**Voluntary Disclosures and the Firm-Value Effects of Carbon Emissions**

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# Voluntary Disclosures and the Firm-Value Effects of Carbon Emissions


## ABSTRACT

Concern about carbon emissions, and hence concern about disclosure of carbon emission levels, has been expressed by various stakeholders, including corporate executives, boards of directors, investors, creditors, standard setters, government regulators, and NGOs. Indeed, some informed observers expect that the relationship between carbon emissions and global climate change will drive a redistribution of value from firms that do not control their carbon emissions successfully to firms that do (GS Sustain 2009). Using hand-collected carbon emissions data for 2006-2008 that S&P 500 firms disclosed voluntarily to the Carbon Disclosure Project, we examine two separate, yet, related questions. The first question addresses firm-level characteristics associated with the choice to disclose carbon emissions. Consistent with economic theory, we predict and find a higher likelihood of carbon emission disclosures by firms with *superior* environmental performance, conditional on firms taking environmentally proactive actions. However, contrary to our predictions based on socio-political theories, we find no association between *inferior* environmental performance and the likelihood of disclosing carbon emissions, conditional on firms taking environmentally damaging actions. Further, we predict and find that firms are more likely to voluntarily disclose their carbon emissions as the proportion of industry peer firm disclosers increases. To address the second question concerning the relationship between carbon emission levels and firm value, we correct for self-selection bias caused by firm- and industry-level characteristics associated with the decision to disclose such emissions. We predict and find a negative association between carbon emission levels and firm value. On average, for every additional thousand metric tons of carbon emissions for our sample of S&P 500 firms, firm value decreases by $202,000. Our sensitivity analyses and robustness test results are similar to our main results.

# I. INTRODUCTION

Using hand-collected carbon emissions data for 2006-2008 that S&P 500 firms disclosed voluntarily to the Carbon Disclosure Project (CDP),[1] we examine two separate but related questions. The first question addresses the firms' choice to voluntarily disclose carbon emissions information to the public. The second question addresses the relationship between carbon emissions and firm value. We argue that managers choose to voluntarily disclose carbon emissions if the relative benefits of doing so outweigh the costs. However, because managers' evaluations of the benefits and costs of disclosing are unobservable, we rely on economic theory (e.g., Healy and Palepu 2001; Dye 1985; Verrecchia 1983), institutional theory (DiMaggio and Powell 1983) and socio-political theories (Patten 2002) of voluntary disclosure to address the first research question, and model managers' disclosure decisions as a function of various firm-level characteristics. Next, correcting for self-selection bias caused by systematic firm-level characteristics that are associated with managers' decisions to voluntarily disclose carbon emissions, we address the second question concerning the relationship between carbon emissions and firm value.

Our study is motivated by concern about carbon emissions, and hence concern about disclosure of carbon emission levels, as expressed by corporate executives, boards of directors, investors, creditors, standard setters, government regulators, and NGOs. Some informed observers expect that the relationship between carbon emissions and global climate change[2] will drive a redistribution of value from firms that do not control

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1 The CDP is the largest carbon registry in the world. We describe it in more detail later in the paper.

2 The Environmental Protection Agency (EPA) has concluded that fuel burning and other human activities are adding large amounts of carbon dioxide ($CO_2$)—considered the major greenhouse gas (GHG)—to the natural mix at a fast rate. The more $CO_2$ and other GHGs there are in the atmosphere, the more heat is trapped. This leads to rising temperatures and thus, climate change. Source: http://www.epa.gov/climatechange/downloads/Climate_Basics.pdf (accessed March 30, 2011).

carbon emissions successfully to firms that do (GS Sustain 2009, p. 1).[3] Indeed, Goldman Sachs' GS Sustain report asserts that "the equity market is only beginning to recognize the magnitude of impact the transition to a low carbon global economy will have on companies' competitive positions and long-term valuations" (GS Sustain 2009, p. 2).

Our inquiry on voluntary disclosures and the firm-value effects of carbon emission levels is important for various reasons. First, while accounting research on corporate environmental disclosures[4] can be traced back to the 1970s, several recent major initiatives exert pressure on U.S. and non-U.S. firms to increase their transparency through disclosures of new nonfinancial climate change and environmental information, including carbon emissions. These initiatives stem from organizations such as the CDP, Ceres, the Global Reporting Initiative (GRI), and the International Integrated Reporting Committee (IIRC).[5] In addition, a group of more than 90 institutional investors in the $9 trillion Investor Network on Climate Risk (INCR) presses businesses to improve their analysis and disclosure of climate-related risks. This pressure creates an impetus for internal management control systems to collect and analyze related information, and to understand the financial consequences of decisions related to climate change, as well as

3 Goldman Sachs' GS Sustain report is available at: http://www2.goldmansachs.com/ideas/environment-and-energy/goldman-sachs/gs-sustain/climate-change-research.pdf.

4 Corporate environmental disclosure is the set of information items that relate to a firm's past, current, and future environmental management activities and performance, and the past, current, and future financial implications resulting from a firm's environmental management decisions or actions (Berthelot, Cormier, and Magnan 2003, p. 1). Voluntary environmental disclosures (VED) are quantitative and qualitative nonfinancial measures related to firm-specific environmental issues that provide information beyond that which is required by law. VEDs can address the broad range of environmental issues that the firm confronts in its activities, including procurement, manufacturing, selling, marketing, and other operational elements (Marshall and Brown 2003).

5 Ceres is a national network of investors, environmental organizations, and other public interest groups working with companies and investors to address sustainability challenges such as global climate change. The Global Reporting Initiative (GRI) developed what is now the most widely used sustainability reporting framework around the world. The IIRC brings together a cross section of representatives from the corporate, accounting, securities, regulatory, NGOs, and standard-setting sectors responsible for individual elements of reporting (e.g., the International Accounting Standards Board, the Financial Accounting Standards Board, The Prince's Sustainability Reporting, and GRI). The IIRC's goals include, among others: (1) developing an overarching integrated reporting framework; (2) considering whether standards in this area should be voluntary or mandatory, and facilitating collaboration between standard-setters; and (3) promoting the adoption of integrated reporting by relevant regulators and report preparers.

broader sustainability issues (Institute of Chartered Accountants in England and Wales 2004 and Leonard 2008).

Second, our inquiry is important to corporate management because, as a firm makes costly capital investments that reduce emissions, it reduces the number of potential claimants on its rents through fines or other compliance costs (Sharfman and Fernando 2008). Our paper provides evidence that the market attaches an implicit cost to carbon emissions even though there is currently no explicit cost. This evidence is consistent with the argument that the capital markets reward firms that reduce their carbon emissions. Moreover, the company's enhanced reputation for environmental and social responsibility can bring economic benefits from the broader stakeholder community. These benefits include increased revenues and a talented and committed work force (Heal, 2004).

Third, our study is important to standard setters—both U.S. and international— as they work towards developing standards for measuring, verification, and disclosure of greenhouse gas (GHG) emissions.[6] For instance, the International Auditing and Assurance Standards Board (IAASB) issued an exposure draft on assurance engagements on GHG statements in January 2011.[7] In addition, climate-change-related concerns, including concerns about GHG emissions, have prompted investors to request the SEC for new explicit guidance on disclosures of risks and opportunities related to climate change.[8] In January 2010, the SEC issued related interpretive guidance of its existing

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6 Like much of the literature on carbon emissions, we use "carbon emissions" and "greenhouse gas emissions" interchangeably.

7 The exposure draft on ISAE 3410, Assurance Engagements on Greenhouse Gas Statements, is available at: http://www.ifac.org/Guidance/EXD-Details.php?EDID=0152.

8 In addition to U.S. investors, participants in the growing European Union emissions trading markets have requested authoritative accounting guidance. Efforts to provide such guidance were initiated in 2004 by the International Financial Reporting Interpretations Committee (IFRIC) of the International Accounting Standards Board (IASB), which issued IFRIC 3, Emissions Rights (Fornaro, Winkelman, and Glodstein 2009). The draft proposed specific guidance on several key issues under cap-and-trade programs, including asset valuation,

statements. Among the responses to investors' requests for guidance, SEC Commissioner Luis Aguilar asserted:[9]

> It is no surprise that regulation of greenhouse gases has the attention of state governments, Capitol Hill, and the Environmental Protection Agency (EPA), as well as the attention of investors and companies. Against this backdrop of a changing climate and changing legislative and regulatory landscapes, it is only natural that there are questions about what companies should be disclosing to investors.

Further, SEC Commissioner Elisse Walter stated:[10]

> I am concerned by the fact that today many public companies are in fact providing disclosure about significant climate change related matters through mechanisms outside of the disclosure documents they file with the Commission. While all of the information provided voluntarily by companies through these mechanisms undoubtedly is not required to be disclosed under our rules, I do not believe that public companies today are doing the best job they possibly can do with respect to their current mandated disclosures.

Our study contributes to the literature in three distinct and important ways. First, much of the prior research examines environmental-related liabilities that are either recognized on the balance sheet or disclosed in the notes to the financial statements. In contrast, we focus on carbon emissions, which are largely unregulated in the U.S. and disclosed at management's discretion but are of utmost importance in relation to climate change concerns. In doing so, we examine a set of environmental measures—nonfinancial metrics whose potential effects are currently neither recognized on the balance sheet nor disclosed in the notes—and yet likely represent significant future potential liabilities.[11] Prior to the EPA's GHG Mandatory Reporting Rule, which became effective December 29, 2009 and requires reporting of carbon emissions for

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income recognition for rights received from a government body, and the measurement and recognition of a liability (and expense) for actual emissions.

9 Available at http://www.sec.gov/news/speech/2010/spch012710laa-climate.htm.

10 Available at http://www.sec.gov/news/speech/2010/spch012710ebw-climate.htm.

11 For instance, S&P downgraded Drax's debt, owing in part to concerns over future business risks, particularly in 2013 when new European emissions trading rules will push up carbon costs (Barley 2009). Fitch downgraded PPL Energy Supply for similar reasons (article posted 10/30/09, available at http://www.finreg21.com/news/fitch-downgrades-ppl-energy-supplys-sr-unsecured-debt-affirms-other-ratings-ppl-amp-subs).

2010 and thereafter, carbon emission disclosures were not required by any national regulatory body in the U.S.[12] For the period of our study (2006-2008), the firms' management chose whether or not to provide these disclosures. Thus, our study provides evidence on whether investors recognize highly uncertain future liabilities that are not recorded by the accounting system and look to relevant new or emerging, frequently unverified sources of nonfinancial information, beyond the financial statements and notes.[13]

Second, we examine the relationship between carbon emissions and firm value correcting for self-selection bias caused by systematic firm-level characteristics that may be associated with managers' decisions to disclose carbon emissions. To our knowledge, this is the first study that examines the firm-value effects of carbon emissions while correcting for self-selection bias. Third, our paper is the first that looks at the relation between carbon emission *levels* and firm value. This is the first paper to provide evidence on the price that U.S. capital markets are imputing to carbon emissions.

To elaborate on our contribution to the literature, we contrast our study with the extant accounting literature on environmental information. One body of research reports that the capital markets impound environmental disclosure/liability information in their assessments of how well firms are managing their exposure to environmental risk (e.g., Campbell, Sefcik, and Soderstrom 1998; Barth and McNichols 1994; and Blacconiere and Patten 1994). Unlike our context, this

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[12] The EPA's Greenhouse Gas Mandatory Reporting Rule requires fossil fuel and industrial gas suppliers, direct GHG emitters, and manufacturers of heavy-duty and off-road vehicles and engines to report their GHG emissions to the EPA. The rule is available at http://epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf. This year's original reporting deadline of March 30, 2011 has been extended (http://www.epa.gov/climatechange/emissions/extension.html).

[13] Some prior research uses information required by regulatory agencies, such as the EPA. Prior to December 29, 2009, carbon emission disclosures were not required by the EPA. Thus, our study also provides evidence on whether the market impounds information that is not available from national governmental regulatory agencies.

body of research studies environmental disclosure that is required by the EPA or financial reporting regulations.

A recent body of research examines the association between: voluntary environmental disclosure quality and expected cash flows (e.g., Plumlee, Brown, and Marshall 2009) or firm value (Clarkson et al. 2010); and voluntary disclosure of corporate social responsibility reports and the cost of equity capital (Dhaliwal et al. 2011). Our study focuses on voluntary disclosure and firm-value effects of carbon emissions *levels* rather than the act or quality of the disclosure only. A further body of research examines the firm-value effects of sulfur dioxide emissions (Johnston, Sefcik, and Soderstrom 2008; Hughes 2000) in the electric utilities industry, which generates most of the U.S. sulfur dioxide emissions. Much different from our context, reporting of sulfur dioxide emissions in the U.S. is now mandatory and most of this takes place through highly accurate continuous emissions monitors. Finally, Chapple, Clarkson, and Gold (2009) examine the association between high and low carbon emission intensity firms (a dichotomous variable) and the market value of equity in a sample of 58 Australian firms.

We build upon and add to prior research by, first, modeling managers' disclosure decisions as a function of various firm-level characteristics for the S&P 500 firms, and second, by examining the association between carbon emission levels and firm value after correcting for self-selection bias. Our analyses use all the S&P 500 firms, and also subdivide our sample based on firms' membership category: those that will be subject to the EPA's GHG Mandatory Reporting Rule to report their carbon emissions, and those that will not be subject to the rule. Consistent with economic theory, we predict and find a higher likelihood of carbon emission disclosures by firms with *superior* environmental performance, conditional on firms taking environmentally proactive actions. However, contrary to our predictions based on socio-political theories, we find no association between *inferior* environmental performance and the likelihood of disclosing carbon emissions, conditional on firms taking environmentally damaging actions. Furthermore, we predict and find that firms are more likely to voluntarily disclose their carbon emission levels as the proportion of industry peer firm disclosers increases, consistent with institutional theory.

