THE UNIVERSITY OF
NEW SOUTH WALES

School of Accounting

Seminar – Session 2, 2011

The Relevance to Investors of Greenhouse Gas Emission Disclosures

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Date: **Friday 21st October**
Time: **3:00 to 4:30 pm**
Venue: **ASB130**

The Relevance to Investors of Greenhouse Gas Emission Disclosures

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October 3, 2011.

We thank Shannon Anderson, Mike Bradbury, Steve Cahan, Scott Chaput, Peter Clarkson, Nina Dorata, Roger Edelen, David Hay, Gordon Richardson, and a reviewer for the American Accounting National Meetings, Denver, for their comments. This paper also incorporates the comments from presentations at the University of California, Davis, the University of Otago, and the Auckland Business School 2011 Quantitative Accounting Research Symposium. Comments welcome. Version of October 3, 2011.

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Abstract

This study documents that investors care about companies' greenhouse gas (GHG) emission disclosures. Three kinds of evidence support this finding. First, using companies that disclose GHG emissions voluntarily through the Carbon Disclosure Project (CDP), we show that investors act as if they use GHG emission information to assess company value. Second, our evidence finds that investors view *estimates* of non-disclosed GHG emission amounts as value relevant, suggesting that stock prices reflect GHG information from channels other than CDP disclosure. Third, we conduct an event study and observe a significant stock market response when companies disclose climate change information in an 8-K filing. Our results strengthen for GHG-intensive industries such as utilities, energy, and materials companies, whose valuation effects are more negative. Economically, our results suggest that for every ton of GHG emitted by the median company in our sample at an assumed cost of $20 per ton, the stock market recognizes about 35-50 percent of that amount as an off-balance sheet liability.

JEL Classification: G14, M41, M45, K22, Q20.

Keywords: Greenhouse gas emissions, investor relevance, climate change reporting, S&P 500 companies, TSE 200 companies, U.S. and Canadian disclosure regulations, EPA Rule 40 CFR Part 98, stock market impact, event study.

The Relevance to Investors of Greenhouse Gas Emission Disclosures

1 Introduction

Companies today face a daunting challenge of what and how much to disclose publicly about the risks and costs of climate change. On the one hand, investors and public interest groups worldwide call for more disclosure, greater uniformity, and more transparency. Companies and insurers, on the other hand, worry about the costs of disclosure, particularly from competitive disadvantage and liability exposure, and press for a more balanced consideration of the costs and benefits. 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 investors' reassessment of stock price conditional on the total mix of available information. As explained 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 laws on climate change and environmental issues.

We focus our investigation on greenhouse gas (GHG) emission disclosures, which many companies now reveal voluntarily, in response to the needs of investors and analysts. We further restrict our analysis to S&P 500 and Toronto Stock Exchange (TSE) 200 companies to assess the relevance of carbon emissions for large companies in two environments. As evidence of investor relevance, we find that (1) investors care about GHG emissions in assessing company value and (2) GHG emission information in a company press release or 8-K filing elicits a significant price and trading reaction around the day of the report as investors update their expectations. We further find that investors' valuations and responses differ on the basis of GHG emission intensity, where higher intensity associates negatively with stock price and news response. Our valuation results are also economically interpretable. We calculate that for every ton of GHG emitted by the median company in our sample at an assumed cost of $20 per ton, the stock market recognizes about 35-50 percent of that amount as an off-balance sheet liability.

In addition, we estimate GHG emissions for S&P 500 and TSE 200 companies that do not report GHG emissions and control for possible sample selection bias. We find that estimated GHGs also relate to market prices in much the same manner as disclosed GHGs. This suggests that stock prices reflect GHG information irrespective of whether the company makes a formal disclosure. This is central to the debate because it implies that non-disclosers' stock prices are not devoid of GHG information, contrary to the beliefs of some advocates who contend capital markets need full disclosure to solve an information deficiency.[1] Advocates' and regulators' proposals that focus on full disclosure rather than *incremental* information relative to the total mix might also be

[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).

economically wasteful in the context of market efficiency.

These results add to the literature in several unique ways. First, we extend earlier results on the market pricing of environmental obligations by focusing on the market's off-balance sheet recognition of GHG emission obligations, now even more relevant to company disclosure policy because of the legal standing of emissions and climate change in *Massachusetts v. EPA* (127 Sup. Ct. 1438,1440). Second, we extend a nascent empirical literature on the value relevance of GHG emissions to investors by documenting predictable valuation and disclosure effects for GHG discloser and non-discloser companies in two economic environments (the United States and Canada). We use a research design that exploits variation in emissions cross-sectionally and temporally, and we use an event study approach to measure short-term announcement effects. Our dual approach produces reliable evidence across the two perspectives in support of our hypotheses. Third, our results should also be important for evolving regulatory guidance on what companies should disclose to investors about GHG emissions and climate change in that we document investor relevance for such disclosures.[2]

Our paper continues as follows. Section 2 discusses key features of the institutional

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[2] Although investor relevance (an economic concept) does not equate to materiality (a legal concept), courts have often viewed a statistically significant stock price adjustment reliably attributable to a disclosure as dispositive in testing for materiality, and in some instances courts have wed the two concepts on pragmatic grounds. As such, our results should also be of interest to companies and regulators about whether GHG information might be ex ante material. 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. 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).

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 disclose GHG emissions voluntarily through the Carbon Disclosure Project (CDP), a U.K. organization representing mostly institutional investors. CDP works with large companies worldwide to measure and manage their emissions and climate change strategies and collects and publishes emissions data as part of its annual surveys. Companies may decline to participate or simply not reply, but CDP tracks such indications so that each survey covers a well-defined sample, such as the S&P 500 or TSE 200. The proportion of companies in our 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[3] doubtlessly account for some of this growth, but company incentives may also be a factor if investors view nonparticipation negatively. Required disclosure is also a reality for

[3] For example, Ceres' Web site (www.ceres.org) states as its mission "integrating sustainability into capital markets for the health of the planet and its people." 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).

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 will apply to large U.S. emitters following implementation in 2011.[4]

Rather than set forth specific rules for measuring and disclosing climate change risk, U.S. and Canadian securities regulators have, thus far, issued guidance releases only on their existing disclosure frameworks. In the United States, Release 33-9106 (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 include 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.

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[4] Also, 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 General of the State of New York 2008a, 2008b). In addition, California recently approved a cap-and-trade plan with mandatory GHG reporting beginning in 2011 for entities emitting more than 25,000 tons of GHG annually (California Air Resources Board 2010).

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 potentially material but not necessarily sufficient from a rule-making perspective.

While our evidence 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 items might note the evidence in this study about non-discloser companies, which suggests that climate change information may be telegraphed to investors through channels other than CDP disclosure.

2.2 Prior research

The most relevant prior literature relates to work on the valuation effects of environmental disclosures.[5] The categories studied include examination 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 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 have valuation relevance for investors (Hughes 2000, Johnston et al. 2008), and whether investors find carbon emissions as value relevant (Chapple et al. 2011, Matsumura et al. 2011).

These studies also provide a basis for our primary research expectation of a negative relation between GHG emissions and stock price. We reason that higher emissions will drain more cash flow from the company in the form of higher future compliance, abatement, regulatory, and tax costs not already reflected in the market's assessments of reported earnings and shareholders' equity (and other control variables in our model). We also predict a negative relation between GHG emissions and stock price in light of the additional risk from regulatory and enforcement uncertainty, which should also be increasing in emissions.[6]

Two studies relate directly to the present analysis. Chapple et al. (2011) study 58 Australian

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[5] This review is intended to highlight relevant studies rather than comprehensively summarize the empirical literature.

[6] Bauer and Hann (2010) add political risk as another factor in the calculus of a relation between stock price and GHG emissions. "In view of the persistent media coverage and public pressure on policy makers to implement environmental reforms, state and federal governments are expected to eventually respond by more rigorously enforcing existing environmental regulations, imposing more stringent regulations, and introducing more severe criminal and civil penalties for polluters." (p.6).

disclosures and find that a dichotomous emissions variable (one for high carbon intensity, zero otherwise) associates negatively with stock price. Matsumura et al. (2011) examine 549 CDP disclosures by S&P 500 discloser companies over the period 2006-2008 and find that higher carbon emissions associate with lower market value. While these two studies offer some initial findings on valuation effects, our study benefits from several design enhancements to expand our knowledge of how investors view emission disclosures. We examine larger samples of CDP disclosures, comprising four years of data for U.S. companies and five years for Canadian companies. We investigate the valuation effects of non-CDP disclosers by estimating GHG emissions for such companies and by assessing whether the self-selected nature of CDP disclosers makes a difference to the results. We control for disclosure quality and other off-balance sheet disclosures affecting valuation such as leases and pensions, as these factors could affect the prior results as omitted variables. We also examine the consistency of our evidence across two research approaches – a valuation analysis and an event study – and subject our results to an array of robustness tests.[7]

3 Data, sample, and research design

3.1 Data and sample

We use GHG emission and disclosure quality data from the CDP for the S&P 500 for CDP reporting years 2006-2009 and the TSE 200 for CDP reporting years 2005-2009.[8] We select large

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[7] See, also, note 31.

