The Relevance to Investors of Greenhouse Gas Emission Disclosures

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Abstract

This study documents that investors care about companies' greenhouse gas (GHG) emission disclosures. We present two kinds of evidence to support this finding. First, we show that investors act as if they use GHG emissions information to assess company stock market value. Second, by conducting an event study, we observe a significant market response around the date a company discloses new climate change information in a press release or 8-K filing. Sensitivity tests show that these findings are robust to alternative ways to model company value and assess the news content of emissions information. As anticipated, our results strengthen for companies in the U.S. environment and for emission-intensive industries, such as utilities and energy. Lastly, our results convey a message to those companies that may have chosen not to disclose GHG emissions, in that we find that investors view *estimates* of non-disclosed GHG emission amounts as value relevant also. SEC-registered non-discloser companies might, therefore, reconsider whether their policies adhere to the most basic rule of disclosure – to report "such further material information, if any, as may be necessary to make the required statements, in light of the circumstances under which they are made, not misleading." (17 CFR 240,12b-20).

JEL Classification: G14, M41, M48, K22, Q56.

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1 Introduction

Companies today face a daunting challenge of what and how much to disclose publicly about the risks of climate change. On the one hand, investors and public interest groups, worldwide, call for additional disclosure, greater uniformity, and more transparency. Companies and insurers, on the other hand, worry about the costs of such added disclosure, particularly from competitive disadvantage and liability exposure, and press for a more balanced consideration of the costs and benefits of disclosure. This study focuses on an essential element of this debate, namely, whether stock investors view climate change disclosures by companies as relevant for valuation purposes, where investor relevance means that the disclosures relate to a reassessment by investors of stock price conditional on the total mix of information available. As we explain below, such findings can be critically important for companies' disclosure decisions, regulators' views on mandating climate change reporting and disclosure, investors' and analysts' understandings of the role of climate change information in pricing stocks, and courts' determinations in adjudicating securities fraud laws regarding environmental matters.

We restrict our investigation to the disclosure of greenhouse gas (GHG) emissions – as this is one item of interest to investors and analysts that many companies now disclose voluntarily, which is measurable according to common standards. We also narrow our focus to the S&P 500 and large Canadian companies to assess the relevance of carbon emissions across the two environments. As evidence of investor relevance, we find that (1) investors care about GHG emissions in assessing company value and (2) GHG emissions information in a company press release or 8-K filing elicits a significant price and trading reaction around the day of the event as investors update their expectations. We further find that investors value companies and respond to company news announcements conditional on GHG emission intensity, where higher intensity associates negatively with price and news reaction. Our dual research approach produces internally consistent evidence that investors value companies differently conditional on GHG emissions.

We also *estimate* GHG emissions for those S&P 500 and large Canadian companies that do not report GHG emissions, and find that these estimates also relate to market price and news reaction in the same manner as our preceding results. This analysis, therefore, suggests that stock prices reflect some GHG information irrespective of whether or not the company makes a formal disclosure. This is particularly pertinent to the disclosure debate because it implies that non-disclosers' stock prices are not devoid of GHG information, which is contrary to the beliefs of some advocates who contend capital markets need full disclosure about GHG emissions to solve an information deficiency.[1] Advocates' proposals that focus on full

[1] For instance, Young et al. (2009), in a project sponsored by Ceres and the Environmental Defense Fund, state as follows regarding the conclusions of their 2008 disclosure survey. "Absent SEC action, investors are left in the dark about companies' plans for evaluating and managing material risks in a changing climate." (p. iv).

disclosure rather than *incremental* information relative to total mix might also be economically inefficient in the context of an efficient market. Just as with the great debate of several decades ago on accounting rules for the impact of inflation, reliable evidence eventually emerged that much information about inflation was already reflected in stock price through channels other than formal company disclosure (Beaver and Landsman 1983). Notably, some seven years after issuance in 1979, the inflation accounting rules were made voluntary (SFAS Statement 89).

As we further discuss in the section on prior research (section 2), these results add to the literature in several ways. First, we extend the earlier results on the market recognition of environmental obligations by focusing on companies' GHG emissions as a climate change factor, now even more relevant to company disclosure policy because of the legal standing of climate change written into the Supreme Court's landmark 2007 decision in *Massachusetts v. EPA* (127 Sup. Ct. 1438,1440). Here, for the first time, the court endorsed the view that company-made GHG emissions relate causally to climate change. Second, we extend the nascent empirical literature on the value relevance of GHG emissions to investors by documenting predictable valuation effects for GHG discloser companies and GHG non-discloser companies in two economic environments (the United States and Canada). We also use a research design that not only exploits variation in emissions cross-sectionally and temporally but, also, employs an event study to measure short-term announcement effects. Contrary to earlier work, our dual approach produces reliable evidence across the two perspectives in support of our hypotheses. This reduces the chances that other variables might explain the findings. Sensitivity tests, moreover, show that our findings are robust to economic environment, alternative ways to assess the news content of a GHG emissions disclosure, and different specifications of company value.

Our results should be especially important for evolving regulatory guidance on what and how much companies should disclose to investors about climate change and GHG emissions in that, first and foremost, we document investor relevance for emission disclosures. Although investor relevance (an economic concept) does not equate to materiality (a legal concept), courts commonly view a statistically significant stock price adjustment that is reliably attributable to a disclosure as a dispositive factor in testing for materiality, and in some instances courts have wedded the two concepts on pragmatic grounds, as in the *Oran v. Stafford*, 226 F.3d 275 (3rd Cir. 2000) decision.[2] As such, our results, particularly our event study findings, should be of interest to companies and regulators about whether GHG information might be ex ante material and, contrariwise, whether the absence of GHG information might place company officers in jeopardy for not disclosing material facts or circumstances or satisfying their duties as fiduciaries.[3] For example, we document an almost

[2] More recently, see *American International Group, Inc. Securities Litigation Group, Inc*., 2010 WL 646720, at *3 (S.D.N.Y. Feb. 22, 2010), where the court looked at the statistical significance of a stock price drop as dispositive of shareholder damages.

[3] Barth et al. (2001) also discuss why investor or "value relevance" might have implications for accounting rule makers, such as the Financial Accounting Standards Board. Note that the FASB has yet to issue standards on uniform accounting and reporting for climate change, in particular, standards for emission obligations under a cap-and-trade system (FASB 2007, 2008, 2010).

two percent decline in market-adjusted stock price for an emissions intensive company relative to a non-emissions intensive company in the short window around a climate change disclosure in an 8-K report. On the other hand, we show that much information about climate change is already in stock price, which can be critical to the legal notion of loss causation (*Apollo Group Securities Litigation*, 08-16971, 9th Cir. 2010). Materiality tests are evolving, moreover, to cover more non-financial information, as evidenced by new guidance on the application of existing disclosure rules to climate change issues from the Securities and Exchange Commission (SEC) and the Canadian Securities Administrators (CSA). We discuss this guidance in section 2.

Our paper continues as follows. Section 2 discusses key features of the institutional environment and relevant prior research. Section 3 summarizes the data, sample, and research design to test our expectations. Section 4 presents the results, section 5 describes additional analysis and robustness tests, and section 6 concludes.

2 Institutional features and prior research

2.1 Institutional features

Many U.S. and Canadian companies presently disclose their GHG emissions on a voluntary basis, primarily, through the Carbon Disclosure Project (CDP), a U.K. organization representing mostly institutional investors that works with large companies worldwide to measure and manage their emissions and climate change strategies. CDP collects and publishes emissions data as part of its series of annual surveys. A company may decline to participate in a survey or simply not reply, but CDP tracks such indication so that each survey covers a well-defined sample, such as the S&P 500 or TSE 200. The proportion of companies in our empirical sample reporting GHG emissions to the CDP has grown over the years studied, for example, from 29 percent in 2006 to 53 percent in 2009 for the S&P 500, with a similar trend but lower percentages for the TSE 200 (table 1).

Heightened investor interest and pressure from public interest advocates such as Ceres and Friends of the Earth[4], doubtless, account for some of this increase, but company incentives may also be increasingly affected by the Akerlof "lemons rule", wherein news of nonparticipation may be interpreted negatively. Required disclosure is also a reality for some U.S. companies, but this is not yet at the federal level, with the possible exception of EPA Rule 40 CFR Part 98 (EPA 2009), which is expected to apply to large U.S. emitters following possible implementation in 2011[5,6]. At the state level, some attorneys general have used litigation to force additional disclosure of climate change risk, such as New York State's application of the fraud provision (section 352) of the Martin Act of 1921 to Xcel Energy and Dynegy (Attorney

[4] For example, Ceres' web site states as its mission "integrating sustainability into capital markets for the health of the planet and its people." (www.ceres.org). Friends of the Earth states that it "seeks to change the perception of the public, media and policy makers--and effect policy change--with hard-hitting, well-reasoned policy analysis and advocacy campaigns that describe what needs to be done, rather than what is seen as politically feasible or politically correct." (www.foe.org).

[5] On December 17, 2010, the EPA deferred the required reporting date of 40 CFR Part 98, and indicated that it would seek further comment on the business impact of the rule before mandated company emissions data might be made public (EPA 2010).

[6] However, some U.K. subsidiaries of U.S. companies may have to comply with the U.K. climate change act, which requires mandatory greenhouse gas reporting for large U. K. emitters starting in 2010 (U.K. Government 2008).

General of the State of New York 2008a, 2008b). Also, California recently approved a cap-and-trade plan with mandatory GHG reporting beginning in 2011 for entities in the state emitting more than 25,000 tons of GHG annually (California Air Resources Board 2010). Other state disclosure rules are surely on their way, with climate change legislation the subject of 300 bills in 40 state legislatures (Hettrick 2008).

Rather than state specific rules for measuring and disclosing climate change risk, federal U.S. and Canadian securities regulators have, thus far, issued guidance releases only that relate to their existing disclosure frameworks. In the United States, Release 33-9016 (SEC 2010) outlines the SEC's views on what constitutes compliance with existing disclosure laws such as Regulation S-K, Item 101, on compliance with environmental laws, and Item 103 on environmental litigation. Regulation S-K further requires disclosure of material risks and trends as either a separate section or as part of management's discussion and analysis. Such risks and trends arguably should consider climate change factors such as GHG emissions.

Parallel regulations also obligate Canadian companies to disclose material information to investors, such as CSA National Instrument 51-102 (CSA 2004), which is similar to Item 103 of Regulation S-K, and CSA Annual Information Form, which is similar to a combined 10-K and DEF 14A filing. Also, CSA Staff Notice 51-333 (2010) provides additional guidance for Canadian companies on how National Instrument 51-102 applies to environmental risk, trends and uncertainties, liabilities, and the financial and operational effects of environmental laws. Interestingly, regarding materiality, Staff Notice 51-333 states that many investors and shareholders “think that, in some cases, material information regarding environmental matters is found in voluntary reports and not in regulatory filings,” but that such information is “not necessarily complete, reliable or comparable among issuers” and is “not necessarily provided in a timely manner.” (p. 4). This document also refers specifically to “voluntary reports” as those relating to the CDP (p. 24). In other words, in some cases, some regulators see voluntary disclosures as, indeed, material but not necessarily sufficiently comprehensive from a rule-making perspective.

While the evidence we present in this paper might buttress regulators’ and disclosure advocates’ views on the usefulness of climate change information for assessing stock return, our results also have implications for companies and their insurers, in that any system of required disclosure ups the ante on competitive disadvantage, litigation risk (Barth et al. 1997, Erion 2009) and liability exposure for insurance purposes (Allen et al. 2009, Weigand 2010). Investors, typically, do not sue companies for failure to follow voluntary guidelines but, rather, for failure to adhere to mandated rules and regulations. On the other hand, companies sued for failure to disclose material climate change information might note the evidence in this study for similar non-discloser companies, which suggests that investors in an efficient market may not necessarily be deprived of climate change information in that stock prices apparently reflect some emissions information even in the absence of a CDP or similar disclosure.

