What Explains Participation and Effort in Voluntary Climate Action by Businesses?: Evidence from the Carbon Disclosure Project

Lily Hsueh*

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Abstract

In parallel with the top down, intergovernmental climate talks at the 2015 Paris Climate Conference, there was a "Climate Solutions Hub," which showcased concrete climate actions by businesses, cities, states and provinces. According to a Yale University report, 2,138 companies from 145 countries representing $36.6 trillion USD in revenue, roughly equivalent to the combined GDPs of the U.S., China, Japan, Germany, and the UK have pledged climate action. Some businesses "talk a good game", but which ones are actually contributing to meaningful climate change mitigation? Drawing on the private provision of public goods and the economics of corporate social responsibility literatures, this paper employs the Double-Hurdle model, which accounts for the related and sequential decisions of participation and effort by corporations to uncover the firm-level factors that differentiate leaders from greenwashers in proactive climate action. Based on an analysis of the participation of the Global 500 firms in the Carbon Disclosure Project during 2011-2015, preliminary results suggest that the existence of a senior manager or executive-level officer with direct responsibility for climate change is associated with higher participation in voluntary carbon disclosure. Notwithstanding, firms that have integrated climate change risks into their business operations, notably the adoption of emissions reduction targets are associated with higher levels of carbon disclosure: these companies not only voluntarily report their climate change strategies and carbon emissions but have verified their disclosures with third-party audits. By making use of President Obama's announcement of a series of executive actions on climate change, which increased the likelihood of climate change regulation in the U.S. during the period under study, I find that firms based in the U.S. were more likely to participate *and* engaged in higher levels of carbon disclosure relative to other firms.

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*Hsueh: Corresponding Author, School of Public Affairs, Arizona State University [Lily.Hsueh@asu.edu]. Hsueh thanks Joshua Abbott, Kelly Bishop, Chris Herbst, Michael Hanemann, Nicolai Kuminoff, Andrew Waxman and participants at the ASU Environment, Resource and Energy Economics Seminar and the 2016 AERE summer conference for helpful comments.

1 Introduction

Conventional wisdom is that climate change is a global commons problem: Nations agree under the United Nations Framework Convention on Climate Change (UNFCCC) on greenhouse gas emission reductions. Governments then introduce in their jurisdictions the right incentives for climate change mitigation. Companies, municipalities, and citizens take measures to reduce emissions in response to public policies. It became clear after gridlocks at the 15th Conference of Parties (COP15) in Copenhagen that the top-down approach alone would not work (Hoffmann 2011; Bernstein et al. 2010). In recent years, bottom-up or mixed approaches to climate change governance have been favored by scholars as a policy solution for "wedging the gap" (Blok et al. 2012) between what intergovernmental efforts are able to achieve and what is necessary to limit temperature rise below two degrees Celsius during this century (Nordhaus 2015; Falkner 2016; Potoski 2015; Falkner 2015; Bulkeley et al. 2014; Nordhaus 2013; Keohane and Victor 2011). The consensus is that the implementation of the Paris Agreement, which went into force in late 2016 requires not only countries but also cities and corporations, the latter of which is the focus on this paper's analysis.

A Yale University study reports that 2,138 companies from 145 countries representing $36.6 trillion USD in revenue, roughly equivalent to the combined GDPs of the U.S., China, Japan, Germany, and the UK have pledged climate action (Hsu et al. 2016). Proactive climate action by corporations range from voluntary commitments to reduce CO2 emissions, increase energy efficiency, invest in renewable energy sources and set an internal price on carbon. Notwithstanding, some businesses "talk a good game", but which ones are actually contributing to meaningful climate change mitigation? In other words, what factors distinguish companies that not only participate in voluntary climate action but "go the extra mile" in their level of participation?

To answer these questions, this paper draws on the private provision of public goods and the economics of corporate social responsibility literatures to first justify "whether" and "why" proactive or voluntary climate action by businesses before hypothesizing firm-level drivers for voluntary carbon disclosure as a case of proactive climate action. Specifically, this paper examines a less emphasized set of factors in the literature—management structures and practices—*internal* to the firm, which I argue shape a firm's participation and intensity of participation, i.e., effort, in voluntary climate action. I turn to the literature on "policy supporters" and chief executives (e.g.,

Prakash 2001; Esty and Lubin 2010; Rivera and Leon 2005; Strand 2013) to highlight the importance of internal firm factors involving the agency of corporate management for explaining a corporation's decision to engage in activities that are beyond what is required by law. Furthermore, I argue that a firm's choice about its intensity of participation is related to whether and to what extent climate change risks are integrated into its day-to-day business operations. The more integrated climate change risks are to the core of a firm's operations the more likely and able the firm is to engage in higher levels of voluntary climate action because the marginal cost of doing so is relatively low.

Empirical evidence is drawn from the participation of the Global 500—which are the world's largest companies with respect to market capitalization—in the CDP (formerly known as the Carbon Disclosure Project) during 2011-2015. On behalf of over 800 institutional investors totaling $100 trillion USD in investments, the CDP requests companies of various sizes across a wide-range of industries, on an annual basis, to voluntarily disclose their plans for measuring, reporting, and reducing GHG emissions, including whether companies have adopted science-based quantified emissions targets, among other proactive climate change mitigation activities.

The CDP also surveys companies about their management structure and practices and climate-related risks and opportunities. Furthermore, the CDP quantitatively scores and ranks firms based on the level of their disclosures: companies that engage in high levels of carbon disclosure not only report their proactive strategies for managing climate change, they also report their carbon emissions with verification by third-party audits.

This paper focuses on the Global 500 because the Global 500's sheer size, economic contribution, and carbon footprint worldwide warrant a need to investigate the factors that motivate their climate mitigation activities. Moreover, the Global 500 provides a coherent and self-contained universe of companies: both participants and non-participants operate globally and face similar investor pressures, which alleviates the need for restrictive assumptions about businesses that could have engaged in proactive climate action but do not.[1] Finally, the role of the Global 500 in "wedging the gap" could be significant since coordination problems across countries as

[1] That said, this paper controls for a plethora of variables, including firm size and external conditions, such as trends in natural gas prices, as well as exploit an exogenous policy announcement (Obama's Climate Proposal) that increased regulatory pressures for U.S. based firms for resolving identification.

described above have weaken the role of governments in the provision of climate change mitigation, a global public good. In the concluding section, I provide a brief discussion on how this paper's results generalize to a broader population of firms.

Unlike the existing literature that either models carbon disclosure as a binary or continuous variable this study distinguishes between a firm's decision to disclose and the related but subsequent decision of how much to disclose climate change information in a two-tiered model. To empirically disentangle a firm's extensive and intensive margins of participation and adequately account for corner solutions, this paper employs the Double Hurdle model (Cragg 1971).[2] This modeling approach explicitly accounts for the finding in the literature that firms may engage in self-regulation—thus signaling their "green" leadership—only to exert varying degrees of actual "green" behavior, some of which may be no better than greenwashing (Lyon and Montgomery 2015; Maxwell, Lyon, and Hackett 2000; Lyon and Maxwell 2011; Gamper-Rabindran 2006; Bowen and Aragon-Correa 2014).

A feature of the paper is a novel identification strategy: this paper exploits President Obama's announcement of a series of executive actions on climate change starting in 2012 as a natural experiment for uncovering causal inference. Given the contentious and divisive politics of climate change in the U.S., evidenced by the failures of proposed climate change legislations in Congress, there was little expectation that federal regulation on climate change was on the horizon. As such, I argue that President Obama's Climate Proposal serves as an exogenous shock that exposed firms in the greenhouse gas (GHG) intensive industries operating in the U.S. to regulatory pressure about impending regulation on carbon emissions.

This paper's main findings can be summarized as follows. Results indicate that, after controlling for firm size, natural gas prices, sector, country, and year effects, the existence of a "policy supporter" at the managerial or executive levels who advocates for climate change and sustainability practices and policies is associated with participation in voluntary carbon disclosure. Notwithstanding, "green" firms look different from "grey" firms: firms that have integrated climate change risks into their business operations, notably the adoption of emissions reduction targets are associated with higher levels of carbon disclosure: these companies not only voluntarily

[2] See section 5 for a discussion of the Double Hurdle model versus the Heckman Selection model. A model specification test (the Vuong test) rejects the Heckman Selection model. See Appendix Table A1 for test results.

report their climate change strategies and carbon emissions but have verified their disclosures with third-party audits.

By making use of President Obama's announcement of a series of executive actions on climate change, which increased the likelihood of climate change regulation in the U.S. during the period under study, I find that firms based in the U.S. were more likely to participate *and* engaged in higher levels of carbon disclosure relative to other firms. Moreover, the adoption of an integrated climate change strategy and a quantifiable emissions target increased the probability of voluntary carbon disclosure by U.S. based companies even though on average U.S. based firms were less likely than other firms to disclose their climate change mitigation activities. The hypothesized firm-level managerial drivers are robust to a large number of alternative specifications.

The reminder of the paper proceeds as follows. Section 2 reviews the theory: I first set the scene for *whether* proactive climate action before moving to *why* proactive climate action with a review of the literature on the private provision of public goods and corporate social responsibility. I then present hypotheses for how management structures and practices internal to firms influence a firm's decision about participation and effort in voluntary carbon disclosure. Section 3 describes the CDP. In section 4, I describe the data on the Global 500 and present descriptive statistics. The next section presents the Double Hurdle model that is employed for testing the proposed hypotheses. Section 5 also describes this paper's identification strategy for resolving endogeneity. Empirical results and a discussion of these results are reported in section 6. The final section concludes by identifying areas for future research and offering policy implications.

2 Theory and Hypotheses

Friedman (2009; 1970) famously argued that the only responsibility of business is profit maximization and that public preferences combined with democratic empowerment implied that governments, and not firms, should manage externalities and provide public goods. In the classic dichotomy—i.e., the division of corporate and government responsibility vis-à-vis society—the government is endowed with the necessary democratic legitimacy and have the power to correct market inefficiencies such as free-riding and related collective action problems.

Whether Proactive Climate Action?

Buchanan (1965) was the first to define the joint provision of a public and private good as an "impure public good": Firms sometime produce a public good or an externality jointly with their main task of providing private goods or services for consumption. Electric cars is a modern example of an impure public good whereby the car, a private good is jointly produced with reduced carbon footprints as a positive externality.

Since Buchanan, an entire literature has emerged around the comparative welfare implications of the private provision of public goods to explain *whether* the private provision of public goods was desirable. Depending on whether private and public goods are substitutes or complements, private public good provision in equilibrium can be interpreted as welfare enhancing, neutral or reducing shift between competing supply channels (Bagnoli and Watts 2003; M. J. Kotchen 2005; M. J. Kotchen 2006; Chan and Kotchen 2014). If private and public good provision are perfect substitutes in consumption, public provision crowds out its private counterpart almost perfectly (Bergstrom, Blume, and Varian 1986). Having said that, given incomplete contracts, a public good should be owned by the party that "values the benefits generated by the related investments relatively more," according to Besley and Ghatak (2001), who based their results on the earlier work of Grossman and Hart (1986) and Hart and Moore (1990). In sum, the main finding from this literature is that the private provision of public goods produces 2nd best equilibrium levels of public good provision.

Besley and Ghatak (2007) and Kitzmueller and Shimshack (2012) explicitly link the private provision of public goods to corporate social responsibility (CSR). According to Besley and Ghatak (2007), CSR is the corporate provision of public goods or curtailment of public bads independent of legal benchmarks. It is in this framework of CSR, as linked to the standard treatment of the private provision of public goods that I consider proactive climate action by firms, of which voluntary carbon disclosure is a case.

In the 2nd best world, in absence of regulation, competitive markets are able to reach a separating equilibrium of CSR and non-CSR firms because of heterogeneous consumers (Besley and Ghatak 2007). Some firms engage in CSR by charging higher prices and catering to "caring" consumers. Other firms do not engage in CSR; they charge lower prices and selling only to neutral consumers. Besley and Ghatak (2007) show that if government does not intervene, CSR constitutes

a Pareto improvement benefiting consumers with preferences for the public good, as well as free riders without harming neutral (non) consumers.

Even if government intervenes with regulation, there are reasons to believe government failure could exist beyond free riding and externalities (e.g., bias, opportunism, limited monitoring/enforcement) can lead to deviations from first best, which further justify CSR as welfare optimal channel to provide public goods (Besley and Ghatak 2007; Kitzmueller and Shimshack 2012). When governments fail to deliver optimal levels of public good CSR will be potentially efficient.

