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Halo effect or fallen angel effect? Firm value consequences of greenhouse gas emissions and reputation for corporate social responsibility

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ABSTRACT

Greenhouse gas (GHG) emissions are perceived to have negative consequences for society at large by contributing to potential climate change and represent a potential cash drain from firms from exposure to future regulatory, abatement, and compliance costs. Beginning in 2010, US companies are required to report their GHG emissions to the Environmental Protection Agency (EPA). We utilize these data for 2010–2014 to examine whether the possible adverse firm value impact of these GHG emissions is alleviated or exacerbated by the firm's reputation for corporate social responsibility. Our findings suggest that there is *no* halo effect, i.e., a firm's reputation for social responsibility (as reflected in its CSR score) does *not* protect the firm from the adverse firm value effects of GHG emissions. Rather, our findings suggest a fallen angel effect, i.e., for any given level of GHG emissions, the higher the firm's CSR score, the greater the adverse impact on firm value. In other words, the decline in firm value due to the adverse impact of GHG emissions is compounded by the hit to the firm's reputation for corporate social performance. Our paper contributes to the sparse prior US literature on the firm value effects of GHG emissions. Further, by providing scholarly evidence on the existence of a fallen angel effect, our findings suggest that boards and managers of firms that provide voluntary CSR disclosures cannot afford to be complacent about their GHG emissions.

1. Introduction

Although corporate social responsibility (CSR) appears to deviate from maximizing shareholder wealth (Friedman, 1970), prior research (e.g., Elliott et al., 2014; Gregory et al., 2016) suggests that a reputation for responsible social performance can endow a firm with a competitive advantage that is reflected in a *higher* firm value. Relatedly, because of their potential adverse impact on the environment (e.g., climate change), corporate greenhouse gas (GHG) emissions may be viewed as an element of negative, if not *ir*responsible, social performance (Huang and Watson, 2015). In recent research, Griffin et al. (2017) and Matsumura et al. (2014) use data obtained from US firms' *voluntary* disclosures of GHG emissions to the Carbon Disclosure Project (CDP) as well as estimates of GHG emissions for non-disclosers to suggest that investors in US equity markets penalize GHG emitters.[1] Separately, beginning in

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[1] The Carbon Disclosure Project (CDP) is supported by institutional investors and offers self-reported but standardized high quality environmental information for use by investors and academics. The CDP (www.cdp.net) is widely recognized as a source of reliable albeit voluntarily supplied environmental data for academic research.

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2010, the US Environmental Protection Agency's (or EPA's) Greenhouse Gas Reporting Program (GHGRP) *requires* US fossil fuel suppliers, direct GHG emitters and industrial gas suppliers, to report their GHG emissions to the EPA.

In this study, the research question we address is whether the adverse impact of EPA-mandated GHG emission data on firm value is attenuated or exacerbated by the firm's reputation for corporate social responsibility. Relative to prior US-based GHG research (e.g., Griffin et al., 2017; Matsumura et al., 2014), our use of the standardized and uniformly reported mandatory EPA GHG emissions data allows us to examine *actual* (rather than estimated) GHG emissions and firm value effects for larger firms as well as for smaller firms that do not voluntarily report GHG emissions to the CDP. As discussed later in the paper, our findings with respect to the valuation effects of mandatory GHG emission disclosures are consistent with prior findings in the literature with respect to such voluntary disclosures. Hence, rather than focus on the main effect, i.e., the valuation effect of mandatory GHG emission disclosures alone, we focus on the interaction effect between firms' GHG emissions and their reputation for social responsibility. In effect, the research question we examine is whether a firm's reputation for social responsibility (as reflected in the firm's CSR score) has a cushioning (or "halo") effect that protects the firm against the adverse market effects of GHG emissions. Alternatively, for firms with a reputation for social responsibility, the GHG emissions could have a disillusioning (or "fallen angel") effect that exacerbates the adverse market effects associated with the EPA-mandated GHG data.

