mentioned 5,417 times by CDP respondents, only 4,079 risks related to changes in physical parameters were identified. In other words, firms with public response permission identified on average 2.9 regulatory risk drivers (i.e. number of regulatory risk

drivers/number of firms with public response permission=5,417/1,816=2.9), while the same respondents identified only 2.25 risk drivers related to changes in physical climate parameters (4,079/1,816=2.25).

Respondents mentioned change in precipitation extremes and droughts (18 percent), change in temperature extremes (10.69 percent) and tropical cyclones, e.g., hurricanes and typhoons (10 percent), as the most common physical climate change risk drivers. Hence, almost half of the responses acknowledge that severe weather events are going to have the potential to generate a substantive change in the respondent's business operations, revenue, or expenditure.

Akin to regulatory risks, respondents expect changes in physical climate parameters to impact the operations of business through increased operational cost (34.98 percent) alongside reduction/disruption in production capacity (30.82 percent). Again, the nature of these physical risk drivers are mostly regarded as being direct (73.6 percent) and the time frame is current (30.91 percent) or unknown (21.65 percent). The latter finding is quite interesting, as it suggests that the corporate sector sees much greater uncertainty as to when exactly changes in physical climate parameters will start having an economic impact on the bottom line of firms. Also, in contrast to regulatory risks, there is more disagreement regarding the likelihood of physical climate change risks to materialize: for instance, 21.72 percent of the responses suggest that risks resulting from changes in physical climate parameters are Likely to materialize, whereas a large fraction of the reported risks are also regarded as being More likely than not (21.28 percent) or About as likely as not (16.5 percent) to materialize. Similar to regulatory risk drivers, however, physical risks are mostly regarded as having Medium (23.29 percent), Low-medium (20.86 percent), or Low (16.89 percent) impact.

[Table D.III about here.]

Finally, respondents are also asked to qualify Risks driven by changes in other climate-related developments. Risk drivers from these categories receive the fewest responses: only 2,369 risk drivers related to other climate-related developments have been identified. As Panel A shows, the two risk drivers that stick out in this category are concerns about (i) Reputation (35.58 percent) and (ii) Changing consumer behavior (28.24 percent). The most commonly chosen impact through which these other risk drivers are likely to manifest is Reduced demand for goods/services (50.44 percent) and increased operational costs (13.93 percent). Similar to regulatory risks, risk drivers related to other climate-related developments are seen as being mainly direct (74.42 percent) and to be relevant already today or in the near future: more than 60 percent of the risk drivers are likely to manifest within the next 1–5 years or today. The likelihood of these risks is regarded

as Likely (20.18 percent), About as likely as not (18.11), or More likely than not (17.35 percent). Risks driven by changes in other climate-related appear to be regarded more relevant than the risks with respect to changes in physical climate parameters: 27.14 percent of the risks are medium, 17.9 percent medium-high, and 16.88 percent low.

Concluding, it seems as if the main climate change related risks seen by the corporate sector are regarded as being of regulatory nature.

Table D.I

Risks Driven by Changes in Regulation (All CDP Respondents in 2013)

This table reports the main regulatory climate change risks respondents to the CDP identified in 2013. Count gives the raw count of the number of times the answer was chosen. Percent shows the relative frequency of the response. In their replies, firms can choose as many risk drivers as they like.

	Count	**Percent**
Panel A: Risk Driver		
Carbon taxes	764	14.1
Fuel/energy taxes and regulations	704	13
Cap and trade schemes	688	12.7
Emission reporting obligations	577	10.65
Uncertainty surrounding new regulation	488	9.01
General environmental regulations, including planning	421	7.77
International agreements	382	7.05
Product efficiency regulations and standards	364	6.72
Air pollution limits	260	4.8
Product labeling regulations and standards	238	4.39
Other regulatory drivers	225	4.15
Renewable energy regulation	109	2.01
Voluntary agreements	103	1.9
Lack of regulation	94	1.74
Panel B: Potential Impact		
Increased operational cost	3513	64.85
Increased capital cost	539	9.95
Reduced demand for goods/services	527	9.73
Other	420	7.75
Inability to do business	136	2.51
Reduction/disruption in production capacity	131	2.42
Reduced stock price (market valuation)	69	1.27
Reduction in capital availability	45	0.83
Wider social disadvantages	37	0.68
Panel C: Nature of Impact		
Direct	4421	81.61
Indirect (Supply chain)	521	9.62
Indirect (Client)	475	8.77
Panel D: Time Frame		
1-5 years	2488	45.93
Current	1794	33.12
6-10 years	572	10.56
Unknown	413	7.62
>10 years	150	2.77
Panel E: Likelihood		
Virtually certain	1449	26.75
Likely	1002	18.5
Very likely	933	17.22
More likely than not	763	14.09
About as likely as not	639	11.8
Unlikely	294	5.43
Unknown	218	4.02
Very unlikely	92	1.7
Exceptionally unlikely	27	0.5
Panel F: Magnitude of Impact		
Medium	1356	25.03
Low	1250	23.08
Low-medium	1064	19.64
Medium-high	777	14.34
High	639	11.8
Unknown	331	6.11