In the case of climate change, the general consensus is that governments have failed to coordinate effectively and do what is necessary to prevent temperatures to rise above 2 degrees Celsius in this century. As such, corporations have stepped in to mitigate climate change. This is a 2nd best equilibrium level of public good provision, according to theory. I argue that the real world is a little more complicated than described by theory: Aside from non-CSR firms, there are two types of CSR firms—"green" versus "grey" firms. In the context of voluntary carbon disclosure, which is a case of proactive climate action, green firms will participate and engage in higher levels of voluntary carbon disclosure and grey firms will participate in the CDP but will fail to "go the extra mile". The grey firms are the "greenwashers": Lyon and Maxwell (2011) define greenwash as "the selective disclosure of positive information about a company's environmental performance or social performance, without full disclosure of negative information on these dimensions, so as to create an overly positive corporate image."

Why Proactive Climate Action?

Given the 2nd best world as the relevant analytical framework, the attention in the literature has turned to the interaction between strategic actors—firms, activists, regulators, consumers or investors—and how CSR arise in a "political economy" or "stakeholder interaction" context with imperfect and asymmetric information. In departing from the classical treatment, there is a broader set of attitudes, preferences and calculations for considering prosocial or altruistic behavior by firms or individuals (Andreoni 1989; Bénabou and Tirole 2003; Bénabou and Tirole 2006; Besley and Ghatak 2005; Graff and Small 2005; Arora and Gangopadhyay 1995).

A rich literature spanning economics, public policy, and business management has emerged to examine the conditions under which firms will engage in CSR and other prosocial behavior given that the production of public alongside private goods is costly (assuming a classic static environment). In the context of product markets, Graff Zivin and Small (2005) find that given heterogeneous investors, if corporate philanthropy and private charitable giving are imperfect substitutes, a positive level of CSR is necessary to maximize shareholder value. There will be variation in the willingness to pay for CSR as a function of income levels, in the spirit of the environmental Kuznets curve (Arora and Gangopadhyay 1995; G. M. Grossman and Krueger 1995; Dasgupta et al. 2002). This implies, as the advertising and marketing literature also underscores, that firms will engage in product differentiation and invest in brand loyalty and reputation so as to compete for consumers or investors with "warm glow" or other related prosocial preferences; in doing so, firms send positive signals about firm quality and type in order to corner the market for social responsible consumption (Navarro 1988).

The consideration of politics—both private politics, i.e., stakeholder activism by NGOs or civil society and public politics, i.e., actual or potential government engagement with firms via laws and regulation—have gained much attention by scholars of industry self-regulation because of the plethora of empirical evidence that suggests political motivations are the most salient for explaining the emergence of CSR (Delmas and Toffel 2008; Doonan, Lanoie, and Laplante 2005; Innes and Sam 2008; Decker 2003; Shimshack and Ward 2008; Bandyopadhyay and Horowitz 2006).

At the center of firms and politics is the existence of information asymmetries between companies and the outside world. Activists pose a threat of negative publicity. The mere possibility of being targeted is sufficient to integrate CSR as part of corporate strategy because the threat of activism is an integral part of profit maximization on the cost side (Lyon and Maxwell 2004; Lyon and Maxwell 2008; Lyon and Maxwell 2011). At the equilibrium, only realistic demands are posed by strategic activists: ex ante agreements regarding CSR are reached and coordinated by firms and industries and boycotts are not enacted but serve as sufficient threats (Kitzmueller and Shimshack 2012; Baron and Diermeier 2007; Baron 2001). Thus, CSR are used to build reputation and avoid any form of activism that could harm business conduct (Klein, Smith, and John 2004).

The incentive to do CSR could also be derived from the threat of public rather than private politics. Potential changes in regulation and related adjustment costs may lead firms to hedge against such an event and build a strategic "buffer zone" via overcompliance, i.e., CSR (Kitzmueller and Shimshack 2012; Shimshack and Ward 2008; Maxwell, Lyon, and Hackett 2000). Similarly, if firms expect stochastic shocks to their environmental or social performance, overcompliance may reduce the risk of future noncompliance. Furthermore, CSR can be used to to improve regulatory relations today with the aim of getting preferential treatment, e.g., better permits or less enforcement tomorrow. The common strategic effects include preservation of competitive position in the event of changes in regulation as well as discouragement of such intervention (Kitzmueller and Shimshack 2012).

Ultimately, the corporate incentive to respond and change behavior (even before activist or legal action is taken) stems from the threat posed by increased costs, decreased demand, and competitive disadvantage. Similar logic as hedging against future risk in financial markets; here firms insure itself against potential activist campaign or regulatory action via CSR. In sum, economics, public policy, and marketing literatures equally suggest that CSR can differentiate a product, help build reputation, and avoid private and public politics. While the main hypotheses that this paper seeks to test are about firm-level management drivers, public politics in the form of President Obama's Climate Proposal will be exploited as a natural experiment and identification strategy in the paper's empirical analysis.

Drivers for Voluntary Carbon Disclosure: A Case of Proactive Climate Action

There is a vast business management literature that examines the drivers and effects of carbon disclosure by businesses, emphasizing external conditions, including private and public politics as described above: direct economic consequences, supply chain pressures, stakeholder actions, regulatory threats (Ben-Amar, Chang, and McIlkenny 2015; Jira and Toffel 2013; Cotter and Najah 2012; Luo, Lan, and Tang 2012; Freedman and Jaggi 2011; Erin M. Reid and Toffel 2009; Kolk and Pinkse 2007; Kim and Lyon 2011; Stanny and Ely 2008). A majority of the literature defines

carbon disclosure as a binary decision: to disclose or not to disclose information about climate change strategies and carbon emissions.[3]

A gap in this literature is an examination of the management factors internal to firms that could propel or further constrain corporate participation in voluntary carbon disclosure. This paper contributes to the literature by emphasizing the variables involving the agency of corporate management, which I elaborate by drawing on the literature on "policy supporters" and chief executives for explaining a corporation's participation and effort decisions in voluntary carbon disclosure. Once the decision about participation has been made, a firm's choice about the extent to which it will engage in higher levels of carbon disclosure will be contingent on the integration of climate risks and related concerns in a corporation's modus operandi, as reflected in a corporation's business strategy and adoption of quantifiable carbon emissions targets.

The literatures on voluntary programs and corporate social performance and accounting provide guidance on the nature of these micro-level factors. Prakash (2001) posits that in firms that adopt environmental policies that go beyond the law, two kinds of processes are at work: managers who are "policy supporters" as opposed to "policy-neutrals and "policy-sceptics" either "capture" top management or induce consensus toward these policies. Along this same logic, Liao, Luo, and Tang (2015) and Berthelot and Robert (2011) find that when a corporation's Board of Directors has a dedicated environmental committee the company's propensity for and the level of climate change disclosure is higher, respectively.

In a study of chief executive officers and voluntary environmental performance, Rivera and De Leon (2005) find that a CEO's environmental expertise appear to be significantly associated with higher corporate participation in voluntary programs and also with higher "beyond-compliance" environmental performance ratings. Likewise, Strand (2013) shows that corporations with a chief social responsibility officer are three times more likely to be included in the Down Jones Sustainability Index (DJSI) than corporations with none. In rationalizing the importance of upper management support, Esty and Lubin (2010) suggest that a "chief sustainability officer"

[3] An exception, albeit outside of carbon disclosure, is Bouten, Everaert and Roberts (2012). The authors take a similar two-step approach as I do in this paper where they also employ a Double Hurdle model to examine the determinants of voluntary social and environmental reporting for listed Belgian and US firms. While the authors considered firm-level factors such as an environmentally sensitive profile, strategic posture, and media exposure they do not consider management and organization factors in their analysis.

helps the executive team align vision of "strategic sustainability initiatives" with business strategy and allocate the necessary resources and responsibilities toward these efforts.

Hypotheses 1 recapitulate these insights for the propensity of voluntary carbon disclosure and level of disclosure by firms.

Hypothesis 1: The likelihood of participation in voluntary carbon disclosure increases when there is a policy supporter of climate change at the managerial or executive levels in the firm.

Sustainability executives exercise leadership and creativity, moving beyond structural constraints as generative agents, similar to the way Avant et al. (2010) describe the new twenty-first century "governors" of global governance. Transformational leaders within a company can create new issues, new interests, new strategies, and new modes of action in global climate change, and thus motivate and persuade people on the part of company management to promote carbon disclosure at high levels as central to business objectives.

Once a decision about whether to participate in voluntary carbon disclosure or not has been made, a global business's commitment to sustainability, as they are signaled publicly through corporate values, norms, and practices is conjectured in this paper to be a predictor of a corporation's engagement in carbon disclosure at high levels. High levels of carbon disclosure mean a company voluntarily reports its carbon emissions and related management plans but do so publicly and verify carbon disclosures with third-party audits.

In their comparative study of corporate social responsibility (CSR), Matten and Moon (2008) distinguish between "implicit" and "explicit" CSR. Companies that engage in "explicit" CSR readily join voluntary social initiatives and articulate and communicate widely their responsibility policies, programs, and practices to stakeholders and the public as a reflection of company discretion and initiative (Matten and Moon 2008; Vidaver-Cohen and Brønn 2013). When a corporation is already engaged in explicit CSR activities the marginal cost of engaging in voluntary carbon disclosure at higher levels is likely to be relatively low. By contrast, "implicit" CSR is not

a voluntary and deliberate corporate decision, but rather, a reflection of a corporation's institutional environment (Porter and Kramer 2006).

Matten and Moon's (2008) explicit CSR is in line with Benabou and Tirole's (2010) and Baron's (2008) theories of CSR, which posit that shareholders, including consumers have delegated their social responsibility to the corporation. In related theoretical work, Besley and Ghatak (2007) suggest that firms caught cheating on CSR promises will earn lower profits, while more responsible firms will earn higher profits as a reputational premium to support good behavior. By engaging in explicit CSR, the firm will avoid myopic decisions and strengthening their market position in the long-run (Bénabou and Tirole 2010).

For global businesses, explicit CSR may take various forms. These companies have brand reputations to protect and they work proactively to ensure that they are out in front of emerging issues by detailing how they are upholding their vision and values and then integrating that vision and values into strategies and operating practices (Waddock 2008; Scherer and Palazzo 2008). Moreover, in the area of climate change mitigation, companies may proactively adopt quantifiable emissions reduction targets as a tangible means of integrating climate change risks and opportunities into their day-to-day business operations.

Voluntary carbon disclosure at high levels should be the domain of firms that have integrated climate risks and opportunities into their business operations. Voluntary carbon disclosure at high levels is a low cost extension of what these firms are already doing. For these firms, the marginal cost of disclosure is low since they are already engaged in proactive climate mitigation. Moreover, "going the extra mile" in voluntary carbon disclosure helps firms safeguard brand reputations and to corner new markets because they are further signaling to consumers their corporate social responsibility.

Hypothesis 2: Firms that integrate climate risks and opportunities into business operations will engage in higher levels of carbon disclosure because it is relatively low cost to signal that they are "green" firms.

3 The CDP

The CDP (formerly known as the Carbon Disclosure Project) has been called "The most powerful green NGO you've never heard of" by the Harvard Business Review (Winston 2010). The CDP is a nonprofit climate initiative founded in 2000 to encourage voluntary disclosure of greenhouse gas emissions, water usage, and voluntary strategies for managing climate change, water, and deforestation risks by companies. Annually, on behalf of over 800 investors, the CDP invites firms, from Global 500 companies to mid-sized companies in emerging markets across a wide range of industries to disclose their climate change, water, and forest-risk information. Any organization wishing to publicly report their GHG gas emissions, climate change strategies, water stewardship approach and deforestation risk management can do so through the CDP.[4]

Specific to the CDP's Climate Change program is an annual questionnaire in which executives of corporations are asked to report information about their management structure, describe the risks and opportunities to climate change posed to their businesses, outline their corporate strategies for managing these risks and opportunities, and detail their greenhouse gas emissions. Examples of the type of questions asked in the CDP's 2015 Climate Change Information Request is in Exhibit A1 in the Appendix.

In addition to tracking corporate strategies and emissions, the CDP rates and ranks corporations on the quality of their information disclosure by publishing disclosure scores (with a maximum score of 100; see section 4 for more details) for companies that disclose to it on an annual basis. In this paper's empirical analysis, the CDP's disclosure scores serve as a proxy for the intensity of participation, i.e., carbon disclosure effort or the level of disclosure.

