



Carbon footprint stomps on firm value

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Foreword

KPMG's Global Valuation Institute (GVI) is pleased to introduce its third management paper since the launch of our research agenda, authored by Ella Mae Matsumura from the University of Wisconsin-Madison, Rachna Prakash from Georgetown University, and Sandra C. Vera-Muñoz from the University of Notre Dame.

As an independent think tank, we recognize that valuation is a constantly evolving discipline that has been shaped by practical and theoretical advances. Many high quality research papers on valuation subjects never find their way to influencing the evolution of standards and practice due to a lack of exposure to practitioners.

Our goal is to act as a catalyst for the adoption of breakthrough valuation research. To this end, KPMG's GVI benefits from the expertise of an Academic Advisory Board comprised of professors from Beijing University in China, Northwestern University in the US and Oxford University in the UK. This Board designs a research agenda and selects and reviews the research we sponsor.

We work closely with researchers to present their managerial papers in a format that is understandable to a broad range of business professionals. This includes illustrative papers with applications and/or case studies. Through this process, we keep KPMG's global network of 1,200 valuation professionals informed of emerging valuation issues.

The debate on carbon emissions reduction has crystallized among all society stakeholders for a while now but few have tried to quantify its financial impact on businesses. This is precisely what Matsumura et al have accomplished in their study.

The authors use carbon emission data reported voluntarily to the Carbon Disclosure Project (CDP) by companies on the Standards & Poor's (S&P) 500 Index. Their premise is that voluntary disclosure of carbon emissions by companies is primarily driven by the perceived benefits doing so outweighing the perceived costs.

This paper explores the firm value effect of carbon disclosures across carbon emission disclosing and non disclosing firms. They match both groups of firms on a host of environment and financial characteristics, both at the firm and industry levels, and test for differences in firm values.

The authors found that firm value decreases on average by US\$212,000 for every thousand metric tons of carbon emissions produced by the firms. The median value of disclosing firms from the S&P500 sample is also about US\$ 2.3 billion higher than the market value of non disclosing firms.

This paper is the third in a series that will be sponsored by KPMG's Global Valuation Institute. As practitioners, we trust that you will find these of interest.



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Abstract

A large carbon footprint has a negative impact on firm value, according to Matsumura, Prakash, and Vera-Muñoz (2012). The study, which uses carbon emissions data reported over a 3 year period to the Carbon Disclosure Project (CDP) by companies on the Standard & Poor's 500 Index, finds that firm value decreases, on average, by US\$212,000 for every additional thousand metric tons of carbon emissions produced by the firms. This result translates to a firm-value penalty of US\$1.4 billion for firms in the third quartile (in terms of carbon emissions) relative to firms in the first quartile. The study also examines the firm-value effects of voluntarily disclosing carbon emissions to the CDP. The study finds that the median firm value of firms that disclose their carbon emissions is about US\$2.3 billion higher than the median value of non disclosing firms. These results are consistent with the argument that the capital markets integrate both carbon emissions and the act of voluntary disclosure of this information in their firm valuations. While both disclosing and non disclosing firms are penalized for their carbon emissions, non disclosures face a further penalty for non disclosure.

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1.

Introduction

A large carbon footprint has a negative impact on firm value according to Matsumura, Prakash, and Vera-Muñoz (2012).¹ Our study, which uses 2006–2008 carbon emissions data reported voluntarily to the Carbon Disclosure Project (CDP) by companies on the Standard & Poor's (S&P) 500 Index, finds that a company's value decreases, on average, by US\$212,000 for every additional thousand metric tons of carbon emissions. The estimated total economic effect of carbon emissions on firm value is large, but how large? To provide some perspective on this number, there is a firm-value penalty of US\$1.4 billion for firms in the third quartile (in terms of carbon emissions) relative to firms in the first quartile.² Remarkably, these results hold even though in the U.S. there is currently no explicit cost to firms for emitting carbon emissions and most of the carbon emission disclosures are voluntary and not verified by third parties.

The CDP S&P 500 Report (2011) reveals an increasing trend in the number of responding firms that are voluntarily disclosing their carbon emissions to the CDP: 262 (52 percent) in 2009, 294 (59 percent) in 2010 and 306 (61 percent) in 2011.

Given our finding that the capital markets penalize the firms for their carbon emissions, then why do firms choose to disclose this information?

We argue that managers weigh the costs and benefits of disclosing carbon emissions and choose to disclose only if the perceived benefits of doing so outweigh the perceived costs. Therefore, we also examine the firm-value effects of the act of voluntarily disclosing carbon emissions. Our

results show that the median market value of firms that disclose their carbon emissions is about \$2.3 billion higher than the median market value of firms that do not disclose their emissions. These results, combined with our main result of a negative association between carbon emissions and firm value, are consistent with the argument that the capital markets integrate both carbon emissions and the act of voluntary disclosure of this information into their firm valuations. While all firms are penalized for their carbon emissions regardless of whether or not they disclose this information, firms that do not disclose their carbon emissions face a further penalty for non disclosure.

Our study is the first to provide evidence of the price that U.S. capital markets are imputing to carbon emissions. Although federal regulation has yet to be adopted, our results suggest that the capital markets are already anticipating the effects of the costs of carbon emissions on firm value. According to the IRRCI/Trucost Report (2009), applying its suggested market price of US\$28.24 to each ton of carbon emissions by the S&P 500 firms would lead to over US\$92.8 billion in costs.³

Who should care about the link between the value of a firm and its carbon footprint, and why is this important? To answer this question, it is essential to keep in mind that the U.S. Environmental Protection Agency (EPA) and myriad scientists have concluded that the more carbon emissions (of which carbon dioxide is the major greenhouse gas) there are in the atmosphere, the more heat is trapped. This leads to rising temperatures and thus, climate change.⁴ Importantly,

as temperatures rise, so does the subject of global climate change risk in corporate agendas. To this point, Mr. Timothy P. Flynn, Former Chairman of KPMG International,⁵ asserts:

"Climate change no longer needs an introduction. It is now widely regarded as one of the most serious challenges the world faces, with consequences that go far beyond its effects on the environment. Businesses are also increasingly confronted with the implications of climate change. We observe among clients around the world that the subject is steadily moving up their agendas. They recognize that climate change poses both risks and opportunities, with strategic and financial implications for their businesses."