Table D.II

Risks Driven by Changes in Physical Climate Parameters (All CDP Respondents in 2013)

This table reports the main physical climate change risks respondents to the CDP identified in 2013. Count gives the raw count of the number of times the answer was chosen. Percent shows the relative frequency of the response. In their replies, firms can choose as many risk drivers as they like.

	Count	**Percent**
Panel A: Risk Driver		
Change in precipitation extremes and droughts	751	18.41
Change in temperature extremes	436	10.69
Tropical cyclones (hurricanes and typhoons)	410	10.05
Change in mean (average) temperature	394	9.66
Change in precipitation pattern	376	9.22
Other physical climate drivers	345	8.46
Induced changes in natural resources	342	8.38
Sea level rise	316	7.75
Uncertainty of physical risks	294	7.21
Change in mean (average) precipitation	226	5.54
Snow and ice	189	4.63
Panel B: Potential Impact		
Increased operational cost	1427	34.98
Reduction/disruption in production capacity	1257	30.82
Inability to do business	358	8.78
Other	350	8.58
Reduced demand for goods/services	284	6.96
Increased capital cost	272	6.67
Wider social disadvantages	82	2.01
Reduction in capital availability	26	0.64
Reduced stock price (market valuation)	23	0.56
Panel C: Nature of Impact		
Direct	3002	73.6
Indirect (Supply chain)	647	15.86
Indirect (Client)	430	10.54
Panel D: Time Frame		
Current	1261	30.91
Unknown	883	21.65
>10 years	761	18.66
1-5 years	678	16.62
6-10 years	496	12.16
Panel E: Likelihood		
Likely	886	21.72
More likely than not	868	21.28
About as likely as not	673	16.5
Very likely	548	13.43
Unknown	407	9.98
Unlikely	296	7.26
Virtually certain	276	6.77
Very unlikely	85	2.08
Exceptionally unlikely	40	0.98
Panel F: Magnitude of Impact		
Medium	950	23.29
Low-medium	851	20.86
Low	689	16.89
Medium-high	684	16.77
High	509	12.48
Unknown	396	9.71

Table D.III

Risks Driven by Changes in Other Climate-Related Developments (All CDP Respondents in 2013)

This table reports the risks driven by changes in other climate-related developments that respondents to the CDP identified in 2013. Count gives the raw count of the number of times the answer was chosen. Percent shows the relative frequency of the response. In their replies, firms can choose as many risk drivers as they like.

	Count	**Percent**
Panel A: Risk Driver		
Reputation	843	35.58
Changing consumer behaviour	669	28.24
Other drivers	266	11.23
Fluctuating socio-economic conditions	206	8.7
Uncertainty in market signals	194	8.19
Induced changes in human and cultural environment	76	3.21
Increasing humanitarian demands	59	2.49
Uncertainty in social drivers	56	2.36
Panel B: Potential Impact		
Reduced demand for goods/services	1195	50.44
Increased operational cost	330	13.93
Reduced stock price (market valuation)	241	10.17
Other	194	8.19
Wider social disadvantages	134	5.66
Inability to do business	91	3.84
Increased capital cost	74	3.12
Reduction/disruption in production capacity	72	3.04
Reduction in capital availability	38	1.6
Panel C: Nature of Impact		
Direct	1763	74.42
Indirect (Client)	461	19.46
Indirect (Supply chain)	145	6.12
Panel D: Timeframe		
1-5 years	742	31.32
Current	736	31.07
Unknown	383	16.17
6-10 years	331	13.97
>10 years	177	7.47
Panel E: Likelihood		
Likely	478	20.18
About as likely as not	429	18.11
More likely than not	411	17.35
Unlikely	362	15.28
Very likely	257	10.85
Unknown	170	7.18
Virtually certain	124	5.23
Very unlikely	102	4.31
Exceptionally unlikely	36	1.52
Panel F: Magnitude of Impact		
Medium	643	27.14
Medium-high	424	17.9
Low	400	16.88
Low-medium	399	16.84
High	324	13.68
Unknown	179	7.56