According to the CDP, their scoring methodology has been developed with inputs from companies, investors and other partners—"It is based on scrutiny of the thoroughness or level of detail and comprehensiveness of the content responses, as well as the company's awareness of climate change issues, management methods and progress towards action on climate change as reported in the response" to the CDP questionnaire, including a company's choice of measurement

[4] Source: https://www.cdp.net/Documents/disclosure/2015/Companies-requested-to-respond-CDP-climate-change.pdf (Retrieved October 21, 2016)

and verification of carbon emissions, such as a firm's selection of boundaries, adjustments, carbon accounting principles, and the verification status of the reported data.[5]

The participation in the CDP is voluntary and high (72% in 2015) but by no means assured. (See Section 4 for how this paper operationalizes what it means to participate in the CDP.) The primary motivation, according to the CDP, is economic opportunity: "Companies that measure their environmental risk are better able to manage it strategically…creating opportunities to innovate and generate revenue from sustainable products and services."[6] While reporting (including detailed guidance on how to do it) and monitoring of carbon disclosures are part and parcel to participation in the CDP, there are no direct penalty for nonadherence. Despite this, the increasing scrutiny of financial investors, particularly institutional investors, on environmental and carbon asset risks suggests that nonadherence to the CDP could lead to financial consequences, in line with the theoretical literature that links private politics with CSR (Kim and Lyon 2011; Reid and Toffel 2009; Kolk, Levy, and Pinkse 2008).

4 Data and Descriptive Statistics

Data

Data for this research are drawn from the CDP Climate Change Information Request questionnaire to 683 companies that were listed as part of the Global 500 firms between 2011and 2015. As explicated in the previous section, the survey was designed to track companies' climate change strategies and carbon emissions by asking detailed questions about corporations' management structure, risks and opportunities to climate change, strategies to respond to the risks and opportunities, and accounting of greenhouse gas emissions. Based on the responses of corporations, CDP rates and ranks firms based on the quality of their responses, i.e., the extent of information disclosure by respondents, by assigning a disclosure score to respondents. More details about the CDP's calculation of the disclosure scores are below.

[5] Source: https://www.cdp.net/Documents/Guidance/2015/CDP-climate-change-scoring-methodology.pdf (Retrieved October 21, 2016)
[6] Source: https://www.cdp.net/en-US/Respond/Pages/companies.aspx (Retrieved October 21, 2016)

All disclosure scores are public by default, but companies can request for privacy of their climate change information, including their disclosure scores. In 2011-2015, less than 5 percent of the Global 500 companies that have disclosed to the CDP made this request.[7] To avoid making assumptions about the missing disclosure scores of the "private" responses, the analysis sample is a panel of the Global 500 companies in 2011-2015 excluding the 164 firm × year observations (<5%) where a company has requested for privacy of its score.[8] The result is an unbalanced panel of a total of 682 companies over five years, providing 3251 firm × year observations. The paper's main analysis will thus pertain to voluntary *public* disclosure by the Global 500.

Dependent Variables

There are two dependent variables in this paper: one for measuring the binary choice of voluntary disclosure and the other for measuring the intensity of participation or the level of disclosure. The outcome variables, respectively, makeup the two stages or hurdles of decision-making in the Double Hurdle Model, which will be discussed in detail in the next section.

In the first stage of decision-making, a simple dichotomized variable, *Participation* is operationalized as 1 for participation and 0 for non-participation in year 2015 for a firm, which is the unit of analysis. A company chooses on an annual basis whether or not to participate in voluntary carbon disclosure; in other words, a company may decide to participate in the CDP in one year but not the next year.[9]

In the second stage, the intensity of participation by a business, is measured by *Carbon Disclosure Score*, which is the degree to which a company is committed to a higher level of voluntary carbon disclosure; this variable can also be conceived as a measure of carbon disclosure quality, i.e., the level of detail and comprehensiveness of information disclosure.[10]

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[7] According to Alex Cameron-Smith, CDP's Corporate Partnership Executive, "The scores are public by default, unless they request otherwise." This information is provided to the author via telephone interview and confirmed via email on November 17, 2015.

[8] A separate robustness check specification includes the 164 firm × year observations (where I code the disclosure scores as "0"), which shows that the paper's empirical results are robust to the exclusion of these observations.

[9] For example, there were 7 companies that disclosed their carbon emissions to the CDP in 2014 but not in 2015. That said, this paper's model controls for participation in the prior year because presumably it is less cumbersome to participate in the CDP if a firm has already committed to voluntary carbon disclosure in the prior year.

[10] The existing literature by and large measures a company's climate change disclosure level in the form of disclosure indices that are study specific. For example, Amran et al. (2014), following Freedman and Jaggi (2005; 2011), develop two disclosure indices based on five criteria that are expected to capture Kyoto Protocol-related

Carbon_Disclosure_Score is a continuous variable that ranges from 0 to 100 (100 is the maximum score). This is a disclosure score assigned to a company by the CDP based on the number of points a company has been awarded for answering questions regarding their climate change strategies and carbon emissions (the numerator) as part of the CDP's climate change questionnaire[11], divided by the maximum number attainable (the denominator).[12] This fraction is then converted to a percentage by multiplying by 100 and rounded to the nearest whole number. The higher the score, the more information a company has provided to the CDP about its carbon emissions and related management plans.

The CDP gives more weight to company responses in some categories of the questionnaire than others. The weights are based on the importance of a question to climate change mitigation (as determined by the CDP) and the amount of data requested. For example, the three "highest points" attainable questions and responses are those about a firm's climate change risks and opportunities (27), respectively, and request for information about a company's GHG emissions, namely boundary for GHG inventory, global Scope 1 & 2 emissions, exclusions, and sources of uncertainty in data gathering, handling and calculations (25). By contrast, the "lowest points" attainable questions and responses are those about a corporation's climate change communications (3) and Scope 1 and 2 emissions breakdowns (4), respectively. Information about corporate governance and adoption of emission targets are allocated a maximum score of 5 to 15 points, respectively.

In the baseline specification (see Table 4), I have coded "0" for C*arbon_Disclosure_Score* for the 88 companies that have not disclosed their carbon emissions to the CDP. These companies receive a "0" score because they have not engaged in voluntary carbon disclosure. Altogether, there are 532 companies (~78 percent) in 2011-2015 that have a *Carbon_Disclosure_Score* greater than "0" in the main analysis.

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disclosure via content analysis of sustainability reports by firms in Asia Pacific. Similarly, Berthelot and Robert (2011) develop a disclosure index using content-analysis technique based on the Canadian Institute of Chartered Accountant (CICA) climate change disclosure recommendations for examining Canadian oil and gas firms.

[11] The CDP Climate Change Information Request questionnaires can be found on the CDP website (source: https://www.cdp.net/CDP%20Questionaire%20Documents/CDP-Climate-Change-Information-request-2016.pdf).

[12] In general, the number of points allocated to each question depends on the amount of data requested. Questions that have more than one point attached to a single piece of information are deemed of particular high importance by the CDP, e.g., the "gross global Scope 1 emissions." (Source: https://www.cdp.net/Documents/Guidance/2015/CDP-climate-change-scoring-methodology.pdf).

Figure 1 shows the distribution of the voluntary disclosure scores of the Global 500 companies by year for 2011-2015. First, the persistence of zeros representing non-participation suggests that that voluntary carbon disclosure, and voluntary climate action by corporations more generally is characterized by corner solutions. An objective of this paper is to account for and explain the persistence of the "zeros," along with variation in positive levels of voluntary carbon disclosure over time.

[Figure 1 Here]

Second, the increasingly thicker tail on the right side of the distribution suggests that while variation exists in carbon disclosure quality there is an increasing bias toward higher levels of carbon disclosure amongst companies that report their carbon emissions and related information to the CDP. In fact, the disclosure scores take on an increasingly bimodal distribution with a concentration of zeros and then increasing density of high scores. In 2011, the mean score was 47 with a median of 59. By 2015, the mean score was 59.6 and the median was close to 90.

Despite the upward bias in the distribution of disclosure scores over the duration of 2011-2015, the variation in scores that exist represents the differential costs that these companies are willing to undertake in their voluntary carbon disclosure. This paper's empirical analysis provides information about the characteristics of the "leaders among leaders" of the global businesses that choose not only to disclose their carbon emissions and management strategies but engage in carbon disclosure at high levels and allow the CDP to make this information public.

Key Independent Variables

There are three key explanatory variables of interests. The CDP climate change questionnaires between 2011 and 2015 is the main source of data for the key explanatory variables. See Appendix Figure A1 for the specific survey questions in which these managerial and organizational variables are based on. I describe below my strategy for collecting and coding *Manager*, *Strategy*, and *Target* for non-participants of the CDP and how I impute missing data for company × year observations

based on existing information on a company's management structure, climate change strategy, and emissions target.

With respect to the firm-level variables of interest, *Manager* is coded 1 and 0 otherwise if a company houses a senior or executive level manager responsible for climate change, environmental sustainability, or environmental policy in a given year. *Manager* is also coded 1 if a firm has a committee responsible for setting vision and planning for climate risk management as part of its Board of Directors.[13] Second, *Strategy* is an indicator variable that captures whether climate change risks and opportunities have been integrated into a firm's business strategy and operations in 2011-2015.[14] Third, *Target* is coded 1 and 0 otherwise if a firm has adopted a quantifiable emissions reduction target in a given year.[15] *Target* serves as an alternative specification and a more concrete measure of whether a firm has integrated climate change concerns into a firm's modus operandi.

For companies that report to the CDP about their company's management structure, climate change strategy, and emissions target in some years but not during other years, I impute missing data based on existing information. Missing data are imputed based on information available in the most recent year. For example, if a company responds to the CDP questionnaire in 2011 and *Strategy* = 1 ("Yes" for having a climate change strategy), but *Participation* =0 for 2012-2015 then *Strategy* would be coded as 1 for the latter years. If a company responds to the CDP survey in 2011 and Strategy = 0 ("No" for having a climate change strategy), but *Participation* =0 for 2012-2015 then *Strategy* would be coded 0 for 2012-2015. Conversely, if a company responds to the CDP survey in 2015 but *Participation*=0 for the previous years, *Strategy* is code 0 for all previous years. A similar strategy is used for the in-between cases: if a company responds to the CDP survey in

[13] The *Manager* variable is based on response to CC1.1 ("Where is the highest level of direct responsibility for climate change within your organization?").
[14] The Strategy variable is based on responses to CC2.2 ("Is climate change integrated into your business strategy?").
[15] The *Target* variable is based on responses to CC3.1 ("Did you have an emission reduction target that was active (ongoing or reached completion) in the reporting year?"). For companies that respond "Yes" to having an emissions reduction target that is active they are also requested to report information about "scope, % of emission in scope, % reduction from base year, base year, base year emissions, and target year," in addition to whether they have an absolute versus an intensity target. For the purpose of this paper, I do not differentiate between an absolute versus an intensity target.

2013 and *Strategy* is 1, then I code S*trategy* =0 all prior years (2011-2012) and *Strategy* =1 for subsequent years (2014-2015). This same strategy pertains to coding *Manager* and *Target*.

I collect and code data on *Manager*, *Strategy*, and *Target* separately for companies that did not participate in the CDP during 2011-2015. Data sources are corporate websites and published reports, such as a company's standard annual reports or their Corporate Social Responsibility reports in 2011-2015. For *Manager* and *Target*, coding was straightforward: *Manager* is coded 1 and 0 otherwise if there exist a senior or executive level manager responsible for climate change, environmental sustainability, or environmental policy and/or if there exists a Board of Directors committee devoted to addressing these issues in year 2011, 2012, 2013, 2014 and 2015, respectively. *Target* is coded 1 and 0 otherwise when a company has adopted an emissions target in a given year of the study period.

Coding whether a non-participating firm has integrated climate into their business strategy was more challenging because it was less clear what constitute an integrated business and climate change strategy. My approach to data collection and coding *Strategy* was to err on the conservative side. I adopt a broader but stricter definition of what constituents an integrated business and climate change strategy than the CDP: If a company adopts and incorporates ESG (Environmental, Social and Governance) principles into its decision-making processes and day-to-day operations in a given year, as explicitly stated and described in detail on its corporate website and CSR publications, *Strategy* is coded as 1 or 0 otherwise.

The ESG principles are a set of globally accepted principles for a company's operations that assess how a company manages opportunities and risks associated with its energy use, waste, pollution, carbon emissions, natural resources conservation and animal treatment; a company's relationships with the employees, suppliers, customers, and other stakeholders; and a company's accuracy and transparency in financial accounting and general governance rules and processes about avoiding and resolving potential conflicts of interest, such as in a company's choice of board members or political contributions. The adoption of ESG principles by companies have in recent years been used by institutional investors to judge the overall quality of the company's governance and risk management processes in the area of environment, social and corporate governance issues. As such, the adoption of ESG principles by a firm is likely to be a good proxy for its adoption of an integrated business and climate change strategy.

Table 1 summarizes the definitions, sources, and construction of *Manager*, *Strategy*, and *Target*, as well as that of the control variables.

[Table 1 Here]

Control Variables

In Hahn et al.'s (2015) review of the business literature on carbon disclosure, the authors conclude that comparability of previous studies has been hampered by the lack of a common set of control variables. Taking heed, this paper includes a set of control variables that have been identified as significant drivers of voluntary carbon disclosure in existing empirical studies. The natural log of a firm's annual, fiscal year corporate *Revenues* in millions of dollars measures firm size. The natural log of a firm's corporate *Assets* in millions of dollar and number of employees, *Employees*, serve as alternative specifications in the robustness checks (see Section 6 Table 9).