2.2 Prior research

The most relevant prior literature to date relates to work on the valuation effects of environmental disclosures. The categories studied include examinations of the relation between environmental liabilities and stock price (Barth and McNichols 1994, Lim and McConomy 1999, Campbell et al. 2003), how environmental and social responsibility disclosures might relate to the cost of equity or debt (Blacconiere and Patton 1994, Campbell et al. 1998, Konar and Cohen 2001, Plumlee et al. 2008, Stanny and Ely 2008, Bauer and Hann 2010, Clarkson et al. 2010, Dhaliwal et al. 2010), whether SO_2 emissions might have valuation relevance for investors (Hughes 2000, Johnson et al. 2008) and, most recently, whether investors might find carbon emissions as value relevant (Chapple et al. 2009, Matsumura 2010). This last category is most similar to the present study. Chapple et al. (2009) study 58 Australian disclosures and find that a dichotomous emissions variable (1 for high carbon intensity, 0 otherwise) associates negatively with stock price. Matsumura et al. (2010) examine 549 CDP disclosures by the S&P 500 over 2006-2008 and find that higher carbon emissions associate with lower market value, higher debt yields, and, opposite to their hypothesis, a lower equity cost of capital. The authors conjecture that their third result, which seems counterintuitive, might relate to information asymmetry, but this is not tested.[7] These two studies, therefore, offer some initial findings. However, design features may affect their general acceptance, for example, sample size limits the first study, and the second study finds counterintuitive results. Our study addresses these concerns. First, we examine a large sample,

[7] Information asymmetry, however, affects investors' assessment of return for stocks in imperfect capital markets only (Armstrong et al. 2011). Since this is surely not the case for the S&P 500 companies examined by Matsumura et al. (2010); and because we find some information about GHG emissions apparently already reflected in stock prices but for a CDP disclosure, information asymmetry would seem an unlikely explanation.

namely, four years of disclosures by U.S. and five years by Canadian companies with CDP data. Second, we investigate the potential valuation effects of non-response to the CDP surveys by *estimating* GHG emissions for non-discloser companies, such that we study nearly all S&P and TSE companies in the CDP surveys. Third, we control for disclosure quality and off-balance sheet disclosures such as leases and pensions, as these factors could affect the earlier results, as they could be correlated, omitted variables. Our larger sample size also allows us to subject our results to a battery of robustness tests that the smaller sample studies do not allow. Section 5 discusses some results in this regard.

3 Data, sample, and research design

3.1 Data and sample

We use data on GHG emissions and disclosure quality from the Carbon Disclosure Project (CDP) for the S&P 500 for CDP reporting years 2006-2009 and large TSE companies for CDP years 2005-2009.[8] These data, available at www.cdproject.net, are the most comprehensive and reliable to date. We select large U.S. and Canadian samples as these share similar regulatory disclosure incentives (section 2) but may differ on the basis of emission intensity and disclosure quality. Specifically, we extract the three fields of emissions data from the two surveys, namely, direct (scope 1), indirect (scope 2), and other (scope 3). We also extract the

[8] The TSE sample includes some additional (smaller) companies in 2005-2008. We allow for membership changes in the S&P 500 and the TSE sample. CDP intends reporting year to coincide with a company's fiscal year. CDP publishes a summary of the survey data usually in the succeeding September or October of the reporting year.

Carbon Disclosure Leadership Index (CDLI) score as a proxy of disclosure quality.[9] Not all companies report these data in all categories for all years, however. We combine these data with financial information from *CRSP*, *Compustat*, and *IBES* to provide a basis for the descriptive statistics and the valuation and event studies in section 4.

Table 1 summarizes the sample of 1,083 company-year emissions observations, including 824 for the S&P 500. Panels A and B report the data for the S&P and TSE samples by year and sector, respectively. Panel A shows that GHGE (greenhouse gas emissions) response rates have been increasing for both samples, from a combined 29.1 percent in 2006 to 53.0 percent in 2009, with the S&P rates higher for most years. Panel B reveals that utilities have the highest GHGE response rate in both countries with consumer discretionary, financials, and health care having the lowest rates. Panel B also suggests that the composition of sectors differs across the S&P and TSE samples, with the U.S. noticeably higher in consumer spending, healthcare, and information technology, whereas the Canadian economy dominates in energy and materials. Both companies reflect a similar proportion of utilities. In addition, untabulated analysis indicates that the CDP response rate correlates positively with emissions and disclosure quality. For example, combined response rate and mean emissions and combined response rate and mean CDLI have product-moment correlations across the 10 sectors of 0.68 and 0.75, respectively. We control for variation in sector and disclosure quality in the later sections.

[9] A high CDLI indicates a comprehensive response to the CDP survey, including "clear consideration of business-specific risks and potential opportunities related to climate change and good internal data management practices for understanding GHG emissions." (www.cdproject.net).

3.2 Research design

3.2.1 GHG prediction model

The first stage of our design estimates GHG emissions for those companies not responding to the CDP survey – more than one-half of those companies questioned according to table 1. This enables us to assess differences in investor relevance conditional on actual or predicted GHG data. We build upon the model in Griffin (2010) and predict GHGE for a non-discloser company by regressing GHGE for a discloser company on sector, scale of operations, investment, asset composition, and other key financial data. Our model, without subscripts i and fiscal year t for company and year for convenience, is:

$$\log GHGE = \alpha_0 + \alpha_1 SECT + \alpha_2 \log REVT + \alpha_3 \log CAPX + \alpha_4 \log INTAN + \alpha_5 GMAR + \alpha_6 LEVG + \varepsilon, \quad (1)$$

where GHGE = greenhouse gas emissions per CDP reporting year in metric tons, SECT = one for each of 10 S&P sectors, otherwise zero, REVT = total revenue for year (*Compustat = revt*), CAPX = capital expenditures for year (*capx*), INTAN = intangibles at end of year (*intan*), GMAR = gross margin (1-*cogs*/*sale*), LEVG = long-term debt to total assets (*dltt/at*), and ε = random error.[10] We use a logarithmic model, as the distributions of GHGE, REVT, CAPX, and INTAN would otherwise be highly skewed and could lead to improper parameter estimates. We expect α_1 to reflect differences across the sectors, $\alpha_2>0$ and $\alpha_3>0$ to reflect a positive relation between company operations and investment and GHGE, and $\alpha_4<0$ as companies with

[10] For financial companies, we set net sales revenue equal to net interest income and gross margin to zero.

more intangible assets should emit fewer emissions.[11] We are less clear about the signs of α_5 and α_6. For example, a negative sign for α_6 might suggest that higher debt companies emit fewer emissions through creditors' monitoring activities. Our estimation approach increases the sample size from 1,083 actual to a maximum of 2,917 actual and predicted GHG observations.[12] As we explain in section 4, we estimate model (1) initially as a pooled cross-sectional regression over *i* companies in each country using CDP emission data for years up to and including prediction year *t*. For example, we predict $\log GHG_{2008}$ for non-discloser S&P companies in 2008 based on S&P companies with CDP emissions data in 2006-2008. We also estimate more detailed versions of model (1) with additional controls, which we discuss in section 5.

3.2.2 Residual income valuation model

We use a specification of the residual income equity valuation framework (Ohlson 1995, p. 667) to assess valuation relevance by regressing market price at t ($PRCC_t$) on per share deflated amounts of the carrying value of common equity at t-1 ($CVCE_{t-1}$), residual income for t ($RESI_t = NETI_t - r_e\, CVCE_{t-1}$, where r_e = cost of equity capital), actual or estimated GHG emissions for t ($GHGE_t$), and controls for variables representing disclosure quality, country, and off-balance

[11] The relation between GHG emissions and sales revenue, which is reflected in our logarithmic regression model as α_2, is also popularly known as a measure of "carbon intensity" in that higher α_2 means higher intensity of emissions.

[12] This number declines in the regression analyses as some variables are unavailable for all company-years.

sheet items such as operating leases and pensions.[13] Our price model, omitting company subscript i, is hence:

$$PRCC_t = \beta_0 + \beta_1 CVCE_{t-1} + \beta_2 RESI_t + \beta_3 GHGE_t + \Sigma_k \beta_k CNTL_{kt} + \varepsilon_t, \quad (2)$$

Barth and Clinch (2009) show that a share-deflated specification of model (2) works well under several model performance metrics. Following prior research (Dechow et al. 1998, Begley and Feltham 2002, Callen and Segal 2005, Barth and Clinch 2009), we predict positive coefficients for common equity per share (β_1>0) and residual income per share (β_2>0). We also predict a negative coefficient for GHGE per share (β_3<0) under the assumption that higher emissions amounts impose increased *future* costs on the company (not in $RESI_t$) to mitigate GHG output either through future investment policy, carbon reduction legislation, or both, which translate into a lower price at t. Section 4 discusses different specifications of the variables such as the measurement date for $PRCC_t$, operational definitions of residual income and cost of capital, and the predicted signs of the control variable coefficients.

3.2.3 Event study

An event study examines the relation between a news event and a contemporaneous response by investors, usually in terms of daily abnormal trading or price change. Evidence of a persuasive relation occurs when the events do not cluster around common dates, as this increases the chances that the news events themselves, and not other factors, trigger the response. Rather than study a few legislative events as per earlier work (Blacconiere and

[13] We deflate $GHGE_t$ by *csho* x 1,000 to rescale the β_3 coefficient, but with unchanged test statistics, hereafter referred to as $GHGE_t$ per share.

Northcut 1997, Chapple et al. 2009), we focus on the market response to a large sample of company news releases relating to climate change over several days surrounding each news event.

We select news items in 8-K reports that relate to climate change, since companies view these news events as potentially ex ante material.[14] Under present SEC rules, an 8-K report must be filed within four days of conform date (the date of the actual event or company news release). The list of items subject to an 8-K report is extensive, and covers all material items relating to financial statements not disclosed elsewhere.[15] Moreover, a company must attach a news release (if one is issued) to the 8-K information as an Exhibit 99.1. The 8-K reports we study are ideal for an event study since they distribute well over the study period, do not cluster around common dates, relate mostly to a single news item that we can pinpoint to a day with precision, and relate to trading by investors in efficient markets (primarily, large companies traded on the NYSE, TSE, and NASDAQ exchanges). We use *Direct Edgar* to extract the data by searching over all 8-Ks during January 1, 2005 to January 1, 2010 based on the following terms or phrases: carbon and emission, carbon and climate, emission and climate, greenhouse, and climate change. This search produced 6,543 8-K filings. We then eliminate 8-Ks with the same CIK and filing date and, after matching the CIKs with each company's *CRSP* PERMNO,

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[14] We use the term "ex ante material" to indicate that companies base their decisions to release news in an 8-K filing on the predicted importance of such news, which is unknown at the time, and not what might have happened ex post.

[15] www.sec.gov/about/forms/form8-**k**.pdf.

we obtain a final sample of 1,540 8-K filings of which 1,395 contain a press release.[16]

Our event study model examines the significance of investor response or $RESP_t$ for t = -10 to 10, where t=0 is the day of filing (or conform date) of a 8-K report about climate change. We measure $RESP_t$ as (1) unsigned daily stock return for trading day t in excess of the day t return on the *CRSP* value-weighted market index, $XRET_t$, and (2) adjusted trading volume, defined as trading volume (divided by two if a NASDAQ company to account for interdealer trading) divided by common shares outstanding at trading day t, $TRAD_t$. For $RESP_t$, we test whether the metric differs significantly on day zero versus the other days. This establishes whether investors respond to climate change disclosures when they should, upon announcement. We also merge our 8-K news file with the data used in model (2) to test for valuation relevance, based on actual and estimated CDP data.[17] This enables us to estimate

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[16] The extent of GHG emission disclosure and related climate change information varies in these 1,540 8-K filings. The most common types of disclosure include: (1) mention of GHG related environmental and regulatory concerns as a risk factor (e.g., Dow Chemical Company, filed 9/25/2009); (2) discussion of the operational and financial impact of potential GHG-related legislation (e.g., Vectren Utility Holdings, Inc., filed 3/6/2009, Enterprise Products Partners L.P., filed 12/4/2009, PNM Resources, Inc., filed 5/19/2009); (3) discussion of activities to reduce GHG emissions and improve energy efficiency in operations (e.g., Exxon Mobil Corporation, filed 3/30/2009); (4) summary of achievements in GHG emission reduction (e.g., FirstEnergy, filed 12/1/2005, Alcoa Inc. sustainability report, filed 3/23/2005); (5) disclosure of an environmental strategic plan (e.g., Exelon Corporation, filed 7/17/2008, Westar Energy, Inc., filed 2/20/2008, Public Service Enterprise Group, Inc., filed 9/26/2007); and (6) other disclosures with a GHG or climate change focus (e.g., appointment of a director with extensive experience on climate change issues such as Boeing Company, filed 6/27/2007, and Energy Recovery, Inc., filed 2/26/2009). Since some of the 1,540 filings may capture GHG disclosures as well as other events, we also repeat the event study and find qualitatively similar results when we use a subset of the 8-K filings that relate specifically to GHG emission or climate change matters only.