Some informed observers expect that concerns about the link between carbon emissions and global climate change will drive a redistribution of value from firms that do not control carbon emissions successfully to firms that do (GS Sustain 2009). The Goldman Sachs' GS Sustain report goes on to assert that, "the 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). It makes sense, then, that sell-side analysts are integrating the financial implications of carbon emissions into their investment recommendations (Eccles et al. 2011).

Further, in response to investors' concern about the link between carbon emissions and global climate change risk, in January 2010 the Securities and Exchange Commission (SEC) provided new explicit guidance on disclosures

¹ The report that follows draws on a more technical paper, "Firm-value effects of carbon emissions and carbon disclosures," available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1921809

² Another way to view the US\$212 per metric ton is to see it as the net present value of, for example, US\$15.70 (US\$10.10) per metric ton discounted in perpetuity at an interest rate of 8 (5) percent.

³ Anant Sundaram, an authority in business and climate change, notes, "With an average price of US\$20 per ton of carbon dioxide – which is consistent with European Union prices [for carbon allowances] over the past two years – the S&P 500 companies, should they start paying full value for their carbon emissions, will have to write a collective check for US\$60 billion to US\$80 billion each year" (Serchuk 2009).

⁴ Source: <http://www.epa.gov/climatechange/basics/>

⁵ Foreword, "Climate Changes Your Business" (KPMG International 2008), available at: <http://www.kpmginstitutes.com/global-energy-institute/insights/2008/pdf/climate-changes-your-business.pdf>



of risks and opportunities related to climate change in regulatory filings to the SEC. In their January 2010 responses to investors' requests for guidance, SEC Commissioners Elisse B. Walter⁶ and Luis A. Aguilar⁷ asserted, respectively:

"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." (Elisse B. Walter).

"It is no surprise that regulation of greenhouse gases has the attention of state governments, Capitol Hill, and the Environmental Protection

Agency, 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." (Luis A. Aguilar).

U.S. firms face ever increasing pressure from their stakeholders (e.g., investors, financial risk managers, insurance companies, carbon traders, NGOs) to measure, disclose, monitor, and manage their carbon emissions. The ultimate goal of these actions is to reduce the overall level of emissions in the environment (Fornaro et al. 2009). Even firms with low emissions will bear the costs of monitoring and reporting in order to respond to pressure to report. Other potential carbon-related costs include capital expenditures to acquire or develop less carbon-intensive technologies and processes, research and development to create

goods and services associated with a smaller carbon footprint, and other corporate initiatives such as measuring and reducing employees' carbon footprint (e.g., from using air and ground transportation).

With stakeholders expecting companies to transition to low carbon or carbon neutrality⁸ in the future (Simnett et al. 2009), firms' reputations and customers' demand for goods and services stand to suffer if firms do not make the transition. Furthermore, carbon emissions have become an essential element in analyzing a company's risk profile, potential liabilities, and financial performance. For instance, Standard & Poor's downgraded the debt of a large U.K. power generating company, Drax, owing in part to future business risks from new European emissions trading rules that are expected to increase carbon costs (Barley 2009).

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

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

8 Carbon neutrality occurs when a firm balances the amount of carbon released with carbon reductions through such activities as buying carbon offsets, sequestering carbon, or producing renewable energy.



Within the context described, it is not difficult to understand why corporate managers are facing growing shareholder pressure to evaluate and report on the risks and opportunities their companies face with respect to global climate change, including the exposure of their firms to regulatory and market pressures. To this point, Mr. Ben van der Veer, Chairman, KPMG's Europe, Middle East and Africa Region,⁹ asserts:

"Risk is still often viewed as anathema, an added burden that limits initiative and performance. However, in the face of today's increasing complexity and interdependence, I believe that ad-hoc responses to global risks such as climate change are no longer sufficient. Perhaps the biggest challenge business leaders face in this context is balancing short-term objectives with long-term risks. Risks to long-term profitability are often overlooked when organizations are only focused on the delivery of short-term performance targets."

A firm's enhanced reputation for environmental responsibility (for example, by investing in renewable energy alternatives that reduce its carbon footprint) can bring economic benefits from the broader stakeholder community. These benefits include, among others: increased revenue, positive perceptions of employees, customers, suppliers, and other stakeholders who identify the corporation with its environmentally friendly side (Simnett et al. 2009), a talented and committed work force (Heal 2004; Castelo Branco and Lima Rodrigues 2006) and fewer potential claimants on the firm's rents through fines or other compliance costs (Sharfman and Fernando 2008). Therefore, our findings also have important implications for managers' decisions regarding the cost-benefit tradeoffs of allocating resources to carbon emissions-reduction initiatives (Thaler and Sunstein 2009).

The most recent CDP S&P 500 2011 report reveals that 242 (71 percent) of

the 339 S&P 500 firms that responded to the CDP questionnaire identified risks, and 233 firms (69 percent) identified opportunities that have the potential to substantively impact business operations (CDP S&P 500 Report 2011, 7). As shown in Figure 1, the most prevalent risk identified by the S&P 500 firms that discussed risks is regulatory (identified by 63 percent of the respondents). This risk entails market-based regulation, such as carbon taxes, emissions-trading schemes, and fuel tariffs.

The second most prevalent risk discussed is physical (identified by 59 percent of respondents). Physical risk includes the impact of weather-related events, such as storms and floods, droughts, strong winds, heat waves and forest fires.

The third most prevalent risk identified by the S&P 500 firms is reputation (identified by 40 percent of the respondents). Reputation risk includes a decrease in consumer confidence and brand value if the firm is perceived by consumers as failing to address

⁹ Foreword, "Climate Changes Your Business" (KPMG International 2008), available at: <http://www.kpmginstitutes.com/global-energy-institute/insights/2008/pdf/climate-changes-your-business.pdf>.



climate-change risks. They may also suffer a loss of reputation among other stakeholders such as the financial sector, governments, employees, or the media. Other risks, including litigation (e.g., as a result of new state and federal carbon controls and a related focus on GHG disclosures), were identified by 21 percent of the responding firms.¹⁰

The study is also important to standard setters – both U.S. and international – as they work towards developing standards for measuring, verifying, and reporting on a firm’s greenhouse gas (GHG) statement (Simnett et al. 2009). The International Federation of Accountants (IFAC) asserts:

“Given the link between GHG emissions and climate change, many entities are quantifying their GHG emissions for internal management purposes, and many are also preparing a GHG statement: (a) as part of a regulatory disclosure regime, (b) as part of an emissions trading scheme or (c) to inform investors and others on a voluntary basis.” (IFAC 2012).