Scholars of voluntary environmental programs and policies have found that larger firms are more likely to participate in voluntary environmental programs (Arora and Cason 1996; Arora and Cason 1996; DeCanio and Watkins 1998; Videras and Alberini 2000; Khanna et al. 2007; Stanny and Ely 2008). According to Khanna et al. (2007), this is because larger facilities have a greater capacity to bear the fixed cost of participating in voluntary programs, seeking certification, and providing environmental training to personnel. Moreover, external pressures from regulators, competitors, and the public may also be greater; consequently, larger firms have more incentive than small firms to join voluntary programs, including carbon disclosure to mitigate the potential negative impacts of a tarnished imaged (Guenther et al. 2015; Luo, Lan, and Tang 2012; Aerts, Cormier, and Magnan 2008).

A measure of financial leverage is included as a control variable. Financial leverage or a company's total abilities divided by total assets has not been found to be a statistical significant driver of voluntary carbon disclosure by firms in the literature (see a review of the literature by Hahn et al., 2015), however, I have included financial leverage as control covariate with the conjecture that *Leverage* could help distinguish between the two stages of voluntary disclosure

decisions in the Double Hurdle model. The thesis is that highly leveraged firms are associated with lower disclosure effort because they will have less resources to "go the extra mile" in carbon disclosure, i.e., engage in higher levels of disclosure given participation in the CDP, holding everything constant.

Other control variables include a company's participation status and disclosure score in the previous year—*Participation Last Year* and *Score Last Year*—respectively, to account for the fact that a firm's decision about participation in the CDP and how much effort to exert in voluntary carbon disclosure is likely to be correlated with that firm's decisions in the previous period.

Moreover, the empirical analysis includes the natural log of the annual average of The Dow Jones Commodity Index for Natural Gas (Total Returns), which is an index of monthly natural gas prices designed to track the natural gas market through futures contracts, for 2011-2015. *Natural Gas Price* controls for an alternative explanation for a company's participation and effort in voluntary carbon disclosure: the downward trend in natural gas prices in recent years could instead be the motivating factor for voluntary climate action rather than internal firm management structure and practices (as proxies for explicit CSR), namely *Manager*, *Strategy* or *Target*. Burning natural gas produces nearly half as much carbon dioxide per unit energy compared to that of coal (Zielinski 2016).

I include sector and country fixed effects to control for exogenous factors that affect in some unobserved way all companies operating in the same industry or originating from the same country but that do not change systematically over time (at least not during 2011-2015). Findings on industry sector variation and industry self-regulation have been mixed. Arora and Cason (1996) find that voluntary program participation rates are higher in industries with greater consumer contact. By contrast, recent studies have shown that firms that operate in sectors that emit substantial amounts of greenhouse gases are more likely to engage in climate change mitigation activities (M. Kotchen and Moon 2012; Kolk and Pinkse 2008; Haigh and Griffiths 2012).

Certain domestic political and institutional contexts (e.g., high levels of country level commitment to climate change mitigation, protection of shareholder rights, civil liberties) will favor firms based there to engage in proactive climate action more than others (Freedman and Jaggi 2011; Pinkse and Kolk 2012; Berliner and Prakash 2014; Kollman and Prakash 2001; Buthe and Mattli 2011; Hsueh 2016; Roger, Hale, and Andonova 2016).

Finally, the inclusion of year fixed effects is based on the conjecture that in each passing year, there are contemporaneous events in the global economy that affect in some unobserved way all companies in the Global 500.

Descriptive Statistics

Table 2 reports summary statistics for the major variables used in our empirical models.

[Table 2 Here]

As discussed above, on average, closer to three-fourth of the Global 500 companies have participated in voluntary carbon disclosure in 2011-2015. Participation in the CDP in the previous year was close to 60 percent.

During 2011-2015, the mean disclosure score is 58 with a high standard deviation, suggesting that the disclosure scores are spread out over a wide distribution with a minimum score of 0 and a maximum score of 100. As Figure 1 shows, the disclosure scores have increasingly taken on a bimodal distribution over the six year period with a persistence of zeros and increasing mass around high scores. On average, the score in the previous year was 52.

With respect to the main explanatory variables of interest, close to 70 percent of the Global 500 firms have a designated manager at the senior or executive level responsible for climate change and environmental sustainability more generally. 63 percent of them have integrated climate change risks into their business strategy, while 57 percent of them have adopted quantifiable emissions targets.

The Global 500 comprises of very large firms whether measured in revenues, assets or number of employees. During 2011-2015, the mean Dow Jones Natural Gas Price Index was 2.17; between 2011 and 2015, the index fell an average annual decline of 21 percent.

As Figures 2 and 3 show, there is heterogeneity in country of origin and industry sector, respectively, among the Global 500 firms. 36 percent and 21 percent of the Global 500 companies originate from the U.S. and the European Union, respectively; most other firms have headquarters in Japan (8%), Canada (5%), Hong Kong (4%), Switzerland (3%), India (3%), China (2%), Australia (2%), Brazil (2%), South Korea (2%), Russia (2%), South Africa (1%), Taiwan (1%), Singapore (1%), Mexico (1%), Malaysia (1%) and Indonesia (1%).

[Figure 2 Here]

[Figure 3 Here]

Figure 3 shows that the Global 500 firms operate across diverse sectors: Companies are involved in consumer discretionary (12%), consumer staples (8%), energy (10%), financials (23%), health care (8%), industrials (10%), information technology (15%), materials (9%), and utilities (5%). Close to 34 percent of the Global 500 companies operate in greenhouse gas intensive industries, namely in the energy, industrials, materials and utilities sectors.

Table 3 presents the participation rates and mean and median disclosure scores across nine industry sectors in 2011-2015 and in 2011 and 2015 separately. Participation in the CDP is high across sectors, notably consumer staples and industrials. As in the pooled data, the mass of the distribution is skewed to the right. Moreover, there has been a ratcheting up of scores in recent years across sectors with the exception of the utilities sector. This paper exploits the exogenous shock of Obama's climate proposal to explain (at least some of) this increase in disclosure scores between 2011 and 2015.

[Table 3 Here]

5 Empirical Framework

Basic Estimation Strategy: Double Hurdle and Fixed Effects

This paper employs a Double Hurdle (DH) model (Cragg 1971; Burke 2009) to model a firm's decision to participate in voluntary carbon disclosure and the related but separate and sequential decision about the company's intensity of participation or the level of carbon disclosure. This estimation approach accounts for the fact that businesses may participate in voluntary carbon disclosure but choose to disclose information about their carbon management strategies and carbon emissions at different levels; this suggests that the incentives and conditions driving the (binary) decision to participate may be different from the decision about effort level. Specifications that ignore the fact that the decision to disclose and the decision about the level of disclosure could be influenced by different motivating factors could lead to biased and inconsistent estimates of carbon disclosure efforts by firms.

The DH model is more general than the standard truncated regression model or Tobit model (which is a special case of Cragg's model), as it allows the participation and effort decisions to be determined by separate processes through the incorporation of two stages or tiers of estimation. In doing so, it allows different parameters and variables to differentially affect the two decisions. By contrast, the Tobit model assumes that the same mechanism generates both the zeros and the positive values of disclosure levels.

The standard Heckman Selection (HS) model serves as an alternative specification, although it is shown by a cluster-robst Vuong test for nonnested models, following Wooldridge (2010) that the DH model is a superior model (see Table A1 in the Appendix). The HS model is not the most appropriate model because there is no missing data: we have information about whether a Global 500 firm chooses to participate or not in the CDP. Rather, this is a problem about corner solutions: some firms choose not to disclose their climate change information. As such, the data of the continuous outcome variable (disclosure score) are truncated and "piled up" at 0. As such, there is a corner at zero: the problem to be solved in this incidence is how to better model $D(y|x)$ where y or the decision whether to disclose carbon information or not (and by how much) takes on a zero.

The DH model is specified as follows (Newman, Henchion, and Matthews 2003; Blundell and Meghir 1987):

$$y_{i1}^{*} = x_{i1}\gamma + T'\theta_i + \alpha_j + \delta_k + u_i \qquad \text{Participation Decision} \qquad (1a)$$

$$y_{i2}^{*} = x_{i2}\beta + T'\theta_i + \alpha_j + \delta_k + v_i \qquad \text{Effort Decision} \qquad (1b)$$

$$y_i = x_i\beta + T'\theta_i + \alpha_j + \delta_k + v_i \qquad \text{if } y_{i1}^{*} > 0 \text{ and } y_{i2}^{*} > 0 \qquad (1c)$$

$$y_i = 0 \qquad \text{other} \qquad (1d)$$

Where y_{i1}^{*} is a latent endogenous variable representing a firm's participation decision, y_{i2}^{*} is a latent endogenous variable representing a firm's effort or level of carbon disclosure, y_i is the observed second stage outcome variable (level of carbon disclosure), x_{i1} is a set of individual firm characteristics and controls explaining the participation decision, x_{i2} is a vector of variables explaining the effort decision. T is a vector of time fixed effect that control for contemporaneous shocks in the world economy that affect all firms. α_j represents a whole host of not readily observed factors in a firm's industry sector where $j = 1,...,9$ for the nine industry sectors. Country fixed effects are represented by δ_k where $k = 1,...,48$ for the countries represented by the Global 500 firms. Finally, u_i and v_i are independent, homoscedastic, normally distributed error terms.

The vector x_{i1} (participation stage) in basic models (Models 1A and 1B) contains the following variables, as described above: *Manager*, *Strategy* or *Target*, the explanatory variables of interest, and *Revenues*, *Leverage*, and *Participation Last Year*. The vector x_{i2} (effort stage) contains the same variables except for *Score Last Year* instead of *Participation Last Year*.

The DH model is estimated using maximum likelihood techniques in *Stata* with the log likelihood given as follows:

$$LL_{DH} = \sum_{0} \ln\left[1 - \Phi(x_{i1}\gamma)\Phi\left(\frac{x_{i2}\beta}{\sigma_i}\right)\right] + \sum_{+} \ln\left[\Phi(x_{i1}\gamma)\frac{1}{\sigma_i}\phi\left(\frac{y_i - x_i\beta}{\sigma_i}\right)\right] \qquad (2)$$

Φ and ϕ are the standard normal cumulative distribution function and probability density function. The estimation is performed in Stata using the "churdle" command in Stata, including robust standard errors and vessel level cluster correction. Results for the basic models are displayed in Panel A and Panel B in Table 4 (see section 5).

Identification Strategy: Obama's Climate Proposal and Regulatory Pressure

The non-experimental nature of voluntary carbon disclosure and voluntary climate action by corporations more generally means that there are a plethora of potential threats to identification in an empirical analysis about the drivers of proactive climate action. Omitted variables and/or simultaneity are two common threats to identification. Specifically, endogeneity exists if independent variables are potentially choice variables, correlated with unobservables relegated to the error term (Cameron and Trivedi 2005; Wooldridge 2010).

One potential source of endogeneity bias that the basic models has not controlled for, which has been salient in the literature (see section 2) is regulatory pressure, i.e., the extent to which firms face public politics and thus are incentivized to engage in voluntary carbon disclosure (and other acts of voluntary climate action) as a way to deflect regulatory scrutiny and preempt government regulation. As a solution to this endogeneity threat, this paper makes use of President Obama's announcement of a series of executive actions on climate change in 2012-2015 as an exogenous shock—i.e., a natural experiment—for identification.

The logic of how President Obama's proposed climate policy serves as a natural experiment for reaching causal inference goes like this. Before President Obama made an announcement about his intention for climate policy as an executive action, no viable climate change proposals for federal regulation had survived in Congress. The first proposal for federal legislation on climate change took place over a decade ago; the McCain-Lieberman Climate Stewardship Act failed a Senate vote in 2003 and 2005, respectively. Senators Bernie Sanders and Barbara Boxer introduced The Global Warming Pollution Reduction Act of 2007, which died in committee, as did two more bills—the Climate Protection Act and Sustainable Energy Act proposed in early 2013. On the House side, The American Clean Energy and Security Act of 2009 was approved by the House of Representatives but did not survive a vote in the Senate.

Given the contentious politics surrounding climate change, evidenced by the failures of the abovementioned proposals in Congress, there was little expectation that regulation on climate change would be on the horizon. As such, I argue that President Obama's Climate Proposal directed at power plants could be interpreted and exploited as an exogenous shock that exposed firms in the GHG intensive industries operating in the U.S. to regulatory pressure about impending federal regulation on carbon emissions.