[17] This merge results in 569 8-K filings for the S&P and TSE samples, of which 478 relate to high GHG intensity companies based on CDP emissions data.

model (3) below, which regresses $RESP_t$ ($XRET_t$ or $TRAD_t$) for event day t on three fiscal year end variables, namely, emission intensity for year t-1, $GHGE_{t-1}$, company size, $CVCE_{t-1}$, and disclosure quality as proxied by $CDLI_{t-1}$ for year t-1, and disclosure status, DISC = 1 if GHG emissions disclosed to the CDP in year t-1, 0 otherwise, and country = S&P 500 or TSE.[18] Our model is:

$$RESP_t = \eta_0 + \eta_1 GHGE_{t-1} + \eta_2 CVCE_{t-1} + \eta_3 CDLI_{t-1} + \eta_4 DISC_{t-1} + \eta_5 Country + \varepsilon_t, \qquad (3)$$

where we estimate the regression cross-sectionally for each day around event date t=0. Following prior research, we expect η_2<0, η_3<0, and η_4<0 for all event days t, as return and trading volatility are generally lower for larger companies and companies with higher disclosure quality independent of a specific news event. Regarding the coefficient for GHGE, if investors condition their response to climate change news known on event day 0, then we should observe $\eta_1 \neq 0$ on t=0 and $\eta_1 = 0$ for the other days after controlling for scale and disclosure quality. We choose emission intensity (GHG emissions, in tons, divided by dollar revenues, in thousands) for the prior year, $GHGE_{t-1}$, as the conditioning variable because this amount is a commonly recognized indicator of emissions output by researchers, investors, and regulators. We are uncertain of the sign of η_1, however, since it could reflect countervailing effects. On the one hand, we might expect $\eta_1 < 0$ because climate change news for a low emission intensity company would be more surprising to the market, in that for a low (high)

[18] For model (3), to avoid extreme values, we specify GHGE intensity as the quintile rank of GHGE/*revt*, where quintile 5 has the highest emission intensity. We also examine model (3) with GHGE intensity defined as dummy variable, where high GHGE intensity = 1 and low GHGE intensity = 0, with no change in the results.

emission intensity company, the market expects less (more) news events about climate change, so that when a low emission intensity company makes an announcement, this is a more newsworthy event. On the other hand, investors might simply react more when emission intensity is higher, regardless of prior investor expectations. In short, we use model (3) to test whether investors condition their response to a climate change announcement conditional on a climate change characteristic such as emission intensity after controlling for scale and disclosure effects.

4 Results

4.1 Descriptive statistics

First, table 2, panel A, summarizes the variables used in model (1) and offers several observations. Discloser companies clearly differ from non-discloser companies in terms of the scale of operations (logREVT) and investment (logCAPEX, logINTAN), and this occurs regardless of sector or country (Discloser company = GHGE disclosed to CDP, otherwise non-discloser). As such, we expect discloser companies to reflect higher average GHGE, which panel A indicates occurs for each sector and country. Prior research that relies on disclosed data only, therefore, documents results for larger companies with higher emissions.[19] On the other hand, panel A also shows that discloser and non-discloser companies are mostly equally profitable (GMAR), and the two groups share about the same amount of outside financing

[19] For example, Matsumura et al. (2010) report a mean of 46.0 million metric tons of GHGE for 72 U.S. utility disclosers, whereas untabulated analysis of our data shows a mean for the same NAICS code 221 of 38.5 million metric tons for 85 U.S utility disclosers, and a much lower amount for 39 U.S. utility non-disclosers of 15.6 million metric tons.

(LEVG). Panel A further shows that, apart from scale, the sectors rank identically on GHG level regardless of whether a company discloses or not and, as expected, utilities, energy, and materials lead in GHG output, whereas financials, health care, and information technology rank at the bottom. In short, our use of model (1) to predict non-discloser emissions allows us not only to study the entire reference sample of smaller and larger S&P 500 or TSE 200 companies (not studied earlier) but, also, to compare and contrast disclosers and non-disclosers and, in particular, to check for possible differences in valuation relevance and investor response across the two groups.

Second, table 2, panel B, shows descriptive statistics for the variables in models (2) - (4). As the panel shows, scaling has the effect of reducing the differences between disclosers and non-disclosers, and in several instances, GHGE per share is actually higher for the non-discloser group. The same holds for emission intensity (GHGE/*revt*), which is also higher for several of the non-discloser groups. We scale the data, primarily, to improve our regression analysis, as a per-share or per-total sales specification means that heterogeneity affects our regression estimates less, within each discloser sector and across the sectors. This can degrade estimates' reliability relative to an approach that regresses market capitalization on total emissions (Barth and Clinch 2009). Note, also, that CDLI is significantly higher for disclosers versus non-disclosers, as it should because CDLI is a CDP-generated index.

Third, panel B of table 2 reports the mean size-adjusted residual annual stock return for the 10 sectors and for the U.S. and Canadian samples. Observe that neither disclosers nor non-disclosers have an edge on higher residual stock return (XRET_Q5) (two sectors have higher mean annual stock return, and the other differences are not significant), although the TSE companies perform slightly better, due possibly to common currency effects, as *CRSP* records stock prices in U.S. dollars. This variation occurs regardless of whether we measure return at the end of the calendar year, fiscal year, or several months after balance date. The fact that we have variability in residual stock return across both sectors and discloser groups also suggests that the companies we analyze face a mix of economic circumstances unrelated to the effects of carbon emissions. Indeed, the more mixed the unrelated circumstances, the less likely they might influence the empirical relation between annual stock return and residual emissions as per model (4).

4.2 Residual income model regressions

Table 3 summarizes the tests of model (2). Each panel shows 15 regressions, where a regression relates either to the full sample (regressions 1-5) or a partition of the full sample, as is evident in regressions 6 and 7 (GHG intensive companies) and regressions 8 and 9 (non-GHG intensive companies). Some regressions test model (2) without controls (regression 1), whereas others include one or more controls, depending on the sample. For example, regression 2 includes a control for country (U.S. versus Canada) and interacts this variable with GHGE per share to test whether the GHGE coefficient differs across the two countries. We also show four panels of tests depending on the measurement date for PRCC and the definition of RESI. Panel A assumes PRCC three months after fiscal year end, and RESI = *epspx*. Panel

B assumes PRCC at end of CPD release month, and RESI = *epspx.* Panel C assumes PRCC three months after fiscal year end, and RESI = *eps_ibes – ibes,* where *eps_ibes* and *ibes* are *IBES* actual earnings per share and *IBES* consensus forecast of earnings per share at end of fiscal year. Panel D assumes PRCC at the end of CPD release month and RESI = *eps_ibes – ibes*. We use two observation dates for PRCC because we are unsure as to when investors update their price expectations. While company insiders likely have that information three months after balance date, such information is not disclosed publicly until release of the CDP survey, usually in September-October.

To summarize our results, we focus on panel A and note differences between the other panels. First, we observe results for the residual income model consistent with the prior literature (see section 3.2.2). The coefficients on CVCE and RESI are positive and significant, and the β_1 and β_2 coefficients on CVCE and RESI approximate one and three, respectively.[20] The control variables also accord with expectations. The coefficient on operating leases is positive, suggesting that an increase in operating leases increases PRCC, since we expect that additional leases would add value as positive net present value investments. The coefficient on pension plan assets is also positive and significant, consistent with the view that higher expected return adds shareholder value by lowering future pension costs. Our proxy for disclosure quality, which is the actual or estimated CDLI score[21], does not significantly explain

[20] All regression coefficient test statistics adjust for possible heterogeneity using the White (1980) adjustment.

[21] We estimate CDLI for a non-discloser company as the median CDLI for the company sector.

PRCC. This is not an unexpected result, however, in that information quality is not priced by investors as a significant risk factor for large companies trading in competitive markets (Armstrong et al. 2011), which is surely the case for the S&P and TSE companies we study.

Second, we find that negative β_3 coefficients for GHGE per share for each of the 15 regressions, all of which are significant either as a direct effect or an interaction effect. This result also holds for all panels and, thus, documents a key result of this study – that greenhouse gas emissions explain market price as a negative valuation factor in addition to CVCE, RESI, and the other controls. The panels also show a more negative β_3 coefficient for GHGE per share for U.S. versus Canadian companies and for emission intensive versus non-emission intensive companies. For example, regressions 10 and 11 show negative β_3 coefficients of -0.077 and -0.004, for the U.S. and Canada, respectively; and the reduction in the coefficient for U.S. companies is significant for the full sample (regression 2) and for GHG-intensive companies (regression 7). While the β_3 coefficients are uniformly negative for GHG-intensive companies (regressions 6 and 7), we observe more mixed results for non-GHG intensive companies. For example, panel A shows that the GHGE per share coefficient is not significant overall (regression 8) and more positive for U.S. versus Canadian companies (regression 9). Panel D, on the other hand, shows an insignificant β_3 coefficient for GHGE per share (regression 9).

Third, we analyze the valuation relevance of GHGE per share for companies that disclose to the CDP survey versus those that do not. As we note earlier, investors in an efficient market should use the total mix of available information to establish price, not only including CDP information but, also, information about climate change from a direct analysis, for example, a version of model (1), from secondary sources such as analysts' estimates of carbon winners and losers, for example, Point Carbon (2009) and Young et al. (2009), and from company disclosures, such as 8-K filings, whose information content we study in the next section. Regressions 12-15 report the results for GHG-intensive companies, as investors in these companies uniformly view emissions as a negative valuation driver. Importantly, these regressions show GHG emissions as a significant negative valuation factor regardless of whether a company reports to the CDP. In other words, the market acts as if the CDP surveys are not the only source of information about carbon emissions, which of course is entirely what we would expect. Note, also, that while table 2 shows that CDP disclosers tend to operate on a larger scale than non-disclosers, table 2 also shows that disclosers and non-disclosers vary less systematically on GHG intensity, so that pure scale effects unlikely explain this result. In short, table 3 show three key results: one, that investors view GHG emissions as a significant negative valuation driver; two, that the effects are more negative for GHG-intensive companies; and, three, that valuation effects occur regardless of whether the company reports to the CDP survey. Thus, investors price stocks as if higher intensities of GHG emissions impose additional future costs, presumably as additional expenditures to respond to investors' and boards' concerns about changing company responsibilities regarding climate change risk and mitigation and/or as anticipated regulatory, legislative, and tax costs that vary positively with current emissions.

4.3 Event study

4.3.1 Unsigned excess return and adjusted volume

Table 4 summarizes the results. Panel A shows mean unsigned daily excess return and mean adjusted volume for different partitions of the sample from day -10 to 10 relative to day 0, where we define day 0 as the 8-K filing date. We define these variables as follows. Excess return equals daily stock return inclusive of dividends for trading day t in excess of day t return on the *CRSP* value-weighted market index. Adjusted volume equals reported trading volume divided by common shares outstanding at day t (times 50 percent for a NASDAQ company to account for interdealer trading). In addition, we define the filing date as the day of initial disclosure of 8-K climate change news. We also align daily excess return around the 8-K conform date as a check on early release, as such date defines the reporting date of the news in the 8-K, when the information could first be known to insiders. Under present SEC rules (SEC 2004), a company must file an 8-K within four days of conform date.

Panel A shows two key results. First, 8-K news announcements with a press release, and the earliest 8-K announcement when a company has several within a fiscal year, show a higher return response on day 0 versus other days. Early 8-K announcements also reflect significantly higher adjusted volume. Thus, when more attention is placed on the news via a press release, investors react more. Second, we test and find that excess return and adjusted volume significantly increase on day 0 versus the other days. Panel A of figure 1 graphs this for unsigned excess return, and clearly shows a spike on day 0. The last row of panel A shows that we can reject the hypothesis for all partitions that the mean response at t=0 equals the average response for the other days in favor of a higher amount.

We also observe that seven of the eight means at t=0 are the highest on day 0 versus all other days, and in the eighth case it is second highest. We further check the 8-K reports for other information, since an 8-K is not restricted to a single item. A few 8-K reports contain multiple items. But when we restrict the analysis to single item 8-Ks, we also find results similar to panel A. In other words, when a company reports climate change news in an 8-K, investors respond when they should, on day 0. Because these data distribute broadly over the study period, it is highly unlikely that investors could be responding to anything else but a climate change disclosure. In addition, because the company files an 8-K, we can reasonably assume that the company perceived the information as ex ante material, since if this were not the case, the company would have no regulatory reason to file in the first place.