[8] The TSE sample includes some additional (smaller) companies over the 2005-2008 period. 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.

U.S. and Canadian companies as these should be of most interest regarding the effects of climate change. They also share similar disclosure incentives (section 2) but may differ on the basis of emission intensity and disclosure quality. We extract three fields of emission data from the CDP surveys, namely, direct (scope 1, direct), indirect (scope 2, indirect energy), and other (scope 3, indirect other) and combine these data into a single GHG emission measure.[9] We also extract the Carbon Disclosure Leadership Index (CDLI) score as a proxy of disclosure quality.[10] We combine these data with information from *CRSP*, *Compustat*, and *IBES* to provide a basis for the descriptive statistics (this section) and the valuation and event studies (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 greenhouse gas emission (hereafter, GHGE) response rates have increased for both samples, from a combined 30.4 percent in 2006 to 46.4 percent in 2009, with the S&P rates higher for most years. Panel B reveals that utilities have the overall highest GHGE response rate 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,

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[9] We combine the three GHG measures as a single amount because not all companies provide a breakdown of scope 1 (direct) and scope 2 and 3 (indirect) emissions. Where possible, our GHG prediction model (model 1) estimates direct and indirect emissions for non-disclosers separately and then combines them into a single amount.

[10] 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).

whereas the Canadian economy dominates in energy and materials. Unreported 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 research design.

3.2 Research design

3.2.1 GHGE prediction model

The first stage predicts GHGE for those companies not disclosing emissions to the CDP – more than one-half of the companies surveyed according to table 1. We generate a prediction of 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.[11] Our model, without subscripts i and fiscal year t for company and year, is:

$$\text{logGHGE} = \alpha_0 + \alpha_1\text{SECT} + \alpha_2\text{logREVT} + \alpha_3\text{logCAPX} + \alpha_4\text{logINTAN} + \alpha_5\text{GMAR} + \alpha_6\text{LEVG} + \varepsilon, \quad (1)$$

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*), log = log to base *e*, and ε =

[11] We check in section 5.1 if the use of the GHGE amounts of CDP disclosers to model and predict the GHGE amounts of non-disclosers might result in biased predictions.

random error.[12] We use a logarithmic model as skewness in the distributions of GHGE, REVT, CAPX, and INTAN would 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 more intangible assets should emit fewer emissions. We are uncertain about the signs of α_5 and α_6. For instance, a negative sign for α_6 might suggest that higher debt companies emit fewer emissions through creditors' monitoring activities, whereas α_6 could be positive if some highly-levered companies are larger and generate more GHGE. Our estimation approach increases sample size from 1,083 actual to a maximum of 2,917 actual and predicted GHG observations.[13]

Where available, we estimate model 1 for direct and indirect emissions separately (otherwise as a combined amount) as a pooled cross-sectional regression over *i* companies in each country reporting emission data to the CDP for years up to and including prediction year *t*. We then combine the separate predictions of direct and indirect emissions to predict total emissions. 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 the 2006-2008 period. We combine the separate predictions of direct and indirect GHG emissions as different industries incur different levels of direct and indirect emissions. For example, utilities generate more direct emissions (through energy production), whereas consumer- or manufacturing-based industries often generate more indirect

[12] For financial companies, we arbitrarily set net sales revenue equal to net interest income (if available), and gross margin to zero. These assumptions do not affect the overall results.

[13] We compare the actual and predicted signs of the coefficients not as a test of an explanatory model but, simply, to assess the reasonableness of the model's predictions.

emissions (through energy use). This model has an overall adjusted R^2 of 60 percent, with the sector dummy variables contributing 37.6 percent to that amount.[14]

3.2.2 Residual income valuation model

We use the residual income 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 ($CVCE_t$), 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 control variables representing disclosure quality, country, and off-balance sheet items such as operating leases and pensions.[15] Operating leases and pension obligations are similar to GHG emissions in that they are off-balance sheet liabilities that have valuation impact. We measure off-balance sheet financing through operating leases as the change in the present value of future non-cancelable operating lease obligations (Ge 2007, Dechow et al. 2011). We measure pension obligation using the expected return on defined benefit pension plans, denoted as *ppror* in *Compustat*. Our price model, omitting company subscript i, is:

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

Barth and Clinch (2009) show a share-deflated specification of model 2 works well under

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[14] We also confirm the reasonableness of model 1 by determining the extent to which the GHGE observations assigned to deciles using the CDF survey amounts remain in the same deciles based on the GHGE amounts from the prediction model. On average, approximately 33% remain in the same deciles, and about 90% remain in the adjacent deciles (the one above and the one below the expected decile).

[15] 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.

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 CVCE (β_1>0) and RESI (β_2>0). We also predict a negative coefficient for GHGE (β_3<0) assuming that higher emission amounts impose increased *future* costs on the company not in CVCE or RESI to mitigate emission output either through future investment policy, carbon reduction legislation, or both, which translate into a lower stock price at t. Section 4 discusses different specifications of the variables such as the measurement date for PRCC, 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, often 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 some earlier work (Blacconiere and Northcut 1997, Chapple et al. 2011), we focus on investors' response to a large sample of company news releases on climate change over several days surrounding each event.

We select news items in 8-K reports that relate to climate change, since companies through the act of a filing deem these news events as ex ante material.[16] Under SEC rules, an 8-K report must

[16] 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.

be filed within four days of the 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 includes all material items relating to financial statements not disclosed elsewhere.[17] The 8-K climate change reports we study are ideal for an event study since they distribute well over the study period, do not cluster around common dates, relate to one or more 8-K items that we can pinpoint to a day with precision, and relate to trading by investors in efficient markets because we study large companies listed on the NYSE, TSE, and NASDAQ exchanges.

We use *DirectEDGAR* to identify all 8-Ks during the period from January 1, 2005 to January 1, 2010 containing the following terms or phrases: carbon and emission, carbon and climate, emission and climate, greenhouse, and climate change. This search produces 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, we obtain a final sample of 1,984 8-K filings of which 1,728 contain a press release.[18] Inspection of these 8-Ks, however, reveals mentions of the key words that do not

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

[18] The extent of GHG emission disclosure and climate change information varies in these 1,984 8-K climate change 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).

indicate specific climate change information but relate more to phrases about climate change risks and uncertainties associated with forward-looking information disclaimers, often at the bottom of a press release. We therefore split the 1,984 observations into two groups, 1,059 8-Ks with climate change-specific information and 925 with non-specific climate change information, with the expectation that the results should be more conservative for the full sample versus the climate change-specific sub-sample.[19] For each of these filings, we also use *DirectEDGAR* to identify the 8-K item numbers, as this enables us to separate climate change 8-Ks with earnings information (item 2 and item 9 disclosures) from those without earnings information.

Our event study model examines the significance of investor response, $RESP_t$, for t = -10 to 10, where t=0 is the 8-K filing day. We initially 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 (times 50 percent if a NASDAQ company to account for interdealer trading) divided by common shares outstanding at trading day t, $TRAD_t$. We test initially whether $RESP_t$ at t = 0 exceeds $RESP_t$ on the other days. This establishes whether investors respond to a climate change disclosure when they should, that is, on the 8-K filing date.