With this goal in mind, the International Auditing and Assurance Standards Board (IAASB) recently approved a standard on assurance engagements, denoted ISAE 3410, to report on an entity’s GHG statement (IAASB 2012).¹¹

Why do firms choose to disclose their carbon emissions?

The act of disclosure itself – even in the absence of mandated behavioral changes – can have beneficial consequences from the investors’ viewpoint. This argument can be illustrated in the context of the ‘environmental blacklist’ born out of the EPA’s Toxics Release Inventory (TRI) disclosure rule¹² under the Emergency Planning and Community Right to Know Act. According to Thaler and Sunstein’s (2009) concept of “social nudge,” no company likes to be on the ‘environmental blacklist’ because the ensuing bad publicity could lower the company’s stock price. Therefore, the companies that end up on the list are motivated to take steps to reduce their TRI because they want to be removed from the list. And the companies that are not yet on the list are motivated because they want to ensure that they do not end up on the list. Hence, an unintended benefit of the TRI disclosure rule was a large reduction in toxic emissions in the U.S. (Thaler and Sunstein 2009).

Although carbon disclosures are voluntary, large firms face considerable pressure to disclose their emissions.

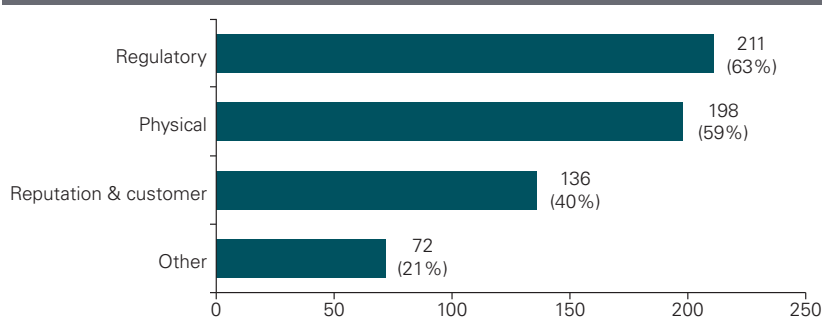
Hence, similar motivations exist for firms to reduce their carbon emissions. Moreover, a firm that discloses its carbon emissions signals its ability to measure its emissions, and measuring is a prerequisite to managing the emissions. Taken together, this discussion suggests that the market will reward the firms that disclose their carbon emissions.

At the same time, Moser and Martin (2012, 804) argue that viewing corporate social responsibility (CSR) disclosures more broadly as being motivated by both shareholders and nonshareholders, raises issues that do not fall within the traditional perspective of shareholder value maximization.

If so, then it is likely that allocation of scarce corporate resources to some CSR investments (e.g., measuring and disclosing carbon emissions) is made at the expense of shareholders. For instance, government regulators (e.g., the EPA) can use carbon emission disclosures – particularly by high carbon-emitting firms – as grounds for: investigations that potentially increase compliance and proprietary costs (Li et al. 1997); 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 regulation. This discussion suggests that the market will penalize the firms that voluntarily disclose their carbon emissions.

Because the answer to the question, “Why do firms choose to disclose their carbon emissions?” is not self-evident in the context of this study, we address the question by examining the firm-value effects of the act of voluntarily disclosing carbon emissions.

Figure 1. Types of climate risks identified by respondents (2011)



Source: CDP S&P 500 report 2011

¹⁰ For a detailed discussion of the four types of climate-change related risk, see “The business risks of climate change,” *Climate Changes Your Business* (KPMG International 2008).

¹¹ The standard was approved in March 2012 and will be effective for assurance reports covering periods ending on or after September 30, 2013. Source: <http://www.ifac.org/auditing-assurance/projects/assurance-greenhouse-gas-statement>.

¹² The EPA collects data annually from facilities that release or transfer certain toxic chemicals. The Toxics Release Program compiles the TRI data and makes them available on the EPA web site (<http://www.epa.gov/tri/triprogram/whatis.htm>).

2.

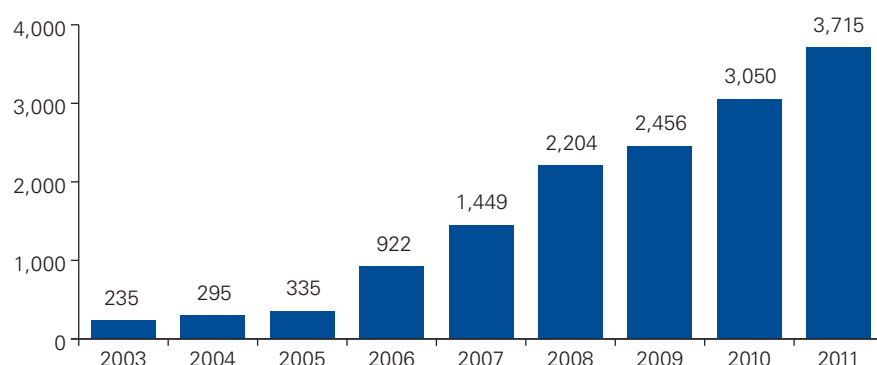
Sample and Data

Carbon disclosure project data

Our study uses carbon emissions data reported voluntarily to the CDP by companies on the S&P 500 Index. The CDP solicits information from the world's largest companies as gauged by market capitalization. Currently, the CDP represents 655 institutional investors representing over US\$78 trillion in assets under management.¹³ As shown in Figure 2, the number of global firms responding to the CDP questionnaire has increased dramatically, from 235 firms at the start of the CDP in 2003, to well over 3,000 firms in 2011. The most recent questionnaire responders included 81 percent of the Global 500 firms and 68 percent of the S&P 500 firms. PricewaterhouseCoopers LLP (the global sponsor of the CDP since 2008) oversees questionnaire response analysis and summary report preparation for the S&P 500, Global 500 and FTSE 600 companies.

The CDP questionnaire requests information on carbon emissions (measured in metric tons), energy usage, and trading of carbon emission allowances. The firms are instructed to respond to this section using the GHG Protocol Corporate Standard.¹⁴ The CDP asks the firms to report their global carbon emissions 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

Figure 2. Number of global firms responding to the CDP questionnaire



Source: CDP website: Overview

company's supply chain). A number of firms in our sample do not provide carbon emissions broken down into the three scopes.