A further aspect of our event study exploits not just the timing of disclosure, as in panel A, but also whether investors might condition their response at t=0 on a climate change factor that differs across companies. We use model (3) to test this notion, and calculate GHG emission intensity response coefficients in much the same way that previous research has used earnings response coefficients to capture differential reaction to earnings news (Collins and Kothari 1989). We, therefore, estimate model (3) for companies in the S&P and TSE samples examined earlier. For these companies, we have the requisite climate change information for the model, such as actual or estimated GHGE intensity and CDLI.

Panel B of table 4 summarizes the results for two versions of model (3). We omit the regression constant for convenience and focus on the first regression to explain the results. First, we observe that CVCE has negative η_2 coefficients for days -3 to 3, and most of these are significant, which indicates that smaller companies on average have higher excess return. The coefficients for control variable DISC are also negative across t, indicating that discloser companies have lower excess return, also possibly because of a scale effect as per table 2. However, the η_1 coefficient for GHGE is negative only for days -1 and 0, and most negative for day 0, and this result holds for excess return and adjusted volume for both the simple regression model and the more complex model. Panel B of figure 1, which graphs the GHGE coefficients, clearly shows a dip on day 0. Note, also, that there is nothing unusual about the coefficients for the other variables at t=0. Indeed, the only variable that appears to drive investor response on day 0 differently from investor response on the other days is GHGE, which is a unique climate change factor that varies across the sample (see, also, table 2).[22]

We reasoned earlier why we would expect a negative coefficient for GHGE at t=0, namely, because investors respond to information relative to expectations, where such expectations depend on the quality and frequency of news events, in this case, about climate change. Since investors naturally demand more (less) information about climate change effects for emissions intensive (emissions non-intensive) companies, those expectations are better (less well) formed, regardless of the source of the information – from the company, CDP, or elsewhere. Relative

[22] We also observe the same results for excess return and adjusted volume when we estimate a simple or complex version of model (4) over events days -10 to 10; that is, the GHGE intensity response coefficient is most significantly negative at day 0, relative to the other days.

to expectations, then, we expect news releases for non-emissions intensive companies to elicit more response, as the news is more of a surprise. Note that our regression analysis controls for disclosure quality, which is insignificant in the regressions, so this is unlikely an explanatory factor. This result is also fully consistent with market efficiency and the use of all information by investors in setting prices. Only if investors were to rely myopically on CDP information and equate higher GHG intensity with more extreme news or uncertainly, might we expect a positive GHGE intensity response coefficient. Investors in an efficient market do not act this way however. We provide further consistent evidence in the next sub-section.

4.3.2 Signed excess return

Rather than analyze unsigned return and adjusted volume, we examine whether signed excess return might indicate a systematic positive or negative response to 8-K climate change news. Similar to the tests of unsigned return and adjusted volume, we condition signed excess return on whether investor response might differ for GHGE intensive and non-intensive companies. Panel C of table 4 presents the results. For each of days -10 to 10, we show mean excess return for each partition, difference in mean excess return for high minus low GHGE intensive companies, cumulative mean excess return, cumulative difference in mean excess return, and the standard deviation of excess return for each group. First, we observe a significant negative response on day 0 for high GHGE intensive companies, which also differs significantly from the response for low GHGE intensive companies. Second, on a cumulative basis, low GHGE intensive companies' excess return generally increases, whereas high GHGE intensive companies show little trend other than a decrease around days 0 and 1. Moreover, the negative trend is accentuated when we cumulate the difference in excess return (high GHGE minus low GHGE) and, as expected, the separation increases around days -1 to 1. Inspection of panels A and B of figure 2 also illustrates the negative response around day 0. Hence, from a timing standpoint, investors respond negatively to 8-K news conditional on high GHGE intensity, and positively conditional on low GHGE intensity, exactly when they should, that is, around the day of release of new climate change information. Untabulated analysis shows further that this result holds approximately equally for CDP disclosers and CDP non-disclosers.

These results agree with those of the previous sub-section and those within this sub-section. For instance, regarding the unsigned excess return results, we find a response on day 0 for both high and low intensity companies that is greater in absolute magnitude for the latter group. This parallels with the signed excess return results for two reasons. First, mean signed excess return for low intensity companies, which is generally positive, exceeds in absolute magnitude mean excess return for the high intensity companies, which tends to be negative. For example, cumulative excess return for low GHGE intensity companies from day -10 to 0 is 1.398 percent, whereas the equivalent cumulative return for high GHGE intensity companies is -0.397 percent. The second reason relates to the standard deviation of each group, which is higher for the low intensity versus the high intensity group, particularly around days -1 to 1, when investors receive the new information. We also examine the results in panel C for the same partitions as in panels A and B, and find no major differences in the implications of the results. In short, we document internally consistent results in panels A-C of table 4 using multiple metrics of investor response.

5 Additional analysis and robustness tests

5.1 Additional analysis

5.1.1 First differences version of residual income model

We also estimate a simplified version of the Ohlson (1995) model in first differences by regressing annual residual stock return on residual change in GHG emissions, with appropriate control variables as before, where the residual change in a variable is relative to the prior year. Our return model is:

$$XRET_t = \rho_0 + \rho_1 XGHGE_t + \Sigma_k \rho_k CNTL_{kt} + \varepsilon_t, \tag{4}$$

where $XRET_t$ = size-adjusted residual stock return computed as raw buy-and-hold return inclusive of dividend and other distributions less the value-weighted average return for all companies in the same-size matched decile, calculated for twelve-months ending *m* months after fiscal year end, where *m* relates to a month in year t+1 when investors likely receive information about $GHGE_t$. We define $XGHGE_t$ as $GHGE_t - E(GHGE_t)_{t-1}$, where $E(GHGE_t)_{t-1}$ is expected GHGE for t, conditional on GHGE at t-1, and $CNTL_k$ reflects controls for the other variables in equation (2). A simple model for expected GHG is $E(GHGE_t)_{t-1} = GHGE_{t-1}$, whereas a more complex model might generate $E(GHGE_t)_{t-1}$ from a regression model. Given model (2) and the prior results, we predict $\rho_1 < 0$ for XGHGE, and the same coefficient signs for changes in the controls in model (2). In other words, with respect to residual GHGE changes, we expect that a residual increase in GHGE signifies an increase in costs relative to market expectations and, hence, a decline in residual annual stock return. While a first differences specification offers an alternative test of investor relevance of GHG information, such specification also accentuates the measurement error in the explanatory variables, which makes it harder to reject the null hypothesis of a zero coefficient in favor of the alternative hypothesis (Barth et al. 2001).

We estimate model (4) for various specifications of the variables, but find it does not produce significant results in accordance with our expectations; but neither does it produce significant results opposite to our expectation. This leans towards a measurement error explanation of the results. In untabulated analysis, we show insignificant ρ_1 coefficients for various forms of model (4) regardless of measurement date of annual return, definition of residual GHGE, and control variables. Design factors doubtless account for this. First, a returns model magnifies the measurement error in levels variables, given that model (4) uses several levels variables from model (2) on a first difference basis. Second, it is difficult to specify an accurate price change window for all companies, such that the calendar period covers new information about climate change similarly for each company. Third, while we examine various forms of expectations model for emissions, residual GHG emissions might still not be sufficiently accurate or free of error such that we can predict reliably that it might increase or decrease stock price over a year. On the other hand, we do find evidence supporting the view that investors interpret high (low) emission intensity as a negative (positive) valuation factor in our short-term announcement tests in table 4, that is, when we narrow the return window to one day. This occurs because a host of factors that attenuates the link between information and investor response examined over a calendar year does not impact an event study, which has minimal attenuation in that we measure investor response in event time spread across a large number of different days over a long study period.

5.1.2 *Cost of equity capital*

Another test examines whether GHG emission intensity relates to equity cost of capital. Matsumura et al. (2010) reason that equity cost of capital should be increasing in climate change risk as proxied by carbon emission intensity, but find the opposite result. They conjecture that a decreasing relation could arise from an omitted variable such as disclosure quality, for example, because high carbon intensive companies have better quality disclosure that might lower equity cost of capital, and vice-versa. Sector could be another factor to explain the inverse relation, as high intensity companies such as utilities reflect lower equity cost of capital, and low intensity companies such as information technology firms have higher equity cost of capital. Indeed, untabulated analysis documents that cost of capital proxies vary significantly across the industry sectors.

To conduct our test, we first estimate cost of capital at the end of fiscal year t in two ways: by (1) the quintile rank of cost of capital from a simple valuation model based on market price at fiscal end-of-year plus three months (p), five-year expected earnings growth from IBES (g), and earnings per share = *epspx*, where estimated $r_e = ((epspx \div p) + g)$ and (2) the quintile rank of CRSP beta (β). We then regress cost of capital quintile rank (low cost of capital = 1) on emission intensity quintile rank (low GHG emission intensity = 1), disclosure quality (CDLI), and country, with additional controls for sector (the same sectors as summarized in table 2).

Table 5 presents the results. We first replicate the Matsumura et al. (2010) result when we estimate the regression model without sector controls. The coefficient for GHGE is significantly negative for both proxies of cost of capital. However, when we add dummy variables for sectors to control for industry differences, we find no relation between cost of capital and emission intensity. The GHGE coefficients are not significantly different from zero. Note, also, that the utilities sector, which is reflected in the intercept in the regressions, decreases the intercept when we add the sector controls because this sector has the lowest cost of capital, based on the quintile ranks (as well as mean CRSP beta and the standard deviation of XRET). The addition of sector has a substantial impact on the regression R^2. In addition, we find no relation between cost of capital and disclosure quality (CDLI), although as we note earlier, we do not expect a significant relation in that we study larger companies trading in competitive markets, wherein investors minimize financial risk from information asymmetry by pricing stocks as a component of a diversified portfolio (Armstrong et al. 2011).

5.2 Robustness

We subject our GHG predictions (model 1), residual income analysis (model 2), and event study tests (model 3) to alternative specifications, methods, definitions, and partitions of the data. The results from these robustness tests do not differ appreciably from those shown in the paper. First, we examine different specifications of model (1), including a more complex version, with additional controls for log of cash, standard deviation of IBES analysts' forecasts, number of IBES analysts' forecasts, log of foreign sales, number of segments, and dummy variables for country and finance sector. Our simplified GHG emission prediction model (model 1) has an overall adjusted R^2 of 60 percent, with the sector dummy variables contributing 37.6 percent to that amount. A more complex version of model (1) increases the adjusted R^2 to 67 percent but at the expense of a smaller sample size. While a comparison of the simplified and complex prediction models, based on an F-test applied to same-company samples, suggests a significant improvement from the additional predictors, we find no qualitative impact on the results in tables 3 and 4 when we use a more complex model.

Second, we examine additional versions of model (2) with alternative calculations of residual income (RESI), for example, RESI = change in *epspx*, RESI = *epspx* – *r*.CVBE/*csho*, where *r* = 12 percent, and RESI = *epspx* – r_e.CVBE/*csho*, where r_e is calculated as $\beta.(R_m - R_f)$ based on the capital asset pricing model, and where R_m = return on market portfolio for year t and R_f = risk free rate for year t, and β = CRSP beta, or as r_e = cost of capital from a simple valuation model as defined in sub-section 5.1.2. These alternative specifications do not change appreciably the results in table 3. Third, we re-estimate models (2) and (3) with data that removes the top and bottom one percent of each variable. The results in tables 3 and 4 are essentially no different under this alternative, so that the presence of outliers does not drive our results.

Fourth, we calculate investor response as daily raw return rather than daily market-adjusted return. This alternative, also, has no appreciable impact on the results in table 4. Fifth, we estimate model (3) for all 8-K disclosures (not just those 8-K filings by sample S&P 500 and TSE companies) and find similar results when we base high or low emission intensity on an indirect measure, namely, whether the company belongs to a high or low GHG emissions intensive sector (based on table 2).

Sixth, as part of our event study, we calculate the *change* in unsigned and signed residual return from day t-1 to t relative to announcement date 0 (Li and Ramesh 2009) and test whether the *change* variable increases before and decreases after t=0 for unsigned return, and whether the *change* variable for signed excess return at t=0 is significantly negative for high emissions intensive companies and for the difference between high and low emission intensive companies. Untabulated t-tests of the difference show significant results, consistent with a market reaction on day 0 that differs from day -1, but not for the other event days, for example, a market reaction on day -1 that differs from the reaction on day -2.