We also merge our 8-K sample with the sample used in model 2, which tests for a relation

[19] We code "non-specific climate change information" if *DirectEDGAR* identifies the search terms as part of a company disclaimer, forward-looking statement, or a synopsis about the company. We acknowledge the arbitrary nature of this coding.

between stock price and actual or estimated GHGE.[20] This enables us to estimate model 3 below, which regresses $RESP_t$ ($XRET_t$ or $TRAD_t$) on eight variables common to all event days (t=-10 to 10) and six variables that interact six of the common variables with the response on a particular event day, such as t=0. The first set comprises the following: whether the 8-K contains earnings information as per item 2 and item 9 disclosures (EARN=1 if item 2 or 9, otherwise 0), GHGE intensity for prior year (GHGE/(*revt**1,000), hereafter, GHGI), company size for prior year (SIZE=log*revt*), disclosure quality for prior year (CDLI), S&P 500 or TSE 200 company (USAC=1 if U.S. company, otherwise 0), whether GHGE disclosed to the CDP (DSCL=1 if disclosed, otherwise 0), and *CRSP* beta for prior year (RISK). The second set interacts event day t ($EVTD_t$) with EARN, GHGI, SIZE, CDLI, USAC, and DSCL. The model is:

$$RESP_t = \eta_0 + \eta_1 EARN_{t-1} + \eta_2 GHGI_{t-1} + \eta_3 SIZE_{t-1} + \eta_4 CDLI_{t-1} + \eta_5 USAC + \eta_6 DSCL_{t-1} + \eta_7 RISK_{t-1} + \eta_8 EVTD_t.EARN_{t-1} + \eta_9 EVTD_t.GHGI_{t-1} + \eta_{10} EVTD_t.SIZE_t + \eta_{11} EVTD_t.CDLI_{t-1} + \eta_{12} EVTD_t.USAC + \eta_{13} EVTD_t.DSCL_{t-1} + \varepsilon_t, \quad (3)$$

where we regress $RESP_t$ for each of days -10 to 10 and event days -1 to 1 on the common and event day-specific independent variables. For example, when we define $EVTD_t$ =1 for day 0 and zero otherwise, the coefficient η_8 in model 3 tests whether the investor response to an 8-K with earnings news on day 0 (versus no earnings news on day 0) differs on day 0 versus days ˉ10 to 10 (excluding day 0). When we define $EVTD_t$ as another event day, say, EVTD=1 for event day $t \neq 0$, model 3

[20] This merge results in 714 (373) 8-K filings out of a total of 1,984 filings (1,059 climate change specific filings), of which 358 (149) relate to high GHGE intensity companies based on actual or estimated CDP emissions data.

tests whether the response to an 8-K with earnings news on day 0 differs on day t versus days -10 to 10 excluding day t. Following prior research, we expect η_3<0, η_5<0, and η_6<0 for all event days t, as return and trading volatility generally decrease for larger companies, which also tend to be U.S. companies and those that report to the CDP. In addition, we expect η_7>0 as investors respond more to riskier companies in general. We are unsure of the sign of CDLI, in that higher quality disclosure could elicit more (η_4>0) or less (η_4<0) investor interest. We predict η_1=0 for events day t≠0, since only at t=0 do some of the climate change 8-K filings contain earnings information.

Regarding the coefficient for GHGI, as a general effect, we expect η_2<0 for t = -10 to 10, as higher GHGE intensive companies tend to represent utilities, energy, and materials companies, which also tend to be larger and less risky than the rest of the sample. Of more interest from an investor perspective, however, are the expected signs of the coefficients on event day 0 when investors receive 8-K information about climate change. We test formally for these effects using five interaction variables as per model 3. We expect the following coefficient signs: η_8>0, as there should be more interest when a climate change 8-K also contains earnings information; η_{11}<0 and η_{13}<0 as these coefficients should reflect a lower response to higher disclosure quality as per CDLI and DSCL, respectively; and η_{10}<0 to reflect a larger U.S. company.

Regarding the coefficient for $EVTD_t$.GHGI (η_9), if investors condition their response to climate change news on event day 0, then we should observe $\eta_9 \neq 0$, after controlling for the other variables in model 3. We are unsure of the *sign* of η_9, however, since it could reflect offsetting effects. On the one hand, we might expect η_9< 0 because climate change news for a low GHGE intensity company surprises the market more. That is, for a low (high) GHGE intensity company, the market expects less (more) news about climate change, so that when a low GHGE intensity company makes a disclosure, it is a more price-sensitive event. Alternatively, investors might simply react more to high GHGE intensity, regardless of expectations, so we might expect $\eta_9 > 0$.

We also test for investor response based on signed excess return and posit that the mean signed excess return around 8-K filing date varies negatively conditional on GHGE intensity. We posit a negative relation as GHGE intensity (GHGE in relation to sales) is a variable that many companies seek to minimize or reduce as part of their sustainability efforts.

4 Results

4.1 Descriptive statistics

First, table 2, panel A, summarizes the variables used in model 1. Discloser companies differ from non-discloser companies in terms of the size of operations (logREVT) and investment (logCAPEX), 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. 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 (LEVG). Panel A further shows that, apart from scale, the sectors rank identically on GHGE 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 but, also, to compare 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 and 3. 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 higher for the non-discloser group. The same holds for emission intensity (GHGE/(*revt**1000)), 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 revenues specification means that heterogeneity affects our regression estimates less, within each discloser sector and across the sectors, which can degrade estimates' reliability (Barth and Clinch 2009).

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 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 sectors and discloser groups also suggests that the companies we analyze face a mix of economic circumstances unrelated to the effects of carbon emissions.

4.2 Residual income model regressions

Table 3 summarizes the tests of model 2. Each panel shows 13 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 (GHGE intensive companies) and regressions 8 and 9 (non-GHGE intensive companies). Some regressions test model 2 without controls (regression 1), whereas others include one or more controls, depending on the sample. We also show two panels of tests, where panel A assumes PRCC three months after fiscal year end (PRCC_Q5) and panel B assumes PRCC at end of the CDP release month (PRCC_CDP). We use two observation dates for PRCC because we are unsure when investors update their price expectations. While some company insiders may have GHGE information three months after balance date, such information is not disclosed publicly until release of the CDP survey, usually in September-October of the succeeding year. We also estimated each of the regressions in panels A and B for residual income based on analysts' forecasts.[21]

We summarize the results by focusing on panel A, noting differences to panel B where appropriate. First, we observe results consistent with the prior literature (section 3.2.2). The coefficients on CVCE and RESI are positive and significant, and the β_1 and β_2 coefficients on

[21] Residual income based on analysts' forecasts = *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.

CVCE and RESI approximate one and three, respectively.[22] The control variables also accord with expectations. The coefficient on change in operating leases is positive, suggesting that an increase in operating leases increases PRCC, since we expect additional leases to 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 value by lowering future pension costs. Our proxy for disclosure quality, actual or estimated CDLI[23], shows a mixed result across panels A and B. On the other hand, if information quality were priced by investors as a risk factor we would expect a positive coefficient (Akins et al. 2011, Armstrong et al. 2011).

Second, we report negative β_3 coefficients for GHGE per share for each of the 13 regressions, all of which are significant as direct or interaction effects. This result holds for both 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 intensive versus non-GHGE intensive companies[24] (regressions 6 and 8), which suggests that the valuation relevance of emission information may depend on a measure of GHGE intensity.

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 noted earlier, investors in an efficient market

[22] All regression coefficient test statistics adjust for heterogeneity using the White (1980) estimator.

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

[24] For this tests, we classify a company as high or low GHGE intensity based on whether the company belongs to a high or low GHGE intensity industry. High GHG industries cover the utilities, energy, material, consumer discretionary, and industrials sectors.

should use the total mix of available information to establish price, not only including CDP information but, also, information from other channels, for example, Maplecroft, the Corporate Social Responsibility wire service, company sustainability reports, and 8-K filings. Regressions 10-13 report the results for GHG-intensive companies only, as investors in these companies view emissions as a negative valuation driver. With one exception, these regressions show GHGE as a significant negative 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 is what one would expect in an efficient market.[25]

To summarize, table 3 shows three key results: one, that investors view greenhouse gas emissions as a significant negative valuation driver; two, that the valuation effects are more negative for GHGE-intensive companies; and, three, that a negative valuation effect occurs regardless of whether or not the company discloses to the CDP. Thus, in line with our research expectation, our evidence indicates that investors price stocks as if higher GHG emissions impose an additional off-balance sheet liability (not already reflected in the market's assessments of reported earnings and shareholders' equity). This off-balance sheet amount reflects investors' assessment of the additional expenditures or uncertainties regarding company responsibilities for climate change and/or as increased cash outflows from future compliance, abatement, regulatory, and tax costs not captured by the accounting statements.

[25] We also examine (section 5.1) whether selection bias might affect a valuation analysis based on the GHGE amounts reported by CDP disclosers, namely, whether the GHGE amounts for CDP-discloser companies might reflect other company attributes that explain stock price, the omission of which could have influenced our estimates of the valuation effects of GHGE in table 3.