Next, we predict and find that firm value is negatively associated with carbon emission levels. Specifically, on average, for every additional thousand metric tons of carbon emissions for our sample of S&P 500 firms, firm value decreases by $202,000.[14] This translates into a firm-value penalty of $1.28 billion for firms in the third quartile (in terms of carbon emissions) relative to firms in the first quartile. The economic effect of carbon emissions on firm value is large, particularly since the direct costs of carbon emissions have been less than $40 per metric ton in the recent past (see Figure 1). However, the indirect costs associated with emissions, such as increased regulatory intervention, litigation and remediation expenses, and reputational impact are likely to be significant. The negative association between carbon emission levels and firm value obtains for both high and low carbon-emitting firms. We conduct several sensitivity analyses to assess the robustness of our main results. These tests include: (1) scaling market value (i.e., our dependent variable) and our independent variables by sales;[15] (2) using December fiscal-year-end firms only; and (3) running a changes regression. Our sensitivity analyses results are similar to our main results.

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[14] To provide some context, assume, for example, that the direct and indirect costs of carbon emissions are $47 per metric ton. Then, the net present value of these costs discounted over five years at an interest rate of 8 percent is $202 per metric ton.

[15] The sensitivity analysis of scaling our main independent variable (i.e., total emissions) by sales also captures the firms' eco-efficiency.

The rest of the paper is organized as follows. In the next section, we review the literature and develop our hypotheses. Sections III and IV present our research design and results, respectively, and Section V concludes the paper.

## II. LITERATURE REVIEW AND HYPOTHESES

### Firm-Level Characteristics and Voluntary Disclosures of Carbon Emissions

We argue that managers choose to voluntarily disclose carbon emissions if the relative benefits of doing so outweigh the costs. Disclosures reduce information asymmetry between the firm and outsiders, including its investors, facilitating efficient allocation of scarce resources (Healy and Palepu 2001). Carbon emission disclosures inform investors about possible future costs that may be imposed upon the firm due to its carbon emissions. If firms do not disclose their carbon emissions, then investors will not only impute the firms' carbon emission levels, but may also treat nondisclosure as an adverse signal and thus, penalize the firms. Additionally, investors may undertake costly information search regarding the nondisclosers' emissions, thus increasing costs to investors, and ultimately the firms' costs (see Johnston [2005] for a more detailed discussion). Voluntary disclosures may also be used to reduce potential regulatory intervention (Blacconiere and Patten 1994).

However, emission disclosures also impose costs on the firms. For example, government regulators (e.g., EPA) could use disclosures of carbon emission levels—particularly by high carbon-emitting firms—as grounds for investigation that would increase compliance costs. Furthermore, disclosure of carbon emission levels could invite costly litigation by previously uninformed victims of GHG-related climate change; benefit competitors' green-marketing strategies aimed at environmentally conscious consumers; and provide ammunition for public interest groups (e.g., Ceres) to press for stricter regulations.

Because managers' evaluations of the cost-benefit tradeoffs are unobservable, we rely on economic theory (Healy and Palepu 2001; Dye 1985; Verrecchia 1983), institutional theory (DiMaggio and Powell 1983), and socio-political theories (Patten 2002) to model managers' disclosure decisions as a function of various firm-level characteristics. We first examine managers' decisions to disclose carbon emissions conditional on their types of environmental actions. Specifically, we draw on economic theory to predict the likelihood of carbon emission disclosures conditional on firms taking proactive environmental actions, and then draw on socio-political theories to predict the likelihood of carbon emission disclosures conditional on firms taking damaging environmental actions. Finally, using institutional theory we examine the association between the proportion of industry peer firm disclosers and the likelihood of disclosing carbon emissions.

***Relative Environmental Performance and Likelihood of Disclosing Carbon Emissions Conditional on Environmental Actions***

We begin our discussion by focusing on the likelihood of carbon emission disclosures conditional on whether firms take proactive actions that directly benefit the environment. Such actions include implementing strong pollution prevention programs and using renewable energy, among others. According to economic theory, firms have incentives to disclose "good news" to *separate* themselves from firms with "bad news" in order to avoid the adverse selection problem. That is, firms will voluntarily reveal private information to distinguish themselves from the worst types (Milgrom 1981; Spence 1973; Akerlof 1970). In contrast, "bad news" firms have incentives to disclose less or to be "silent," such that they can be placed in the *pool* of firms where outsiders ascribe the "average" type to that pool (Healy and Palepu 2001; Dye 1985; Verrecchia 1983).

Recent research that examines the association between environmental performance and environmental disclosure provides empirical evidence consistent with economic theory (Clarkson, Li, Richardson, and Vasvari 2008). Clarkson et al. (2008) use a sample of 191 firms in five high-pollution industries, and develop a content analysis index based on the GRI to assess the level of discretionary environmental disclosures in environmental and CSR reports (or similar disclosures provided on the firms' websites). The authors use two environmental performance proxies, Toxics Release Inventory (TRI) emissions[16] scaled by sales, and percentage of toxic waste treated, recycled, or processed in the production. The study provides evidence that firms with better (worse) environmental performance are more (less) likely to provide voluntary environmental disclosures in environmental and CSR reports.

The above discussion suggests that, conditional on firms taking environmentally proactive actions, firms with superior environmental performance will have incentives to inform investors and other stakeholders of their actions by voluntarily disclosing environmental information. That is, they seek to reveal their performance type, which is not directly observable to outsiders, through direct voluntary disclosures that cannot costlessly be mimicked by inferior environmental performers. In doing so, they may potentially increase firm valuation because knowledgeable investors will perceive these disclosers as environmentally proactive. In contrast, firms with inferior environmental performance will be less likely to disclose their carbon emission levels if outsiders are unable to distinguish whether the nondisclosure arises from poor environmental performance or from high proprietary costs (Verrecchia 1983). Accordingly, based on economic theory of voluntary disclosures and prior research, we hypothesize:

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[16] TRI emissions represent legal releases of over 650 toxic chemicals and other waste management activities that firms must report to the federal government under the Emergency Planning and Community Right-to-Know Act. TRI emissions reflect the firm's overall U.S. environmentally-related risks (see, e.g., Campbell et al. 2007).

H1: Conditional on firms taking environmentally proactive actions, firms that have superior environmental performance are more likely to disclose their carbon emission levels than firms that have inferior environmental performance.

We next turn to the likelihood of disclosing carbon emission levels by inferior environmental performers, conditional on firms taking environmentally damaging actions that are detrimental to the environment. Such actions include violations of environmental regulations or creation of large amounts of hazardous wastes, among others. We examine this context separately because it is unclear whether the likelihood of disclosing carbon emission levels by *superior* environmental performing firms, conditional on the firms taking environmentally proactive actions, is similar to the likelihood of disclosing carbon emission levels by *inferior* environmental performing firms, conditional on the firms taking environmentally damaging actions. To address this potential asymmetry, we turn to socio-political theories, including political economy, legitimacy theory, and stakeholder theory (Patten 2002), which, together, argue that social disclosure is a function of social and political pressures facing the firm. Legitimacy theory suggests that corporate social and environmental reporting is motivated by a desire, by management, to legitimize their organization's operations (Adams 2004; Deegan 2002, 282; Hughes et al. 2001). That is, organizations exist to the extent that society "confers" upon the organization the state of legitimacy (Deegan 2002, 292). It follows that an organization's survival will be threatened if society perceives that the organization has breached its "social contract."

Tests of legitimacy theory in an environmental disclosure context typically examine the content of these disclosures and whether firms with inferior environmental performance are more likely to make environmental disclosures than firms with superior environmental performance.

For instance, Cho, Freedman, and Patten (2009) find that, after controlling for firm size and industry, firms with worse environmental performance (based on TRI emissions) are more likely to disclose environmental capital spending, relative to firms with better environmental performance. These findings suggest that, conditional on firms taking environmentally damaging actions, firms with inferior environmental performance face greater exposure to social and political pressures. Therefore, these firms have an incentive to make more extensive disclosures to create favorable perceptions of the firms and to reduce potential regulatory costs. Accordingly, based on socio-political theories and prior research we hypothesize:

> H2: Conditional on firms taking environmentally damaging actions, firms that have inferior environmental performance are more likely to disclose their carbon emission levels than firms that have superior environmental performance.

H2, which is motivated by socio-political theories, predicts a higher likelihood of carbon emission disclosures by firms that have *inferior* environmental performance, conditional on firms taking environmentally damaging actions. In contrast, H1, which is motivated by economic theory, predicts a higher likelihood of carbon emission disclosures by firms that have *superior* environmental performance, conditional on firms taking environmentally proactive actions. As discussed in the research design section, we construct a measure of relative environmental performance that reflects the firms' environmentally proactive actions, and a separate measure of relative environmental performance that reflects the firms' environmentally damaging actions. We argue that these measures are not mirror images of each other.

***"Peer" Pressure to Disclose and Likelihood of Disclosing Carbon Emissions***

According to institutional theory (DiMaggio and Powell 1983), organizations adapt their structure or operations to conform to external expectations about what forms or structures are acceptable (legitimate). That is, institutional theory posits that managers (and their firms) are expected to conform to "norms" that are largely imposed upon them, which will lead to some form of movement toward conformance with other "established" organizations. Failure to undertake this process leading to congruence has direct implications for a firm's survival (DiMaggio and Powell 1983, 149).[17] Application of institutional theory to our study suggests that, as increasing numbers of firms in a given industry disclose carbon emissions information, non-disclosers might be more likely to respond to the "peer" pressure by disclosing their carbon emissions information. Accordingly, we hypothesize:

H3: Firms are more likely to disclose their carbon emission levels as the proportion of industry peer firm disclosers increases.

In summary, as discussed above, the first part of our analyses models the likelihood of carbon emission disclosures as a function of their firms' relative environmental performance conditional on their environmental actions (i.e., proactive or damaging), and the "peer" pressure to disclose carbon emissions. We elaborate further in the research design section.

Next, we motivate and develop our hypothesis about the association between carbon emission levels and firm value for S&P 500 firms. We first briefly discuss the current status of market-based climate change regulation outside the U.S. and then describe the different institutional context in which U.S. firms operate. We motivate our hypothesis from the institutional context that firms face with respect to carbon emissions, as well as extant literature.

**European Union Emissions Trading Scheme**

The origins of market-based climate change regulation can be traced to the European Union Emissions Trading Scheme (EU ETS), which began in 2005. This scheme involves a cap-

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17 This concept is known as isomorphism, which is described as a constraining process that forces one unit in a population to resemble other units that face the same set of environmental conditions (Hawley 1968).

and-trade system in which firms were allotted carbon allowances called European Union Allowances (EUAs). The average price of EUAs over the period January, 2008 to January, 2010 has fluctuated from a low of $12 per metric ton to a high of $39 (Kossoy and Ambrosi 2010; see Figure 1). Recently, the penalty for each unit of emissions not covered by purchased European Union Allowances (EUAs) was set at €100/EUA, which was ten times the average price at which the EUAs were trading in 2007 (Bebbington and Larrinaga-González 2008).

Two important characteristics of the trading program are transaction costs and uncertainty. Transaction costs are all the costs that firms incur in preparing for and setting up systems to comply with the regulations required by their participation in the EU ETS and by engaging in the market. Engaging in the market entails a need to acquire information, seek out contract partners, negotiate trades, choose from among alternative options, and monitor and enforce outcomes. Uncertainty in the emissions trading market stems from such factors as unclear rules and ongoing changes in the system's institutional design, inherent market uncertainty, and technical uncertainty regarding the benefits of emissions abatement investments (Matisoff 2010).[18]

**Carbon Emission Levels and Firm Value for U.S. Firms**

The U.S. does not have a national mandatory emissions trading scheme. However, firms face ever increasing pressure from their stakeholders (e.g., investors, financial risk managers, insurance companies, carbon traders, NGOs) to measure, monitor, and disclose their carbon emission levels. Moreover, based in part on the European Union experience, investors in U.S. companies recognize that companies with high carbon emission levels and energy-intensive

[18] The trading program functions through the following trading periods: 2005-2007, 2008-2012, and 2013-2020. During the 2013-2020 trading period, emissions allocation, reporting, and verification will be centralized through the EU and will focus on compliance, in contrast to the current system, which focuses on goals and implementation (Matisoff 2010).

operations face risks from emerging regulations prompted by concerns about global climate change. Furthermore, proposed U.S. cap-and-trade policies raise the specter of paying for excessive carbon emissions.

The costs of complying with the increasing regulatory requirements related to carbon emissions are expected to be economically significant, and experts agree that the firms' carbon intensity will dictate which ones will face the greatest costs of regulatory compliance (PricewaterhouseCoopers 2009).[19] For instance, a report issued jointly by the Investor Responsibility Research Center Institute (IRRCi) and Trucost finds that, on average, S&P 500 firms emit 382 tons of $CO_2$-e (carbon dioxide-equivalent) for every U.S. $1 million of revenue generated by the firms. If the report's suggested market price of $28.24[20] were applied to each ton of $CO_2$-e emitted by the S&P 500, then carbon emission costs would total over $92.8 billion. This is equivalent to 1.08 percent of revenue from the companies in 2007, and 5.5 percent of earnings before interest, tax, depreciation, and amortization (EBITDA) (IRRCi/Trucost 2009).

The goal of requiring firms to measure, disclose, monitor, and pay for their carbon emissions is to ultimately reduce the overall level of emissions in the environment (Fornaro, Winkelman, and Glodstein 2009). In order to reduce their carbon emissions, high carbon emitters will be required to switch to less carbon intensive technologies and processes, which in turn will further increase the costs associated with their current carbon intensity. Even the firms with low emissions will bear the costs of monitoring and reporting in order to respond to pressure to report or to comply with the proposed emissions regulations. Credit rating companies have also downgraded firm debt, citing concerns over future business risks (e.g., Barley 2009). Thus,

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[19] Available at: http://www.pwc.com/us/en/transaction-services/publications/assets/capitalizing-climate-change.pdf

[20] Note that this estimate reflects only the direct cost of carbon emissions. Indirect costs related to carbon emissions may include capital expenditures to reduce emissions, reduced demand for goods associated with high carbon emissions, and research and developments costs to develop products with lower carbon emissions.

carbon emissions have become an essential element in analyzing a company's risk profile, potential liabilities, and financial performance.