Overall, our robustness checks suggest that differences in definition and method have no significant bearing on our results. Some additional splits of the data, however, do affect our results, but in a predictable way, for example, investors respond more to climate change announcements with a press release than without a press release, and investors treat companies with higher emission intensity more negatively than those with lower intensity, both in assessing market value and in responding to climate change news announcements, regardless of whether they disclose to the CDP. Other splits such as country, stock exchange, and whether the company responded or did not respond to the CDP survey have only limited effects on the results and, certainly, do not change the overall findings.[23]

6 Conclusions and implications

Companies today worldwide face mounting pressure from investors, environmental agencies, and other groups, demanding full disclosure of companies' impacts on and responses to climate change. These groups also advocate additional required disclosure to correct what they perceive as deficiencies in the present system that may underserve investors' needs for voting and decision making in capital markets. For example, Ann Stausboll, CEO of CalPERS, a public pension fund with assets under management of $224 billion[24], believes that "reporting on climate issues in SEC filings is a necessity" (Young et al. 2009). Companies and insurers, on the other side, point out that the cost of additional disclosure from competitive disadvantage, litigation risk, and insurance exposure, particularly through mandated rules and standards, can be significant, and call for an even-handed analysis of the costs and benefits of additional disclosure. Possibly in light of these competing concerns, the SEC and Canadian securities regulators have, thus far, issued guidance releases that relate to existing law only, and the U.S. Environmental Protection Agency recently placed on hold its proposed rules for mandatory greenhouse gas emission reporting (40 CFR Part 98), following concerns that the rules would cause companies "serious competitive harm." (EPA 2010). Our paper contributes to an

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[23] All robustness test results are available on request.

[24] As of December 31, 2010.

understanding of a critical element of this debate, namely, whether there might be a relation between greenhouse gas disclosures and investors' assessments of stock price or reactions to climate change news. Indeed, from a public policy perspective, it is imperative that companies' and regulators' decisions about climate change disclosure consider the expected consequences of their actions.

This paper increases our knowledge of the consequences of climate change disclosure by examining the issue in three ways. First, we examine the relation between voluntary greenhouse gas emission disclosures and company stock price. We analyze companies' disclosures of greenhouse gas emissions from the Carbon Disclosure Project (CDP), which is the most comprehensive source of public data available about such emissions, and focus on U.S. and Canadian companies, namely, the S&P 500 and the TSE 200. Our stock price analysis generates two key findings: (1) that greenhouse gas emission levels associate negatively with stock price, and (2) that the negative relation between emissions and price is more pronounced for carbon-intensive companies. These results suggest that investors view greenhouse gas information as value-relevant and consequential for stock price and, hence, potentially useful for capital market voting and decision-making.

While not all S&P 500 or TSE 200 companies disclose to the CDP, possibly for reasons indicated above, an efficient market might, nevertheless, factor emissions information into stock price based on the total mix of information available, and not just the CDP data. This is what we find, which is our second way of understanding the investor relevance of climate change information. We predict greenhouse gas emissions for non-CDP discloser companies based on industry and operating characteristics and produce the same two key findings as above – that stock price varies negatively with predicted emissions, and the negative relation with stock price increases for predicted emission-intensive companies. Moreover, the negative relation holds approximately equally for CDP discloser and non-CDP discloser companies. We cannot argue, though, that these relations would be no different in a counterfactual world without CDP information, for the CDP provides one important source of information for our prediction model of the greenhouse gas emissions of non-discloser companies, which have similar industry and operating characteristics to discloser companies but for a CDP disclosure.

Our knowledge also increases in a third way, by an analysis of the short-term stock price effects of climate change disclosure that should, consistent with the earlier results, differ between emission intensive and emission non-intensive companies. First, we observe a distinct price and trading volume reaction by investors around the day of an 8-K filing, when a company releases ex ante material news relating to climate change or emissions, and the market response to 8-K filings with a company press release exceeds the response without a press release. We also observe significant negative residual return for 8-K filings of emission intensive companies and significant positive residual return for 8-K filings of emission non-intensive companies on days -1 or 0, and the return difference increases to almost two percent over a longer (10 day) period around the announcement. Hence, from a timing standpoint, investors respond negatively to 8-K news conditional on high emissions intensity, and positively conditional on low emissions intensity, exactly when they should, that is, around the day of release of new climate change information. This result also holds approximately equally for CDP disclosers and CDP non-disclosers, again suggesting that in an efficient market investors rely of a broad set of information, not just disclosures made public by the CDP. Our finding that stock prices respond significantly to climate change information on the day of disclosure also has implications for market reaction tests of materiality and loss causation in securities litigation, in that we show a statistically significant stock price adjustment that is reliably attributable to a climate change disclosure not attenuated by other factors. We cannot claim, however, that such reaction would differ under a system of increased mandated disclosure, although as our short-term reaction and price level tests indicate, we find the same empirical relations regardless of whether a company discloses to the CDP or not.

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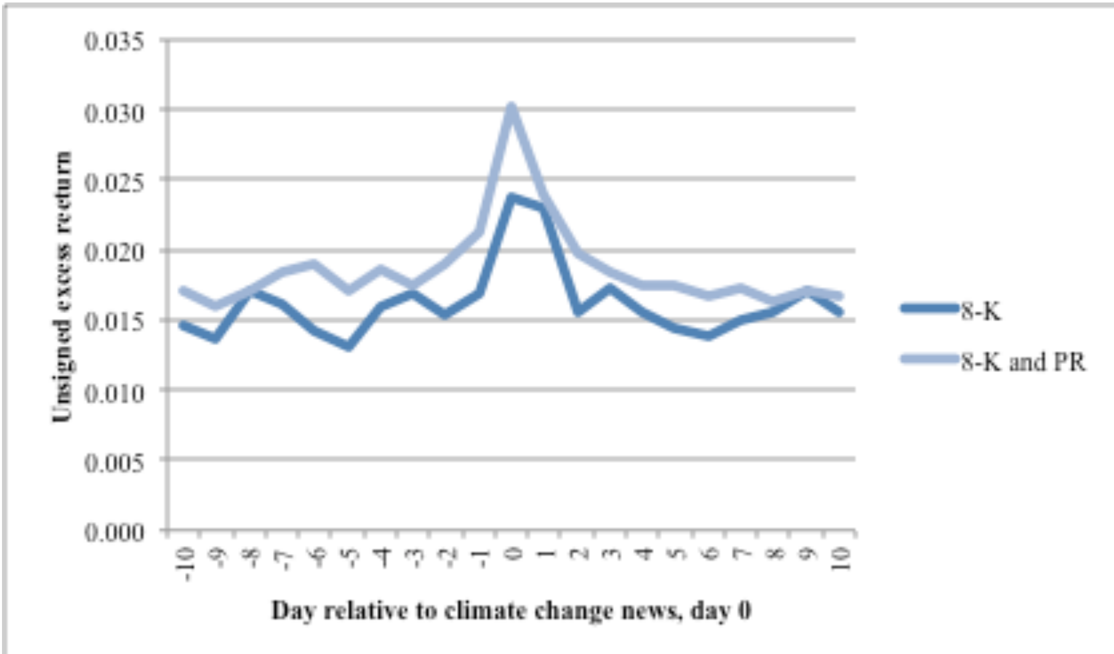
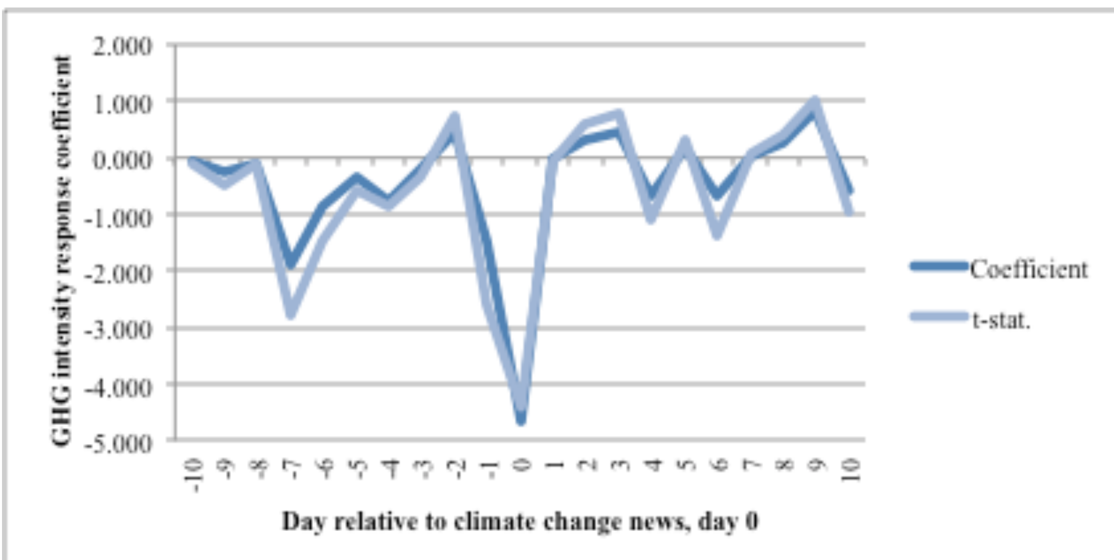
Figure 1: Investor response to climate change news: Unsigned excess return

Panel A: 8-K versus 8-K and a company press release (PR)



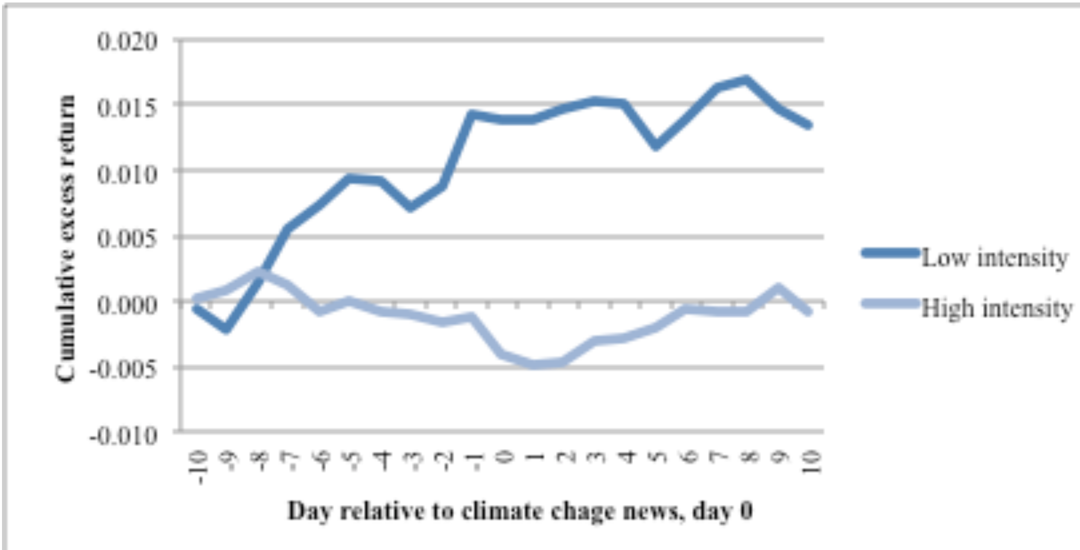
Panel B: GHG intensity response coefficient x 1,000 and t-statistic x -1 by event day



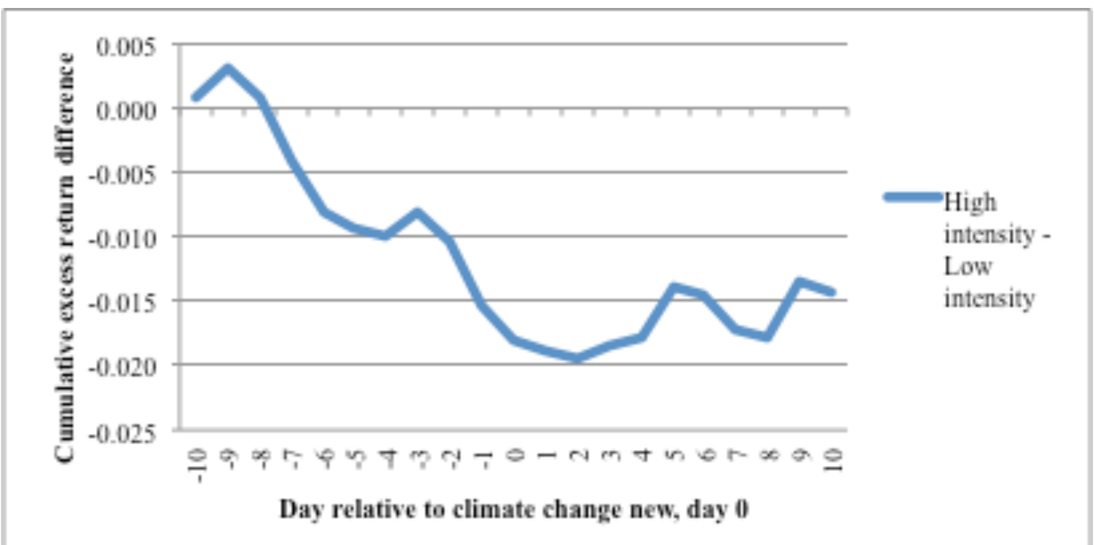
Panel A plots the mean unsigned return data in table 4, panel A. Panel B plots the GHG intensity response coefficients and t-statistics (times minus 1) in table 4, panel B.