4.3 Event study

4.3.1 Unsigned excess return and adjusted volume

Table 4 presents the results about whether investors respond to climate change news announcements. Panel A shows mean unsigned excess return and mean adjusted volume for different partitions of the 1,984 observation sample from day -10 to 10 relative to day 0, where day 0 is the climate change 8-K filing date. 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 (times 50 percent for a NASDAQ company to account for interdealer trading) divided by common shares outstanding at day t. We set the 8-K filing date as the day of initial public release the climate change news. In a separate analysis, we also align excess return to the 8-K conform date to 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. Under present SEC rules (SEC 2004), a company must file an 8-K within four days of the conform date.

Panel A shows two main results. First, 8-K filings with a press release exhibit (8-K and PR) (1,728 observations) and first 8-K filings when a company files several over the study period (First 8-K) (781 observations) show significantly higher mean unsigned excess return on day 0 versus other days. The last row of panel A shows that we can reject the hypothesis for all partitions that mean unsigned excess return at t=0 equals the mean response for the other days in favor of a higher amount.[26] Panel A of figure 1 graphs columns 2 and 3 of table 4, panel A, and clearly shows a

[26] We also replicate panel A of table 4 for 1,059 (925) 8-K filings with (without) climate-specific information, as per our discussion in sub-section 3.2.3. Unreported analysis finds a stronger response on day 0 for the

spike on day 0. Second, both groups indicate significantly higher mean adjusted volume on day 0. All eight means are highest at t=0 versus the mean for the other days. The unsigned excess return and adjusted trading responses around t=0 for the first 8-K and subsequent 8-K groups, however, are not significantly different from each other, suggesting that investors view each 8-K filing as uniquely informative.

We further check each filing by focusing on the number of item disclosures in an 8-K, as an 8-K is not restricted to a single item. When we restrict the analysis to single-item 8-Ks (climate change disclosures and nothing else), 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) and this does not appear to be subsumed by earnings or other information. This makes it unlikely that investors would be responding to news unrelated to a climate change disclosure. Also, because the company files an 8-K report, we can reasonably assume that the company perceived the climate change news 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 second analysis exploits not just the timing of the disclosure (panel A) but, also, whether investors might condition their response at t=0 on a climate change factor that varies across the sample. As before, we choose GHGE intensity as the conditioning variable for our event study,

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former group. We also repeat the analysis in panel A restricted to a sample to 1,436 8-K filings that do not contain earnings disclosures by excluding 8-Ks with references to earnings, profits, or net income. Even though earnings disclosures make up 27.6 percent of the 8-K sample, these results are qualitatively equivalent to those in panel A of table 4.

defined as high depending on whether a company's GHGE/*revt* exceeds it sector median in a CDP year. We use model 3 to test this notion, and calculate GHGE intensity response coefficients in the same way that previous research has used earnings response coefficients to capture differential reaction to earnings announcements (Collins and Kothari 1989). We estimate model 3 for the CDP sample used in the residual income regressions (model 2), as we have actual or estimated GHGE intensity and disclosure quality (CDLI) measures for this sample.

Panel B of table 4 shows the results of estimating model 3 for event day (EVTD) 0 and days -1 to 1. We also estimate model 3 excluding EARN and EVTD.EARN as independent variables; that is, we estimate separate regressions for climate change 8-K disclosures with and without earnings information. We focus on event day 0 to summarize the results (column 2). We first note that EARN has an insignificant coefficient (η_1=0.0386), whereas the EVTD.EARN coefficient is positive and significant (η_8=1.2827). In other words, as per the prior literature, investors respond to an 8-K with earnings news on day 0 but not on days without earnings news.

We are most interested, however, in investors' response to GHGE on day 0. For this variable (EVTD.GHGI), we observe a significantly negative coefficient (η_9=-0.4750). This indicates that investors respond negatively on day 0 conditional on GHGE intensity, where this response is incremental to the average effect of GHGI over days -10 to 10 as per the η_2 coefficient. The η_9 coefficient is also significantly negative for days -1 to 1. The η_9 coefficient is also significantly negative for the EARN=1 sub-sample but not for the EARN=0 sub-sample. In other words, investors respond at t=0 differently conditional on GHGI and whether the 8-K climate change disclosure also contains earnings news, although we observe negative EVTD.GHGI coefficients in all cases. We reasoned earlier why we should see a significant coefficient for EVTD.GHGI at t=0, namely, because investors respond to information relative to expectations, which depend on the quality, mix, and totality of all news events about climate change. Since investors naturally demand more (less) information about climate change effects for GHGE intensive (non-GHGE intensive) companies, those expectations are better (less well) formed, regardless of the information channel – from the company, CDP, or elsewhere. Relative to expectations, then, we expect news releases for non-GHGE intensive companies to elicit more response, as the news is more of a surprise. Our evidence of a negative GHG intensity response coefficient is consistent with this explanation. Only if investors were to rely myopically on CDP information and equate higher GHGE intensity to more extreme news or uncertainty, might we expect a positive GHGE intensity response coefficient, but this not what we find. Our regression analysis controls for disclosure quality (CDLI), so quality differences unlikely explain the result.

The unsigned return regressions in section 1 of panel B show four other interaction effects. A majority of the interactions are not significant for day 0 and days -1 or 1. It makes no difference, for example, whether the company disclosed or did not disclose to the CDP (EVTD.DSCL). We also find similar results for adjusted volume. For example, for event day 0, the EVTD.EARN coefficient is positive and significant (η_8=7.0036), and we observe a significantly negative coefficient for EVTD.GHGI (η_9=-3.0331). The coefficient for EVTD.GHGI is also significantly negative for the EARN=1 sub-sample, indicating that investors condition their trading response to a climate change 8-K on GHGE intensity and whether the 8-K contains earnings information. We also estimate model 3 for each of days -10 to 10. Unreported analysis shows that the η_9 coefficients for EVDT.GHGI (times 100) over event days -10 to 10 dip significantly on day 0. Yet we observe nothing unusual about the η_9 coefficients on the other days. In sum, GHGE intensity is one factor that drives investor response on day 0 differently from the response on the other days, after controlling for the other factors in the model. GHGE intensity is a unique climate change factor that varies across the sample on day 0.

4.3.2 Signed excess return

To test whether signed excess return varies with 8-K climate change news, we condition signed excess return on GHGE intensive and non-intensive companies. Panel C of table 4 presents the results for the CDP sample used to test model 2 (with actual or estimated GHGE). For each of days -10 to 10, we report the mean signed excess return for each partition, the difference in mean excess return for high minus low GHGE intensive companies, the cumulative mean excess return, cumulative difference in mean excess return, and the standard deviation of excess return for each group. First, we observe a more negative response for high GHGE intensive companies over days -10 to -1 relative to low GHGE intensive companies. Second, we find that the cumulative difference in mean excess return (high GHGE minus low GHGE) is significant from t=-6 to t=1, indicating a significant separation in mean excess return for high GHGE versus low GHGE companies around the news announcement date. Panel B of figure 1 illustrates this negative trend in mean excess return difference around day 0. Hence, from a timing standpoint, investors respond negatively to 8-K news conditional on high GHGE intensity precisely when they should, that is, around the day of release of new climate change information. Unreported analysis shows that this result holds approximately equally for CDP disclosers and CDP non-disclosers and is unchanged when we analyze the sub-sample of climate change-specific 8-K disclosures (section 3.2.3).

The results for signed excess return also agree with those documented earlier. For instance, panel A of table 4 shows a mean response on day 0 for both high and low GHGE intensity companies that is greater in absolute magnitude for the latter group. This parallels with the signed excess return results in that panel C of table 4 shows the standard deviation of the low GHGE intensity group also exceeds that of the high GHGE intensity group, particularly over days -1 to 1 when investors receive the new climate change information. We also examine the results in panel C of table 4 for the same partitions as in panel A of table 4, with no major differences in the results. The event study results in table 4, panel C, also parallel with the valuation results in table 3, in that we find more negative announcement effects (based on signed excess return) for GHGE intensive companies and less negative announcement effects for non-GHGE intensive companies.