To our knowledge, there is only one study that examines the effects of carbon emissions on firm value. Chapple, Clarkson, and Gold (2009) examine the association between more and less carbon emission intensity and the market value of equity for a sample of 58 publicly-traded Australian firms that were expected to be affected by a proposed national Emissions Trading Scheme (ETS) that, at the time of their study, was scheduled to start in 2011.[21] Chapple, Clarkson, and Gold (2009) find that the market penalizes firms that will be affected by the proposed ETS. Specifically, relative to less carbon-intensive firms, more carbon-intensive firms suffer a greater penalty, estimated at 6.57 percent of market capitalization.

The evidence on the firm-value (measured as market value of equity) effects of other environmental emissions is also sparse. Hughes (2000) examines the association between sulfur dioxide ($SO_2$) emissions and the market value of equity using a sample of publicly-traded electric utilities targeted as high-polluting by the 1990 Clean Air Act Amendments (CAAA). Hughes (2000) finds that the market penalizes the high-polluting utilities, but only during the years surrounding the enactment of the CAAA (1989-1991), which is presumably the time period when the estimated future costs to comply with the CAAA were the highest. The study finds no significant association between $SO_2$ emissions and market value of equity before 1989 or after 1991 for the high-polluting utilities. Johnston, Sefcik, and Soderstrom (2008) extend Hughes (2000) by examining the firm-value (as measured by market value) relevance of $SO_2$ emission allowances held by publicly-traded U.S. electric utilities, which are subject to the emissions trading scheme put into place by the 1990 CAAA. The authors find support for their reasoning

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[21] Australia has shelved plans for their proposed ETS for at least three years due to parliamentary opposition and slow progress on a global climate pact.

that the emission allowances have two components—an asset value and a real option value—that will be valued by the market.

It is unclear, however, whether the results of the studies described above will generalize to the association between carbon emission levels and firm value for the S&P 500 firms. First, Hughes (2000) examines $SO_2$ emissions, which are restricted only to fossil fuel burning power plants and whose disclosures are required under the CAAA. In contrast, $CO_2$ emissions will be regulated across industries and are disclosed voluntarily in the U.S. Further, Hughes' (2000) and Johnston, Sefcik, and Soderstrom's (2008) findings are based only on a sample drawn from the electric utilities industry. The results of the Chapple, Clarkson, and Gold (2009) study are based on a partitioning of firms into less and more carbon intensity across a small sample of 58 Australian firms from 2007. Furthermore, unlike the S&P 500 firms, the more carbon-intensive firms in their sample are smaller, less profitable, and riskier than their less carbon-intensive counterparts. Notwithstanding these caveats, both studies document a negative firm-value effect of environmental emissions. Therefore, in light of these findings and the increasing costs of measuring, disclosing, monitoring, and reducing carbon emissions, we propose the following hypothesis (in alternative form) regarding the firm-value effect of carbon emission levels for the S&P 500 firms:

H4: Firm value is negatively associated with carbon emission levels.

## III. RESEARCH DESIGN

### Sample and Data

Our sample consists of all the S&P 500 firms for the period 2006-2008. We selected this period for two reasons. First, the S&P 500 firms were first included as a group in the 2007 CDP report, which provides 2006 data. Second, the report containing 2008 data was issued in mid-

2009, when we collected the data. In order to maintain a constant sample over this period we use firms that were included in the S&P 500 index on December 31, 2007. Our total sample for 2006-2008 consists of 1,443 firm-year observations.

We hand-collected carbon emissions data from 2006 to 2008 from the CDP database.[22] CDP is an independent not-for-profit organization holding the largest repository of corporate climate change information. CDP requests information from the world's largest companies as measured by market capitalization. Currently, CDP acts on behalf of 534 institutional investors representing more than $64 trillion in assets under management.[23] The number of firms answering the CDP survey has grown tenfold since its inception, from 235 firms in 2003 to 2,456 firms from about sixty countries in 2009. PricewaterhouseCoopers LLP is the global advisor to the CDP and is responsible for analyzing the survey responses and writing the reports.

Participation in the CDP questionnaire is voluntary. Specifically, firms may choose to: (a) not respond or to respond to CDP indicating their decision to decline participation;
(b) provide partial information (e.g., provide links to information generally available at the firm's website, such as their corporate social responsibility reports) without answering the questionnaire; (c) respond to the questionnaire but not allow the CDP to make the responses publicly available (only the institutional investors who are signatories of the CDP are allowed access to these firms' responses)**;** or (d) respond to the questionnaire and allow the CDP to make the responses publicly available.

22 This entailed manually collecting and cross-validating carbon emissions numbers from data purchased from the CDP and individual firm responses to CDP questionnaires for all S&P 500 firms for our three-year sample. We found numerous discrepancies between the data in CDP's annual summary reports on S&P 500 firms, partly because the summaries only report data available up to the point when the summaries were prepared. These discrepancies imply that caution should be used in relying exclusively on the CDP annual summary reports.

23 See https://www.cdproject.net/en-US/WhatWeDo/Pages/overview.aspx as of November 1, 2010. Some of the member firms are Goldman Sachs, California State Public Employee Retirement System, BlackRock, BNP Paribas, HSBC, Morgan Stanley, and TIAA-CREF.

The CDP questionnaire elicits information on carbon emissions accounting, emissions intensity, energy, and trading.[24] The firms report their global carbon emissions (measured in metric tons) broken down by Scope 1 (direct emissions from GHG sources owned or controlled by the firm), Scope 2 (indirect emissions caused by the firm's consumption of electricity, heat, cooling or steam brought into its reporting boundary), and Scope 3 (emissions from employee business travel, external distribution/logistics, disposal of the company's products and services, and the company's supply chain).

Table 1 provides the frequencies of the firms' responses to the CDP questionnaire and carbon emissions information for 2006-2008. As shown in Table 1, we were able to obtain carbon emissions data for 584 firm-years (out of 1,443 firm-year observations, or 40.47 percent), representing 256 firms.[25,26] Out of the total firm-year observations, 184 firm-years (12.75 percent) responded to the CDP questionnaire but chose to not make their responses public. Further, 205 firm-year observations (14.21 percent) provided only partial information to the CDP. For example, these may have provided links to their stand-alone corporate social responsibility reports generally available on their websites, but did not answer the questionnaire and did not provide carbon emissions data.

Appendix 1 provides descriptive statistics for the firms for which we were able to gather carbon emissions data. Panels A and B present the data broken down by firms that do not and do operate in an industry that is required by the EPA's Greenhouse Gas Mandatory Reporting Rule

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24 The firms are required to respond to this section using the greenhouse gas protocol developed by the World Resources Institute and the World Business Council for Sustainable Development ("the GHG Protocol"), available at http://www.ghgprotocol.org/. In addition, ISO 14064-1 is compatible with the GHG Protocol.

25 The firm-year disclosures per year are as follows (untabulated): 162 (28 percent) firm-years are from 2006, 202 firm-years (35 percent) are from 2007, and 220 firm-years (37 percent) are from 2008.

26 As shown in Table 1, one firm that responded to the CDP questionnaire and made its response publicly available (cell 3) did not provide carbon emissions information. In addition, 30 firms did not respond to the CDP questionnaire in one year (cell 2), one firm did not allow the CDP to make its response publicly available (cell 6), and four firms provided only partial information (cell 8); nevertheless, for these firms we were able to obtain their carbon emissions data from their CDP responses in a subsequent year.

to report their GHG emissions (*EPA* = 0 and *EPA* = 1, respectively). The EPA uses the North American Industry Classification System (NAICS). Consistent with this, we also use the NAICS for our classification of firms as *EPA* = 1 and *EPA* = 0. Appendix 1 shows that the two largest numbers of firm-year observations with publicly available carbon emissions data in our sample are from the *EPA* = 1 firms (Panel B), namely, chemical manufacturing (74 firm-years, or about 13 percent of the total sample of firm-year disclosures), and utilities (72 firm-years), and the third largest is from the *EPA* = 0 firms (Panel A), namely, computer and electronic product manufacturing (69 firm-years).

We also collected environmental performance data from KLD STATS, which is a database with annual snapshots of the environmental, social, and governance (ESG) performance of companies rated by KLD Research & Analytics, Inc. Each year, KLD freezes its ratings to reflect the data at calendar year end. KLD STATS provides a binary summary of KLD's ratings based on each firm's environmentally proactive actions, and separately, their environmentally damaging actions, thus resulting in a full profile of the company's performance. The proactive dimensions are largely distinct from the damaging dimensions.[27] In each case, if KLD identifies a proactive or damaging action in a particular dimension, then KLD indicates this with a "1." If the company did not have a proactive or damaging action in that dimension, then this is indicated with a "0."

[27] The environmentally proactive dimensions are: (1) environmentally beneficial products and services; (2) pollution prevention; (3) recycling; (4) clean energy; (5) communications (e.g., publishes a substantive environmental report); and (6) miscellaneous (e.g., commitment to environmentally proactive activities). The environmentally damaging dimensions are: (1) hazardous waste (e.g., the company has recently paid substantial fines or civil penalties for waste management violations); (2) regulatory problems (e.g., the company has recently paid substantial fines or civil penalties for violations of air, water, or other environmental regulations); (3) ozone depleting chemicals; (4) substantial emissions (i.e., the company's legal emissions of toxic chemicals, as defined by and reported to the EPA, are among the highest of the companies followed by KLD); (5) agriculture chemicals (i.e., pesticides or chemical fertilizers); (6) climate change (i.e., the company derives substantial revenues, directly or indirectly, from the sale of coal or oil and its derivative fuel products); and (7) miscellaneous (i.e., the company has been involved in an environmental controversy that is not otherwise covered by other KLD ratings).

## Empirical Models

We examine two separate but related issues. The first is firms' voluntary disclosure of carbon emissions information to CDP and to the public and the second is the relationship between firms' carbon emissions and firm value. The first issue is important in its own right, and also addresses the self-selection bias, when examining the relationship between emissions and firm value.

### *Decision to Voluntarily Disclose Carbon Emissions*

As discussed earlier, we posit that firms' managers evaluate the relative benefits and costs of providing carbon emissions information to the CDP. However, because managers' evaluations of the benefits and costs of disclosing are unobservable, we model managers' disclosure decisions as a function of various firm-level characteristics. We categorize the firms into two groups: (1) those that choose to voluntarily disclose their carbon emissions to the CDP and allow public disclosure, and (2) all other firms. We use the following logit model to examine the disclosure decision:

$$EM\_DUM_t = \beta_1 STRNG_t + \beta_2 CNCRN_t + \beta_3 PROPDISCL_t + \beta_4 BM_t + \beta_5 LEV_t + \beta_6 II_t + \beta_7 FRNSALE_t + \beta_8 SIZE_t + \beta_9 EPA_t + \beta_{10} LITI_t + \beta_{11} EM\_DUM_{t-1} + \varepsilon_t \quad (1)$$

We model the firm's decision to provide carbon emissions information as an indicator variable, $EM\_DUM_t$, which is coded as one if the firm discloses its year $t$ carbon emissions data to CDP and permits public availability from CDP, and zero otherwise. As discussed earlier, our main independent variables of interest in the logit model, based on economic, socio-political, and institutional theories are the firms' relative environmental performance, treating environmentally proactive and damaging actions as asymmetric, and the "peer" pressure to disclose carbon emissions. We proxy for the firms' relative environmental performance using KLD's environmental performance data. Specifically, we construct two indicator variables, $STRNG_t$ and $CNCRN_t$, where $STRNG_t$ is our measure of the firms' environmentally proactive actions, and $CNCRN_t$ is our measure of the firms' environmentally damaging actions. First, we add all the proactive ratings and separately add all the damaging ratings, and calculate the industry median (using the two-digit SIC code) for each sum. We industry-adjust $STRNG_t$ and $CNCRN_t$ by deducting the industry median score from the firm score, at the 2-digit SIC level. Based on economic theory, we expect that the coefficient on $STRNG_t$ will be positive; based on socio-political theories, we expect that the coefficient on $CNCRN_t$ will also be positive. However, if the coefficients on $STRNG_t$ and $CNCRN_t$ are of opposite signs, then this would suggest that the market responds to these performance measures somewhat symmetrically.

According to institutional theory (DiMaggio and Powell 1983), as increasing numbers of firms in a given industry disclose carbon emissions information, non-disclosers will feel higher "peer" pressure to disclose their carbon emissions. Thus, we measure the pressure to disclose (denoted $PROPDISC_t$) as the ratio of firms disclosing their carbon emissions in year $t$ to the total firms in the industry in our sample (using the 2-digit SIC code). We expect the coefficient on $PROPDISC_{t,}$ to be positive.

Prior research provides evidence of other systematic firm-level characteristics that may increase the likelihood that firms will respond to the CDP questionnaire and provide carbon emissions information. For example, Stanny (2010) and Stanny and Ely (2008) examine characteristics of firms that respond to the CDP survey and find that size is positively correlated with the probability that firms respond to the CDP questionnaire. Therefore, we also expect the coefficient on $SIZE_t$, measured using the log of the firm's total assets, to be positive.

We control for firm growth by including the book-to-market ratio ($BM_t$) of the firm, but we do not predict a sign for $BM_t$. Prior research finds that firms with higher disclosure quality have lower cost of debt (Sengupta 1998). Consistent with higher leverage firms providing higher quality disclosures, we expect the coefficient on firm leverage, $LEV_t$, to be positive. As mentioned earlier, the CDP is a consortium of large institutional investors. Firms with higher institutional holdings may be more likely to disclose their carbon emissions owing to investors' call for more transparent disclosure of socially responsible performance information (Plumlee, Brown, and Marshall 2009). Thus, we also control for the proportion of total shares outstanding held by institutional investors, $II_t$, from the Thomson Reuters 13-F database. Firms with large institutional investor holdings may be more likely to respond to the CDP questionnaire in order to maintain their level of institutional investor ownership, or institutional investors may choose to invest in firms that provide this information. Alternatively, firms with lower institutional investor ownership may be more likely to respond to the CDP questionnaire to attract more institutional investors. Therefore, we do not predict the sign of the $II_t$ coefficient.