The starting point for our sample was all the S&P 500 firms for the years 2006 to 2008. However, the list of firms included in the S&P 500 changes periodically. We chose to use the S&P 500 firms as of December 31, 2007 in order to maintain a constant sample of firms. The result is a sample size of 1,443 S&P 500 observations across the 3 years. We then gathered carbon emissions data reported to the CDP for our sample firms.

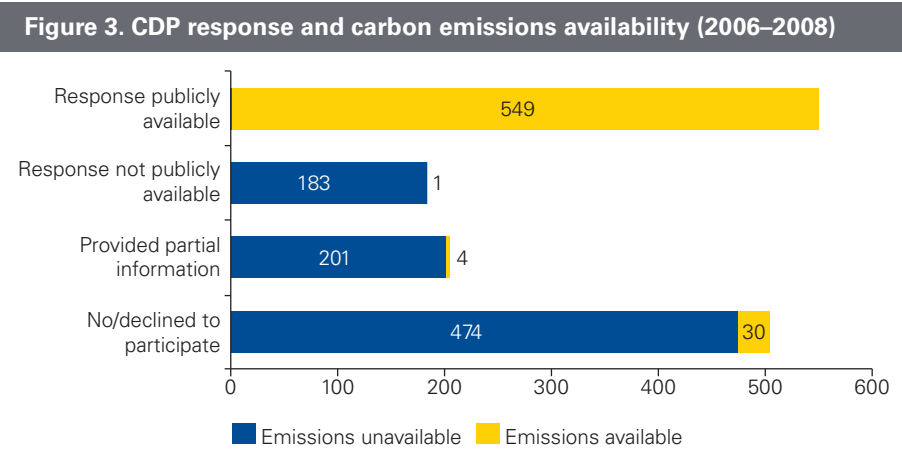
Participation in the CDP questionnaire is voluntary. Figure 3 shows the number of S&P 500 firms among our 1,443 observations that responded to the CDP questionnaire and provided carbon emissions data for 2006 to 2008. Figure 3 indicates the following:

- 550 firm-years (38 percent) responded to the CDP questionnaire and allowed the responses to be publicly available. Of these firms, one firm did not provide carbon emissions data.

- 184 firm-years (13 percent) responded to the CDP questionnaire but chose to not make their responses public (only the institutional investors who are signatories of the CDP are allowed access to these firms' responses). One firm made its carbon emissions information publicly available in a subsequent year.
- 205 firm-years (14 percent) provided only partial information to the CDP (e.g., provided links to information generally available at the firm's website, such as their CSR reports) without answering the questionnaire. Four of these firms made their carbon emissions information publicly available in a subsequent year.
- 504 firm-years (35 percent) either did not respond, or their responses indicated a decision to decline participation. However, 30 of these firms provided carbon emissions data in a subsequent year and allowed the information to be public.

¹³ See <https://www.cdproject.net/en-US/Pages/About-Us.aspx>. Institutional investors, including banks, pension funds, asset managers, and insurance companies who endorse the CDP questionnaire are known as "CDP signatories" (e.g., Goldman Sachs, California Public Employees' Retirement System, BlackRock, BNP Paribas Investment Partners, HSBC Holdings plc, Morgan Stanley, and TIAA-CREF).

¹⁴ The GHG Protocol Corporate Standard (Revised Edition) is available at: <http://www.ghgprotocol.org/standards/corporate-standard>.



In total, we have carbon emissions data for 584 firm-years, representing 256 firms. The disclosures per year increased slightly, as follows: 162 (28 percent) from 2006, 202 (35 percent) from 2007 and 220 (37 percent) from 2008.

KLD data

To examine the association between broad environmental performance and likelihood of disclosing carbon emissions, we developed two measures based on environmental performance data from a database containing annual ratings by KLD Research & Analytics, Inc. KLD rates firms’ environmental, social and governance (ESG) performance. We used KLD’s binary summary of its ratings of each firm’s environmentally proactive initiatives, and separately, each firm’s environmentally damaging actions. The proactive dimensions are largely distinct from the damaging

dimensions and consequently, provide different evaluations of a firm’s environmental performance.

KLD classifies the environmentally proactive dimensions as:

- 1. environmentally beneficial products and services
- 2. pollution prevention
- 3. recycling
- 4. clean energy
- 5. communications (e.g., publishes a substantive environmental report)
- 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)
- 7. miscellaneous (i.e., the company has been involved in an environmental controversy that is not otherwise covered by other KLD ratings).

In each case, if KLD identifies a proactive initiative or a damaging action in a particular dimension, then KLD indicates this with a “1.” If the company did not have a proactive initiative or a damaging action in that dimension, then this is indicated with a “0.” We summed the scores on proactive dimensions to create a “strengths” measure, and similarly, summed the scores on damaging dimensions to create a “concerns” measure for each firm in each of our sample years.



3.

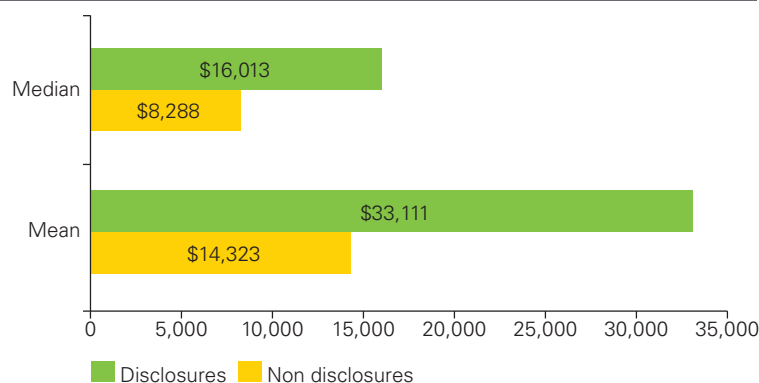
Key characteristics of disclosers versus non disclosure

Our finding that the markets impute a price to the firms' carbon emissions is somewhat surprising given that, currently, in the U.S. there is no explicit cost to the firms for emitting carbon emissions. Moreover, disclosures about carbon emissions are not mandatory. Instead, managers choose to provide this information to the CDP and the public. Finally, these disclosures are not verified by independent third parties and therefore may not be considered sufficiently reliable by the markets. Our results beg the question: If the markets penalize the firms for their carbon emissions, then why do firms disclose this information? Given the voluntary nature of carbon emission disclosures, we assume that managers trade off the costs and benefits of providing this information to the market and choose to disclose their carbon emissions only if the perceived benefits of doing so outweigh the perceived costs. To gain an appreciation of the differences between firms that disclose their emissions versus those that do not, we examine some of the key characteristics of each group separately.