5 Additional analysis

5.1 Sample selection bias

Because companies respond to the CDP survey voluntarily, the GHGE amounts for CDP-disclosers could also reflect other company factors that explain stock price, the omission of which could produce an inconsistent estimate of the GHGE coefficient in model 2. The prediction of

GHGE for non-discloser companies could also be affected, as model 1 predicts GHGE for non-discloser companies based on discloser-company coefficients. While our analysis so far suggests that the GHGE valuation effects do not differ appreciably for CDP disclosers and non-disclosers, we address this issue further by using the two-stage Heckman (1979) approach, which derives an alternative estimator of the GHGE coefficient. The first stage estimates the likelihood of disclosure based on a selection model, and the second stage includes a transformation of that likelihood (the inverse Mills ratio or IMR) as an additional variable in the valuation regression (model 2). We test the null hypothesis that the IMR coefficient is not significantly different from zero, in other words, that companies' decision to disclose to the CDP does not significantly affect the coefficients under model 2, versus the alternative that disclosure matters. We model the disclosure decision as a function of book-to-market ratio (*btm*), leverage (*dltt/at*), and dummy variables (one for the condition, zero otherwise) for previous CDP disclosure, other (non-mandated) channel of emission disclosure, and industry sector. We include the "other channel" variable to indicate whether a non-CDP discloser company in our sample uses other channels for emissions disclosure because the use of other channels suggests that a non-CDP discloser may have made a decision to disclose elsewhere. If an S&P 500 or TSE 200 company chooses another channel, this could attenuate the effects of selection bias, because a non-CDP discloser that discloses elsewhere could have the same characteristics as a CDP discloser. We define our proxy for other channel as a dummy variable equal to one if the company was covered by Maplecroft,[27] California Climate Action Registry,[28]

[27] http://maplecroft.com

EPA, or Corporate Social Responsibility wire service,[29] or filed an 8-K, otherwise zero.[30] We posit the following expectations regarding the signs of the selection model coefficients: positive for leverage (Armstrong et al. 2010), positive for previous CDP disclosure (Stanny and Ely 2008), positive for other channel (Beyer et al. 2010), positive or negative for sector, depending on industry characteristics (Hou and Robinson 2006), and positive or negative for book-to-market ratio, depending on whether growth prospects might encourage or discourage disclosure.[31]

Table 5 summarizes the results of applying the Heckman approach to the first five versions of model 1 (table3, panel A). First, the selection equation shows significantly positive coefficients for previous CDP disclosure and other channel, the sector variables (not reported) vary by the industry, and book-to-market is insignificant, possibly reflecting the offsetting effects of expected growth for disclosure. We also observe a negative coefficient for leverage, suggesting that high leverage

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[28] http://www.climateregistry.org

[29] http://www.csrwire.com

[30] Our limited list of other channels should make this a conservative test, since with additional channels it is more likely that an S&P 500 or TSE 200 company has made a decision to disclose emissions information other than through the CDP. Of our sample of 1,083 actual CDP amounts (2,917 actual and estimated amounts), in an unreported analysis, we identified 53.3% (19.8%) as relating to at least one other channel.

[31] Unlike Matsumura et al. (2011), we exclude company size as a selection model variable because inclusion can induce a correlation between IMR and CVCE, and possibly RESI, in model 2 and, thus, reduce the power of the test for sample selection using the IMR coefficient, which can produce unstable results (Leung and Yu 1996, Puhani 2000). We also include sector in the selection equation and exclude sector from the valuation equation for the same reason. In Matsumura et al. (2011), as a sign of possible instability, we note that the mostly significant IMR coefficients switch in sign depending on whether the valuation model is scaled or not scaled by sales, and the significance of the IMR coefficients differs depending whether the valuation equation and selection equation includes or excludes industry controls. They also base their GHGE intensity partition on EPA-targeted industries, but this can be problematic as the EPA requirements (40 CFR Part 98) apply mostly to energy producers (Scope 1 emitters) and not to energy consumers (Scope 2 and 3 emitters), who can also have high GHGE intensity.

companies are less inclined to disclose to the CDP. For example, they may disclose to lenders privately or not at all in the belief that they may avoid market recognition of an additional off-balance sheet obligation. Second, the IMR coefficient in the second-stage price regressions is insignificant in all cases. Third, we calculate a low variance inflation factor when we regress IMR on the remaining independent variables in model 2, and so we meet a recommended criterion for appropriate use of the Heckman approach (Belsley 1991). Thus, after controlling for self-selection by CDP disclosers, we cannot reject the hypothesis that the GHE coefficients in table 5 differ qualitatively from the GHGE coefficients in table 3. In both instances, we show uniformly and significantly negative GHGE coefficients across the same models. These results also buttress the earlier table 3 results that show significantly negative GHGE coefficients for both discloser and non-discloser companies.

5.2 Economic interpretation of the results

To add further insight, we provide an economic interpretation of the negative GHGE coefficients in tables 3 and 5. We first calculate the off-balance sheet liability assessed by investors using the GHGE coefficient in the valuation model for a company with the median annual GHG emissions of the S&P 500 and TSE 200 samples. Second, we assume a base purchase cost of $20 per ton of GHG and calculate the maximum off-balance sheet GHG obligation if a company were required to pay 100 percent of the median GHG emissions with no liability offset for GHG allowances granted by the government. We then compute the GHG cost ratio as the first calculation divided by the second. This ratio should range between zero and one under the reasonable assumption that the maximum off-balance sheet obligation exceeds investors' stock price assessment of the discounted sum of future net costs related to GHG emissions.

Table 6 shows the cost ratio calculations for regression 1 in table 3 and table 5 for an assumed GHG cost of $20 per ton. Based on the GHGE coefficient for regression 1 of table 3 (-0.0075), table 6 shows that investors factor 35 percent of that cost into stock price as an unrecognized liability (column 1). Equivalently, investors factor an unrecognized liability of $7.00 per ton of GHGE into stock price (column 2) conditional on the table 3 regression model. Alternatively, based on the GHGE coefficient for regression 1 in table 5 (-0.0106), investors factor 49.76 percent of the $20 cost into stock price as an unrecognized liability (column 3) or, equivalently, recognize an off-balance liability of $9.96 per ton (column 4). We add a note of caution to these numbers, however, as they relate to a hypothetical company with median GHG emissions and depend on coefficients from regressions based on pooled observations. Nonetheless, they offer some practical guidance as to the cost per ton of GHG priced by equity investors as an off-balance sheet liability.

5.3 Robustness tests

We subject our GHGE prediction (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 already in the paper. We also test whether the year-to-year change in GHGE relates to annual residual stock return. First, we examine different versions of model 1, including a more complex model, 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. A more complex version of model 1 increases the adjusted R^2 to 67 percent (compared to 60 percent for the version we use to predict GHGE) but at the expense of a smaller sample size. While a comparison of the simplified and complex models suggests some 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.[32] These alternative specifications do not appreciably change 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 has no appreciable impact on the results in table 4. Fifth, we re-estimate the regressions in table 3 under two-way clustering as per Cameron et al. (2011). The results do not change under this alternative procedure.

Sixth, as part of our event study, we calculate the *change* in unsigned and signed residual

[32] $r_e = ((epspx \div p) + g)$, where *p* = market price at fiscal end-of-year plus three months, *g* = five-year expected earnings growth from IBES, and *epspx*, = earnings per share.

return from day t-1 to t relative to t=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 emission intensive companies and for the difference between high and low emission intensive companies. Unreported 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.

Seventh, we investigate whether the Kyoto protocol that came into force in 2005 for Canadian companies (but not U.S. companies) might help understand the results. By signing the Kyoto accord, Canadian companies had to reduce emissions to 6 percent below 1990 levels beginning in 2008. We test for an effect by estimating model 2 with a dummy variable coded as one for years 2008 and 2009 and zero otherwise for Canadian companies only. Unreported results indicate a significant negative coefficient for the Kyoto variable for all Canadian companies but not for a sub-sample of GHG-intensive Canadian companies, which should be the more affected group. This result therefore reveals mixed evidence about a possible Kyoto effect. Overall, our robustness checks suggest that differences in definition and method have little bearing on our results.

Finally, we estimate a first differences version of the Ohlson (1995) model by regressing annual residual stock return on residual change in GHGE, with appropriate controls as before, where the residual change in a variable is relative to the prior year. While we estimate this model for various specifications of the variables, it does not produce significant coefficients for the test variables, although the relation between stock return and residual change in GHGE is still negative. This suggests a measurement-error explanation of the results (Barth et al. 2001). Some reasons include the following. First, our returns model magnifies the measurement error in levels variables, in that model 4 uses variables from model 2 on a first-difference basis. Second, it is difficult to specify a common 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, change in GHGE might still not be sufficiently error-free such that we can predict reliably that it might increase or decrease stock price over a year.