Figure 2: Investor response to climate change news: Cumulative signed excess return

Panel A: High intensity versus low intensity



Panel B: High intensity minus low intensity



Panels A and B plot the cumulative mean excess returns reported in table 4, panel C.

Table 1: Samples and response rates for GHG emissions

	S&P Sample				TSE Sample				Combined Sample	
	CDP Survey	Not Available	Response rate	Total	CDP Survey	Not Available	Response rate	Total	Total	Response rate
Panel A: CDP reporting year										
2005					47	217	17.8%	264	264	17.8%
2006	140	341	29.1%	481	62	121	33.9%	183	664	30.4%
2007	198	298	39.9%	496	57	117	32.8%	174	670	38.1%
2008	222	272	44.9%	494	59	124	32.2%	183	677	41.5%
2009	264	234	53.0%	498	34	110	23.6%	144	642	46.4%
All	824	1,145		1,969	259	689		948	2,917	
Panel B: Sector										
Utilities	93	30	75.6%	123	11	24	31.4%	35	158	65.8%
Consumer Discretionary	87	234	27.1%	321	19	105	15.3%	124	445	23.8%
Consumer Staples	97	62	61.0%	159	3	46	6.1%	49	208	48.1%
Energy	62	81	43.4%	143	77	153	33.5%	230	373	37.3%
Financials	105	239	30.5%	344	32	134	19.3%	166	510	26.9%
Health Care	87	127	40.7%	214	0	17	0.0%	17	231	37.7%
Industrials	80	139	36.5%	219	25	59	29.8%	84	303	34.7%
Information Technology	126	172	42.3%	298	16	32	33.3%	48	346	41.0%
Materials	71	47	60.2%	118	62	111	35.8%	173	291	45.7%
Telecommunications	16	14	53.3%	30	14	8	63.6%	22	52	57.7%
All	824	1,145		1,969	259	689		948	2,917	

These data summarize the GHG emissions data for the S&P 500 and TSE samples, extracted from Carbon Disclosure Project (CDP), available at www.cdproject.net. The column CDP survey indicates that a respondent discloses direct or indirect GHG emissions for that reporting year. The CDP makes public this information in survey results, usually published in September-October of the following year. The TSE sample comprises more than the 200 largest Canadian companies (TSE 200) for 2005-2008. Sector is based on S&P categories, also reported in the CDP surveys. Membership of the S&P 500 and TSE samples, based on market capitalization, may change each year.

Table 2: Descriptive statistics for variables in models by sector and country

Panel A: Model (1) and other variables		Utilities	Cons. Discr.	Cons. Stap.	Energy	Financials	Health Care	Industrials	Info. Tech.	Materials	Telecom.	All	TSE 200	S&P 500	Signif.
GHGE	GHG Discloser	37,100,000	4,308,771	2,405,056	2,282,413	472,783	615,492	2,769,606	488,221	8,371,591	1,721,361	7,465,062	3,504,504	8,746,982	***
	GHG NonDiscloser	11,700,000	1,516,505	2,257,583	348,900	117,718	274,717	776,664	133,047	1,484,485	301,741	1,412,359	1,334,185	1,458,340	ns
	Signif.	***	**	ns	***	***	***	***	***	***	*	***	***	***	
LogGHGE	GHG Discloser	16.45	13.62	13.85	15.04	11.74	12.59	13.55	12.09	14.63	13.08	13.68	13.25	13.82	***
	GHG NonDiscloser	15.62	13.26	13.91	13.93	10.59	11.88	12.95	11.27	13.21	12.25	12.52	12.09	12.78	***
	Signif.	**	**	ns	***	***	***	***	***	***	*	***	***	***	
LogCAPX	GHG Discloser	21.01	19.37	20.08	21.25	13.07	19.81	19.97	19.47	19.75	21.05	19.01	18.40	19.21	*
	GHG NonDiscloser	19.19	18.71	19.60	19.73	11.74	18.40	19.02	18.33	18.02	19.63	16.69	15.05	17.75	***
	Signif.	***	**	***	***	ns	***	***	***	***	ns	***	***	***	
LogREVT	GHG Discloser	22.76	23.09	23.45	22.00	23.39	23.31	23.12	22.69	22.32	23.49	22.60	20.83	23.18	***
	GHG NonDiscloser	21.73	22.26	23.17	20.74	21.89	22.11	22.36	21.66	18.84	22.36	20.77	18.52	22.23	***
	Signif.	***	***	*	***	***	***	***	***	***	**	***	***	***	
LogAT	GHG Discloser	9.90	9.20	9.58	9.57	11.70	9.82	9.47	9.20	8.86	10.38	9.73	8.89	10.00	***
	GHG NonDiscloser	8.79	8.48	8.83	8.14	10.01	8.56	8.59	8.26	7.38	9.45	8.69	7.71	9.28	***
	Signif.	***	***	***	***	***	***	***	***	***	**	***	***	***	
LogINTAN	GHG Discloser	17.72	19.12	22.15	16.16	20.14	22.00	19.66	20.48	16.78	19.90	18.98	16.08	19.92	***
	GHG NonDiscloser	14.77	19.00	20.26	14.30	17.04	20.80	18.39	19.75	12.60	18.83	16.83	14.16	18.56	***
	Signif.	*	ns	***	*	***	**	ns	*	***	ns	***	**	***	
GMAR	GHG Discloser	0.28	0.31	0.45	0.46	0.39	0.61	0.31	0.53	0.33	0.62	0.41	0.41	0.41	ns
	GHG NonDiscloser	0.30	0.37	0.25	0.35	0.36	0.41	0.32	0.54	-0.52	0.60	0.30	0.14	0.40	*
	Signif.	ns	**	***	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	
LEVG	GHG Discloser	0.32	0.21	0.28	0.21	0.15	0.18	0.22	0.11	0.19	0.34	0.21	0.21	0.21	ns
	GHG NonDiscloser	0.33	0.23	0.22	0.22	0.22	0.18	0.20	0.13	0.18	0.45	0.21	0.22	0.20	*
	Signif.	ns	ns	***	ns	***	ns	ns	ns	ns	*	ns	ns	ns	
No. of observations	GHG Discloser	104	106	100	139	137	87	105	142	133	30	1083	259	824	
	GHG NonDiscloser	54	339	108	234	373	144	198	204	158	22	1,834	689	1,145	
	All	158	445	208	373	510	231	303	346	291	52	2,917	948	1,969	

Variable definitions, with *Compustat* names in parentheses, are: GHGE=GHG emissions per CDP reporting year in metric tons, CAPX=capital expenditures for year (*capx*), REVT=total revenue for year (*revt*), AT=total assets at end of year (*at*), INTAN=intangibles at end of year (*intan*), GMAR=gross margin (1-*cogs*/*sale*), LEVG=long-term debt to total assets (*dltt/at*), and Log refers to the natural logarithm of a variable. Tests of significance are whether the difference in mean is zero under a two-tailed test: *** = less than .001, ** = less than .01, * = less than .10, ns = not significant. Table 2 continued on next page.

Table 2: Descriptive statistics for variables in models by sector and country, contd.

Panel B: Models (2)-(4) and other variables		Utilities	Cons. Discr.	Cons. Stap.	Energy	Financials	Health Care	Industrials	Info. Tech.	Materials	Telecom.	All	TSE 200	S&P 500	Signif.
PRCC_Q5	GHG Discloser	39.63	30.95	44.62	47.69	41.45	44.44	48.96	25.48	42.46	30.13	39.68	35.76	40.49	*
	GHG NonDiscloser	33.94	41.20	35.18	37.15	46.65	45.73	48.62	41.46	29.21	26.23	41.29	28.49	44.61	***
	Signif.	ns	*	**	**	ns	ns	ns	**	ns	ns	ns	*	*	
PRCC_F	GHG Discloser	39.92	31.23	43.57	43.74	45.67	45.97	49.11	25.54	41.73	33.19	40.10	33.57	42.11	***
	GHG NonDiscloser	29.04	39.09	37.35	31.37	49.50	44.61	44.65	41.24	25.01	28.35	39.57	29.38	45.93	***
	Signif.	**	ns	*	***	ns	ns	ns	ns	***	ns	ns	ns	ns	
CVCE	GHG Discloser	22.98	13.29	11.13	18.99	33.34	15.13	17.14	16.29	15.63	12.67	17.02	14.43	17.84	***
	GHG NonDiscloser	15.05	16.50	15.26	13.73	26.99	14.35	16.53	16.26	10.87	9.95	14.99	11.66	16.99	***
	Signif.	***	ns	**	***	ns	ns	ns	ns	***	ns	***	***	ns	
GHGE/*csho*	GHG Discloser	102.55	6.47	3.44	14.32	1.16	0.74	7.56	0.60	25.26	0.91	16.12	12.24	17.28	*
	GHG NonDiscloser	61.62	9.29	13.45	14.19	0.57	1.29	3.66	0.62	13.51	0.80	7.99	11.26	6.14	***
	Signif.	***	ns	**	ns	ns	ns	***	ns	***	ns	***	ns	***	
GHGE/*revt*	GHG Discloser	3.09	0.44	0.09	0.77	0.04	0.04	0.20	0.06	0.83	0.06	0.54	0.77	0.47	***
	GHG NonDiscloser	2.53	0.40	0.23	0.77	0.02	0.12	0.10	0.04	0.69	0.05	0.34	0.65	0.17	***
	Signif.	ns	ns	**	ns	*	*	***	ns	*	ns	***	ns	***	
XRET_Q5	GHG Discloser	0.05	0.03	0.07	0.08	0.03	0.06	0.06	0.01	0.14	0.00	0.06	0.07	0.05	ns
	GHG NonDiscloser	0.05	0.05	-0.02	0.06	-0.06	0.03	0.02	0.00	0.20	0.09	0.03	0.08	0.01	**
	Signif.	ns	ns	*	ns	*	ns	ns	ns	ns	ns	*	ns	*	
CDLI	GHG Discloser	60.72	56.23	65.24	55.00	63.05	57.80	54.22	58.75	53.75	50.23	57.96	51.55	60.01	***
	GHG NonDiscloser	47.43	42.82	48.90	47.20	46.41	46.06	42.78	43.55	47.27	35.70	45.05	47.51	43.56	***
	Signif.	***	***	***	***	***	***	***	***	***	***	***	***	***	
No. of observations	GHG Discloser	104	106	100	139	137	87	105	142	133	30	1,083	259	824	
	GHG NonDiscloser	54	339	108	234	373	144	198	204	158	22	1,834	689	1,145	
	All	158	445	208	373	510	231	303	346	291	52	2,917	948	1,969	

Variable definitions, with *Compustat* names in parentheses, are: PRCC_Q5$_{t+1}$=stock price at end of first quarter after fiscal year t, PRCC_F$_t$=stock price at end of fiscal year t, CVCE=carrying value of common equity at t-1(*ceq*)/common shares outstanding at t-1(*csho*), GHGE/*csho*=GHGE per common share, in thousands, GHGE/*revt*= GHGE per dollar of total revenues, in thousands, XRET_Q5=size-adjusted residual annual stock return from Q5$_t$ to Q5$_{t+1}$, and CDLI = actual or estimated CDP Disclosure Leadership Index. Tests of significance are whether the difference in mean is zero under a two-tailed test: *** = less than .001, ** = less than .01, * = less than .10, ns = not significant.