Firms' voluntary disclosures are affected by their product market interactions (Khanna, Palepu, and Srinivasan 2004). Research also shows that European Union firms with higher proportions of international sales are more likely to provide carbon emissions information (Stanny and Ely 2008). Arguably, these firms are typically subject to more stringent carbon emissions monitoring by regulators and investors. Therefore, to control for international product market interactions, we include in our selection model annual foreign sales as a proportion of total sales ($FRNSALE_t$) from the Worldscope database. S&P 500 firms that generate more earnings from outside the U.S. are expected to be more likely to respond to the CDP questionnaire; thus, we expect a positive sign for the $FRNSALE_t$ coefficient.

Consistent with Stanny (2010), we include an indicator variable, $EPA_t$, which is coded as 1 for firms that will be subject to the EPA's GHG reporting rule and coded as 0 otherwise. Many of the *EPA* = 1 firms also have industry reporting requirements regarding their GHG emissions.[28] Therefore, we expect a positive coefficient for $EPA_t$. Prior research on voluntary disclosure has shown that litigation risk, $LITI_t$, also affects managers' decision to disclose information. Skinner (1997) argues that firms facing higher litigation risk are more likely to provide disclosures to reduce their litigation risk. However, Francis et al. (1994) show that disclosure does not serve as a deterrent. Given the mixed evidence on litigation, we do not predict a sign on $LITI_t$. Consistent with prior research (e.g. Dhaliwal et al. 2011) we include an indicator variable, which equals if the firm is in a high risk litigation industry, based on 4-digit SIC codes (2833-2836, 3570-3577, 3600-3674, 5200-5961 and 7370), and zero otherwise.

Finally, we include a lagged emission indicator, $EM\_DUM_{t-1}$, as an additional explanatory variable in our model. We expect a positive coefficient on $EM\_DUM_{t-1}$ consistent with Stanny's (2010) finding that firms that responded to the CDP questionnaire in the previous year are eight times more likely to respond to the questionnaire in the current year, as compared to firms that did not respond. We also run the model excluding $EM\_DUM_{t-1}$, which allows us to examine the decision to disclose emissions without conditioning it on the firm's prior disclosure decision. Next, we examine the effects of carbon emissions on firm value using the Heckman model to incorporate firms' voluntary disclosures of carbon emissions.

[28] For instance, many high carbon-emitting S&P 500 firms are required to comply with air emission standards such as the EPA's Acid Rain Program, other federal emission programs, or state permitted emission standards. These firms are required to use continuous emissions monitoring systems (CEMS) to continuously collect, record, and report the required emissions data, which is periodically audited by the EPA (see http://www.epa.gov/ttn/emc/index.html). Also, firms in the Oil and Gas industry are required to calculate their GHG emissions using techniques provided by the Compendium of GHG Emission Estimation Methodologies for the Oil and Gas Industry (issued by the American Petroleum Institute) and the Petroleum Industry Guidelines for Reporting GHG Emissions (issued by the International Petroleum Industry Environmental Conservation Association).

***Firm-Value Effect of Carbon Emissions***

To examine the firm value effects of carbon emissions we estimate regression model 2 jointly with the disclosure-decision model (described above) to control for the firms' choice to disclose carbon emissions.[29] The market value model that we estimate jointly with the disclosure choice model is:

$$MKT_t = \beta_1 TEMIT_t + \beta_2 ASSET_t + \beta_3 LIAB_t + \beta_4 OPINC_t + \varepsilon_t \qquad (2)$$

Our measure of firm value, $MKT_t$, is the market value of common equity (in millions of dollars), calculated as the number of shares outstanding multiplied by the price per share of the firm's common stock at the end of the calendar year. Seventy-four percent of our sample of firms has a December fiscal year end (untabulated). Furthermore, the CDP reports are issued in the following calendar year for the previous year. For example, the CDP report for 2008 is issued in 2009. However, we expect that the market will form an estimate of the current year's emissions based on information available at the end of the calendar year (e.g., firm- and industry-level emissions from the previous year). Consequently, we use calendar year-end prices for year t. The accounting data are at the end of the fiscal year.

The primary independent variable of interest is $TEMIT_t$, which denotes emissions in thousands of metric tons.[30] Consistent with our prediction, we expect a negative $TEMIT_t$ coefficient. Based on prior related research (e.g., Barth and McNichols 1994; Campbell, Sefcik, and Soderstrom 2003), we include total assets ($ASSET_t$) and liabilities ($LIAB_t$) at the end of the fiscal year, and we expect a positive $ASSET_t$ coefficient and a negative $LIAB_t$ coefficient.

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[29] We modified the disclosure-decision model by dropping the $LITI_t$ variable because the results concerning this variable are not significant (at $p < 0.10$) in any of our specifications.

[30] We do not scale our independent variable, *TEMIT* in this specification because our dependent variable, *MKT*, is also unscaled, which is consistent with prior research (e.g., Barth and McNichols 1995; Campbell, Sefcik, and Soderstrom 2003). Furthermore, Barth and Clinch (2009) find that unscaled market value of equity estimates generally perform better than scaled market value specifications.

Because market value is also expected to be a function of the firm's operating performance, we include operating income in year *t*, $OPINC_t$, as a measure of firm performance. We expect firms with higher operating income to be valued more by the market, and therefore expect a positive $OPINC_t$ coefficient. To control for industry characteristics, we include industry fixed effects at the 2-digit SIC code level in both the disclosure choice and market value models.

## IV. RESULTS

### Descriptive Statistics

Panel A of Table 2 shows summary statistics for our full sample of S&P 500 firms, and Panel B shows the firms broken down into two groups: firms required by the EPA to disclose their carbon emissions (coded *EPA* = 1) and firms exempt from the EPA's reporting rule (coded *EPA* = 0). Panel C of Table 2 provides summary statistics for our sample firms broken down into two groups: those that made their carbon emissions information (in the CDP questionnaire) publicly available, and those that did not. We winsorize all the continuous variables at the 1 percent level on both tails of the distribution.

Panel A reports that mean total carbon emissions (*TEMIT*) as well as carbon emissions scaled by $1,000 of sales (*EMIT*). *TEMIT*) and *EMIT* are significantly skewed. Therefore, in Panel B we report parametric tests for the means and nonparametric tests for the medians. Panel B reports that carbon emissions are significantly higher for the *EPA* = 1 firms; both the mean *TEMIT* and *EMIT* for the *EPA* = 1 firms are more than ten times as large as for the *EPA* = 0 group (*p*-value = 0.000). The median emissions are also significantly larger for the *EPA* = 1 firms (Wilcoxon test *p*-value = 0.000). These statistics suggest that *EPA* = 1 firms are significantly more carbon intensive than the firms classified in the *EPA* = 0 group.

Panel A shows that, not surprisingly, our sample consists of extremely large firms, with mean (median) market value of \$21.92 (\$10.611) billion.[31] Panel B of Table 2 shows that the *EPA* = 1 firms are marginally larger, based on market value of common equity (*MKT*), than *EPA* = 0 firms ($p$ = 0.085). Interestingly, panel B also shows that the mean values for book value of total assets (*ASSET*) and total liabilities (*LIAB*) are significantly higher for the *EPA* = 0 group than for the *EPA* = 1 group ($p$ = 0.000). However, the difference in median *ASSET* and *LIAB* between the two groups is not significant at conventional levels. Comparing the market value and total assets and total liabilities for firms that made their carbon emissions information publicly available (*EM_DUM* = 1) versus those that did not (*EM_DUM* = 0), panel C of Table 2 shows that firms in the former group are bigger than firms in the latter group for all three measures, with both mean and medians being significantly larger for *EM_DUM* = 1 firms ($p$-value and Wilcoxon test $p$-value = 0.000).

Consistent with institutional investors owning a significant portion of S&P 500 firms, both the mean and median institutional ownership (*II*) for our sample firms is about 80 percent (Table 2, panel A). Interestingly, both the mean and median levels of *II* are higher for *EPA* = 0 firms and for firms that did not make their carbon emissions information publicly available (*EM_DUM* = 0) (panels B and C, respectively, Table 2).

Finally, both the percentage of foreign sales, *FRNSALE*, and the percentage of firms disclosing emissions in the firm's industry, *PROPDISCL*, is higher for the *EPA* = 1 and *EM_DUM* = 1 firms. The higher *FRNSALE* as well as *PROPDISCL* for these firms suggest that the probability of firms disclosing carbon emissions information is increasing in both of these characteristics.

[31] These statistics are comparable to the statistics reported by Standards & Poor in their fact sheet on S&P 500 firms on June 30, 2010, of \$18.64 and \$ 8.29 billion for the mean and median, respectively.

Table 3 reports correlation coefficients. Because a number of the variables used in our analyses are indicator variables and there is considerable skewness in the data, as described above, we discuss the Spearman correlation coefficients here. *TEMIT* and *MKT* are positively correlated, which may be due to a size effect; that is, larger firms with high *MKT* also have higher carbon emissions. Consistent with larger firms having higher emissions, when we scale emissions by sales we find that *EMIT* is negatively and significantly correlated with *MKT* ($p < 0.01$). The correlation between emissions *(TEMIT* and *EMIT)* and leverage (*LEV*) is positive and significant (0.244 and 0.225 respectively; $p < 0.01$), possibly signifying that firms with higher carbon emissions are viewed as less risky by debt-holders. This is consistent with firms with higher emissions having more assets in place and thus, being more attractive to debt-holders (Myers 1977). The correlation between *EMIT* and percentage of shares held by institutional investors (*II*) is negative and significant ($p < 0.10$), consistent with high carbon-emitting firms having lower institutional investor holdings. Finally, the correlation between *EMIT* and the percentage of foreign sales (*FRNSALE*) is negative and significant (−0.133; $p < 0.01$), suggesting that higher (lower) carbon-emitting firms have a lower (higher) percentage of foreign sales.

**Results of the Choice to Disclose Carbon Emissions**

Table 4 reports the logit model results of the firms' decision to disclose their carbon emissions. Panel A of Table 4 presents the results not controlling for within-industry correlations, and Panel B shows the results including industry fixed effects at the 2-digit SIC code level. Since our results are similar under both specifications, and given the importance of controlling for within-industry correlations, we discuss the results reported in Panel B of Table 4.

The dependent variable in the model is $EM\_DUM_t$, which equals one if the firm made its carbon emissions information reported to the CDP publicly available, and zero otherwise.

Our first set of variables of interest includes $STRNG_t$ and $CNCRN_t$. As shown in Table 4, panel B, column 1, the $STRNG_t$ coefficient is positive and significant ($p < 0.01$). The odds ratio (1.646) indicates that the probability of disclosing emissions is roughly 65 percent higher if the firms' environmental strengths are one standard deviation higher than the industry median. These results indicate a higher likelihood of voluntarily disclosing carbon emissions by firms with superior environmental performance (relative to the industry median), conditional on firms taking environmentally proactive actions. Therefore, our results support H1, which is based on economic theory. However, the $CNCRN_t$ coefficient is not statistically significant ($p > 0.10$). Therefore, our results do not provide evidence of an association between inferior environmental performance (relative to the industry median), and the likelihood of voluntarily disclosing carbon emissions, conditional on firms taking environmentally damaging actions. Thus, our results do not support H2, which is based on socio-political theories.

The coefficient on our third variable of interest, $PROPDISCL_t$, is positive and significant ($p < 0.01$), with an odds ratio of 1.061, thus suggesting that firms are more likely to voluntarily disclose their carbon emissions as the proportion of industry peer firm disclosers increases (Table 4, panel B, column 1). These results support H3, consistent with the "peer pressure" argument based on institutional theory.

The coefficient on $FRNSALE_t$ is positive and significant ($\beta = 0.021$; $p < 0.01$). This is consistent with Stanny and Ely (2008), who find that the proportion of a firm's foreign sales to total sales is positively associated with the firm's choice to respond to the CDP questionnaire.

Furthermore, firms that may be required to report their GHG emissions to the EPA (*EPA* = 1) are more than twice as likely to disclose their emissions as *EPA* = 0 firms ($p < 0.05$).

The coefficient for $SIZE_t$ is positive and highly significant ($p < 0.01$). The odds ratio (2.016) indicates that a one standard deviation increase in firm size approximately doubles the probability of disclosing carbon emissions. Firms with higher book-to-market ratio are less likely to disclose their emissions, as the coefficient on $BM_t$ is negative and significant ($p < 0.05$). The coefficient on $II_t$ is not significantly different from zero. This result may owe to institutional investors already holding a large proportion of the shares of the S&P 500 firms, which affords very little variation in the data on this dimension. The mean (median) institutional ownership for our sample firms is 80.04 percent (81.06 percent), with a standard deviation of 14.6.

Consistent with our expectations, our results (shown in Table 4, panel B, column 2) indicate that firms which disclosed their carbon emissions in the prior year are significantly more likely to disclose their emissions in the current year. The odds ratio on $EM\_DUM_{t-1}$ is 12.12, thus indicating that the probability of disclosing emissions in year *t* is twelve times higher if the firm disclosed emissions in year $t-1$. The other results are unchanged. In the next set of analyses, we also split our sample based on EPA group membership and run the disclosure choice model separately for each group.

**Firm-Value Effect of Carbon Emissions**

We now examine the effects of carbon emissions on firm value. Since we only observe emissions for firms that choose to disclose them, we estimate a Heckman model, using Full Information Maximum Likelihood (FIML), to correct for self-selection bias.[32] We estimate the

[32] Prior research, including Tucker (2011), recommends using FIML if possible, since it is a more efficient estimation method as compared to Limited Information Maximum Likelihood (LIML).

market value model jointly with the disclosure choice model, which allows us to make inferences regarding the average effects of carbon emissions for *all* firms, not just disclosing firms.