In 2012, Obama began work on a series of executive actions to reduce carbon pollution, prepare the U.S. for the impacts of climate change and lead international efforts to address global climate change. The EPA was directed to work on carbon pollution standards for the power sector, with the agency making its first proposal in early March and a second refinement of the proposal in late 2013. The EPA's final standards "Carbon Pollution Standard for New Power Plants" (as amendment to the Clean Air Act) for new coal- and natural gas-fired power plants was issued on August 3, 2015. It is also known as the Clean Power Plan.[16]

While Obama's Climate Proposal was not yet enshrined in law[17], potential changes in regulation and related adjustment costs likely led firms, particularly those in the GHG intensive industries based in the U.S. to hedge against impending regulation. I contend that voluntary climate action, and voluntary carbon disclosure in particular became a strategic "buffer zone" for firms to reduce the risk of future noncompliance. Firms engage in rational behavior *today*—such as, participate in voluntary carbon emission or install managers, integrate climate change into business operations, and adopt emission targets or all of the above—to improve regulatory relations and to signal climate leadership with the aim of getting preferential treatment *tomorrow* when Obama's proposed regulation becomes rule of law.

In sum, the hypothesis is that for corporations in GHG intensive industries based in the U.S., the likelihood of climate change regulation rose, motivating these firms ("treated") to not only participate but engage in higher levels of carbon disclosure relative to other firms ("controls").

[16] Source: https://www.epa.gov/cleanpowerplan (Retrieved December 23, 2016).

[17] In fact, there may be reasons to believe that the new "Carbon Pollution Standard for New Power Plants" may never come to fruition or scaled back because President-elect Donald Trump will likely reverse at least some of President Obama's executive actions on climate change. That said, during the study period (2011-2015) there was little reason to expect a different regulatory world than the one that was emerging, which was carbon pollution standards new, modified and reconstructed power plants.

Furthermore, companies that have installed managers, integrated climate change into business operations or adopted emission targets in GHG intensive industries headquartered in the U.S. were more likely to participate in the CDP after Obama's proposed standard for carbon pollution from new power plants. With respect to the intensity of participation, companies that have installed climate change managers, integrated climate change into business operations or adopted emission targets in GHG intensive industries headquartered in the U.S. are hypothesized to have participated in the CDP at higher levels after Obama's proposed standard for carbon pollution.

I operationalize the above described natural experiment and identification strategy as a difference-in-difference-in-differences (DDD) estimator. The treatment group is firms in the GHG intensive industries from the U.S. because the Obama's proposed climate change policy only applies to companies in the GHG intensive industries in the U.S. Two specifications (Models 2 and 3) operationalize the proposed identification strategy. First, I construct a time indicator variable, *Obama Climate Proposal* that is turned on after 2013; I assume there is a lag between when the President Obama makes his first announcement in 2012 and actual responses by firms. In 2013, Obama's Administration published their first concrete proposal and refinements after seeking public comments.

GHG intensive is a dummy that accounts for the energy, industrials, materials, and utilities industries. *USA HQ* is a dummy for having a U.S. headquarter. The interaction between *USA HQ* and *Obama Climate Proposal* or *USA* × *Obama* indicates that a firm is based in the U.S. post-Obama's Climate Proposal announcement. *USA* × *Obama* × *GHG* designates GHG intensive firms based in the U.S. in the years following President Obama's executive actions on climate change.

To further test the validity of the identification strategy, a series of interactions between *Manager* and *Strategy* and *USA HQ*, *USA* × *Obama*, and *USA* × *Obama* × *GHG*, respectively, are included in Model 2A. Model 2B includes the interactions of *Manager* and *Target* and *USA HQ*, *USA* × *Obama*, and *USA* × *Obama* × *GHG*, respectively. These interaction terms, included in both the participation and effort equations, account for the possibility of simultaneity in the causal chain of the Obama Climate Proposal as described above. Public politics could affect corporate decision-making about voluntary climate action directly or through other pathways, including via the explanatory variables of interest. Management structures and business operations are internal firm

decision levers that firms could modify and adjust (given time) with relative ease in response to regulatory pressures compared to external factors.

A final specification (Models 3A and 3B) allows firms to adjust to new policy and react their behavior temporally as the threat of climate change regulation becomes more credible over time. For a more flexible treatment of time, *Obama 2013* is a time dummy that is turned on in 2013 and 0 otherwise. *Obama 2013* is then interacted with *USA HQ* and *GHG intensive* similarly as in the first DDD specification, as well as with *Manager*, *Strategy* and *Target* in the various possible combinations similar to Models 2A and 2B. These interaction terms explicitly allow for a period of "policy adjustment" by firms.

A final set of "policy reaction" variables are also include for identification: a time dummy, *Obama 2014-15*, which cover the two year-period after Obama's Climate Proposal was first announced is interacted with *USA HQ* and *GHG intensive* and *Manager*, *Strategy* and *Target*, respectively. While opposition to President Obama's climate change policy was strong (which eventually led to lawsuits that reached the Supreme Court), federal regulation on carbon emissions appeared imminent from the perspective of the private sector, especially with the momentum of Paris Agreement on the rise in 2014 and 2015, and with the U.S. and China playing an increasing role in galvanizing global climate action.[18]

6 Empirical Results

Double Hurdle Basic Models Estimates

Estimation results from the basic models (equations 1a-1d) are shown in Table 4. Model 1A contains results with *Strategy* instead of *Target*, the latter which are in Model 2B. *Strategy* and *Target* are in separate specifications because the two explanatory variables of interest are highly correlated (0.78) and are alternative measures of the how integrated climate change risks and

[18] In September 2016 (which is beyond the scope of the paper), the Lawrence Berkeley National Laboratory's assessment of the Obama Climate Proposal finds that the proposed rules are insufficient to meet the US intended nationally determined contribution (INDC) under the Paris Agreement. Additional greenhouse gas reduction measures will probably be required to meet this international commitment.

opportunities are in a firm's business strategy and operations. Both models include sector, country, and year fixed effects. Robust standard errors with firm-level cluster correction are reported.

Table A1 reports results from cluster-robust Vuong tests for the basic models, as well as the Obama natural experiment models; in all cases, the null hypothesis that the Double Hurdle model and the Heckman Selection model are equivalent models is rejected, implying that the Double Hurdle model is a better model fit than the Heckman Selection model.

Overall, the regression results from the basic models provide strong support for Hypothesis 1, which refers to the important role that "policy supporters" in the form of senior or executive managers responsible for climate change play in motivating participation in voluntary carbon disclosure, and for Hypothesis 2, which postulates that a firm's integration of climate change risks and opportunities into its business strategy and operations is associated with its level of carbon disclosure. Models 1A and 1B results largely mirror each other, as expected, since *Strategy* and *Target* are alternative specifications of the same measure.

[Table 4 Here]

I first discuss the results with respect to the Hypotheses 1 and 2 before turning to the control variables. With respect to H1, which postulates a positive relationship between managers at the senior or executive level and participation, results indicate that the existence of policy supporters of climate change mitigation inside the firm to be robustly associated with participation at the one percent significance level, respectively. In both Models 1A and 1B, a firm that houses a manager responsible for climate change is more likely to engage in voluntary carbon disclosure than firms without a manager dedicated to climate change and sustainability. These results suggest that senior or executive managers elevate climate change as a critical concern and induce a firm to participate in proactive climate action including voluntary carbon disclosure.

That said, *Manager* is not statistically significant in the second-hurdle decision about effort allocation, as expected. A manager's championship for participation in voluntary carbon disclosure

is necessary but sufficient. Meaningful commitment with respect to the level of carbon disclosure requires investments in carbon management, including third-party audit and verification protocols.

The rest of Table 4 (column 3) in Panels A and B shows the results from the second-hurdle decision, involving the truncated regression of the level of carbon disclosure.[19] In Model 1A (see Panel A), as expected, the existence of a *Strategy* that integrate climate change risks and opportunities into business operations positively influence a firm's carbon disclosure effort or level of carbon disclosure at the 10 percent level. This result confirms Hypothesis 2: Companies that earn higher scores on their carbon disclosure effort (by three to eight points out of a scale of 100) are associated with the incorporation of climate change risks and opportunities into business strategy and operations.

In Panel B, Model 1B results further underscore the importance of having an integrated strategy: the adoption of an emissions target, which is a concrete and quantifiable measure of climate change mitigation is statistically significant at the one percent level. In fact, firms that have instituted an emissions target earn approximately eight more points on their disclosure scores than those that have not adopted a target. The bottom-line is that firms that integrate climate change as central to their operations are the ones that "go the extra mile" in their carbon disclosure effort, likely because they bear lower marginal costs of disclosing climate change information, including carbon emissions since they are more likely to have complementary resources, such as efficiency-saving technologies, all of which make reducing and tracking carbon more easily. Moreover, higher levels of carbon disclosure may help safeguard brand reputations because a firm is further signaling to consumers that it is a socially responsible corporation.

With respect to firm-level controls, in both Models 1A and 1B a firm's voluntary carbon disclosure participation and effort in the previous year garner the largest marginal effects. This is not surprising since these dummy variables serve as a measure of past behavior as well as a catch-all variable for what is not captured in the other proposed variables. In both models, firm size matters; the larger the company the more likely it participates in the CDP and the higher its carbon

[19] The Appendix includes information on how I estimate marginal impacts of the explanatory variables. Estimates of average marginal effects, conditional marginal effects and unconditional average marginal effects will be reported in an updated version of the paper.

disclosure score. Furthermore, more leveraged companies are less likely to engage in voluntary carbon disclosure.

In the basic models, results suggest that as natural gas prices rise firms are more likely to participate in the CDP but with lower effort. Conversely, as natural gas prices fall firms increase their level of carbon disclosure. The former result appears a bit puzzling, while the latter is intuitive: cheaper natural gas makes it easier for companies reduce their carbon emissions and thus they would be willing and able to disclose their climate change mitigation strategies at higher levels, holding everything else constant. The next set of results, which exploits President Obama's Climate Proposal as a natural experiment provides some clarity on the estimated coefficients of the natural gas prices.

Obama Climate Proposal Models Estimates

By making use of President Obama's announcement of a series of executive actions on climate change, which I argue increased the likelihood of climate change regulation in the U.S. during the period under study, I find that firms based in the U.S. were more likely to participate and engaged in higher levels of carbon disclosure relative to other firms in 2011-2015. Moreover, Hypotheses 1 and 2 are by and large robust to the difference-in-difference-in-differences models: The existence of a senior or executive level manager in charge of climate change increases the propensity of a firm's participation in voluntary carbon disclosure. Moreover, setting emission targets is correlated with higher levels of carbon disclosure, although integrating climate change into a firm's business strategy is no longer statistical significant in the second hurdle regressions when regulatory pressure has been accounted for in the Obama regressions.

Tables 5-7 report results from two separate specifications; the second set of specifications allows a more flexible treatment of time and gives firms a time path for reacting and adjusting to President Obama's Climate Proposal. As in the basic models, Models 2A-2B and Models 3A-3B (Tables 5-8, respectively) include sector, country, and year fixed effects. Robust standard errors with firm-level cluster correction are also reported. Table A1 in the Appendix shows that the DH model is a better model fit than the HS model for both of the Obama specifications.

[Table 5 Here]

[Table 6 Here]

The results from Models 2A-2B and Models 3A-3B underscore the statistical significance of *Manager* in the first hurdle "participation" regression and *Target* in both the first and second hurdle "participation" and "effort" regressions, respectively. Climate change managers may compel firms to participate in voluntary carbon disclosure but wield no discernable effect on a firm's level of carbon disclosure. Rather, results indicate a strong statistically significant association (at the 1 percent level) between quantifiable emissions targets and higher levels of voluntary carbon disclosure.

Firm size as proxied by annual revenues (log) remain a significant correlate of both participation and the intensity of participation in voluntary carbon disclosure at the 5 and 10 percent significance levels. As in the basic models, *Leverage* is inversely related to participation in the CDP. In the Obama specifications, natural gas prices affect voluntary carbon disclosure in the expected direction: a one percent increase in natural gas prices leads to about an eight point decrease in a firm's disclosure score. The estimated coefficient for (the natural log of) natural gas prices no longer has a perverse effect on a firm's participation in the CDP.

Turning to the variables that make up the identification strategy, results in Model 2B and 3B (specifications that include *Target* as a covariate) indicate that U.S. based corporations are associated with approximately six less points in their disclosure scores compared to firms headquartered elsewhere. That being said, U.S. based companies were more likely to participate in the CDP after Obama announced his proposal to regulate GHG emissions in power plants (see column 2 in Tables 5 and 6). This is likely because U.S. based firms experienced relatively more regulatory pressures about impending climate change regulation than firms based elsewhere during 2013-2015.

When firms are allowed a time path to react and adjust to President Obama's Climate Proposal (see Tables 7 and 8), results show that U.S. based companies that were already participating in voluntary carbon disclosure engaged in higher levels of carbon disclosure in 2013; their disclosure scores were on average close to eight points higher than other participants not based in the U.S.