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. Some within these groups also advocate additional required disclosure to correct what they perceive as a deficiency in the present system that underserves investors' needs for decision making. For example, Ann Stausboll, CEO of CalPERS, a public pension fund with December 31, 2010 assets under management of $224 billion, believes that "reporting on climate issues in SEC filings is a necessity" (Young et al. 2009). Companies and insurers, on the other hand, 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 relating to existing law only, and the U.S. Environmental Protection Agency only recently finalized its 2009 proposal for mandatory GHG reporting by entities that are "direct emitters or suppliers of greenhouse gases", following concerns that the rule could cause competitive harm (EPA 2011). Our paper contributes to an 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. 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 topic 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) and focus on companies in two environments. 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 emission-intensive industries such as utilities, energy, and materials. 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 U.S. or Canadian companies disclose to the CDP, an efficient market should, nevertheless, factor emission information into stock prices from multiple channels, and not just the

CDP data. We find evidence consistent with this view, which is our second way of understanding the investor relevance of climate change information. We estimate 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 estimated emissions, and the negative relation with stock price increases for emission-intensive industries. Moreover, the negative relation holds approximately equally for CDP discloser and non-CDP discloser companies and after we control for self-selection.

Our knowledge increases in a third way, by evidence of a short-term stock market effect around climate change disclosures whose effects differ for emission intensive and emission non-intensive companies. We observe a distinct increase in stock price volatility (measured as mean unsigned residual return) and trading volume around the day of an 8-K filing, when a company reports news relating to climate change or emissions, and this market response is not subsumed by earnings information that accompanies some filings. We also observe a more negative response (measured as signed residual return) for the 8-K filings of emission intensive companies relative to non-emission intensive companies' filings. Hence, from a timing standpoint, investors respond significantly and negatively to 8-K news conditional on high emission intensity when they should, that is, around the day of release of the new climate change information.

Our study also raises interesting issues for future research. In addition to CDP emissions data and 8-K filings about climate change, investors have available numerous other channels of information, and will shortly have a wealth of additional information about emissions under the U.S.

EPA's 40 CFR Part 98 reporting program. Yet, much is unknown at this stage how these alternative channels might influence investors' returns. The perception of a link between emissions amounts and stock price could also prompt strategic or opportunistic reporting by managers, for example, in choosing a base year for meeting or beating planned GHGE reductions.

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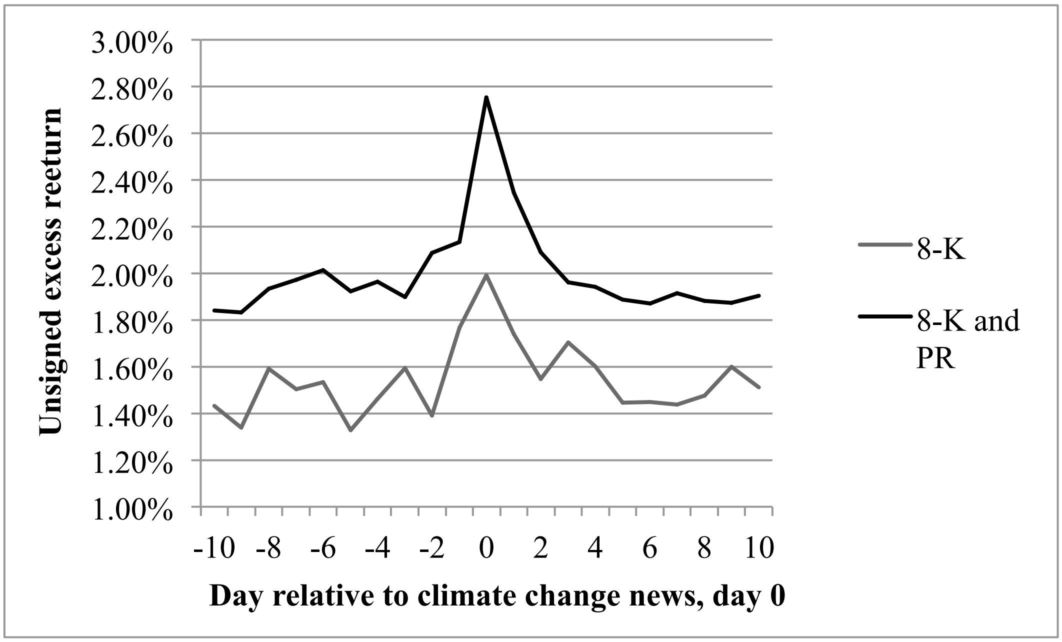
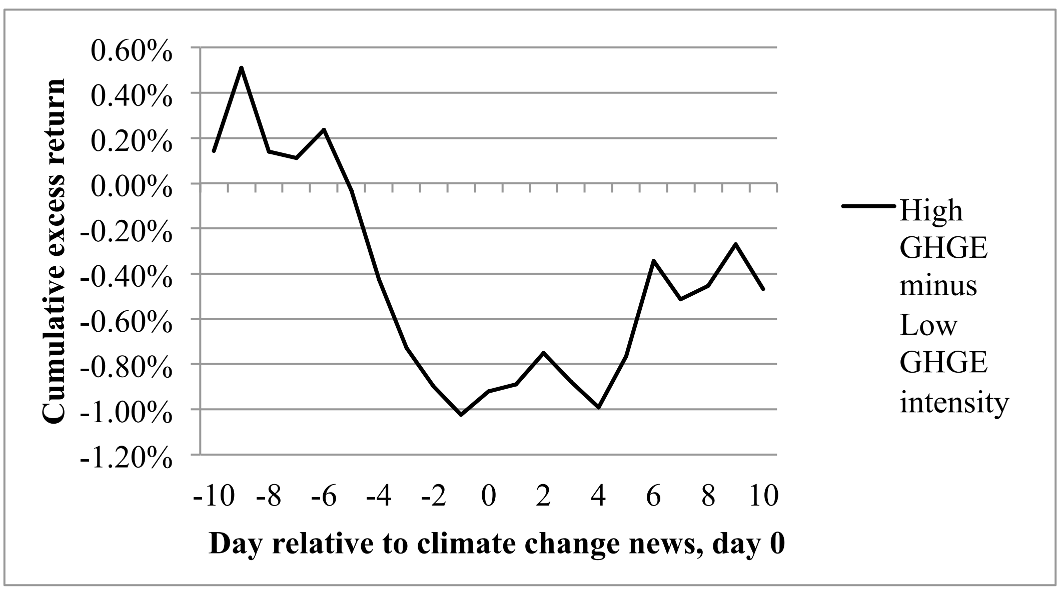
Figure 1: Investor response to climate change news:

Panel A: Unsigned excess return: By 8-K versus 8-K and a press release (PR)



Panel B: Signed excess return: High minus low GHGE intensity



Panel A plots the mean unsigned excess return from table 4, panel A. Panel B plots the cumulative difference in mean signed excess return for high GHGE minus low GHGE intensity companies from 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 (GHGE) 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 GHGE 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 covers the 280 largest Canadian companies in 2005 and the top 200 in 2006-2008. 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 obs.	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)-(3) 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 obs.	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 (*ceq*)/common shares outstanding at t (*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 (estimated as the median CDLI for the company sector). 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 GHGE per share	CDLI	Change in operating leases	Exp. ret. pension assets	No. of obs.	Adjusted R^2
All	1	17.328	1.003	2.865	-0.007						2310	50.4%
		***	***	***	**							
All	2	11.462	1.001	2.880	-0.003	7.617	-0.049				2310	51.0%
		***	***	***	ns	***	***					
All	3	20.263	1.001	2.881	-0.007			-0.059			2310	50.5%
		***	***	***	**			*				
All	4	18.394	1.033	2.772	-0.019				1.101		1990	51.5%
		***	***	***	***				ns			
All	5	8.981	0.985	2.137	-0.022					1.402	1354	57.2%
		**	***	***	**					**		
GHGE intensive	6	14.278	1.130	3.047	-0.008						1176	63.7%
		***	***	***	*							
	7	10.336	1.130	3.053	-0.004	6.538	-0.065				1176	64.7%
		***	***	***	ns	***	***					
Non-GHGE intensive	8	19.524	0.885	2.935	0.093						1134	42.7%
		***	***	***	ns							
	9	12.252	0.870	3.113	-0.035	7.410	0.693				1134	43.3%
		***	***	***	**	**	***					
GHG intensive: Discloser	10	20.895	0.829	2.155	-0.006						495	35.5%
		***	***	***	*							
	11	17.656	0.861	2.160	-0.004	4.683	-0.035				495	36.3%
		***	***	***	ns	*	*					
GHGE intensive: Non-Discloser	12	12.884	1.152	4.078	-0.021						681	73.4%
		***	***	***	***							
	13	8.349	1.140	4.014	-0.013	7.352	-0.093				681	73.9%
		***	***	***	***	***	***					