Recall that H4 predicts that firm value is negatively associated with carbon emissions. If the market penalizes high carbon-emitting firms, then we would expect a negative sign on the $\beta_1$ coefficient for $TEMIT_t$ in regression model (2). As shown in Panel B of Table 5, our results support H4, as indicated by the negative $TEMIT_t$ coefficient for the full sample ($\beta_1 = -0.202$; $p < 0.01$). This result has economic significance, and indicates that for every additional thousand metric tons of carbon emissions, firm value decreases by $202,000 on average. This translates into a firm-value penalty of $1.28 billion for firms in the third quartile (in terms of carbon emissions) relative to firms in the first quartile.[33]

We also examine whether the market values carbon emissions differently for high and low carbon emitting firms. Therefore, we split our sample into two sub-groups based on the EPA's GHG Mandatory Reporting Rule variable (as explained earlier) and estimate regression model (2) separately for each sub-group. As shown in Panel B of Table 5, the coefficient on $TEMIT_t$ for the $EPA = 1$ group is negative and significant ($\beta_1 = -0.185$; $p < 0.01$). Similarly, the coefficient on $TEMIT_t$ for the $EPA = 0$ group is negative and significant ($\beta_1 = -0.184$; $p < 0.05$). In summary, carbon emissions negatively affect firm value for both high and low carbon-emitting firms.

We control for a number of factors that are expected to affect the firms' market value. As shown in Table 5, panel B, the coefficients for both $ASSET_t$ and $LIAB_t$ at the end of the fiscal year are significantly associated with the firms' market value ($p < 0.01$). The coefficient for $ASSET_t$ ($\beta_2$) is positive and significant ($p < 0.01$) for the full sample and for both sub-groups.

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[33] Using the Heckman model allows us to make inferences regarding firms that choose to not disclose their carbon emissions. That is, the average effect of carbon emissions on firm value is $202 per metric ton for all the firms and not just the firms that disclose their emissions.

And, the coefficient for $LIAB_t$ ($\beta_3$) is negative and significant for the full sample and for both EPA groups ($p < 0.01$). The coefficient on $OPINC_t$ (which proxies for current year operating performance) is positive and significant for the full sample ($\beta_4 = 5.602$; $p < 0.01$) as well as the two EPA groups ($p < 0.01$).

Panel A of Table 5 presents our regression results without industry fixed-effects. The coefficients for $TEMIT_t$ for the full sample and for the $EPA = 1$ sub-group of firms are negative and highly significant ($p < 0.01$), and they are also larger in magnitude than the coefficients reported in panel B (which include industry fixed effects). The $TEMIT_t$ coefficient for the $EPA = 0$ sub-group of firms is also negative but only marginally significant ($p < 0.10$). Other results are qualitatively similar to those reported above. Taken together, our results without industry fixed effects are consistent with our main results reported above.

Also, our likelihood ratio test results allow us to reject the null hypothesis of independence in both panels A and B of Table 5 for the full sample and for $EPA = 1$ firms, but not for the $EPA = 0$ firms. This result supports the need to correct for self-selection when examining the firm-value effects of carbon emissions, particularly if the sample is drawn from the firms subject to the GHG reporting rule, or from industries that are likely to be subject to the rule in the future.

Table 5 also presents the results of the selection equation separately for the firms in the two EPA reporting groups, $EPA = 1$ and $EPA = 0$. As shown in panel B of Table 5 for firms in the $EPA = 1$ group, the coefficient on $STRNG_t$ is positive and significant ($p < 0.05$); however, the coefficient on $CNCRN_t$ is not significantly different from zero. In contrast, for firms in the EPA = 0 group, the coefficient on $CNCRN_t$ is negative and significant ($p < 0.05$); however, the coefficient on $STRNG_t$ is not significantly different from zero. This suggests that, for firms in the

*EPA* = 1 group, those that score higher based on their environmentally proactive actions are more likely to disclose their carbon emissions. In contrast, for firms in the *EPA* = 0 group, those that score higher based on their environmentally damaging actions are less likely to disclose their carbon emissions. Taken together, we find support for the likelihood of voluntarily disclosing carbon emissions based on economic theory.

Overall, our results support our prediction that firm value is negatively associated with carbon emissions. Our results for the full sample as well as for the *EPA* = 1 and *EPA* = 0 sub-groups are both economically large and statistically significant.

**Sensitivity Analyses**

In this section we report the results of several sensitivity analyses conducted to assess the robustness of our main results. We conducted the sensitivity analyses with and without industry fixed-effects, but we report and discuss the former results here. The results without industry fixed-effects (untabulated) are stronger except where otherwise indicated. First, we scaled both the dependent variable (market value, $MKT_t$) and the independent variables in regression model (2) by sales (Table 6). Our main independent variable ($EMIT_t$) scaled by sales captures the firms' eco-efficiency. Recall that regression model (2) includes both $ASSET_t$ and $LIAB_t$. However, since total assets and sales are highly correlated ($\rho = 0.71$; $p < 0.01$), we substitute book value of equity ($BVE_t$) for assets and liabilities in our model specification, consistent with Johnston, Sefcik, and Soderstrom (2008). As shown in Table 6, the coefficient on scaled emissions ($EMIT_t$) is negative and significant for the full sample ($p < 0.01$) and for the *EPA* = 1 firms ($p < 0.05$). However, the $EMIT_t$ coefficient is not significant for the *EPA* = 0 firms ($p > 0.10$). Our results for the other variables in this specification, with all variables scaled by sales, are generally consistent with our main results reported above.

Our second sensitivity analysis includes firms with December fiscal year-end only (reported in Table 7). Since the carbon emissions data and market value data are for the calendar year-end but the accounting data is for fiscal year-end, using firms with December fiscal year-end only aligns the accounting data better with the carbon emissions and price data. Our results are consistent with the main results reported in Table 5. Specifically, the coefficient on $TEMIT_t$ is negative and significant for the full sample and for the *EPA* = 1 firms (at $p < 0.01$), and for the *EPA* = 0 firms (at $p < 0.05$).[34]

Our final sensitivity analysis examines the relationship between changes in firm value, ($\Delta MKT_t$) and changes in carbon emissions ($\Delta TEMIT_t$) (reported in Table 8). Consistent with our main results, we find that increases in carbon emissions are associated with decreases in firm value. In particular, the coefficient on $\Delta TEMIT_t$ is negative and significant for the full sample ($p < 0.05$) and for *EPA* = 1 firms ($p < 0.10$), but not for the *EPA* = 0 firms. In summary, the results of our sensitivity analyses are generally consistent with our main results reported above and support our prediction that firm value is negatively associated with carbon emissions.[35]

## V. CONCLUSION AND DISCUSSION

We use carbon emissions data from CDP for 2006-2008 that S&P 500 firms disclosed voluntarily to the CDP to examine two separate, yet, related questions. The first question addresses firm-level characteristics associated with the choice to disclose carbon emissions. Consistent with economic theory, we predict and find a higher likelihood of carbon emission disclosures by firms with *superior* environmental performance, conditional on firms taking

34 We ran the regression for *EPA* = 1 firms using LIML instead of FIML. This is because the regression using FIML and including industry fixed-effects did not converge for December fiscal year-end firms. This is likely due to the loss of 44 observations without December fiscal-year end, or a little over 10 percent of the sample.

35 In untabulated results, we also included return on assets as an additional independent variable in the selection equation, but return on assets was only marginally significant. This result may be due to our sample of generally successful firms.

environmentally proactive actions. However, contrary to our predictions based on socio-political theories, we find no association between *inferior* environmental performance and the likelihood of disclosing carbon emissions, conditional on firms taking environmentally damaging actions. Further, we predict and find that firms are more likely to voluntarily disclose their carbon emissions as the proportion of industry peer firm disclosers increases.

To address the second question concerning the relationship between carbon emission levels and firm value, we correct for self-selection bias caused by firm- and industry-level characteristics associated with the decision to disclose such emissions. We predict and find a negative association between carbon emission levels and firm value. On average, for every additional thousand metric tons of carbon emissions, firm value decreases by $202,000. The effect of carbon emissions on firm value is economically significant, especially since the direct costs of carbon emissions have been less than $40 per metric ton in the recent past. However, in addition to the direct costs of carbon, firms also face indirect costs that include increased monitoring and regulatory intervention, litigation and remediation costs, and reputational costs, all of which combined may be considerable.

Our results provide evidence on the trade-offs that managers make between costs and benefits as they decide whether to publicly disclose their carbon emissions. Additionally, our results suggest that the market attaches an implicit cost to carbon emissions, even though there is currently no explicit cost. This evidence is consistent with capital markets rewarding firms that reduce their carbon emissions. Furthermore, although federal regulation that will require firms to pay for their emissions has yet to be adopted in the U.S., our results suggest that the markets are already anticipating the effects of the costs of emissions on firm value. Our results are therefore important to managers, investors, regulators, accounting practitioners, and to the U.S. Congress as it continues to deliberate legislation to report and curb carbon emissions.

The limitations of our study point to potential ideas for future research. First, although the CDP requires that firms use the GRI's sustainability reporting framework, the methods used by different firms to measure their emissions are less than uniform, even within industries. There is also diversity in the number of emission scopes reported. Some firms report emissions under all three scopes, while others may report only direct emissions (Scope 1). Still others may report only total emissions. Further, in addition to the uncertainty about measuring and reporting practices, firms self-report their emissions with little or no external verification of this information. The verification that occurs is typically performed by either audit firms or engineering firms, and the extent of verification and what constitutes verification is ill-defined. In future research we plan to examine managers' decisions to request verification or assurance of their carbon emissions, as well as their choice of assurance provider.

Finally, our findings point naturally to the need for carbon emission allowances information, which is not yet available for the U.S. S&P 500 firms due to the lack of a national carbon trading market in the U.S. To our knowledge, only one study examines emission allowances (Johnston, Sefcik, and Soderstrom 2008), but not for carbon emissions. Johnston et al. (2008) examine the firm-value (as measured by market value) relevance of $SO_2$ emission allowances held by publicly-traded U.S. electric utilities, which are subject to the emissions trading scheme put into place by the 1990 CAAA. Johnston et al.'s results suggest that it is possible that the market will incorporate—albeit implicitly—expectations of possible future carbon emission allowances for high carbon-emitting firms. However, more research is needed to examine these conjectures. Whether Johnston et al.'s (2008) results generalize to carbon emission allowances for the S&P 500 firms is an empirical question in need of further research.

In conclusion, we provide evidence on the factors that affect managers' decisions to publicly disclose their carbon emissions. We also show that investors in equity markets are incorporating the effects of carbon emissions in their valuation decisions. In response to heightened concerns about climate change, proposals to reduce carbon emissions aim to internalize the costs of emitting GHG by requiring the firm to pay for its emissions – the "Polluter Pays Principle." Although there are no U.S. regulatory penalties currently in place for carbon emissions, our findings suggest that the market finds the frequently unverified, non-financial disclosures of carbon emissions useful and implicitly imputes a price to carbon emissions.

## APPENDIX 1

*Descriptive Statistics of $CO_2$ Emissions (in Thousand Metric Tons), EPA = 0 vs. EPA = 1 Firms, by 3-digit NAICS Code*

**Panel A. *EPA* = 0 Firms**[a]

| NAICS | Industry | Full Sample | | Firm-years Emissions Data Available | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Firm-Yrs | % of 1,443 | Firm-Yrs | % of 583 | Mean | Median | Std Dev |
| 212 | Mining (except oil & gas) | 15 | 1.04% | 6 | 1.03% | 5,043 | 4,172 | 2,343 |
| 213 | Support activities for mining | 20 | 1.39% | 4 | 0.69% | 3,585 | 3,618 | 363 |
| 236 | Construction of buildings | 17 | 1.18% | 1 | 0.17% | 42 | 42 | N.A. |
| 311 | Food manufacturing | 44 | 3.05% | 29 | 4.97% | 2,464 | 1,175 | 3,675 |
| 312 | Beverage & tobacco product manufacturing | 25 | 1.73% | 19 | 3.26% | 1,184 | 748 | 1,456 |
| 333 | Machinery manufacturing | 48 | 3.33% | 24 | 4.12% | 589 | 250 | 671 |
| 334 | Computer & electronic product manufacturing | 146 | 10.12% | 69 | 11.84% | 1,469 | 341 | 5,830 |
| 424 | Merchant wholesalers, nondurable goods | 18 | 1.25% | 5 | 0.86% | 315 | 241 | 257 |
| 448 | Clothing & clothing accessories stores | 17 | 1.18% | 7 | 1.20% | 556 | 640 | 236 |
| 452 | General merchandise stores | 29 | 2.01% | 14 | 2.40% | 5,746 | 1,929 | 7,916 |
| 511 | Publishing industries | 50 | 3.47% | 14 | 2.40% | 221 | 105 | 304 |
| 515 | Broadcasting (except Internet) | 23 | 1.59% | 6 | 1.03% | 843 | 728 | 415 |
| 517 | Telecommunications | 26 | 1.80% | 14 | 2.40% | 2,299 | 1,375 | 2,639 |
| 519 | Other information services | 16 | 1.11% | 2 | 0.34% | 177 | 177 | 176 |
| 522 | Credit intermediation & related activities | 93 | 6.44% | 23 | 3.95% | 4,043 | 303 | 16,802 |
| 523 | Securities, commodity contracts, other financial investments, & related activities | 52 | 3.60% | 15 | 2.57% | 350 | 292 | 383 |
| 524 | Insurance carriers & related activities | 88 | 6.10% | 28 | 4.80% | 148 | 94 | 149 |
| 531 | Real estate | 36 | 2.49% | 6 | 1.03% | 368 | 367 | 389 |
| 541 | Professional, scientific, & technical services | 35 | 2.43% | 9 | 1.54% | 1,151 | 352 | 1,306 |
| <1% | Others | 238 | 16.49% | 52 | 8.92% | 7,332 | 1,581 | 18,851 |
| Total | | 1,036 | 71.79% | 347 | 59.52% | 2,538 | 474 | 9,316 |

## APPENDIX 1—*continued*

**Panel B. *EPA* = 1 Firms**[a]

| NAICS | Industry | Full Sample | | Firm-years Emissions Data Available | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Firm-Yrs | % of 1,443 | Firm-Yrs | % of 583 | Mean | Median | Std Dev |
| 211 | Oil & gas extraction | 28 | 1.94% | 15 | 2.57% | 9,490 | 8,320 | 8,161 |
| 221 | Utilities | 88 | 6.10% | 72 | 12.35% | 46,032 | 37,132 | 40,126 |
| 322 | Paper manufacturing | 18 | 1.25% | 14 | 2.40% | 6,705 | 6,739 | 5,458 |
| 324 | Petroleum & coal product manufacturing | 26 | 1.80% | 16 | 2.74% | 112,366 | 62,998 | 144,168 |
| 325 | Chemical manufacturing | 120 | 8.32% | 74 | 12.69% | 4,726 | 1,125 | 8,948 |
| 332 | Fabricated metal product manufacturing | 15 | 1.04% | 4 | 0.69% | 809 | 731 | 515 |
| 336 | Transport equipment manufacturing | 47 | 3.26% | 20 | 3.43% | 7,798 | 1,873 | 21,836 |
| 339 | Miscellaneous manufacturing | 24 | 1.66% | 8 | 1.37% | 277 | 230 | 178 |
| < 1% | Others | 41 | 2.84% | 13 | 2.23% | 26,212 | 7,500 | 27,610 |
| Total | | 407 | 28.21% | 236 | 40.48% | 26,272 | 6,577 | 52,872 |

[a] *EPA* is an indicator variable equal to 1 if the firm operates in an industry that is required by the Environmental Protection Agency's (EPA) Greenhouse Gas Mandatory Reporting Rule to report GHG emissions, and 0 otherwise. The rule, which became in effect on December 29, 2009, applies to fossil fuel and industrial gas suppliers, direct greenhouse gas emitters, and manufacturers of heavy-duty and off-road vehicles and engines. The rule is available at: http://epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf.