Participating firms in the U.S. were able to respond swiftly to regulatory pressures by disclosing a little more information about their climate change plans. By 2014-15, all companies headquartered in the U.S. were more likely to participate in the CDP than other firms, presumably because more time has passed and all firms—participants and non-participants in all industries—are more able to react and adjust their behavior in anticipation of compulsory rules about carbon emissions.

[Table 7 Here]

[Table 8 Here]

Across all four models (Models 2A-3B), the estimated coefficients for the Obama Climate Proposal indicator variables are negative and statistically significant for the first hurdle probit regressions, suggesting that the Obama climate change policy had a negative effect on corporate participation in the CDP. Conditional on participation, however, *Obama Climate Proposal* and *Obama 2014-15* exert a positive effect (~2 points) on the level of disclosure effort (Column 4 in Tables 5-8). The former set of results is puzzling, although perhaps not surprising because there are many world and country-level events and policies that are occurring at the same time, which could be picked up by the estimated coefficients in the participation stage of the DH model.

For firms that are participating in voluntary carbon disclosure, results show that they have responded to impending climate change regulation by disclosing to the CDP at higher levels. For participants of voluntary carbon disclosure, the decision of whether to participate in the CDP has already been made and the cost of participation is sunk. As such, for these firms their benefit cost analysis is based on the marginal cost of disclosing at a higher level, which is arguably on balance less costly than for companies that are at the first hurdle decision about whether to participate in carbon disclosure or not, ceteris paribus. In the participation decision, the marginal cost of participation includes the cost of participation as well as some expectation about the cost of disclosure effort, albeit no decision about the actual level of disclosure or effort has been realized.

Aside from the direct effect of Obama's executive actions on a firm's decisions about participation and effort in voluntary carbon disclosure, there are other channels through which Obama's Climate Proposal could potentially lead to participation (or not) and lower or higher levels of voluntary carbon disclosure, respectively. Specifically, the empirical results present the estimated coefficients on the various combinations of interaction terms made up of the explanatory variables of interest (*Manager*, *Strategy* and *Target*) and the various DDD variables, respectively.

In Models 2A and 2B, the only statistically significant interaction terms are *Strategy* × *USA* and *Target* ×*USA*. The results underscore the importance of an integrated climate change strategy and a quantifiable emissions target as drivers of voluntary carbon disclosure for firms that are headquartered in the U.S. For U.S. based firms, the existence of management practices directed at addressing climate risks compensate for the reduced probability of participation in the CDP by the virtue of being a company headquartered in the U.S. The result for *Target* ×*USA* is replicated in Models 3B, but for U.S. based companies that operate in GHG intensive industries having adopted an emissions target are associated with a lower rather than higher probability of participation after the announcement of President Obama's Climate Proposal (2014-15).

When firms are allowed a time path to react and adjust to Obama's climate change policy proposal in Models 3A and 3B, the estimated coefficients on *Manager* × *USA* × *Obama 2013* × *GHG* are negative and statistically significant in both hurdles of the DH model (see Table 7). The first hurdle result subtracts slightly from the direct positive effect that *Manager* has on a firm's participation in voluntary carbon disclosure. By contrast, the second hurdle result indicates a decrease in the average disclosure score of a company by approximately 28 points (at the 10 percent level). In Model 3B, *Manager* × *USA* × *Obama 2013* is negative and statistically significant in the second hurdle (carbon disclosure score). In 2013, a U.S. based company with a climate change manager is associated with nine fewer points on its disclosure score (see Table 8). These results highlight the fact that installing a manager responsible for climate change is by no means sufficient and may in fact be correlated with greenwashing behavior. That said, the standard errors on the coefficient estimates are relatively high suggesting that these estimates are imprecise.

Robustness Checks

Table 9 summarizes the results from a battery of specification tests intended to check the robustness of the paper's main models.[20] The focus of the specification tests are on the robustnessness of the main explanatory variables of interest, *Manager*, *Strategy* and *Target*. I run two separate sets of robustness checks. One set of robustness checks includes the DDD estimator, i.e., President Obama's Climate Proposal serves as an identification strategy for estimating the hypothesized internal firm management structure and practices. These specification tests are on the robustness of Models 2A-2B. The other set are robustness checks on Models 1A-1B. On balance, the paper's main model results are overall robust to these alternative specifications.

[Table 9 Here]

First, I replace *Revenues* with other related measures—log forms of *Assets* and *Employees*—that have also been used in the literature to control for firm size. Second, I drop the lagged variables, *Participation Last Year* and *Score Last Year*, from the models. Third, I replace the Dow Jones natural gas index with the S&P GSCI natural gas index as an alternative measure of natural gas prices. I also include a set of results that are based on company fixed effects. These alternative specifications underscore the paper's key findings, which are that in-house champions of climate change at the managerial and executive levels and corporate commitments to climate change mitigation in the form of explicit integration of climate risks (*Strategy* and *Target*) are positively associated with participation and effort in voluntary carbon disclosure by businesses. With that said, *Target* is somewhat more robust to alternative operationalization of variables than *Strategy*. This is likely because *Target* is a more concrete and tangible measure of integrated climate change strategy than is *Strategy*.

7 Conclusion

One private voluntary climate initiative that has emerged over the past decade and half is the CDP (formerly known as the Carbon Disclosure Project). The CDP invites corporations to voluntarily disclose information about their climate change mitigation activities and carbon

[20] The results from the robustness checks are excluded from the preliminary draft of the paper but are available from the author upon request.

emissions. This paper focuses on the Global 500 corporations to make the central argument that management structure and practices internal to firms are key correlates of decision-making by a firm about 1) whether to participate in voluntary carbon disclosure *and* their choice regarding 2) how much effort to allocate to carbon disclosure. This paper's empirical analysis characterizes the "leaders among leaders" that choose not only to disclose their climate change information but "go the extra mile" in disclosing their climate change information and carbon emissions. High levels of carbon disclosure mean that a company not only voluntarily participates in carbon disclosure but does so publicly and verifies carbon disclosures with third-party audits.

Drawing on the private provision of public goods and the economics of corporate social responsibility literatures, this paper first justifies "whether" and "why" proactive or voluntary climate action by businesses before hypothesizing drivers for voluntary carbon disclosure as a case of proactive climate action. The paper's theoretical anchor is a rational political economy argument that voluntary carbon disclosure is both beneficial and costly for corporations with respect to the existence of supportive management structures and the integration of climate risks into business operations inside the firm. There is a disparity in the willingness of global companies to engage in disclosures at different levels because of the variation among firms with respect to internal managerial factors and dynamics.

To disentangle the factors and dynamics that are associated with the related but sequential decisions of participation and effort in voluntary carbon disclosure, this paper employs the Double Hurdle Model: a two-stage modeling approach that deals with the persistence of "zeros" and allows different parameters and variables to differentially affect a firm's participation and effort decisions. This modeling approach has seldom been employed to examine voluntary social and environmental behavior by corporations even though the factors underlying the decision to disclose and the disclosure level could be different, as demonstrated by this paper's empirical analysis. Importantly, modeling participation and effort in two-steps accounts for greenwashing behavior by corporations, i.e., firms that engage in self-regulation—such as participation in the CDP—to signal their "green" leadership without engaging in actual activities that reduce their carbon footprints.

As an identification strategy, this paper exploits President Obama's announcement of a series of executive actions on climate change as a natural experiment for uncovering causal inference: for corporations in greenhouse gas intensive industries based in the U.S., the

likelihood of climate change regulation rose, motivating these firms to not only participate but engage in higher levels of carbon disclosure relative to other firms. Given the contentiousness surrounding climate change evidenced by the failures of the climate change legislative proposals in Congress, there was little expectation that federal regulation on climate change would be on the horizon. As such, President Obama's Climate Proposal serves as an exogenous shock that exposed firms in the GHG intensive industries operating in the U.S. to undue regulatory pressure about impending regulation on their carbon emissions.

Based on an analysis of the participation of the Global 500 firms in the CDP during 2011-2015, preliminary results suggest that the existence of a senior manager or executive-level officer with direct responsibility for climate change is associated with higher participation in voluntary carbon disclosure. Notwithstanding, firms that have integrated climate change risks into their business operations, notably the adoption of emissions reduction targets are associated with higher levels of carbon disclosure: these companies not only proactively report their climate change strategies and carbon emissions but have verified their disclosures with third-party audits. By making use of President Obama's announcement of a series of executive actions on climate change, which increased the likelihood of climate change regulation in the U.S. during the period under study, I find that firms based in the U.S. were more likely to participate *and* engaged in higher levels of carbon disclosure relative to other firms. While U.S. based companies were less likely to participate in the CDP overall, those that have adopted an integrated climate change strategy or a quantifiable emissions target were more likely voluntarily disclose their climate change mitigation activities, including reductions in carbon emissions.

An important question that is worth asking albeit outside of the scope of this analysis is whether and/or under what conditions do the results of this study on global businesses generalize to a broader population of firms. Without the benefit of actual data on other firms, my conjecture is that this paper's propositions explain participation and effort in voluntary carbon disclosure in the private sector more generally, and that, in fact, this study's empirical results are likely to be lower bound estimates in an analysis that includes firms of various sizes and scope of business. If global businesses—which by the virtue of its size and scope of production invite more public scrutiny than privately held firms—require the leadership of sustainability champions within the firm, it would appear probable that businesses smaller in size and scope would also require internal champions since studies have shown that by and large privately held companies face less

stakeholder pressures. This same logic should apply regarding the extent of integration of climate change risks and opportunities into day-to-day operations by companies in influencing the level of voluntary carbon disclosure of firms of various sizes and scope of business.

Several implications for future research follow from this paper. First of all, more research needs to be conducted regarding moral hazard and "grey" firms, i.e., firms that "talk a good game". These firms install senior and executive level managers dedicated to climate change but in fact invest in low levels of effort in carbon disclosure and climate action more generally. Grey firms have not integrated climate change risks or opportunities into their business operations: they have not adopted an integrated climate change strategy or a quantifiable emissions target. Future research contributing to the literature on the private provision of public goods should systematically examine how heterogeneity in market structures and sectors could lead to different distribution of green versus grey firms in different political economy contexts.

Second, the existing literature shows that private and public provisions of public goods are imperfect substitutions (Calveras, Ganuza, and Llobet 2007)—this implies that increased self-regulation could crowd out formal government regulation when society free rides on a small group of activist consumers, investors or producers. Yet, this study shows that regulatory pressure in the form of public politics cannot be underestimated in propelling firms to act proactively in climate mitigation, especially when formal government regulation lags behind climate science because of contentious politics.

Questions remain about the link between the scope of participation and effectiveness. For example, existing research has raised doubts about whether corporate carbon disclosure—while impressive in terms of increasing response rates—provide information that is valuable for investors, NGOs, or policymakers (Kolk, Levy, and Pinkse 2008). Or are firms exploiting merely symbolic corporate environmentalism or greenwashing (Bowen and Aragon-Correa 2014; Aragón-Correa, Marcus, and Hurtado-Torres 2016)?[21] Additionally, Mattisoff (2012) finds evidence to suggest that the CDP does not have an effect on carbon emissions, and in fact,

[21] On the other hand, Cheng, Ioannou, and Serafeim (2014) find that superior performance on corporate social responsibility strategies more generally leads to better access to finance because of (a) reduced agency costs due to enhanced stakeholder engagement and (b) reduced information asymmetry due to increased transparency. Related, corporations that voluntarily adopt sustainability policies early outperform their counterparts over the long term, both in terms of stock market and accounting performance (Eccles, Ioannou, and Serafeim 2014).

program participation is associated with an increase in carbon intensity. However, Matisoff (2012) acknowledges that his analysis does not account for the intensity of participation, i.e., the level of carbon disclosure, which this paper emphasizes is related but distinct from the binary decision of participation. As such, an implication of this paper is that in addressing the link between participation and firm-level and industry-wise behavior, evaluation studies on firms' carbon footprints must account for both the extensive and intensive margins of participation because it is likely that those who participate more intensely are likely to reduce more carbon emissions than those who do not: ultimately, these are the leaders among leaders in proactive climate action. Their role in "wedging the gap" between what intergovernmental efforts are able to achieve and what is necessary to limit temperature rise below two degrees Celsius during this century could be significant since coordination problems across countries have weaken the role of governments in the provision of climate change mitigation.

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Figure 1

Distribution of Disclosure Scores for the Global 500, 2010-2015

(Score: 0-100)

Source: CDP.