As shown in Figure 4, both the mean and median market values are significantly higher for firms that disclose their carbon emissions compared to firms that do not disclose their emissions. In line with the disclosing firms' larger market value, we also find that they have significantly higher mean and median assets and liabilities (Figure 5), and are also significantly more profitable in terms of their operating income (Figure 6). The disclosing firms also have significantly higher scores, both on proactive and damaging environmental performance, relative to the non disclosing firms (Figure 7).

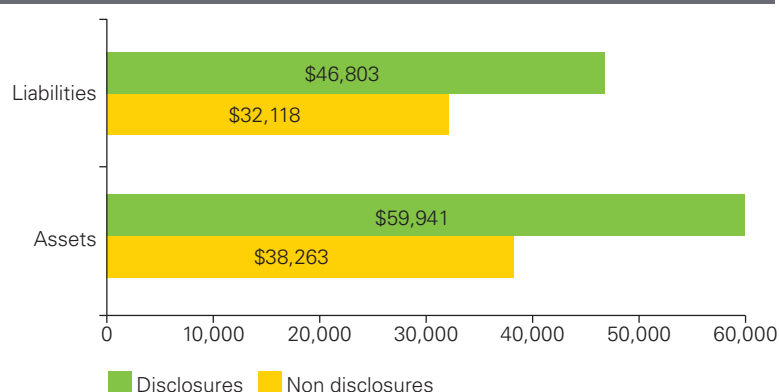
Consistent with prior research that shows that firms with higher foreign sales are more likely to disclose their carbon emissions, we also find that

Figure 4. Market value of disclosures and non disclosures (in US\$ millions)



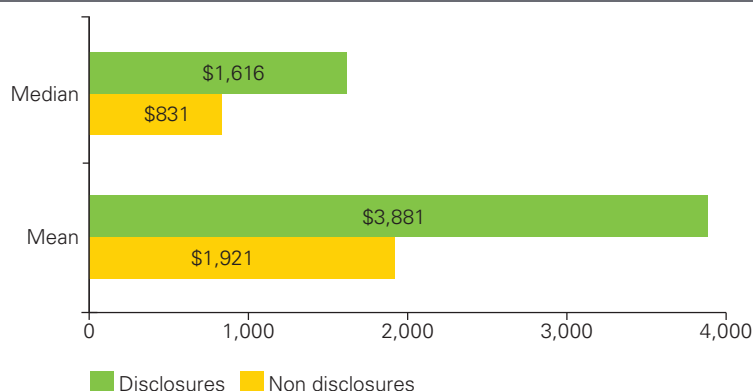
Source: Compustat, CRSP, and CDP S&P 500 reports

Figure 5. Mean liabilities and assets of disclosures and non disclosures (in US\$ millions)



Source: Compustat, and CDP S&P 500 reports

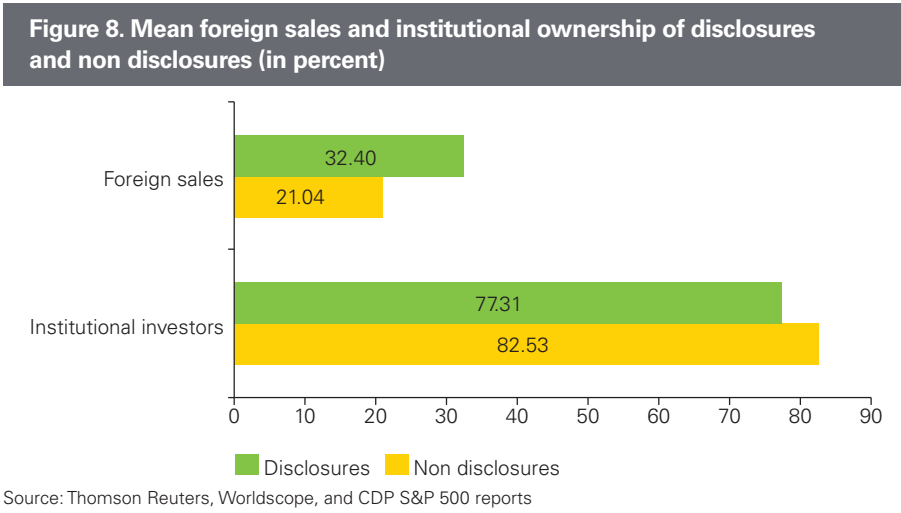
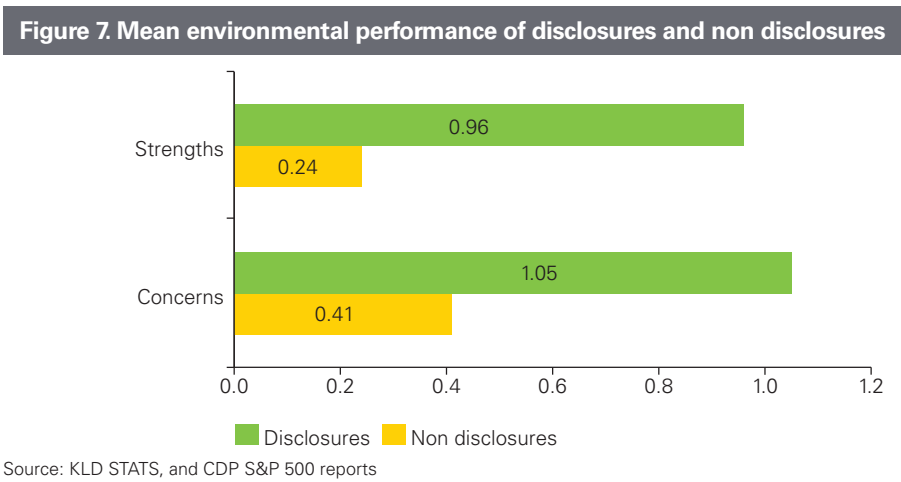
Figure 6. Operating profits of disclosures and non disclosures (in US\$ millions)



Source: Compustat, and CDP S&P 500 reports

foreign sales are significantly higher for disclosures (32.4 percent) than for non disclosures (21.04 percent). Finally, because the CDP is a consortium of institutional investors, we also examine the institutional ownership of the disclosures and non disclosures. As shown in Figure 8, we find that the mean institutional investor shareholding of our sample of firms is higher for those that do not disclose their emissions (82.53 percent) than for the disclosing firms (77.31 percent). However, because our sample comprises S&P 500 firms, both the mean and median ownership is high (over 75 percent of shares outstanding) for both groups.