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 (*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=($mrct_t$+$mrctaa_t$-$mrct_{t-1}$-$mrcta_{t-1}$)/*csho*, following Ge (2007) and Dechow et al. (2011), expected return on pension plan assets=*pbarr*, GHGE intensive=company in GHGE intensive sector based on GHGE/*revt* 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	GHGE per share	Country: US or Canada	Country x GHGE per share	CDLI	Change in operating leases	Exp. ret. pension assets	No. of obs.	Adjusted R^2
All	1	19.512	0.808	3.528	-0.007						2252	29.5%
		***	***	***	***							
All	2	13.057	0.798	3.539	-0.003	8.524	-0.049				2252	30.5%
		***	***	***	***	***	***					
All	3	20.521	0.809	3.534	-0.007			-0.021			2252	29.5%
		***	***	***	***			ns				
All	4	19.623	0.896	3.454	-0.011				0.284		1937	29.5%
		***	***	***	***				ns			
All	5	10.250	0.627	3.169	-0.012					1.741	1320	26.8%
		***	***	***	*					***		
GHGE intensive	6	15.888	1.118	2.618	-0.009						1166	60.1%
		***	***	***	***							
	7	10.367	1.115	2.613	-0.004	8.855	-0.071				1166	61.6%
		***	***	***	**	***	***					
Non-GHGE intensive	8	20.610	0.790	2.800	-0.007						1153	35.0%
		***	***	***	***							
	9	14.399	0.761	2.781	-0.003	9.950	-0.051				1153	37.7%
		***	***	***	**	***	***					
GHGE intensive: Discloser	10	18.234	0.801	4.681	0.217						677	28.1%
		***	***	***	ns							
	11	11.973	0.718	5.336	-0.030	5.941	1.384				677	30.3%
		***	***	***	*	***	***					
GHGE intensive: Non-Discloser	12	22.448	0.831	1.889	-0.009						489	33.4%
		***	***	***	**							
	13	16.571	0.856	1.893	-0.005	8.649	-0.046				489	35.8%
		***	***	***	**	***	***					

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 (*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=($mrct_t$+$mrctaa_t$-$mrct_{t-1}$-$mrcta_{t-1}$)/*csho*, following Ge (2007) and Dechow et al. (2011), 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 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: All 8-K observations

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	0.0143	0.0184	***	8.4511	11.2796	***	0.0180	0.0178	ns	11.1174	10.8563	ns
-9	0.0134	0.0183	***	8.3906	11.2198	***	0.0195	0.0172	*	10.3386	10.9875	ns
-8	0.0159	0.0193	**	8.8030	10.7134	**	0.0180	0.0191	ns	10.6348	10.4170	ns
-7	0.0150	0.0197	***	8.7299	10.9599	**	0.0194	0.0190	ns	10.2905	10.7695	ns
-6	0.0153	0.0201	***	8.7748	10.9973	**	0.0207	0.0192	*	10.6749	10.7173	ns
-5	0.0133	0.0192	***	8.1633	11.1575	***	0.0187	0.0184	ns	10.9310	10.7225	ns
-4	0.0146	0.0197	***	8.2786	11.0375	***	0.0205	0.0186	*	11.0864	10.5664	ns
-3	0.0159	0.0190	**	8.7494	11.1762	***	0.0187	0.0186	ns	11.0278	10.8138	ns
-2	0.0139	0.0209	***	9.0387	11.3998	**	0.0197	0.0201	ns	10.5923	11.2239	ns
-1	0.0177	0.0213	**	10.1134	12.3575	**	0.0208	0.0209	ns	12.0742	12.0648	ns
0	0.0199	0.0275	***	11.2913	15.4774	***	0.0272	0.0264	ns	14.9109	14.9227	ns
1	0.0174	0.0234	***	10.1728	13.8325	***	0.0236	0.0224	ns	13.3430	13.3556	ns
2	0.0155	0.0209	***	10.0642	12.7999	**	0.0213	0.0199	*	12.6487	12.3858	ns
3	0.0170	0.0196	*	9.3266	11.9565	***	0.0204	0.0189	*	12.2209	11.4432	ns
4	0.0160	0.0194	**	8.5395	11.7785	***	0.0201	0.0187	*	11.7286	11.2499	ns
5	0.0145	0.0189	***	8.6591	11.8684	***	0.0192	0.0181	ns	12.0495	11.2849	ns
6	0.0145	0.0187	***	8.8438	11.4840	***	0.0189	0.0179	ns	11.1252	11.1402	ns
7	0.0144	0.0191	***	8.5886	11.5201	***	0.0185	0.0185	ns	11.4303	11.0575	ns
8	0.0148	0.0188	***	8.8829	11.4317	***	0.0189	0.0181	ns	11.6027	10.9633	ns
9	0.0160	0.0187	*	9.1156	11.5880	**	0.0178	0.0185	ns	11.7461	11.1301	ns
10	0.0151	0.0190	**	11.5568	8.4401	***	0.0196	0.0182	*	10.9513	11.2031	ns
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 filing date (day 0), 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 differs from the mean on the other days.

Table 4, contd.

Panel B: Investor response around event days 0 and -1 to 1: Unsigned excess return and adjusted volume

Response variable (cols.)	Event day 0		Event days -1 to 1		Event day 0: EARN=1		Event day 0: EARN=0	
Section 1: Unsigned excess return	Coeff. x 100	Sig.	Coeff. x 100	Sig.	Coeff. x 100	Sig.	Coeff. x 100	Sig.
Intercept	1.9479	***	1.9277	***	3.6161	***	1.1747	*
EARN	0.0386	ns	0.0386	ns				
GHGI	0.0703	*	0.0703	*	-0.0748	ns	0.1245	***
SIZE	-0.0444	*	-0.0444	*	-0.1121	**	-0.0110	ns
CDLI	0.0081	***	0.0081	***	0.0055	*	0.0080	***
USAC	-0.5026	***	-0.5026	***	-0.3195	ns	-0.5255	***
DSLC	-0.3958	***	-0.3958	***	-0.5018	***	-0.3564	***
RISK	0.8184	***	0.8184	***	0.8497	***	0.7860	***
EVTD	0.8680	***	0.4316	***	1.8459	***	0.5565	***
EVTD x EARN	1.2827	***	0.6167	***				
EVTD x GHGI	-0.4750	**	-0.2079	*	-1.3129	***	-0.2719	ns
EVTD x SIZE	-0.0408	ns	0.0339	ns	-0.4499	*	0.0639	ns
EVTD x CDLI	-0.0154	***	-0.0036	ns	-0.0705	***	-0.0020	ns
EVTD x USAC	-1.6900	***	-0.6559	*	1.2487	ns	-2.1495	***
EVTD x DSCL	0.1178	ns	-0.0795	ns	0.9222	*	-0.1675	ns
Adjusted R^2	10.3%		9.6%		17.6%		7.7%	
F statistic	101.41	***	93.51	***	53.77	***	65.29	***
No. of obs.	12,241		12,241		2,959		9,282	
Section 2: Adjusted volume	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.
Intercept	15.3377	***	15.210	***	-16.291	ns	19.338	***
EARN	0.6256	**	0.626	**				
GHGI	0.4767	*	0.477	*	1.330	*	0.3204	ns
SIZE	-1.1736	***	-1.174	***	0.121	ns	-1.1917	***
CDLI	0.0760	***	0.076	***	0.055	**	0.0808	***
USAC	9.0528	***	9.053	***	7.375	***	8.4897	***
DSLC	-4.1430	***	-4.143	***	-6.218	***	-4.5589	***
RISK	13.8121	***	13.812	***	19.501	***	10.6696	***
EVTD	4.1199	***	2.270	***	9.627	***	2.3653	***
EVTD x EARN	7.0036	***	2.906	***				
EVTD x GHGI	-3.0331	**	-1.233	*	-9.596	***	-1.0106	ns
EVTD x SIZE	-0.1047	ns	-0.186	ns			0.7246	ns
EVTD x CDLI	-0.0725	*	-0.025	ns	-0.309	***	-0.0241	ns
EVTD x USAC	1.8894	ns	0.261	ns	11.191	ns	0.6088	ns
EVTD x DSCL	0.4532	ns	-0.432	ns	2.878	ns	-0.2020	ns
Adjusted R^2	35.0%		34.8%		50.1%		26.6%	
F statistic	471.74	***	466.81	***	55.42	***	281.92	***
No. of obs.	12,241		12,241		2,959		9,282	

Variable definitions. Dependent variable = daily unsigned excess return or adjusted volume for given event day window, EARN = 1 if earnings information in 8-K, otherwise 0, GHGI = 1 if GHGE/*revt* in CDP year greater than median, otherwise 0, SIZE = log of *at* for prior fiscal year, CDLI = 1 if actual or estimated CDP Disclosure Leadership Index in CDP year greater than sample median, otherwise 0, USAC = 1 if USA, otherwise Canada, DSCL=1 if GHGE disclosed to CDP, otherwise 0, RISK = *CRSP* beta, EVTD = 1 for event days in event window, 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.