Table 3: Regression of stock price on common equity, residual earnings, and GHG emissions per share

Panel A: Stock price=PRCC_Q5, RESI=*epspx* Sample/Variable		Intercept	CVCE per share	Residual earnings per share	GHGE per share	Country: US or Canada	Country x GHG per share	CDLI	Change in operating leases	Exp. ret. pension assets	No. of obs.	Adjusted R^2
All	1	17.321 ***	1.002 ***	2.866 ***	-0.008 **						2,312	50.5%
All	2	11.376 ***	1.001 ***	2.889 ***	-0.003 ns	7.753 ***	-0.054 **				2,312	51.1%
All	3	20.255 ***	1.001 ***	2.883 ***	-0.007 **			-0.059 ns			2,312	50.6%
All	4	18.281 ***	1.037 ***	2.756 ***	-0.021 ***				79.359 **		1,991	51.6%
All	5	8.314 **	0.986 ***	2.146 ***	-0.037 **					1.514 **	1,355	57.4%
GHGE intensive	6	14.803 ***	1.112 ***	2.906 ***	-0.008 **						1,089	63.3%
	7	10.577 ***	1.122 ***	2.945 ***	-0.003 ns	6.852 ***	-0.068 ***				1,089	64.5%
Non-GHGE intensive	8	19.354 ***	0.902 ***	2.989 ***	0.046 ns						1,223	43.9%
	9	12.077 ***	0.898 ***	2.974 ***	-0.066 **	7.545 **	0.669 **				1,223	44.6%
US	10	16.292 ***	1.062 ***	3.761 ***	-0.069 ***						1,903	53.0%
Canada	11	18.200 ***	0.692 ***	1.753 **	-0.003 ns						409	53.0%
GHG Intensive: Discloser	12	23.452 ***	0.709 ***	2.245 ***	-0.006 **						500	31.3%
	13	21.511 ***	0.751 ***	2.250 ***	-0.031 **	2.660 ns	-0.034 **				500	32.1%
GHG Intensive: Non-Discloser	14	13.081 ***	1.170 ***	3.739 ***	-0.044 **						589	74.5%
	15	9.503 ***	1.162 ***	3.724 ***	-0.110 ***	6.307 **	-0.125 **				589	75.2%

Variable definitions, with *Compustat* names in italics, are: PRCC_Q5=stock price at end of first quarter after fiscal year t, CVCE per share=carrying value of common equity at t-1(*ceq*)/*csho*, RESI=*epspx*, GHGE per share=GHGE/(*csho* x 1,000), CDLI=actual or estimated CDLI (median CDLI for the company sector), Change in operating leases=$mrct_t$+$mrctaa_t$-$mrct_{t-1}$-$mrcta_{t-1}$, expected return on pension plan assets=*pbarr*, GHGE intensive=GHGE/*revt* greater than median in CDP year, otherwise Non-GHGE intensive, Discloser=GHGE disclosed to CDP, otherwise Non-Discloser. Tests of significance are whether the regression coefficient is zero under a two-tailed test: *** = less than .001, ** = less than .01, * = less than .10, ns = not significant.

Table 3, contd.

Panel B: PRC=PRCC_CDP, RESI=*epspx* Sample/Variable		Intercept	CVCE per share	Residual earnings per share	GHG per share	Country: US or Canada	Country x GHG per share	CDLI	Change in operating leases	Exp. ret. pension assets	No. of obs.	Adjusted R^2
All	1	19.709 ***	1.258 ***	2.048 **	-0.022 ***						2,199	47.7%
All	2	13.849 ***	1.258 ***	2.100 **	-0.015 ***	7.354 ***	-0.037 **				2,199	48.2%
All	3	20.853 ***	1.258 ***	2.052 **	-0.022 ***			-0.023 ns			2,199	47.7%
All	4	20.665 ***	1.278 ***	1.804 **	-0.027 ***				81.188 **		1,884	49.1%
All	5	8.041 **	1.157 ***	1.305 **	-0.036 **					1.834 **	1,289	58.8%
GHG intensive	6	18.129 ***	1.334 ***	2.294 ***	-0.023 ***						1,042	57.8%
	7	12.956 ***	1.338 ***	2.439 ***	-0.016 ***	7.655 ***	-0.050 **				1,042	58.8%
Non-GHG intensive	8	20.401 ***	1.189 ***	2.064 **	0.544 **						1,157	42.1%
	9	16.452 ***	1.199 ***	2.119 **	-0.970 **	4.307 ns	1.660 **				1,347	42.5%
US	10	19.621 ***	1.373 ***	3.571 ***	-0.062 ***						1,841	49.4%
Canada	11	19.133 ***	0.921 ***	1.055 **	-0.013 ***						358	50.2%
GHG Intensive: Discloser	12	25.292 ***	0.694 ***	2.036 ***	-0.009 **						486	24.9%
	13	20.818 ***	0.743 ***	2.042 ***	-0.042 ***	6.099 **	-0.046 **				486	25.5%
GHG Intensive: Non-Discloser	14	14.286 ***	1.159 ***	3.099 ***	-0.044 **						556	69.9%
	15	10.489 ***	1.151 ***	3.077 ***	-0.103 **	6.479 **	-0.113 **				556	70.5%

Variable definitions, with *Compustat* names in italics, are: PRCC_CDP= stock price at end of September after fiscal year t, CVCE per share=carrying value of common equity at t-1(*ceq*)/*csho*, RESI=*epspx*, GHGE per share =GHGE/(*csho* x 1,000), CDLI=actual or estimated CDLI (median CDLI for the company sector), Change in operating leases=$mrct_t+mrctaa_t-mrct_{t-1}-mrcta_{t-1}$, expected return on pension plan assets = *pbarr*, GHG intensive = GHGE/*revt* greater than median in CDP year, otherwise Non-GHGE intensive, Discloser =GHGE disclosed to CDP, otherwise Non-Discloser. Tests of significance are whether the regression coefficient is zero under a two-tailed test: *** = less than .001, ** = less than .01, * = less than .10, ns = not significant.

Table 3, contd.

Panel C: PRC=PRCC_Q5, RESI=*eps_ibes-ibes* Sample/Variable		Intercept	CVCE per share	Residual earnings per share	GHG per share	Country: US or Canada	Country x GHG per share	CDLI	Change in operating leases	Exp. ret. pension assets	No. of obs.	Adjusted R^2
All	1	25.896 ***	0.398 ns	4.315 ***	-0.019 **						2,296	34.5%
All	2	16.974 ***	0.397 ns	4.318 ***	-0.014 **	11.127 ***	-0.030 ns				2,296	35.5%
All	3	27.815 ***	0.397 ns	4.325 ***	-0.018 **			-0.038 ns			2,296	34.5%
All	4	19.087 ***	1.074 ***	2.579 ***	-0.023 ***				70.129 **		1,979	48.6%
All	5	15.196 **	0.455 **	3.542 ***	-0.145 **					1.853 **	1,355	40.1%
GHG intensive	6	16.388 ***	1.097 ***	2.474 ***	-0.010 **						1,081	59.6%
	7	10.832 ***	1.104 ***	2.508 ***	-0.005 **	8.706 ***	-0.071 ***				1,081	61.3%
Non-GHG intensive	8	22.532 ***	0.831 ***	3.346 ***	-0.686 ***						1,215	39.7%
	9	14.513 ***	0.860 ***	3.186 ***	-0.716 ***	6.839 **	1.340 ***				1,215	41.2%
US	10	18.110 ***	1.065 ***	3.456 ***	-0.077 ***						1,891	47.5%
Canada	11	23.504 ***	0.067 ns	3.748 ***	-0.004 **						405	42.8%
GHG Intensive: Discloser	12	25.623 ***	0.937 ***	1.899 **	-0.019 ***						496	29.4%
	13	22.253 ***	0.954 ***	1.946 **	-0.035 **	4.479 ns	-0.023 ns				496	32.1%
GHG Intensive: Non-Discloser	14	16.574 ***	1.429 ***	3.106 ***	-0.034 ns						585	67.9%
	15	11.719 ***	1.422 ***	3.241 ***	-0.092 **	7.753 **	-0.109 **				585	68.7%

Variable definitions, with *Compustat* names in italics, are: PRCC_Q5=stock price at end of first quarter after fiscal year t, CVCE per share=carrying value of common equity at t-1(*ceq*)/*csho*, RESI= *eps_ibes*-consensus *IBES* forecast at t, GHGE per share =GHGE/(*csho* x 1,000), CDLI=actual or estimated CDLI (median CDLI for the company sector), Change in operating leases=$mrct_t+mrctaa_t-mrct_{t-1}-mrcta_{t-1}$, expected return on pension plan assets = *pbarr*, GHG intensive = GHGE/*revt* greater than median in CDP year, otherwise Non-GHGE intensive, Discloser=GHGE disclosed to CDP, otherwise Non-Discloser. Tests of significance are whether the regression coefficient is zero under a two-tailed test: *** = less than .001, ** = less than .01, * = less than .10, ns = not significant.

Table 3, contd.

Panel D: Price= PRCC_CDP, RESI=*eps_ibes-ibes* Sample/Variable		Intercept	CVCE per share	Residual earnings per share	GHG per share	Country: US or Canada	Country x GHG per share	CDLI	Change in operating leases	Exp. ret. pension assets	No. of obs.	Adjusted R^2
All	1	20.302 ***	1.276 ***	1.973 ***	-0.025 ***						2183	46.2%
All	2	13.218 ***	1.277 ***	2.042 ***	-0.016 ***	8.898 ***	-0.048 **				2183	46.8%
All	3	19.422 ***	1.276 ***	1.969 ***	-0.025 ***			0.017 ns			2183	46.2%
All	4	21.400 ***	1.299 ***	1.733 **	-0.028 ***				65.759 **		1873	47.5%
All	5	7.790 **	1.172 ***	1.095 **	-0.047 ***					1.946 ***	1288	60.4%
GHG intensive	6	19.293 ***	1.295 ***	2.416 ***	-0.025 ***						1034	56.4%
	7	12.837 ***	1.300 ***	2.622 ***	-0.016 ***	9.424 ***	-0.057 ***				1034	57.8%
Non-GHG intensive	8	20.417 ***	1.252 ***	1.885 **	0.572 **						1149	41.1%
	9	14.820 ***	1.262 ***	1.940 ***	-0.696 ns	6.154 **	1.389 **				1149	41.6%
US	10	21.201 ***	1.352 ***	3.456 ***	-0.071 ***						1830	45.6%
Canada	11	15.765 ***	1.116 ***	0.754 **	-0.015 ***						353	59.3%
GHG Intensive: Discloser	12	27.242 ***	0.908 ***	1.887 **	-0.021 ***						482	24.4%
	13	21.400 ***	0.937 ***	1.985 ***	-0.046 ***	7.725 **	-0.038 **				482	26.8%
GHG Intensive: Non-Discloser	14	17.245 ***	1.398 ***	3.736 ***	-0.038 ns						552	66.2%
	15	12.211 ***	1.392 ***	3.914 ***	-0.093 **	7.888 **	-0.103 ns				552	67.0%

Variable definitions, with *Compustat* names in italics, are: PRCC_CDP= stock price at end of September after fiscal year t, CVCE per share=carrying value of common equity at t-1(*ceq*)/*csho*, RESI= *eps_ibes*-consensus *IBES* forecast at t, GHGE per share =GHGE/(*csho* x 1,000), CDLI=CDP Disclosure Leadership Index, Change in operating leases=$mrct_t$+$mrctaa_t$-$mrct_{t-1}$-$mrcta_{t-1}$, expected return on pension plan assets = *pbarr*, GHG intensive = GHGE/*revt* greater than median in CDP year, otherwise Non-GHGE intensive, Discloser =GHGE disclosed to CDP, otherwise Non-Discloser. Tests of significance are whether the regression coefficient is zero under a two-tailed test: *** = less than .001, ** = less than .01, * = less than .10, ns = not significant.