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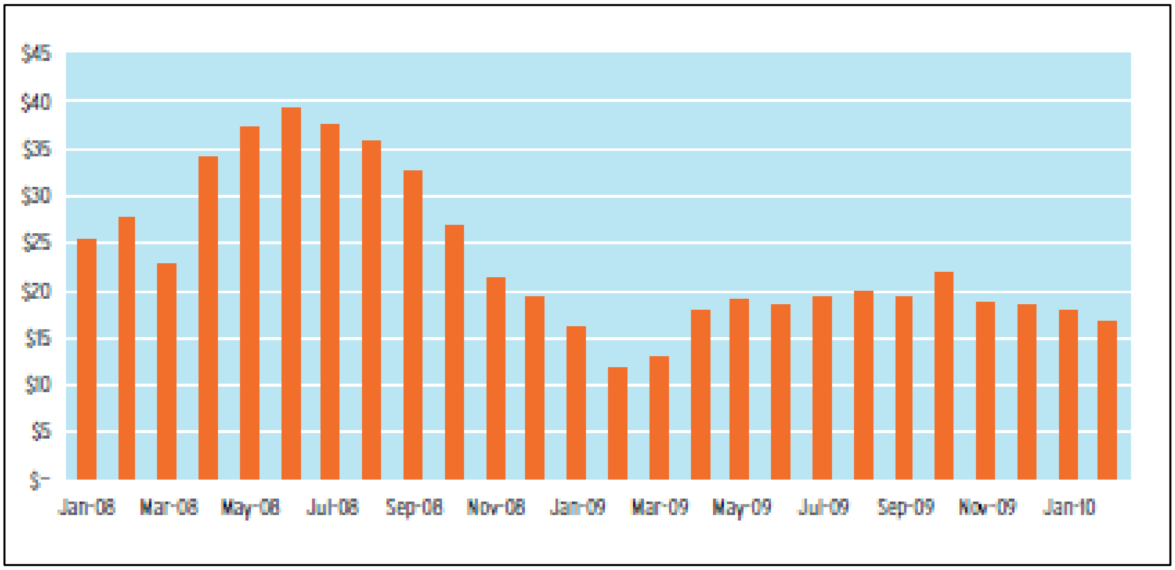
**FIGURE 1**

*European Union Allowance (EUA) Average Prices*

*January 2008 to January 2010*




Source: Kossoy, A., and P. Ambrosi. 2010. *State and Trends of the Carbon Markets*. The World Bank Group

**TABLE 1**

*S&P 500 Firms' Responses to CDP Questionnaire and Carbon Emissions Information (2006-2008)*

| Responded to CDP questionnaire?[a] | Carbon Emissions Information Available? No | Yes | Total |
|---|---|---|---|
| No/Declined to participate | 1<br>474<br>(32.85%) | 2<br>30[c]<br>(2.08%) | 504<br>(34.93%) |
| Response publicly available | 3<br>1[b]<br>(0.07%) | 4<br>549<br>(38.05%) | 550<br>(38.12%) |
| Response not publicly available | 5<br>183<br>(12.68%) | 6<br>1[c]<br>(0.07%) | 184<br>(12.75%) |
| Provided partial information | 7<br>201<br>(13.93%) | 8<br>4[c]<br>(0.28%) | 205<br>(14.21%) |
| Total | 859<br>(59.53%) | 584<br>(40.47%) | 1,443<br>(100%) |

[a] The carbon emissions data are collected annually by the CDP on behalf of institutional investors, purchasing organizations, and government bodies. Participation in the CDP questionnaire is voluntary. Therefore, firms may choose to: not respond to the questionnaire/decline to participate; provide partial information (e.g., provide links to information generally available on the firm's website, such as their corporate social responsibility reports) without answering the questionnaire; respond to the questionnaire but not allow the CDP to make the responses publicly available; or respond to the questionnaire and allow CDP to make the responses publicly available.

[b] One firm that responded to the CDP questionnaire and made its responses publicly available did not provide carbon emissions information.

[c] These firms declined to participate in the CDP questionnaire (cell 2), or did not allow the CDP to make their responses publicly available (cell 6), or provided only partial information (cell 8) in one year, but we were able to obtain their carbon emissions data from the firms' responses to the CDP questionnaire in a subsequent year.

## TABLE 2
*Descriptive Statistics*

### Panel A: Full Sample

| Variable | N | Mean | Q1 | Median | Q3 | Std Dev |
|---|---|---|---|---|---|---|
| *TEMIT* | 584 | 11,052.17 | 247.24 | 944.68 | 6,608.35 | 26,288.29 |
| *EMIT* | 583 | 0.76 | 0.02 | 0.06 | 0.34 | 1.91 |
| *MKT* | 1,460 | 21,922.21 | 5,076.93 | 10,611.20 | 21,550.08 | 34,178.93 |
| *ASSET* | 1,479 | 49,681.10 | 5,268.23 | 12,659.50 | 31,879.00 | 134,743.10 |
| *LIAB* | 1,474 | 41,200.12 | 2,736.00 | 7,556.59 | 21,167.00 | 129,029.10 |
| *OPINC* | 1,479 | 2,757.55 | 514.81 | 1,135.05 | 2,507.00 | 5,622.24 |
| *SALE* | 1,479 | 17,525.24 | 3,791.62 | 8,357.00 | 16,828.00 | 27,080.26 |
| *SIZE* | 1,479 | 9.59 | 8.57 | 9.45 | 10.37 | 1.40 |
| *BM* | 1,474 | 0.49 | 0.24 | 0.39 | 0.63 | 0.38 |
| *LEV* | 1,472 | 0.41 | 0.21 | 0.38 | 0.58 | 0.26 |
| *CNCRN* | 1,448 | 0.07 | 0.00 | 0.00 | 0.00 | 0.68 |
| *STRNG* | 1,451 | 0.20 | 0.00 | 0.00 | 0.00 | 0.73 |
| *II* | 1,401 | 80.04 | 71.53 | 81.06 | 89.58 | 14.64 |
| *FRNSALE* | 1,497 | 25.54 | 0.00 | 20.79 | 44.89 | 25.16 |
| *PROPDISCL* | 1,497 | 38.84 | 22.22 | 37.50 | 55.56 | 23.61 |

**TABLE 2—*continued***

**Panel B: Sample by *EPA***

| Variable | *EPA* = 0 | | | *EPA* = 1 | | | *t*-stat | Wilcoxon |
|---|---|---|---|---|---|---|---|---|
| | N | Mean | Median | N | Mean | Median | *p*-value | *p*-value |
| *TEMIT* | 348 | 2,537.76 | 474.05 | 236 | 23,607.33 | 6,577.43 | 0.000 | 0.000 |
| *EMIT* | 347 | 0.14 | 0.04 | 236 | 1.67 | 0.37 | 0.000 | 0.000 |
| *MKT* | 1,047 | 21,152.10 | 9,763.62 | 413 | 23,874.54 | 12,636.10 | 0.085 | 0.004 |
| *ASSET* | 1,061 | 59,069.56 | 12,190.00 | 418 | 25,850.58 | 14,076.45 | 0.000 | 0.452 |
| *LIAB* | 1,061 | 50,512.43 | 7,011.00 | 413 | 17,276.73 | 9,176.00 | 0.000 | 0.121 |
| *OPINC* | 1,061 | 2,749.72 | 1,043.30 | 418 | 2,777.45 | 1,324.07 | 0.932 | 0.000 |
| *SALE* | 1,061 | 16,723.46 | 7,743.25 | 418 | 19,560.38 | 9,409.00 | 0.070 | 0.003 |
| *SIZE* | 1,061 | 9.60 | 9.41 | 418 | 9.54 | 9.55 | 0.417 | 0.451 |
| *BM* | 1,057 | 0.51 | 0.41 | 417 | 0.43 | 0.36 | 0.000 | 0.016 |
| *LEV* | 1,059 | 0.40 | 0.36 | 413 | 0.42 | 0.41 | 0.105 | 0.005 |
| *CNCRN* | 1,032 | 0.06 | 0.00 | 416 | 0.08 | 0.00 | 0.741 | 0.921 |
| *STRNG* | 1,035 | 0.12 | 0.00 | 416 | 0.38 | 0.00 | 0.000 | 0.000 |
| *II* | 993 | 80.94 | 81.73 | 408 | 77.87 | 79.37 | 0.000 | 0.000 |
| *FRNSALE* | 1,079 | 24.20 | 16.88 | 418 | 28.99 | 30.81 | 0.001 | 0.000 |
| *PROPDISCL* | 1,079 | 32.83 | 33.33 | 418 | 54.34 | 55.56 | 0.000 | 0.000 |

## TABLE 2—*continued*

### Panel C: By Availability of Carbon Emission Information

| Variable | Emissions Not Available N | Mean | Median | Emissions Available N | Mean | Median | *t*-stat *p*-value | Wilcoxon *p*-value |
|---|---|---|---|---|---|---|---|---|
| *TEMIT* | | | | 584 | 11,052.17 | 944.68 | | |
| *EMIT* | | | | 583 | 0.76 | 0.06 | | |
| *MKT* | 881 | 14,141.32 | 8,341.41 | 579 | 33,761.54 | 16,182.83 | 0.000 | 0.000 |
| *ASSET* | 896 | 38,427.98 | 8,964.20 | 583 | 66,975.76 | 20,182.00 | 0.000 | 0.000 |
| *LIAB* | 891 | 32,389.22 | 5,183.20 | 583 | 54,665.84 | 12,741.00 | 0.001 | 0.000 |
| *OPINC* | 896 | 1,846.63 | 851.30 | 583 | 4,157.53 | 1,683.00 | 0.000 | 0.000 |
| *SALE* | 896 | 12,129.48 | 6,188.19 | 583 | 25,817.87 | 12,779.70 | 0.000 | 0.000 |
| *SIZE* | 896 | 9.30 | 9.10 | 583 | 10.03 | 9.91 | 0.000 | 0.000 |
| *BM* | 891 | 0.51 | 0.40 | 583 | 0.46 | 0.39 | 0.038 | 0.306 |
| *LEV* | 889 | 0.39 | 0.36 | 583 | 0.42 | 0.40 | 0.027 | 0.005 |
| *CNCRN* | 880 | 0.02 | 0.00 | 568 | 0.14 | 0.00 | 0.000 | 0.005 |
| *STRNG* | 880 | 0.05 | 0.00 | 571 | 0.42 | 0.00 | 0.000 | 0.000 |
| *II* | 840 | 81.97 | 83.28 | 561 | 77.16 | 77.71 | 0.000 | 0.000 |
| *FRNSALE* | 913 | 21.10 | 12.24 | 584 | 32.47 | 32.14 | 0.000 | 0.000 |
| *PROPDISCL* | 913 | 29.56 | 30.77 | 584 | 53.34 | 50.00 | 0.000 | 0.000 |

where:

*TEMIT* is the total firm emissions in metric tons for year *t* (in thousands)

*EMIT* is the firm emissions in metric tons scaled by sales (in $ thousands) for year *t* (TEMIT/SALES)

*MKT* is the market value of common equity at the end of the calendar year, calculated as SHROUT*PRC (in $ millions), where (SHROUT* PRC) = common shares outstanding multiplied by price per share.

*ASSET* is the book value of the firm's total assets (AT) at the end of fiscal year *t* (in $ millions).

*LIAB* is the book value of the firm's total liabilities (LT) at the end of fiscal year *t* (in $ millions).

*OPINC* is the operating income (in $ millions) of the firm after depreciation (OIADP) for fiscal year *t*.

*SALE* is the sales (in $ millions) of the firm for the fiscal year.

*SIZE* is the log of total assets of the firm at the end of the fiscal year.

*BM* is the book-to-market ratio of the firm.

*LEV* is leverage of the firm, measured as (DLTT+DLC)/(DLTT+DLC+CEQ)

*CNCRN* is industry adjusted concerns for the firm identified in KLD, measured as (CNCRN − median industry CNCRN, at the 2 digit SIC level)

*STRNG* is industry adjusted strength for the firm identified in KLD, measured as (STRNG − median industry STRNG, at the 2 digit SIC level)

*II* is the percentage of total shares outstanding held by institutional investors, from Thomson Reuters 13-F database.

*FRNSALE* is foreign sales as a percentage of total sales of the firm for the year from the Worldscope database.

*PROPDISC* is firms in the 2-digit SIC industry with publicly available carbon emissions information as a percentage of total number firms in the industry in our sample.