Table 4, contd.

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

	Mean				Cumulative mean				Standard deviation	
Event day	Low GHGE intensity	High GHGE intensity	Mean Difference Mean	Sig,	Low GHGE intensity	High GHGE intensity	Cum. mean Difference Mean	Sig,	Low GHGE intensity	High GHGE intensity
-10	0.041%	0.184%	0.143%	ns	0.041%	0.184%	0.143%	ns	2.910%	2.614%
-9	-0.278%	0.091%	0.369%	ns	-0.236%	0.275%	0.512%	ns	2.670%	2.435%
-8	0.324%	-0.048%	-0.372%	*	0.088%	0.228%	0.139%	ns	3.201%	2.226%
-7	0.049%	0.021%	-0.027%	ns	0.137%	0.249%	0.112%	ns	3.487%	2.175%
-6	-0.076%	0.048%	0.124%	ns	0.061%	0.297%	0.236%	*	3.154%	3.765%
-5	0.264%	-0.003%	-0.267%	*	0.325%	0.294%	-0.031%	*	2.887%	2.179%
-4	0.248%	-0.146%	-0.394%	*	0.573%	0.148%	-0.425%	*	3.470%	2.829%
-3	0.227%	-0.076%	-0.303%	*	0.800%	0.072%	-0.728%	*	3.012%	2.171%
-2	0.030%	-0.140%	-0.170%	ns	0.830%	-0.068%	-0.898%	**	3.012%	2.245%
-1	0.185%	0.060%	-0.125%	ns	1.016%	-0.008%	-1.024%	*	3.528%	2.883%
0	-0.229%	-0.127%	0.103%	ns	0.786%	-0.135%	-0.921%	*	5.489%	3.461%
1	-0.111%	-0.079%	0.032%	ns	0.675%	-0.214%	-0.889%	*	4.096%	3.022%
2	0.013%	0.151%	0.138%	ns	0.688%	-0.062%	-0.751%	ns	3.040%	2.260%
3	0.197%	0.069%	-0.128%	ns	0.885%	0.006%	-0.879%	ns	2.944%	2.053%
4	0.134%	0.020%	-0.114%	ns	1.019%	0.027%	-0.992%	*	3.021%	2.311%
5	-0.015%	0.211%	0.226%	ns	1.003%	0.237%	-0.766%	ns	2.531%	2.239%
6	-0.151%	0.273%	0.423%	ns	0.853%	0.510%	-0.343%	ns	2.837%	2.548%
7	0.211%	0.042%	-0.169%	ns	1.064%	0.552%	-0.512%	ns	3.161%	2.246%
8	0.047%	0.106%	0.059%	ns	1.111%	0.658%	-0.453%	ns	2.968%	2.115%
9	-0.137%	0.045%	0.182%	ns	0.974%	0.703%	-0.271%	ns	2.817%	2.112%
10	-0.032%	-0.229%	-0.197%	ns	0.942%	0.474%	-0.468%	ns	3.350%	2.155%

Variable definitions. Signed excess return = daily stock return inclusive of dividends for trading day t in excess of the day t return on the *CRSP* value-weighted market index, Event day = climate change disclosure relative to 8-K filing date, High GHGE intensity = GHGE/(*revt**1000) greater than median in CDP year, otherwise low GHGE intensity. Standard deviation = standard deviation of signed excess return for event day t. Tests of significance are whether the mean difference is zero under a two-tailed test: *** = less than .001, ** = less than .01, * = less than .10, ns = not significant.

Table 5: Regression of stock price on common equity, residual earnings, and GHG emissions per share with selection equation

Dependent variable: Stock price = PRCC_Q5	Regr. 1 in panel A of table 3		Regr. 2 in panel A		Regr. 3 in panel A		Regr. 4 in panel A		Regr. 5 in panel A	
Second-stage valuation regression	Coef.	Signif.	Coef.	Signif.	Coef.	Signif.	Coef.	Signif.	Coef.	Signif.
Intercept	21.211	***	18.160	***	25.968	***	23.259	***	-3.647	ns
CVCE per share	0.627	***	0.633	***	0.633	***	0.666	***	0.625	***
Residual earnings per share	3.209	***	3.229	***	3.212	***	3.207	***	3.066	***
GHGE per share	-0.011	***	-0.008	*	-0.011	***	-0.010	*	-0.030	**
Country			3.301	*						
Country*GHGE per share			-0.014	ns						
CDLI					-0.070	*				
Change in operating leases							-1.078	ns		
Exp. Ret. pension assets									3.474	***
Inverse Mills ratio (IMR)	0.773	ns	1.135	ns	-0.099	ns	-0.641	ns	-0.410	ns
First-stage selection equation										
Sector (same as table 2)	Yes		Yes		Yes		Yes		Yes	
Book-to-market ratio	0.005	ns	0.005	ns	0.005	ns	0.009	ns	-0.009	ns
Long-term debt to total assets	-0.587	***	-0.587	***	-0.587	***	-0.680	***	-0.549	***
Previous discloser	0.510	***	0.510	***	0.510	***	0.571	***	0.448	***
Other channel	1.131	***	1.131	***	1.131	***	0.948	***	1.212	***
Intercept	-0.387	***	-0.387	***	-0.387	***	-1.572	***	-0.402	***
No. of observations in valuation regression[1]	2,309		2,309		2,309		1,989		1,353	
No. of CDP discloser observations in selection equation	970		970		970		809		683	
Wald Chi Square	608.68		615.00		614.09		556.19		434.04	
Average VIF of regressing IMR on independent variables in the second-stage valuation regression	1.21		1.20		1.16		1.29		1.13	

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 (*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=($mrct_t$+$mrctaa_t$-$mrct_{t-1}$-$mrcta_{t-1}$)/*csho*, following Ge (2007) and Dechow et al. (2011), expected return on pension plan assets=*pbarr*, GHGE intensive=company in GHG intensive sector based on GHG/*revt*, otherwise company in non-GHGE sector, 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.

1. The number of observations is less than in table 3 because we require that we have no missing observations for both the selection equation and the valuation regression.

Table 6: Economic significance of GHGE regression coefficients

Variable		Table 3 model 1		Table 5 model 1	
Calculation	Data item	(1)	(2)	(3)	(4)
GHGE market price per ton	1	$20.00	$7.00	$20.00	$9.96
GHGE/(*csho**1000) regression coefficient	2	-0.0075	-0.0075	-0.0106	-0.0106
GHGE/(*csho**1000), median	3	1.3725	1.3725	1.3725	1.3725
GHGE per share times -1	4 = -2 x 3	0.0103	0.0103	0.0146	0.0146
GHGE median, in tons	5	327,237	327,237	327,237	327,237
Number of shares outstanding, median	6	223,000,000	223,000,000	223,000,000	223,000,000
GHGE per share	7 = 1 x 5 ÷ 6	0.0293	0.0103	0.0293	0.0146
GHGE cost ratio	4 ÷ 7	35.00%	100%	49.76%	100%

This table calculates the GHGE cost ratio, where the cost ratio equals GHGE per share for the median company implied by regression model 1 in table 3 or table 5 divided by GHGE per share for the median company in the sample. As such, the numerator represents investors' assessment of the impact of GHGE per share on stock price and the denominator represents total GHGE per share priced at an assumed market price per ton. For example, at a cost of $20 per ton, investors factor 35% of that cost into stock price as an unrecognized liability (calculation 1). Equivalently, investors factor an unrecognized liability of $7.00 per ton of GHGE into stock price (calculation 2), conditional on the regression model. Variable definitions, with *Compustat* name in italics, are: GHGE/(*csho**1000) =GHGE per common share; median = median over all sample observations.