Table 4: Event study of investor response to climate change news

Panel A: Investor response around event days -10 to 10: Unsigned excess return and adjusted volume

Variable	Mean unsigned excess return			Mean adjusted volume			Mean unsigned excess return			Mean adjusted volume		
Partition	8-K	8-K and PR	Sig.	8-K	8-K and PR	Sig.	First 8-K	Subsequent	Sig.	First 8-K	Subsequent	Sig.
Event day												
-10	0.0147	0.0171	ns	10.1486	11.2192	ns	0.0184	0.0157	*	12.2103	10.3296	*
-9	0.0138	0.0160	ns	10.4109	11.0497	ns	0.0171	0.0148	*	11.7737	10.4232	ns
-8	0.0171	0.0172	ns	10.1087	10.5350	ns	0.0177	0.0168	ns	11.3096	9.9063	*
-7	0.0162	0.0183	ns	10.1727	10.9982	ns	0.0200	0.0168	*	11.8203	10.2705	*
-6	0.0144	0.0190	*	9.8252	11.1770	ns	0.0207	0.0170	*	12.1885	10.2272	*
-5	0.0131	0.0171	**	9.3907	11.6277	**	0.0174	0.0162	ns	12.6352	10.5375	*
-4	0.0160	0.0187	ns	9.5670	12.4704	**	0.0212	0.0165	**	15.1790	10.0370	**
-3	0.0169	0.0175	ns	10.4466	11.3710	ns	0.0191	0.0162	*	12.6455	10.2975	**
-2	0.0155	0.0189	ns	10.2554	11.8934	*	0.0194	0.0181	ns	13.1796	10.6926	**
-1	0.0170	0.0214	*	11.7503	15.0495	ns	0.0235	0.0191	*	19.0240	11.6262	ns
0	0.0239	0.0301	*	13.9412	18.7338	**	0.0342	0.0262	***	21.8546	15.6796	**
1	0.0232	0.0239	ns	14.6143	16.0453	ns	0.0253	0.0227	ns	17.8108	14.5262	*
2	0.0156	0.0198	**	12.3168	13.2959	ns	0.0218	0.0176	**	14.7823	12.0539	*
3	0.0173	0.0185	ns	10.9379	13.0225	*	0.0196	0.0175	ns	13.9522	12.0055	ns
4	0.0157	0.0175	ns	9.6751	12.4943	***	0.0190	0.0162	*	13.4509	11.3380	*
5	0.0146	0.0174	*	9.5713	12.4872	**	0.0171	0.0171	ns	12.9744	11.6570	ns
6	0.0140	0.0166	*	10.2219	12.0408	*	0.0181	0.0152	**	13.1950	10.9050	*
7	0.0152	0.0172	ns	9.9911	11.8790	*	0.0181	0.0163	ns	12.7770	10.9183	*
8	0.0154	0.0163	ns	10.9457	11.2708	ns	0.0177	0.0151	*	12.2525	10.5035	*
9	0.0172	0.0171	ns	10.5698	11.3273	ns	0.0194	0.0154	**	11.9848	10.7254	*
10	0.0157	0.0167	ns	10.0694	11.0806	ns	0.0180	0.0156	*	12.1476	10.1404	**
Sig. t=0	***	***		***	***		***	***		***	***	

Variable definitions. Unsigned excess return=absolute value of daily stock return inclusive of dividends for trading day t in excess of the day t return on the *CRSP* value-weighted market index, adjusted volume=reported trading volume divided by common shares outstanding at day t (times 50 percent for a NASDAQ company, 8-K=climate change disclosure on day 0 = filing date, 8-K and PR=press release accompanies 8-K filing, Company's first 8-K filing in fiscal year, otherwise subsequent. Tests of significance are whether the difference in the mean of the two preceding columns is zero under a two-tailed test: *** = less than .001, ** = less than .01, * = less than .10, ns = not significant. The last row tests whether the mean for each column at t=0 is zero.

Table 4, contd.

Panel B: Regression relation between GHG emission intensity and investor response to climate change news

	Model	Simple				Complex			
	Variable	Unsigned excess return		Adjusted volume		Unsigned excess return		Adjusted volume	
Event day		Coeff.	Signif.	Coeff.	Signif.	Coeff.	Signif.	Coeff.	Signif.
-3	CVCE	-0.00013	**	-0.06405	ns	-0.00014	**	-0.07790	ns
-2	CVCE	-0.00020	**	-0.08935	ns	-0.00020	**	-0.10428	ns
-1	CVCE	-0.00015	**	-0.07150	ns	-0.00015	**	-0.08551	ns
0	CVCE	-0.00016	ns	0.01967	ns	-0.00012	ns	0.00650	ns
1	CVCE	-0.00024	**	-0.05810	ns	-0.00024	**	-0.07165	ns
2	CVCE	-0.00015	**	-0.14468	**	-0.00015	**	-0.16257	**
3	CVCE	-0.00011	ns	-0.08719	ns	-0.00009	ns	-0.10038	ns
-3	CDLI					0.00003	ns	0.00620	ns
-2	CDLI					0.00006	ns	0.00784	ns
-1	CDLI					0.00007	ns	0.02171	ns
0	CDLI					-0.00005	ns	-0.03644	ns
1	CDLI					0.00008	ns	0.00565	ns
2	CDLI					0.00003	ns	0.02942	ns
3	CDLI					0.00003	ns	0.01299	ns
-3	Country					0.00054	ns	7.18224	**
-2	Country					-0.00282	ns	7.68784	**
-1	Country					-0.00491	ns	6.51896	**
0	Country					-0.01727	**	8.86960	**
1	Country					-0.00359	ns	7.04431	ns
2	Country					-0.00197	ns	8.24308	**
3	Country					-0.01201	***	6.49676	**
-3	DISC	-0.00124	ns	-3.41090	***	-0.00159	**	-3.41857	***
-2	DISC	-0.00209	**	-3.50501	***	-0.00278	***	-3.52579	***
-1	DISC	-0.00224	***	-3.63459	***	-0.00297	***	-3.81010	***
0	DISC	-0.00437	***	-4.77113	***	-0.00403	**	-4.31863	***
1	DISC	-0.00190	**	-4.94896	***	-0.00273	**	-4.95192	***
2	DISC	-0.00205	**	-3.82465	***	-0.00238	**	-4.06718	***
3	DISC	-0.00165	**	-3.72606	***	-0.00207	**	-3.81032	***
-3	GHGE	-0.00015	ns	-0.29925	ns	-0.00019	ns	-0.22683	ns
-2	GHGE	0.00058	ns	-0.24529	ns	0.00045	ns	-0.16967	ns
-1	GHGE	-0.00129	**	-0.55057	ns	-0.00145	**	-0.51033	ns
0	GHGE	-0.00453	***	-2.66989	***	-0.00466	***	-2.51060	***
1	GHGE	0.00013	ns	-1.46561	**	-0.00004	ns	-1.39390	**
2	GHGE	0.00040	ns	-0.94490	ns	0.00033	ns	-0.89712	ns
3	GHGE	0.00066	ns	-0.45808	ns	0.00047	ns	-0.40426	ns

Variable definitions. The dependent variable for each cross-sectional regression is unsigned excess return or adjusted volume on event day t. CVCE = carrying value of common equity at t-1(*ceq*)/common shares outstanding at t-1(*csho*), CDLI = Actual or estimated CDP Disclosure Leadership Index, Country = 1 if S&P 500, otherwise 0, DISC=1 if GHGE disclosed to CDP, otherwise, 0, GHGE = quintile rank of GHGE/*revt* in CDP year (1 = lowest quintile). Tests of significance are whether the regression coefficient is zero under a two-tailed test: *** = less than .001, ** = less than .01, * = less than .10, ns = not significant.

Table 4, contd.

Panel C: Investor response to climate change news around event days -10 to 10: Signed excess return

Event day	Mean Low intensity		Mean High intensity		Mean Difference High - Low		Cumulative Mean Low intensity	Cumulative Mean High intensity	Cumulative Difference High - Low	Standard deviation Low intensity	Standard deviation High intensity
-10	-0.00063	ns	0.00023	ns	0.00086	ns	-0.00063	0.00023	0.00086	0.01950	0.01871
-9	-0.00154	ns	0.00067	ns	0.00222	ns	-0.00217	0.00090	0.00307	0.01892	0.01800
-8	0.00371	ns	0.00144	ns	-0.00226	ns	0.00154	0.00234	0.00081	0.02158	0.02511
-7	0.00395	ns	-0.00109	ns	-0.00504	ns	0.00548	0.00126	-0.00423	0.03235	0.01789
-6	0.00181	ns	-0.00200	**	-0.00381	**	0.00729	-0.00075	-0.00804	0.01882	0.01863
-5	0.00206	ns	0.00068	ns	-0.00139	ns	0.00936	-0.00007	-0.00943	0.01709	0.01822
-4	-0.00012	ns	-0.00071	ns	-0.00059	ns	0.00923	-0.00078	-0.01001	0.03186	0.02479
-3	-0.00212	ns	-0.00024	ns	0.00187	ns	0.00712	-0.00102	-0.00814	0.01706	0.01925
-2	0.00169	ns	-0.00052	ns	-0.00222	ns	0.00881	-0.00155	-0.01036	0.01700	0.01996
-1	0.00538	*	0.00035	ns	-0.00504	*	0.01419	-0.00120	-0.01539	0.02517	0.01693
0	-0.00022	ns	-0.00277	*	-0.00255	*	0.01398	-0.00397	-0.01795	0.03804	0.03248
1	-0.00012	ns	-0.00095	ns	-0.00083	ns	0.01386	-0.00492	-0.01878	0.02155	0.02315
2	0.00085	ns	0.00018	ns	-0.00067	ns	0.01471	-0.00474	-0.01945	0.01798	0.01895
3	0.00067	ns	0.00174	*	0.00108	*	0.01538	-0.00300	-0.01837	0.01404	0.01912
4	-0.00037	ns	0.00025	ns	0.00062	ns	0.01500	-0.00275	-0.01775	0.01837	0.01914
5	-0.00320	ns	0.00066	ns	0.00386	ns	0.01180	-0.00209	-0.01389	0.01841	0.01811
6	0.00214	ns	0.00153	*	-0.00061	*	0.01394	-0.00056	-0.01450	0.01566	0.01675
7	0.00245	ns	-0.00026	ns	-0.00270	ns	0.01639	-0.00082	-0.01720	0.01893	0.01752
8	0.00061	ns	0.00005	ns	-0.00056	ns	0.01700	-0.00077	-0.01777	0.01519	0.01873
9	-0.00238	ns	0.00181	ns	0.00420	ns	0.01461	0.00105	-0.01357	0.01556	0.02436
10	-0.00109	ns	-0.00187	*	-0.00078	*	0.01352	-0.00082	-0.01435	0.01945	0.01796

Variable definitions. Signed excess return = absolute value of daily stock return inclusive of dividends for trading day t in excess of the day t return on the *CRSP* value-weighted market index, 8-K = climate change disclosure on day 0 = filing date, High intensity = GHGE/*revt* greater than median in CDP year, otherwise low intensity. Standard deviation = standard deviation of signed excess return for event day t. Tests of significance are whether the mean or difference in the mean of the two preceding columns is zero under a two-tailed test: *** = less than .001, ** = less than .01, * = less than .10, ns = not significant.

Table 5: Regression of cost of capital proxy on GHG emission intensity and control variables

Cost of capital	Rank of cost of capital per analysts' forecasts				Rank of cost of capital per CRSP beta			
Controls	No industry controls		Industry controls		No industry controls		Industry controls	
Variable	Coefficient	Signif.	Coefficient	Signif.	Coefficient	Signif.	Coefficient	Signif.
Intercept	2.9937	***	2.0462	***	4.0462	***	2.1419	***
Country	0.4670	***	0.6028	***	-0.2224	**	0.0500	ns
CDLI	-0.0026	ns	-0.0009	ns	-0.0054	**	-0.0022	ns
GHGE	-0.0866	**	-0.0044	ns	-0.1967	***	-0.0506	ns
Consumer Discret.			0.5456	**			1.2733	***
Consumer Staple			-0.2273	ns			-0.1836	ns
Energy			0.3991	*			0.9224	***
Financials			0.6106	**			1.4983	***
Health Care			0.0200	ns			0.2033	ns
Industrials			0.5323	**			1.1708	***
Info Technology			1.1724	***			1.9852	***
Materials			0.6558	***			1.3562	***
Telecommunications			0.7165	*			1.2077	***
Adjusted R^2	2.5%		8.7%		3.9%		22.6%	
No. of observations	1,539		1,539		2,057		2,057	

Variable definitions. Rank of capital per analysts' forecasts = quintile rank of cost of capital from a simple valuation model based on market price at fiscal end-of-year plus three months (*p*), five-year expected earnings growth from IBES (*g*), and earnings per share = *epspx*, where estimated $r = ((epspx \div p) + g)$, rank of cost of capital per CRSP beta = quintile rank of CRSP beta , Country = 1 if S&P 500, otherwise 0, CDLI = actual or estimated CDP Disclosure Leadership Index, and GHGE = 1 for GHGE/*revt* greater than median in CDP year, otherwise 0. Tests of significance are whether the regression coefficient is zero under a two-tailed test: *** = less than .001, ** = less than .01, * = less than .10, ns = not significant.