## TABLE 3

*Correlation Coefficients*

| | *TEMIT* | *EMIT* | *MKT* | *ASSET* | *LIAB* | *OPINC* | *SALE* | *SIZE* | *BM* | *LEV* | *CNCRN* | *STRNG* | *II* | *FRNSALE* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *TEMIT* | | **0.538** | **0.234** | 0.020 | 0.000 | **0.270** | **0.363** | **0.187** | *-0.082* | -0.017 | **0.482** | 0.037 | **-0.195** | -0.042 |
| *EMIT* | **0.848** | | **-0.114** | *-0.078* | *-0.075* | *-0.086* | *-0.100* | 0.014 | 0.027 | **0.116** | **0.378** | *-0.086* | **-0.141** | **-0.285** |
| *MKT* | **0.261** | **-0.108** | | **0.404** | **0.353** | **0.708** | **0.711** | **0.507** | 0.004 | *-0.050* | **0.221** | **0.188** | **-0.291** | **0.173** |
| *ASSET* | **0.370** | -0.061 | **0.635** | | **0.997** | **0.610** | **0.407** | **0.628** | **-0.110** | **0.226** | -0.023 | -0.016 | **-0.181** | *-0.061* |
| *LIAB* | **0.393** | -0.023 | **0.535** | **0.966** | | **0.582** | **0.369** | **0.608** | **-0.132** | **0.240** | -0.041 | -0.026 | **-0.172** | **-0.067** |
| *OPINC* | **0.332** | -0.050 | **0.815** | **0.736** | **0.680** | | **0.642** | **0.541** | 0.024 | **0.097** | **0.181** | **0.085** | **-0.213** | 0.035 |
| *SALE* | **0.395** | *-0.101* | **0.643** | **0.726** | **0.702** | **0.744** | | **0.517** | -0.037 | **0.073** | **0.323** | **0.187** | **-0.240** | *0.059* |
| *SIZE* | **0.370** | -0.061 | **0.635** | 1.000 | **0.966** | **0.736** | **0.726** | | **-0.069** | **0.266** | **0.205** | **0.116** | **-0.345** | **-0.150** |
| *BM* | *0.075* | 0.036 | **-0.266** | **0.312** | **0.272** | -0.033 | **0.085** | **0.312** | | *-0.043* | -0.011 | *-0.043* | **0.127** | 0.004 |
| *LEV* | **0.244** | **0.225** | **-0.094** | **0.295** | **0.454** | **0.100** | **0.118** | **0.295** | *0.050* | | **0.071** | 0.008 | -0.044 | **-0.180** |
| *CNCRN* | **0.686** | **0.591** | **0.170** | **0.225** | **0.232** | **0.256** | **0.324** | **0.225** | *0.046* | **0.106** | | **0.375** | **-0.185** | **0.098** |
| *STRNG* | **0.240** | **0.164** | **0.179** | **0.127** | **0.114** | **0.179** | **0.281** | **0.127** | **-0.092** | -0.013 | **0.396** | | **-0.110** | **0.362** |
| *II* | **-0.279** | *-0.093* | **-0.338** | **-0.374** | **-0.362** | **-0.340** | **-0.269** | **-0.374** | 0.007 | **-0.073** | **-0.211** | **-0.124** | | 0.022 |
| *FRNSALE* | **-0.159** | **-0.133** | **0.118** | **-0.163** | **-0.211** | 0.002 | 0.015 | **-0.163** | **-0.270** | **-0.238** | **0.125** | **0.365** | 0.036 | |

Spearman (Pearson) correlation coefficients are below (above) the diagonal.
Coefficients in boldface are significant at $p < 0.01$ or better.
Coefficients in italics are significant at $p < 0.10$.
Coefficients in grey are not significant ($p > 0.10$).
For variable definitions see Table 2.

## TABLE 4

*Firm's Choice to Disclose Carbon Emissions*

**Panel A: Without Industry Fixed Effects**

Firms evaluate the relative costs and benefits of disclosing the carbon emissions information to the CDP. Because the evaluations of the costs and benefits are not directly observable, we use the observable outcome of these evaluations, denoted *EM_DUM*, which is coded as 1 if the firm publicly discloses carbon emissions and 0 otherwise. We use the logit model below to model the disclosure decision as a function of firm-specific characteristics, as well as industry-wide characteristics. The standard errors are Huber-White robust standard errors and clustered on Permno.

$$EM\_DUM_t = \beta_1 STRNG_t + \beta_2 CNCRN_t + \beta_3 PROPDISCL_t + \beta_4 BM_t + \beta_5 LEV_t + \beta_6 II_t + \beta_7 FRNSALE_t + \beta_8 SIZE_t + \beta_9 EPA_t + \beta_{10} LITI_t + \beta_{11} EM\_DUM_{t-1} + \varepsilon_t$$

| | | (1) | | | | (2) | | | |
|---|---|---|---|---|---|---|---|---|---|
| $EM\_DUM_t$ | Pred | Coeff | | Odds Ratio | *t*-stat | Coeff | | Odds Ratio | *t*-stat |
| $STRNG_t$ | + | 0.484 | *** | 1.622 | 3.430 | 0.285 | ** | 1.330 | 2.167 |
| $CNCRN_t$ | + | 0.022 | | 1.022 | 0.157 | -0.032 | | 0.968 | -0.232 |
| $PROPDISCL_t$ | + | 0.058 | *** | 1.060 | 10.773 | 0.048 | *** | 1.049 | 9.597 |
| $BM_t$ | ? | -0.516 | ** | 0.597 | -2.115 | -0.934 | *** | 0.393 | -4.001 |
| $LEV_t$ | + | -0.569 | | 0.566 | -1.382 | -0.785 | ** | 0.456 | -2.239 |
| $II_t$ | ? | 0.002 | | 1.002 | 0.223 | 0.001 | | 1.001 | 0.132 |
| $FRNSALE_t$ | + | 0.017 | *** | 1.017 | 3.889 | 0.014 | *** | 1.014 | 3.707 |
| $SIZE_t$ | + | 0.584 | *** | 1.793 | 7.006 | 0.537 | *** | 1.710 | 7.218 |
| $EPA_t$ | + | -0.010 | | 0.990 | -0.042 | -0.008 | | 0.992 | -0.04 |
| $LITI_t$ | ? | 0.099 | | 1.104 | 0.366 | 0.114 | | 1.120 | 0.497 |
| $EM\_DUM_{t-1}$ | + | | | | | 2.614 | *** | 13.658 | 11.386 |
| *INTERCEPT* | | -8.702 | *** | 0.000 | -7.535 | -7.905 | *** | | -7.879 |
| Observations | | 1,366 | | | | 1,366 | | | |
| R-squared | | 0.304 | | | | 0.411 | | | |

***, **, and * denote significance at $p < 0.01$, $< 0.05$, and $< 0.10$, respectively, one-tailed where a directional prediction is made. Otherwise, *p*-values are two-tailed. Other variables are as defined in Table 2.

## TABLE 4—*continued*

**Panel B: Firm's Carbon Emission Disclosure Decision, Including Industry Fixed Effects**

Firms evaluate the relative costs and benefits of disclosing the carbon emissions information to the CDP. Because the evaluations of the costs and benefits are not directly observable, we use the observable outcome of these evaluations, denoted *EM_DUM*, which is coded as 1 if the firm publicly discloses carbon emissions and 0 otherwise. We use the logit model below to model the disclosure decision as a function of firm-specific characteristics, as well as industry-wide characteristics. The standard errors are Huber-White robust standard errors and clustered on Permno.

$$EM\_DUM_t = \beta_1 STRNG_t + \beta_2 CNCRN_t + \beta_3 PROPDISCL_t + \beta_4 BM_t + \beta_5 LEV_t + \beta_6 II_t + \beta_7 FRNSALE_t + \beta_8 SIZE_t + \beta_9 EPA_t + \beta_{10} LITI_t + \beta_{11} EM\_DUM_{t-1} + \varepsilon_t$$

| | | (1) | | | | (2) | | | |
|---|---|---|---|---|---|---|---|---|---|
| $EM\_DUM_t$ | Pred | Coeff | | Odds Ratio | *t*-stat | Coeff | | Odds Ratio | *t*-stat |
| $STRNG_t$ | + | 0.499 | *** | 1.646 | 3.973 | 0.281 | ** | 1.324 | 2.129 |
| $CNCRN_t$ | + | 0.004 | | 1.004 | 0.036 | -0.057 | | 0.945 | -0.436 |
| $PROPDISCL_t$ | + | 0.059 | *** | 1.061 | 7.097 | 0.041 | *** | 1.042 | 5.014 |
| $BM_t$ | ? | -0.541 | ** | 0.582 | -2.443 | -0.966 | *** | 0.381 | -3.711 |
| $LEV_t$ | + | -0.365 | | 0.694 | -1.015 | -0.677 | * | 0.508 | -1.673 |
| $II_t$ | ? | 0.001 | | 1.001 | 0.121 | 0 | | 1.000 | 0.058 |
| $FRNSALE_t$ | + | 0.021 | *** | 1.021 | 4.890 | 0.016 | *** | 1.017 | 3.562 |
| $SIZE_t$ | + | 0.701 | *** | 2.016 | 8.596 | 0.634 | *** | 1.884 | 7.081 |
| $EPA_t$ | + | 0.759 | ** | 2.135 | 2.006 | 0.606 | | 1.833 | 1.469 |
| $LITI_t$ | ? | -0.011 | | 0.989 | -0.037 | 0.104 | | 1.110 | 0.316 |
| $EM\_DUM_{t-1}$ | + | | | | | 2.495 | *** | 12.120 | 11.629 |
| Observations | | 1,237 | | | | 1,237 | | | |

***, **, and * denote significance at $p < 0.01$, $< 0.05$, and $< 0.10$, respectively, one-tailed where a directional prediction is made. Otherwise, *p*-values are two-tailed. Other variables are as defined in Table 2.

**TABLE 5**

*Firm-Value Effects of Carbon Emissions*

**Panel A: Baseline Regression Results, Without Industry Fixed Effects**

We estimate the regression model below to examine the firm-value effect of carbon emissions, controlling for other factors that are associated with firm value. We estimate the model on the full sample and separately for *EPA* = 1 and *EPA* = 0 firms. We run Heckman's (1979) model to control for selection bias using the Full Information Maximum Likelihood (FIML) method.

$$MKT_t = \beta_1 TEMIT_t + \beta_2 ASSET_t + \beta_3 LIAB_t + \beta_4 OPINC_t + \varepsilon_t$$

Selection Model:

$$EM\_DUM_t = \beta_1 STRNG_t + \beta_2 CNCRN_t + \beta_3 PROPDISCL_t + \beta_4 BM_t + \beta_5 LEV_t + \beta_6 II_t + \beta_7 FRNSALE_t + \beta_8 SIZE_t + \beta_9 EPA_t + \beta_{10} EM\_DUM_{t-1} + \varepsilon_t$$

| $MKT_t$ | | Full Sample | | | EPA = 1 | | | EPA = 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pred | Coeff | | z-stat | Coeff | | z-stat | Coeff | | z-stat |
| $TEMIT_t$ | - | -0.269 | *** | -8.07 | -0.263 | *** | -7.96 | -0.158 | * | -1.38 |
| $ASSET_t$ | + | 0.674 | *** | 9.09 | 1.602 | *** | 8.17 | 0.655 | *** | 8.08 |
| $LIAB_t$ | - | -0.711 | *** | -9.87 | -1.609 | *** | -8.05 | -0.720 | *** | -9.03 |
| $OPINC_t$ | + | 5.465 | *** | 21.03 | 1.745 | *** | 2.71 | 6.547 | *** | 21.62 |
| *INTERCEPT* | | 13,447.35 | *** | 8.53 | 18,414.30 | *** | 10.40 | 7,537.30 | *** | 3.66 |
| *Selection Model* | | $EM\_DUM_t$ | | | | | | | | |
| $STRNG_t$ | + | 0.153 | *** | 2.32 | 0.216 | *** | 2.28 | 0.114 | | 1.24 |
| $CNCRN_t$ | + | 0.023 | | 0.34 | 0.147 | ** | 2.07 | -0.262 | ** | -1.79 |
| $PROPDISCL_t$ | + | 0.027 | *** | 10.91 | 0.023 | *** | 5.40 | 0.027 | *** | 9.15 |
| $BM_t$ | ? | -0.657 | *** | -4.79 | -1.353 | *** | -5.14 | -0.530 | *** | -3.38 |
| $LEV_t$ | + | -0.613 | *** | -3.29 | -0.575 | * | -1.72 | -0.457 | ** | -2.06 |
| $II_t$ | ? | -0.001 | | -0.27 | -0.012 | ** | -2.02 | 0.001 | | 0.29 |
| $FRNSALE_t$ | + | 0.009 | *** | 4.49 | 0.007 | ** | 2.08 | 0.008 | *** | 3.20 |
| $SIZE_t$ | + | 0.340 | *** | 8.28 | 0.647 | *** | 7.84 | 0.273 | *** | 5.88 |
| $EPA_t$ | + | -0.002 | | -0.02 | | | | | | |
| $EM\_DUM_{t-1}$ | + | 1.351 | *** | 11.03 | 0.644 | *** | 3.54 | 1.642 | *** | 10.82 |
| *INTERCEPT* | | -4.597 | *** | -8.34 | -5.973 | *** | -5.91 | -4.257 | *** | -6.56 |
| LR Test of Independence (χ-sq) | | | | 14.7 | | | 39.08 | | | 1.6 |
| N | | 1,366 | | | 401 | | | 965 | | |
| Uncensored | | 550 | | | 229 | | | 321 | | |
| Wald Chi-square | | 2,350 | | | 1,035 | | | 1,563 | | |

***, **, and * denote significance at $p < 0.01$, $< 0.05$, and $< 0.10$, respectively, one-tailed where a directional prediction is made. Otherwise, *p*-values are two-tailed. $EM\_DUM_t$ is an indicator variable equal to one if the firm publicly discloses carbon emissions, and 0 otherwise. Other variables are as defined in Table 2.