In light of the differences between firms that disclose their emissions versus those that do not, documenting an average effect of carbon emissions on firm value without taking these differences into account would present a misleading picture of the costs of carbon emissions. Therefore, in our analyses we explicitly incorporate these differences by first modeling the managers’ decision to disclose as a function of firm and industry characteristics, and then calculating the average effect of carbon emissions on firm value. Some of the factors we examine that are associated with managers’ decision to disclose emissions are: firm size, environmental performance (based on environmental performance scores from KLD), proportion of firms in the industry disclosing their carbon emissions and proportion of foreign sales. The details of



the regression model that we estimate are presented in Box 1. Estimating the firm value effects of carbon emissions after incorporating in the analyses managers’ decision whether or not to disclose allows us to document an average effect of emissions for all the

firms in the sample and not just for firms that disclose their emissions. Specifically, we find that firm value decreases, on average, by US\$212,000 for every additional thousand metric tons of carbon emissions it produces.

Box 1. Firm-value effects of carbon emissions: Heckman model

We first examine the firm-value effects of carbon emissions using the balance sheet valuation model commonly used in the prior literature (e.g., see Barth and McNichols 1994; Campbell et al. 2003; Ahmed et al. 2006). Since managers choose whether or not to disclose their carbon emissions to the CDP and to the public, estimating the firm-value model without first modeling the firms' choice to disclose is likely to produce biased coefficients (Heckman 1979). Therefore, we estimate the firm-value model (Equation (1)) jointly with a disclosure-choice model (Equation (2)).

Firm-value model:

$$MKT_t = \beta_0 + \beta_1 TCO2_t + \beta_2 ASSET_t + \beta_3 LIAB_t + \beta_4 OPINC_t + \epsilon_t \quad (1)$$

In this model, 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 calendar year t . Our independent variable of interest is $TCO2_t$, which denotes carbon emissions in thousands of metric tons. Following prior related research (e.g., Barth and McNichols 1994; Campbell et al. 2003), our balance sheet valuation model includes total assets ($ASSET_t$) and liabilities ($LIAB_t$) at the end of the fiscal year. To control for potential correlated omitted variable bias, we include a proxy for the firm's operating income in year t , denoted as $OPINC_t$.

As indicated earlier, we argue that managers choose to disclose their carbon emissions if the perceived benefits of disclosing outweigh the perceived costs. Therefore, we incorporate in the firm-value model (Equation (1) above) managers' disclosure decisions using the following logit model:

Disclosure-choice model:

$$DISC_CDP_t = \beta_0 + \beta_1 CNCRN_t + \beta_2 STRNG_t + \beta_3 PROPDISCL_t + \beta_4 SIZE_t + \beta_5 MF_t + \beta_6 BM_t + \beta_7 LEV_t + \beta_8 II_t + \beta_9 FRNSALE_t + \beta_{10} DISC_CDP_{t-1} + \beta_{11} EPA_t + \epsilon_t \quad (2)$$

In this model, $DISC_CDP_t$ is an indicator variable that is coded as 1 if the firm discloses its year t carbon emissions data to the CDP and allows public disclosure by the CDP, and 0 otherwise. Other variables are defined as follows:

$CNCRN_t$	The number of environmentally damaging ratings (concerns) for the firm identified in KLD.
$STRNG_t$	The number of environmentally proactive ratings (strengths) for the firm identified in KLD.
$PROPDISCL_t$	The ratio of the number of firms in the 2-digit SIC industry code with publicly available carbon emissions to the total number of firms in the industry in our sample.
$SIZE_t$	The log of the firm's total assets at the end of the fiscal year.
MF_t	The number of management forecasts issued by the firm during the year (to control for the firm's general disclosure propensity).
BM_t	The firm's book-to-market ratio (to control for firm growth).
LEV_t	The firm's leverage.
II_t	The percentage of total shares outstanding held by institutional investors, from the Thomson Reuters 13-F database.
$FRNSALE_t$	The firm's foreign sales as a percentage of total sales for the year, from the Worldscope database (to control for international product market interactions).
EPA_t	An indicator variable equal to 1 if the firm operates in an industry that will be required by the EPA's GHG Mandatory Reporting Rule (effective 2010 and later) to report its GHG emissions, and 0 otherwise.
$DISC_CDP_{t-1}$	An indicator variable equal to 1 if the firm discloses its carbon emissions to the CDP and to the public in year $t-1$, and 0 otherwise.

4.

Firm-value effect of carbon emission disclosures

To examine the firm-value effect of carbon emission disclosures, we examine the differences in firm value between the two groups of firms: firms that disclose their carbon emissions and firms that do not. We match the firms on various characteristics across the two groups, both at the firm level and industry level, and test for differences in mean and median firm values (see Box 2 for more details).

The characteristics that we use to match the firms are the same as used in the analyses above, namely: KLD's environmentally damaging and proactive action ratings for a firm in year t , the proportion of firms in an industry that disclose carbon emissions to the CDP, firm size, the number of management forecasts issued by the firm during the year, book-to-market ratio, and firm leverage, the proportion of total shares outstanding held by institutional

investors, annual foreign sales as a proportion of total sales, and whether the firm will be subject to the EPA's GHG mandatory reporting rule. We also match firms on their total assets, liabilities, and operating income.

After matching the disclosing and non disclosing firms on the characteristics discussed above, we find that the disclosing firms have, on average, significantly higher market values than non disclosing firms. The median market value of disclosing firms is about US\$2.3 billion higher than the median market value of non disclosing firms. The mean market value for disclosures is a little over US\$5 billion higher compared to non disclosures.

Our results are consistent with the argument that disclosures provide benefits to the disclosing firms through reduced information asymmetry

between the firms and outsiders, thus facilitating efficient allocation of their scarce resources (Healy and Palepu 2001). This is because, in making voluntary carbon emission disclosures, firms deliver more transparent nonfinancial information to investors, as compared to firms that do not voluntarily disclose their carbon emissions. If firms do not disclose carbon emissions, then investors not only impute the firms' carbon emissions, but may also treat non disclosure as an adverse signal and thus, penalize the firms. In addition, investors may undertake a costly information search regarding the non disclosures' emissions, thus increasing costs to investors, and ultimately the firms' costs. Finally, voluntary disclosures may also be used to reduce potential regulatory intervention (Blacconiere and Patten 1994).