Figure 2

Global 500 by Country of Origin

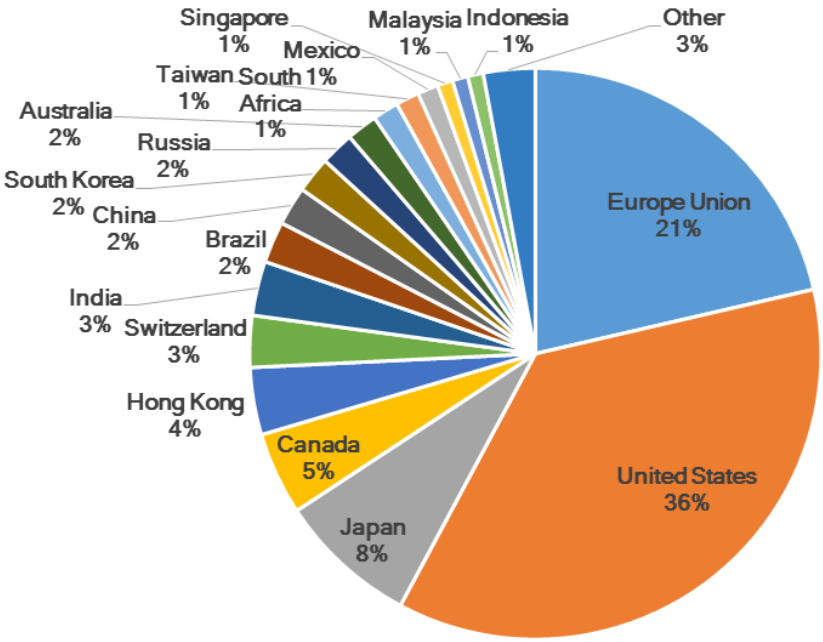
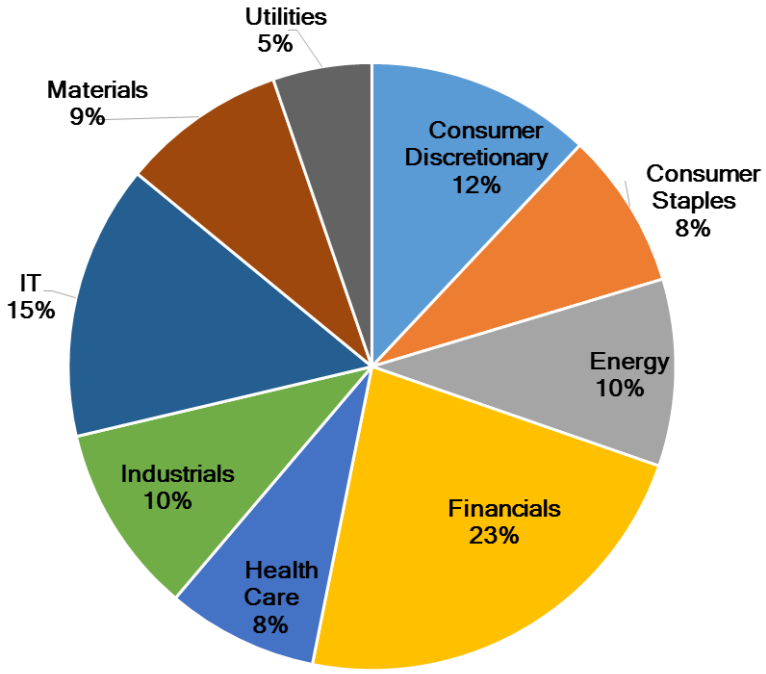


Figure 3

The Global 500 by Industry Sector[1]



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[1] Industry sectors defined by the Global Industrial Classification Standard (GICS).

Table 1

Variable Description and Construction/Operation

Variable	**Brief Description and Operation (Source)**
Dependent Variables	
Participation	Coded as 1 and 0 otherwise if a firm participates in the CDP's climate change questionnaire in year *j* (The CDP)
Carbon Disclosure Score	The disclosure score assigned to firm *i* by the CDP based on a quantitative assessment of the extent of firm *i*'s responses to the CDP's annual climate change questionnaire. The higher the score (with a maximum of 100), the more information a company has provided to the CDP about its carbon emissions and related management plans. (The CDP)
Firm-level variables of interest[22]	
Manager	Coded as 1 and 0 otherwise if firm *i* houses a senior or executive level manager responsible for climate change, environmental sustainability, or environmental policy has a committee responsible for setting visiting and planning for climate risk management as part of its Board of Directors in year *j*. For respondents to the CDP climate change questionnaire, coding is based on responses to CC1.1 ("Where is the highest level of direct responsibility for climate change within your organization?") (The CDP, corporate websites or CSR reports)
Strategy	Coded as 1 and 0 otherwise if firm *i* answers "Yes" to the following CDP climate change questionnaire question (CC1.1): "Is climate change integrated into your business strategy?" For non-respondents, *Strategy* is coded 1 and 0 otherwise if it has incorporated "ESG" (Environmental, Social and Governance) principles into its decision-making processes and day-to-day operations in year *j*. (Corporate websites or CSR reports)
Target	Coded as 1 and 0 otherwise if firm *i* has adopted an emissions target in year *j*. For respondents, coding is based is on responses to CC3.1 ("Did you have an emission reduction target that was active (ongoing or reached completion) in the reporting year?") (Corporate websites or CSR reports)
Controls	

[22] See section 3 of the paper for the author's strategy on data imputation for missing data.

Revenues (log)	Natural log of corporate annual operating revenues in millions of dollars (MintGlobal, YCharts, Google Finance)
Assets (log)	Natural log of total annual assets for firm *i* in millions of dollars (MintGlobal, YCharts, Google Finance)
Employee size (log)	Natural log of the number of employees (MintGlobal, YCharts, Google Finance)
Leverage (%)	Leverage is a measured as a firm's debt to equity ratio: Total Liabilities / Total Assets (MintGlobal, YCharts)
Score Last Year	Disclosure score or 0 otherwise of company *i* if company *i* responded to the CDP Climate Change Information Request in the previous year *j-1* (The CDP)
Response Last Year	Coded as 1 or 0 otherwise if a company responded to the CDP Climate Change Information Request in the previous year *j-1* (The CDP)
Natural Gas Price (log)	Natural log of the annual average of The Dow Jones Commodity Index for Natural Gas (Total Returns) in year *j* (S&P Dow Jones Indices)
Natural Gas Price – GSCI (log)	Natural log of the annual average of The S&P GSCI Natural Gas Index (Total Returns) in year *j* (S&P Dow Jones Indices)

Table 2

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Participation	3251	0.72	0.45	0.00	1.00
Disclosure Score	3251	57.96	39.39	0.00	100.00
Manager	3251	0.67	0.47	0.00	1.00
Target	3251	0.57	0.50	0.00	1.00
Strategy	3251	0.63	0.48	0.00	1.00
Leverage	3212	0.62	0.28	0.00	9.45
Revenues (millions US $)	3210	32900.15	47830.37	-627.62	485651.00
Assets (millions US $)	3212	151150.40	366214.20	48.19	2810000.00
Employees	3019	78051.29	128101.70	12.00	2200000.00
Natural Gas Price Index (Dow Jones)	3251	2.17	0.86	1.16	3.76
Natural Gas Price Index (S&P GSCI)	3251	69.74	27.94	37.55	121.68
Participation Last Year	3251	0.58	0.49	0.00	1.00
Score Last Year	3251	52.23	38.42	0.00	100.00

Table 3

Sector Heterogeneity

Sector	Share of Global 500	Participation in Voluntary Disclosure	Mean Disclosure Score, 2011-2015	Median Disclosure Score, 2011-2015	Mean Disclosure Score, 2011	Mean Disclosure Score, 2015
Consumer Discretionary	12%	62%	49.7	63.0	38.3	52.8
Consumer Staples	8%	78%	64.1	80.0	53.7	74.4
Energy	10%	62%	46.9	60.5	39.9	48.6
Financials	23%	66%	52.9	71.0	46.1	55.9
Health Care	8%	69%	53.4	69.0	46.3	59.0
Industrials	10%	76%	60.4	74.0	52.2	65.5
Information Technology	15%	72%	57.5	73.0	46.6	64.8
Materials	9%	73%	61.1	81.0	53.6	64.7
Utilities	5%	63%	55.5	78.5	55.8	56.2

Table 4

Double Hurdle Model of
Participation and Effort in Voluntary Carbon Disclosure
Basic Models

Panel A: Model 1A

	(1)			(2)		
	Participation in Voluntary Carbon Disclosure			Level of Carbon Disclosure		
	Coeff.		Robust Std. Err.	Coeff.		Robust Std. Err.
Manager	0.56	***	0.132	1.94		2.009
Strategy	1.11	***	0.136	3.22	*	1.949
Revenues (log)	0.26	***	0.047	0.99	**	0.353
Financial Leverage	-0.55	**	0.238	0.91		0.971
Participation Last Year	2.46	***	0.134			
Score Last Year				0.43	***	0.026
Natural Gas Price (log)	1.77	***	1.773	-9.41	***	0.887
Constant	-3.98	***	0.805	43.44	***	4.849
Sigma	2.48	***	0.031			
Sector fixed effects	YES			YES		
Country fixed effects	YES			YES		
Year fixed effects	YES			YES		
Pseudo R2	0.20					
N of observations	3251			2348		

Panel B: Model 1B

	(1)			(2)		
	Participation in Voluntary Carbon Disclosure			Level of Carbon Disclosure		
	Coeff.		Robust Std. Err.	Coeff.		Robust Std. Err.
Manager	0.94	***	0.116	-0.97		1.522
Target	0.67	***	0.125	8.23	***	1.206
Revenues (log)	0.24	***	0.046	0.74	**	0.356
Financial Leverage	-0.59	**	0.244	0.53		1.019
Participation Last Year	2.64	***	0.140			
Score Last Year				0.40	***	0.025
Natural Gas Price (log)	1.78	***	0.132	-9.65	***	0.843
Constant	-3.59	***	0.739	48.15		4.613
Sigma	2.45	***	0.029			
Sector fixed effects	YES					
Country fixed effects	YES					
Year fixed effects	YES					
Pseudo R2	0.21					
N of observations	3251			2348		

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

[1] Robust standard errors with sector-level cluster correction.

Table 5

Double Hurdle Model of
Participation and Effort in Voluntary Carbon Disclosure
Model 2A

	(1)			(2)		
	Participation in Voluntary Carbon Disclosure			Level of Carbon Disclosure		
	Coeff.		Robust Std. Err.[1]	Coeff.		Robust Std. Err.[1]
Manager	0.72	***	0.189	-0.66		2.068
Strategy	0.82	***	0.191	4.98	**	2.236
Revenues (log)	0.25	***	0.050	0.80	**	0.351
Financial Leverage	-0.56	**	0.241	1.10		0.924
Participation Last Year	2.52	***	0.134			
Score Last Year				0.43	***	0.026
Natural Gas Price (log)	0.25		0.282	-8.01	***	0.985
GHG intensive	0.10		0.170	-0.38		1.373
USA HQ	-0.80	***	0.598	-4.73	*	3.724
Obama Climate Proposal	-1.78	***	0.287	1.44	***	1.201
USA × Obama	0.35	*	0.186	4.95		3.859
USA × Obama × GHG	-0.10		0.329	-4.72		10.444
Manager × USA	-0.11		0.295	6.67		4.443
Manager × USA × Obama	-0.30		0.362	-4.75		5.669

Manager × USA × Obama × GHG	-0.49		0.465	1.45	11.483
Strategy × USA	0.59	*	0.338	-3.01	4.366
Strategy × USA × Obama	0.20		0.438	-0.24	4.818
Strategy × USA × Obama × GHG	-0.52		0.491	3.63	13.832
Constant	-1.84	***	0.910	43.85	4.936
Sigma	2.48	***	0.031		
Sector fixed effects	YES			YES	
Country fixed effects	YES			YES	
Year fixed effects	YES			YES	
Pseudo R2	0.20				
N of observations	3251			2348	

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

[1] Robust standard errors with firm-level cluster correction.

Table 6

Double Hurdle Model of
Participation and Effort in Voluntary Carbon Disclosure
Model 2B

	(1)			(2)		
	Participation in Voluntary Carbon Disclosure			Level of Carbon Disclosure		
	Coeff.		Robust Std. Err.[1]	Coeff.		Robust Std. Err.[1]
Manager	1.08	***	0.163	-1.28		1.592
Target	0.38	**	0.169	7.21	***	1.378
Revenues (log)	0.23	***	0.049	0.59	*	0.347
Financial Leverage	-0.64	**	0.243	0.35		1.011
Participation Last Year	2.68	***	0.140			
Score Last Year				0.40	***	0.025
Natural Gas Price (log)	0.23		0.140	-8.04	***	0.951
GHG intensive	0.09		0.276	-0.17		1.290
USA HQ	-0.86	***	0.163	-6.09	*	3.509
Obama Climate Proposal	-1.82	***	0.568	1.77	***	1.175
USA × Obama	0.41	**	0.286	4.82		3.772
USA × Obama × GHG	-0.06		0.194	-2.32		7.954
Manager × USA	-0.13		0.313	2.90		3.797

Manager × USA × Obama	-0.36		0.260	-5.10	4.763
Manager × USA × Obama × GHG	-0.42		0.302	1.45	8.943
Target × USA	0.69	**	0.436	2.20	2.888
Target × USA × Obama	0.10		0.324	0.26	3.005
Target × USA × Obama × GHG	-0.59		0.535	0.97	4.842
Constant	-2.28	***	1.597	76.42	6.628
Sigma	2.45	***	0.030		
Sector fixed effects	YES			YES	
Country fixed effects	YES			YES	
Year fixed effects	YES			YES	
Pseudo R2	0.21				
N of observations	3251			2348	

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

[1] Robust standard errors with firm-level cluster correction.