**TABLE 5**—*continued*

**Panel B. Firm-Value Effects of Carbon Emissions Including Industry Fixed Effects**

We estimate the regression model below to examine the firm-value effect of carbon emissions, controlling for other factors that are associated with firm value. We estimate the model on the full sample and separately for *EPA* = 1) and *EPA* = 0 carbon-emitting firms. We run Heckman's (1979) model to control for selection bias using the Full Information Maximum Likelihood (FIML) method. We include industry fixed effects at the 2-digit SIC code level in both our selection and valuation models.

$$MKT_t = \beta_1 TEMIT_t + \beta_2 ASSET_t + \beta_3 LIAB_t + \beta_4 OPINC_t + \varepsilon_t$$

Selection Model:

$$EM\_DUM_t = \beta_1 STRNG_t + \beta_2 CNCRN_t + \beta_3 PROPDISCL_t + \beta_4 BM_t + \beta_5 LEV_t + \beta_6 II_t + \beta_7 FRNSALE_t + \beta_8 SIZE_t + \beta_9 EPA_t + \beta_{10} EM\_DUM_{t-1} + \varepsilon_t$$

| $MKT_t$ | | Full Sample | | | *EPA* = 1 | | | *EPA* = 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pred | Coeff | | *z*-stat | Coeff | | *z*-stat | Coeff | | *z*-stat |
| $TEMIT_t$ | - | -0.202 | *** | -5.04 | -0.185 | *** | -4.91 | -0.184 | ** | -1.65 |
| $ASSET_t$ | + | 0.879 | *** | 11.92 | 1.507 | *** | 8.41 | 0.932 | *** | 10.91 |
| $LIAB_t$ | - | -0.903 | *** | -12.63 | -1.549 | *** | -8.32 | -0.973 | *** | -11.57 |
| $OPINC_t$ | + | 5.602 | *** | 21.97 | 2.619 | *** | 4.23 | 6.341 | *** | 21.33 |
| *Selection Model* | $EM\_DUM_t$ | | | | | | | | | |
| $STRNG_t$ | + | 0.148 | ** | 2.07 | 0.219 | ** | 2.15 | 0.113 | | 1.13 |
| $CNCRN_t$ | + | -0.017 | | -0.23 | 0.101 | | 1.28 | -0.303 | ** | -1.87 |
| $PROPDISCL_t$ | + | 0.025 | *** | 5.02 | 0.015 | ** | 1.69 | 0.029 | *** | 5.05 |
| $BM_t$ | ? | -0.658 | *** | -4.30 | -1.395 | *** | -4.78 | -0.505 | *** | -2.91 |
| $LEV_t$ | + | -0.540 | ** | -2.36 | -0.758 | ** | -1.97 | -0.385 | | -1.40 |
| $II_t$ | ? | 0.000 | | -0.13 | -0.006 | | -0.95 | 0.001 | | 0.18 |
| $FRNSALE_t$ | + | 0.010 | *** | 3.71 | 0.005 | | 1.18 | 0.008 | ** | 2.43 |
| $SIZE_t$ | + | 0.410 | *** | 7.33 | 0.744 | *** | 7.66 | 0.330 | *** | 5.51 |
| $EPA_t$ | + | 0.308 | | 1.28 | | | | | | |
| $EM\_DUM_{t-1}$ | + | 1.391 | *** | 10.52 | 0.651 | *** | 3.33 | 1.667 | *** | 10.67 |
| LR Test of Independence (χ-sq) | | | | 3.38 | | | 26.67 | | | 0.05 |
| N | | 1,365 | | | 401 | | | 964 | | |
| Uncensored | | 550 | | | 229 | | | 321 | | |
| Wald Chi-square | | 3,168 | | | 1,453 | | | 1,990 | | |

For parsimony, coefficients on industry dummies are not reported.

***, **, and * denote significance at $p < 0.01$, $< 0.05$, and $< 0.10$, respectively, one-tailed where a directional prediction is made. Otherwise, *p*-values are two-tailed. $EM\_DUM_t$ is an indicator variable equal to one if the firm publicly discloses carbon emissions, and 0 otherwise. For variable definitions see Table 2.

**TABLE 6**

*Firm-Value Effects of Carbon Emissions*

*Dependent and Independent Variables Scaled by Sales*

We estimate the regression model below to examine the firm-value effect of carbon emissions, controlling for other factors that are associated with firm value. We estimate the model on the full sample and separately for high (*EPA* = 1) and low (*EPA* = 0) carbon-emitting firms. We run the analyses scaling the dependent and independent variables by sales. In our original analyses we use assets and liabilities to control for firm size. However, the correlation between assets and sales in our sample is 0.71 ($p < 0.01$); therefore, following Campbell, Sefcik, and Soderstrom (2003), we substitute book value of equity for assets and liabilities. We include industry fixed effects at the 2-digit SIC code level in our analyses. We run Heckman's (1979) model to correct for self-selection using the Full Information Maximum Likelihood (FIML) method.

$$MKT_t = \beta_1 EMIT_t + \beta_2 BVE_t + \beta_3 OPINC_t + \varepsilon_t$$

Selection Model:

$$EM\_DUM_t = \beta_1 STRNG_t + \beta_2 CNCRN_t + \beta_3 PROPDISCL_t + \beta_4 BM_t + \beta_5 LEV_t + \beta_6 II_t + \beta_7 FRNSALE_t + \beta_8 SIZE_t + \beta_9 EPA_t + \beta_{10} EM\_DUM_{t-1} + \varepsilon_t$$

| $MKT_t$ | | Full Sample | | | $EPA = 1$ | | | $EPA = 0$ | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pred | Coeff | | $z$-stat | Coeff | | $z$-stat | Coeff | | $z$-stat |
| $EMIT_t$ | - | -0.063 | *** | -2.26 | -0.050 | ** | -1.88 | -0.120 | | -1.06 |
| $BVE_t$ | + | 1.389 | *** | 13.04 | 1.366 | *** | 7.16 | 1.530 | *** | 12.02 |
| $OPINC_t$ | - | 6.686 | *** | 15.26 | 5.543 | *** | 7.74 | 7.931 | *** | 14.23 |
| *Selection Model* | $EM\_DUM_t$ | | | | | | | | | |
| $STRNG_t$ | + | 0.146 | ** | 2.01 | 0.237 | ** | 2.12 | 0.122 | | 1.24 |
| $CNCRN_t$ | + | -0.017 | | -0.24 | 0.044 | | 0.56 | -0.288 | * | -1.79 |
| $PROPDISCL_t$ | + | 0.026 | *** | 5.34 | 0.016 | ** | 1.82 | 0.029 | *** | 5.15 |
| $BM_t$ | ? | -0.450 | *** | -2.80 | -0.113 | | -0.33 | -0.414 | ** | -2.35 |
| $LEV_t$ | + | -0.448 | ** | -1.96 | -0.348 | | -0.88 | -0.392 | * | -1.43 |
| $II_t$ | ? | 0.000 | | 0.06 | -0.003 | | -0.43 | 0.001 | | 0.27 |
| $FRNSALE_t$ | + | 0.009 | *** | 3.28 | 0.006 | * | 1.48 | 0.008 | *** | 2.36 |
| $SIZE_t$ | + | 0.371 | *** | 7.25 | 0.426 | *** | 3.90 | 0.333 | *** | 5.65 |
| $EPA_t$ | + | 0.380 | * | 1.56 | | | | | | |
| $EM\_DUM_{t-1}$ | + | 1.466 | *** | 12.34 | 0.817 | *** | 3.60 | 1.659 | *** | 10.70 |
| LR Test of Independence ($\chi$-sq) | | | | 4.08 | | | 4.25 | | | 3.47 |
| N | | 1,365 | | | 401 | | | 964 | | |
| Uncensored | | 550 | | | 229 | | | 321 | | |
| Wald Chi-square | | 1,015 | | | 370 | | | 717 | | |

**, **, and * denote significance at $p < 0.01$, $< 0.05$, and $< 0.10$, respectively, one-tailed where a directional prediction is made. Otherwise, $p$-values are two-tailed. For variable definitions see Table 2.

**TABLE 7**

*Firm-Value Effects of Carbon Emissions—December Fiscal Year-End Firms Only*

We estimate the regression model below to examine the firm-value effect of carbon emissions, controlling for other factors that are associated with firm value. We estimate the model on the full sample and separately for high (*EPA* = 1) and low (*EPA* = 0) carbon-emitting firms. We run Heckman's (1979) model to control for selection bias using the Full Information Maximum Likelihood (FIML) method. We include industry fixed effects at the 2-digit SIC code level in both equations for the full sample and EPA = 0 firms. However, we exclude industry fixed effects for EPA = 1 firms. Consequently, we estimate the model not including industry fixed effects for them.

$$MKT_t = \beta_1 TEMIT_t + \beta_2 ASSET_t + \beta_3 LIAB_t + \beta_4 OPINC_t + \varepsilon_t$$

Selection Model:

$$EM\_DUM_t = \beta_1 STRNG_t + \beta_2 CNCRN_t + \beta_3 PROPDISCL_t + \beta_4 BM_t + \beta_5 LEV_t + \beta_6 II_t + \beta_7 FRNSALE_t + \beta_8 SIZE_t + \beta_9 EPA_t + \beta_{10} EM\_DUM_{t-1} + \varepsilon_t$$

| $MKT_t$ | | Full Sample | | | *EPA* = 1 | | | *EPA* = 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pred | Coeff | | *z*-stat | Coeff | | *z*-stat | Coeff | | *z*-stat |
| $TEMIT_t$ | - | -0.143 | *** | -3.99 | -0.218 | *** | -6.51 | -0.197 | ** | -1.87 |
| $ASSET_t$ | + | 0.660 | *** | 9.38 | 0.961 | *** | 4.30 | 0.703 | *** | 8.17 |
| $LIAB_t$ | - | -0.676 | *** | -9.86 | -1.011 | *** | -4.56 | -0.724 | *** | -8.46 |
| $OPINC_t$ | + | 5.072 | *** | 21.26 | 3.421 | *** | 4.84 | 5.476 | *** | 17.21 |
| *INTERCEPT* | | | | | 19,578.26 | *** | 10.57 | | | |
| *Selection Model* | | $EM\_DUM_t$ | | | | | | | | |
| $STRNG_t$ | + | 0.200 | *** | 2.71 | 0.302 | *** | 2.91 | 0.216 | ** | 1.79 |
| $CNCRN_t$ | + | 0.043 | | 0.61 | 0.212 | *** | 2.90 | -0.345 | ** | -1.80 |
| $PROPDISCL_t$ | + | 0.023 | *** | 3.84 | 0.025 | *** | 5.44 | 0.030 | *** | 3.53 |
| $BM_t$ | ? | -0.792 | *** | -5.08 | -1.280 | *** | -4.73 | -0.703 | *** | -3.43 |
| $LEV_t$ | + | -0.665 | ** | -2.42 | -0.662 | * | -1.66 | -0.426 | | -1.19 |
| $II_t$ | ? | 0.004 | | 1.03 | -0.007 | | -1.19 | 0.009 | * | 1.67 |
| $FRNSALE_t$ | + | 0.013 | *** | 4.34 | 0.004 | | 1.15 | 0.016 | *** | 3.63 |
| $SIZE_t$ | + | 0.545 | *** | 9.16 | 0.632 | *** | 7.08 | 0.464 | *** | 5.71 |
| $EPA_t$ | + | -0.028 | | -0.11 | | | | | | |
| $EM\_DUM_{t-1}$ | + | 0.920 | *** | 5.93 | 0.537 | *** | 2.86 | 1.306 | *** | 4.82 |
| *INTERCEPT* | | | | | -6.24 | | -5.59 | | | |
| LR Test of Independence (χ-sq) | | | | 23.47 | | | 41.09 | | | 3.45 |
| N | | 1,003 | | | 357 | | | 646 | | |
| Uncensored | | 416 | | | 207 | | | 209 | | |
| Wald Chi-square | | 2,439 | | | 833 | | | 1,325 | | |

***, **, and * denote significance at $p < 0.01$, $< 0.05$, and $< 0.10$, respectively, one-tailed where a directional prediction is made. Otherwise, *p*-values are two-tailed. $EM\_DUM_t$ is an indicator variable equal to one if the firm publicly discloses carbon emissions, and 0 otherwise. For variable definitions see Table 2.

## TABLE 8

*Firm-Value Effects of Carbon Emissions—Changes Specification*

We estimate the following regression model to examine the changes in firm-value as a function of changes in carbon emission levels, controlling for other factors that are associated with firm value. We estimate the model on the full sample and separately for high (*EPA* = 1) and low (*EPA* = 0) carbon-emitting firms. We include industry fixed effects at the 2-digit SIC code level in our regression model. We report Huber-White standard errors.

$$\Delta MKT_t = \beta_1 \Delta TEMIT_t + \beta_2 \Delta ASSET_t + \beta_3 \Delta LIAB_t + \beta_4 \Delta OPINC_t + \varepsilon_t$$

| | | Full Sample | | | EPA = 1 | | | EPA = 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *ΔMKT* | Pred | Coeff. | | *t*-stat | Coeff. | | *t*-stat | Coeff. | | *t*-stat |
| *ΔTEMIT* | - | -0.018 | ** | -2.12 | -0.023 | * | -1.52 | -0.010 | | -1.25 |
| *ΔAT* | + | 1.012 | *** | 5.08 | 1.455 | *** | 3.71 | 1.013 | *** | 5.99 |
| *ΔLT* | - | -0.102 | | -0.97 | -0.818 | *** | -3.73 | -0.009 | | -0.13 |
| *ΔOPINC* | + | 0.063 | ** | 1.86 | -0.004 | | -0.09 | 0.139 | *** | 2.25 |
| Industry Fixed Effects | | Yes | | | Yes | | | Yes | | |
| Obs | | 317 | | | 137 | | | 180 | | |
| R-squared | | 0.36 | | | 0.24 | | | 0.47 | | |

***, **, and * denote significance at $p < 0.01$, $< 0.05$, and $< 0.10$, respectively, one-tailed where a directional prediction is made. Otherwise, $p$-values are two-tailed.

Where:

$\Delta MKT_t = (MKT_t - MKT_{t-1})/MKT_{t-1}$
$\Delta TEMIT_t = (TEMIT_t - TEMIT_{t-1})/TEMIT_{t-1}$
$\Delta AT_t = (AT_t - AT_{t-1})/AT_{t-1}$
$\Delta LT_t = (LT_t - LT_{t-1})/LT_{t-1}$
$\Delta OPINC_t = (OPINC_t - OPINC_{t-1})/OPINC_{t-1}$