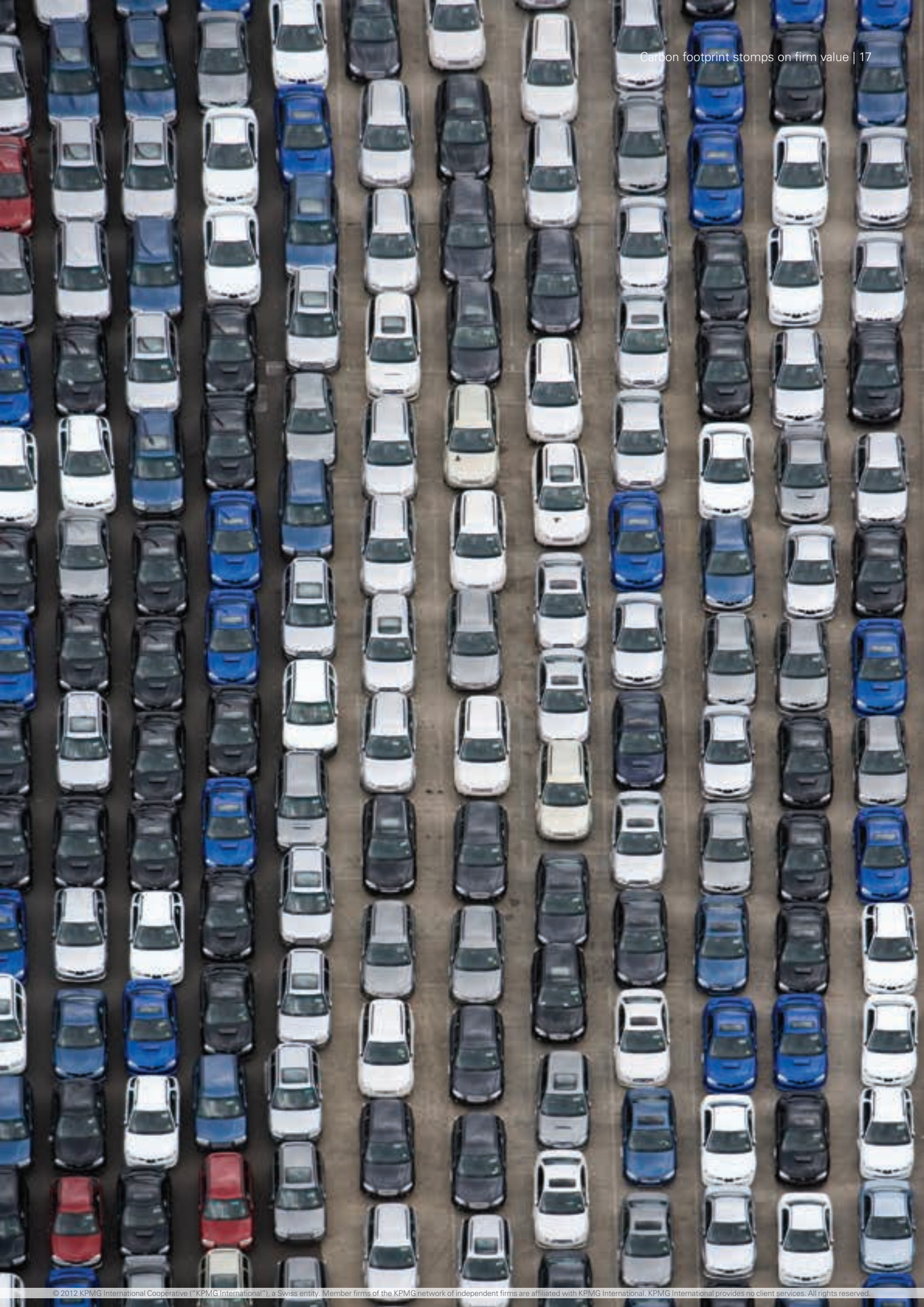
Box 2. Firm-value effects of carbon disclosures: Propensity score matching and doubly robust regressions

We use propensity score matching (Rosenbaum 2005) to compare the firm values for disclosures ("treatment" firms) with a matched sample of non disclosures ("control" firms). We match the treatment firms ($DISC_CDP_t = 1$) with the control firms ($DISC_CDP_t = 0$) using the following logit model that includes all the proper covariates in Equations (1) and (2). We use two different matching algorithms: nearest neighbor matching and caliper matching with a distance of 0.01. We include industry fixed effects at the 2-digit SIC code level.

$$DISC_CDP_t = \beta_0 + \beta_1 CNCRN_t + \beta_2 STRNG_t + \beta_3 PROPDISCL_t + \beta_4 SIZE_t + \beta_5 MF_t + \beta_6 BM_t + \beta_7 LEV_t + \beta_8 II_t + \beta_9 FRNSALE_t + \beta_{10} EPA_t + \beta_{11} ASSET_t + \beta_{12} LIAB_t + \beta_{13} OPINC_t + \varepsilon_t$$

To increase the overlap between the treatment and control firms, we also estimate a reduced model excluding: covariates that were not significant in the logit regression; and (2) those whose means did not differ significantly after matching. The reduced model excludes concerns, book to market, institutional investors, assets, and liabilities. The covariate balances are marginally significantly different between control and treatment group for MF , LEV , $FRNSALE$, and EPA using nearest neighbor matching and not significantly different for any covariates using caliper matching.

We extend our propensity score matching analysis by using doubly robust regression (Imbens and Wooldridge 2007). That is, after matching our treatment and control firms using the propensity scores calculated with the logit model, we estimate Equation (1) only for the matched sample of treatment and control firms, replacing $TCO2_t$ with $DISC_CDP_t$ and using the propensity scores as weights.



5.

Impending U.S. EPA mandatory reporting rule

In December 2009 the U.S. EPA issued a rule requiring reporting of GHG emissions for 2010 and later, applicable to fossil fuel and industrial gas suppliers, direct GHG emitters, and manufacturers of heavy-duty and off-road vehicles and engines. A natural question that arises is whether the markets view the carbon footprint from firms that will be subject to the EPA's GHG mandatory reporting rule (hereafter, *EPA = 1* firms) differently from the carbon footprint from firms that will not (hereafter, *EPA = 0* firms). To answer this question, we used an analysis similar to that described in Box 1,¹⁵ and found a significant firm-value effect of carbon emissions for *EPA = 1* firms, but no evidence of a significant firm-value effect of carbon emissions for *EPA = 0* firms. For the *EPA = 1* firms, we find that a company's value decreases, on average, by US\$182 for every additional metric ton of carbon emissions it produces. This effect is smaller in magnitude than the US\$212 per metric ton documented above for the full sample.