Table 7

Double Hurdle Model of
Participation and Effort in Voluntary Carbon Disclosure
Model 3A

	(1)			(2)		
	Participation in Voluntary Carbon Disclosure			Level of Carbon Disclosure		
	Coeff.		Robust Std. Err.[1]	Coeff.		Robust Std. Err.[1]
Manager	0.76	***	0.199	-0.67		2.066
Strategy	0.89	***	0.205	4.97	**	2.236
Revenues (log)	0.25	***	0.050	0.80	**	0.349
Financial Leverage	-0.57	**	0.244	1.08		0.913
Participation Last Year	2.56	***	0.138			
Score Last Year				0.43	***	0.026
Natural Gas Price (log)	0.27		0.294	-8.00	***	0.985
GHG intensive	0.09		0.172	-0.35		1.371
USA HQ	-0.80		0.602	-4.75		3.729
Obama 2013	-1.08	***	0.250	-0.42	***	1.146
USA × Obama 2013	-0.24		0.219	7.76	**	3.490
USA × Obama 2013 × GHG	-0.15		0.311	-1.52		2.995
Manager × USA	-0.14		0.301	6.69		4.442
Manager × USA × Obama 2013	-0.08		0.590	-0.23	*	6.011

Manager × USA × Obama 2013 ×						
GHG	-0.23	**	0.651	-27.87	*	15.512
Strategy × USA	0.52	**	0.349	-3.02	***	4.366
Strategy × USA × Obama 2013	-0.01		0.575	-8.41		5.798
Strategy × USA × Obama 2013 ×						
GHG	-0.97		0.648	31.68	**	15.565
Obama 2014-15	-1.99	***	0.301	1.52	***	1.195
USA × Obama 2014-15	0.81	***	0.232	2.08		4.881
USA × Obama 2014-15 × GHG	-0.12		0.453	0.83		17.885
Manager × USA × Obama 2014-15	-0.47		0.347	-5.88		6.723
Manager × USA × Obama 2014-15 ×						
GHG	-0.48		0.522	6.98		11.377
Strategy × USA × Obama 2014-15	0.18		0.478	4.13		5.335
Strategy × USA × Obama 2014-15 ×						
GHG	-0.32		0.518	-8.12		17.635
Constant	-1.87	***	0.921	43.85	***	4.935
Sigma	2.47	***	0.030			
Sector fixed effects	YES			YES		
Country fixed effects	YES			YES		
Year fixed effects	YES			YES		
Pseudo R2	0.20					
N of observations	3251			2348		

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

[1] Robust standard errors with firm-level cluster correction.

Table 8

Double Hurdle Model of

Participation and Effort in Voluntary Carbon Disclosure

Obama Model 3B

	(1)			(2)		
	Participation in Voluntary Carbon Disclosure			Level of Carbon Disclosure		
	Coeff.		Robust Std. Err.[1]	Coeff.		Robust Std. Err.[1]
Manager	1.15	***	0.171	-1.29		1.594
Target	0.42	**	0.175	7.22	***	1.378
Revenues (log)	0.23	***	0.049	0.59	*	0.347
Financial Leverage	-0.66	**	0.246	0.34		1.008
Participation Last Year	2.75	***	0.146			
Score Last Year				0.40	***	0.025
Natural Gas Price (log)	0.25		0.287	-7.97	***	0.955
GHG intensive	0.08		0.165	-0.16		1.291
USA HQ	-0.87		0.570	-6.12	*	3.517
Obama 2013	-1.17	***	0.245	-0.16	***	1.135
USA × Obama 2013	-0.23		0.227	7.66	**	3.354
USA × Obama 2013 × GHG	-0.26		0.321	0.23		2.892
Manager × USA	-0.19		0.266	2.91		3.804
Manager × USA × Obama 2013	-0.08		0.523	-9.26	*	4.943

Manager × USA × Obama 2013 ×						
GHG	-1.01		0.678	-4.22		7.883
Target × USA	0.65	**	0.330	2.21		2.889
Target × USA × Obama 2013	-0.60		0.704	1.85		3.936
Target × USA × Obama 2013 ×						
GHG	0.62		0.806	4.26		7.649
Obama 2014-15	-2.06	***	0.298	1.92	***	1.178
USA × Obama 2014-15	0.86	***	0.235	2.53		4.776
USA × Obama 2014-15 × GHG	0.00		0.377	-2.17		11.020
Manager × USA × Obama 2014-15	-0.54		0.331	-2.40		5.741
Manager × USA × Obama 2014-15						
× GHG	-0.14		0.461	2.15		11.390
Target × USA × Obama 2014-15	0.43		0.563	-0.22		3.268
Target × USA × Obama 2014-15 ×						
GHG	-1.20	**	0.552	0.02		4.732
Constant	-1.49	***	0.876	48.45	***	4.714
Sigma	2.45	***	0.030			
Sector fixed effects	YES			YES		
Country fixed effects	YES			YES		
Year fixed effects	YES			YES		
Pseudo R2	0.21					
N of observations	3251			2348		

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

[1] Robust standard errors with firm-level cluster correction.

Table 9

Summary of Robustness Checks

Panel A

		(1) Participation in Voluntary Carbon Disclosure		(2) Level of Carbon Disclosure	
Alternative Specifications	President Obama's Climate Proposal	Manager	Strategy	Manager	Strategy
Company fixed effects	NO	+		+	+
Dropped lagged variables	NO	+	+	+	+
Alt Spec on firm size: ln(assets)	NO	+	+		+
Alt Spec on firm size: ln(employ)	NO	+	+		+
Dropped lagged variables	YES	+	+		+
Alt Spec on firm size: ln(assets)	YES	+	+		
Alt Spec on firm size: ln(employ)	YES	+	+		
Alt Spec on natural gas: ln(GSCI natural gas index)	YES	+	+		+

Panel B

Alternative Specifications	President Obama's Climate Proposal	(1) Participation in Voluntary Carbon Disclosure		(2) Level of Carbon Disclosure	
		Manager	Target	Manager	Target
Company fixed effects	NO	+	+	+	+
Dropped lagged variables	NO	+	+		+
Alt Spec on firm size: ln(assets)	NO	+	+		+
Alt Spec on firm size: ln(employ)	NO	+	+		+
Dropped lagged variables	YES	+	+		+
Alt Spec on firm size: ln(assets)	YES	+	+		+
Alt Spec on firm size: ln(employ)	YES	+	+		+
Alt Spec on natural gas: ln(GSCI natural gas index)	YES	+	+		+

Appendix

Estimation of Marginal Effects

We are interested in estimating the marginal effects of the explanatory variables on the probability of participation in the CDP or voluntary carbon disclosure and on disclosure effort or the level of disclosure. At first, we estimate the probability of participation for each individual firm *i* as:

$$P(d_i > 0 | x_{1i}) = \Phi(x_{1i}\gamma) \tag{2}$$

The conditional expected disclosure effort can then be estimated as:

$$E(d_i | d_i > 0, x_{2i}) = x_{2i}\beta + \sigma \times \lambda(x_{2i}\beta/\sigma) \tag{3}$$

where $\lambda(x)$ is the inverse Mills ratio: $\lambda(x) = \phi(x)/\Phi(x)$.

The first stage marginal effects are based on the first hurdle estimates (AME), while the conditional average marginal effect (CAME) expresses the second hurdle effect, conditional on the first hurdle being met, i.e., conditional on participating in the CDP; both sets of marginal effects of each independent variable are estimated following procedures outlined in Burke (2009).

As we are also interested in the effect of participation in the CDP on individual firm's level of voluntary carbon disclosure overall and not just the effect of voluntary carbon disclosure on those firms that are already participation in the CDP, we estimate the unconditional expected value of *d*, which is somewhat trickier, because the marginal effect will be a function of parameters and explanatory variables in both tiers of the regression. For a given firm *i*, the unconditional expected disclosure level is given by:

$$E(d_i \mid x_{1i}, x_{2i}) = \Phi(x_{1i}\gamma)\{x_{2i}\beta + \sigma \times \lambda(x_{2i}\beta/\sigma)\}, \quad (4)$$

The unconditional average marginal effect (UAME) of a variable (x_j), where $x_j \in \{x_1, x_2\}$, on the expected level of disclosure is then given by (Burke 2009):

$$\frac{\partial E(d \mid x_1, x_2)}{\partial x_j} = \gamma_j \phi(x_1\gamma) \times \{x_2\beta + \sigma \times \lambda(x_2\beta/\sigma)\} + \Phi(x_1\gamma) \times \beta_j \left[1 - \lambda(x_2\beta/\sigma)\{x_2\beta/\sigma + \lambda(x_2\beta/\sigma)\}\right]. \quad (5)$$

It is important to note that the UAME for a given variable will depend on whether it is included in the first or second stages, or both. If $x_j \in \{x_2\}$ and $x_j \notin \{x_1\}$, x_j only determines the value of *d*, given that *d*>0, and $\gamma_j = 0$, so the first term in (3) is equal to zero. Conversely, if x_j only determines the probability that d>0, $\beta_j = 0$, and the second term in (3) is equal to zero. In other words, the UAME quantify the average effects that the explanatory variables have on the joint decision of participation and effort in voluntary carbon disclosure, which are not contingent on the first-hurdle decision or the participation in the CDP being positive.

That being said, as mentioned above, in both of these cases the UAME is still a function of parameters and explanatory variables from both stages of the regression; this underscores the importance of modeling the interrelated choices of whether or not to participate as well as how intensively to participate in voluntary carbon disclosure. We calculate the UAMEs using equation (5) for all variables in either stage and use 10,000 bootstrap replications to derive standard errors for the UAMEs and display the results in Table 4 in the body of the paper.

Exhibit A1

CDP's 2015 Climate Change Information Request

CC1. Governance

Group and Individual Responsibility

CC1.1 Where is the highest level of direct responsibility for climate change within your organization?

If "Board or individual/sub-set of the Board or other committee appointed by the Board"; "Senior Manager/Officer"; or, "Other Manager/Officer":

CC1.1a Please identify the position of the individual or name of the committee with this responsibility

Business Strategy

CC2.2 Is climate change integrated into your business strategy?

If yes: CC2.2a Please describe the process of how climate change is integrated into your business strategy and any outcomes of this process

If no: CC2.2b Please explain why climate change is not integrated into your business strategy

CC3. Targets and Initiatives

Targets

CC3.1 Did you have an emissions reduction target that was active (ongoing or reached completion) in the reporting year?

If you have an absolute target:

CC3.1a Please provide details of your absolute target

If you have an intensity target:

CC3.1b Please provide details of your intensity target

CC3.1c Please also indicate what change in absolute emissions this intensity target reflects

The following details are requested for targets (in Questions CC3.1a and CC3.1b), to be inputted in tables in the ORS:

- Scope
- % of emissions in scope
- % reduction from base year
- Metric denominator (intensity targets only)
- Base year
- Base year emissions
- Target year
- Comment

Direction of change anticipated in absolute Scope 1+2 emissions at target completion?	% change anticipated in absolute Scope 1+2 emissions	Direction of change anticipated in absolute Scope 3 emissions at target completion?	% change anticipated in absolute Scope 3 emissions	Comment

Scope 1 and 2 Emissions Data

CC8.2 Please provide your gross global Scope 1 emissions figures in metric tonnes CO_2e

CC8.3 Please provide your gross global Scope 2 emissions figures in metric tonnes CO_2e

Table A1

Cluster-Robust Vuong Tests

Double Hurdle Model versus Heckman Selection Model

	Vuong Test Statistics[1]		Decision
Model 1A	11.69	***	Reject Heckman
Model 1B	11.72	***	Reject Heckman
Model 2A	11.66	***	Reject Heckman
Model 2B	11.71	***	Reject Heckman
Model 3A	11.67	***	Reject Heckman
Model 3B	11.76	***	Reject Heckman

1 Computation of the cluster-robust Vuong tests is based on the procedure described in Woolridge (2010).