Properties of *EPA = 1* firms versus *EPA = 0* firms

The two industries with the largest numbers of observations with carbon emissions data in our sample are from the *EPA = 1* group. These two industries are chemical manufacturing and utilities (71 firm-years each, or about 13 percent of firm-year disclosures). The next largest number of observations

corresponds to the computer and electronic product manufacturing industry (68 firm-years), which is in the *EPA = 0* group.

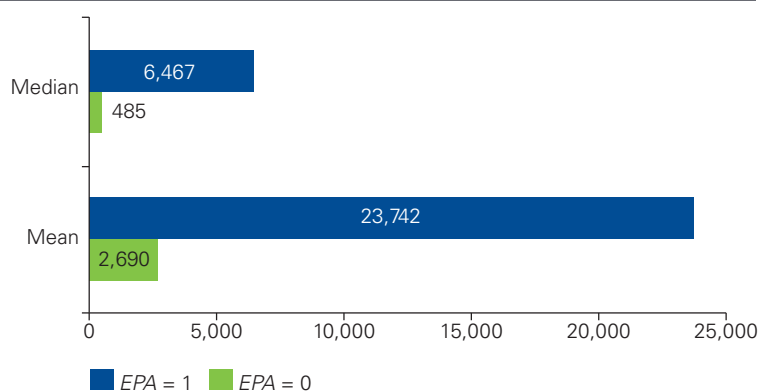
Figure 9 shows that both the mean and median carbon emissions are significantly higher for the *EPA = 1* firms than for the *EPA = 0* firms. The mean (median) metric tons of carbon emissions (in thousands) for the *EPA = 1* firms is approximately 9 (13) times the magnitude of the carbon emissions for the *EPA = 0* firms. These statistics indicate that, in general, *EPA = 1* firms are significantly more carbon intensive than the *EPA = 0* firms.

Although neither the mean nor the median market values are significantly different between the *EPA = 0* and *EPA = 1* groups (Figure 9), the mean total assets and liabilities of the

EPA = 0 firms are significantly larger than those of the *EPA = 1* firms. The two groups are not significantly different based on their median total assets and liabilities (Figure 10).

We also find that the *EPA = 1* firms have significantly higher KLD scores on both environmentally proactive (strengths) and environmentally damaging (concerns) actions, relative to *EPA = 0* firms (Figure 11). The median environmental performance scores on both dimensions are also significantly higher for *EPA = 1* firms. These higher scores for *EPA = 1* firms on both environmentally proactive as well as damaging actions indicate that these industries not only have a greater GHG impact, but in general also have a higher environmental impact.

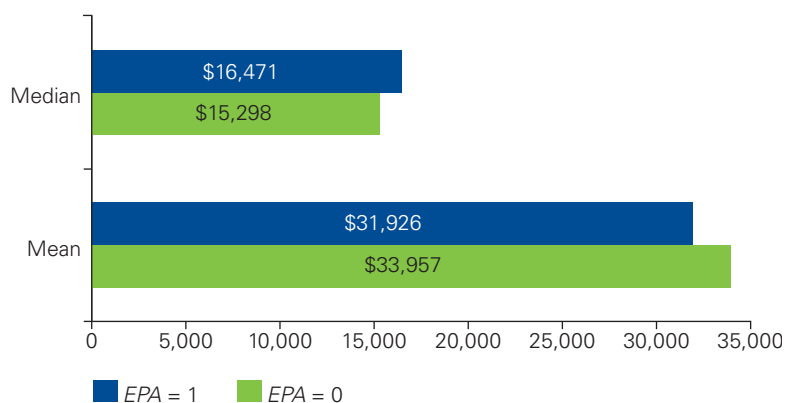
Figure 9. Carbon emissions by EPA group (in '000 tons)



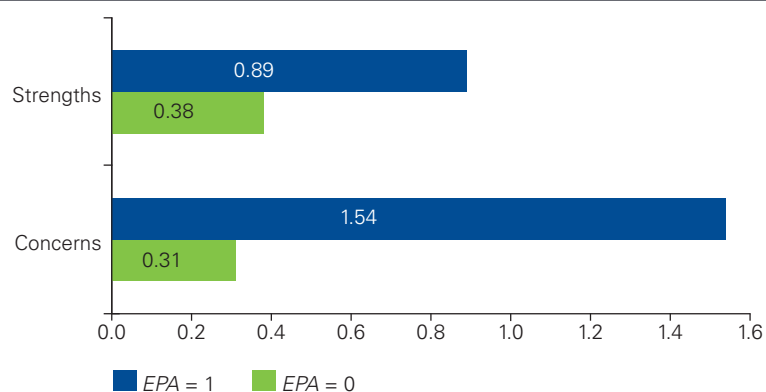
Source: EPA website, and CDP S&P 500 reports



¹⁵ We removed the *EPA* variable from our model and ran separate analyses for the *EPA = 1* and *EPA = 0* groups.

Figure 10. Market value by EPA group (in US\$ millions)

Source: Compustat and EPA website

Figure 11. Mean environmental performance by EPA group

Source: KLD STATS, and EPA website



6.

Summary

U.S. firms face mounting pressure from investors, regulators, NGOs, and other stakeholders to disclose and manage their carbon emissions. Firms that do not successfully reduce their carbon footprint will likely suffer a decrease in firm reputation and demand for their goods and services. In turn, firm value is likely to suffer.

Based on carbon emissions data voluntarily reported over a 3 year period to the CDP by companies on the Standard & Poor's 500 Index, we find that firm value decreases, on average, by US\$212,000 for every additional thousand metric tons of carbon emissions produced by the firms. Hence, we conclude that large carbon footprints, on average, negatively affect firm value.

The study also finds that the median firm value of firms that disclose their carbon emissions is about US\$2.3 billion higher than the median value of non disclosing firms. These results are consistent with the argument that the capital markets integrate both carbon emissions and the act of voluntary disclosure of this information in their firm valuations. Disclosing and non disclosing firms alike are penalized for their carbon emissions, but non disclosures face a further penalty for non disclosure. These results are somewhat surprising given that there is little verification of the carbon emission disclosures.

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