The fundamental notion underlining the halo effect or fallen angel effect is a potential error in expectations. Prior research (e.g., Chiu and Sharfman, 2011) suggests that responsible social performance increases the firm's legitimacy and builds reputation which in turn can attract better employees and loyal customers.[2] Potentially, the firm's corporate social responsibility (CSR) score could create a "halo effect" by which the firm gains broader social legitimacy and causes investors to attribute positive outcomes to the firm in other areas as well (Lyon and Montgomery, 2015).[3] Put differently, responsible social performance, as a form of stakeholder engagement, can build goodwill which can have an insulating effect, i.e., can lower, if not prevent, the harm from negative events such as product safety issues or an environmental accident (Chakravarthy et al., 2014; Godfrey et al., 2009). From this perspective, to the extent that GHG emissions are viewed as impairing firm value (as suggested by Griffin et al., 2017; Matsumura et al., 2014), the insulating properties of responsible social performance may be expected to have a "halo effect," i.e., dampen the potential negative consequence for firm value of GHG emissions.

On the other hand, the firm's CSR scores could have increased social performance expectations which are then lowered when the GHG data become available. Underpinning this lowering of expectations is "greenwashing," an umbrella term for a range of corporate behaviors that induce investors and others to hold an overly positive view of the firm's performance (Lyon and Montgomery, 2015).[4] Along the same lines, Flammer (2015) suggests that the minimum requirements for what is perceived to be responsible social performance have been increasing. What may have once been perceived as exceptional practice may now be perceived as no more than the new normal. Relatedly, there has been rising awareness of climate change in recent years and the potential harmful effects of GHG emissions. Further, although climate change is a component of responsible social performance as measured by the CSR score, GHG emissions data were not specifically identified as a social performance indicator due to lack of data for US companies. Consequently, the new EPA-mandated GHG emissions data could potentially have a disillusioning ("fallen angel") effect, i.e., exacerbate the negative effect of GHG emissions on the value of a firm with a previous reputation for corporate social performance. In other words, firms previously perceived as socially responsible may now be perceived as less so on account of their GHG emissions. Put differently, the greater the firm's CSR score, the greater the original perception of the firm as an angel (i.e., a socially responsible firm), and the greater the reversal (or fall) in terms of how the firm is perceived following the disclosure of the new EPA-mandated GHG emission data. For these reasons, whether the adverse impact of GHG emissions on firm value is alleviated or exacerbated by the firm's reputation for social performance (as reflected in the firm's CSR score) remains an open empirical question.

Our analysis is based on a sample of companies with EPA-mandated GHG data as well as CSR data during the first five years (2010–2014) of the EPA's Greenhouse Gas Reporting Program (GHGRP). We first establish that the EPA-mandated GHG emission data are value relevant (consistent with prior research) by examining whether they have a negative impact on firm market value. Then, we examine whether the negative impact of GHG emissions on a firm's market value is alleviated or exacerbated by its CSR score. We also examine whether the alleviating or exacerbating effect of CSR scores on the market value impact of GHG emissions holds for more profitable vs. less profitable firms, for larger vs. smaller firms, for older vs. younger firms, and for later vs. earlier years of the EPA's GHGRP. Finally, although climate change is a component of responsible social performance as measured by the CSR score, GHG emissions data are not specifically identified as a social performance indicator (MSCI ESG Research, 2015). Still, to eliminate the possibility of a mechanical relation between our dependent and independent variables, in alternative analyses we also utilize a modified CSR score without its environmental component.

We find evidence consistent with EPA-mandated GHG emissions having a negative effect on equity value, i.e., lowering firm value. We also find evidence consistent with CSR score having a positive effect on equity value, i.e., raising firm value. Further, consistent with the fallen angel effect, we find the negative impact of GHG emissions on firm value to be increasing in the level of the CSR score, i.e., the higher the firm's CSR score, the greater the negative impact of GHG emissions on firm value. These findings

[2] Reputation may be defined as how a firm is perceived with respect to some characteristic or performance. Karpoff (2012) views a good reputation as an intangible asset that allows a company to obtain higher fees for its services or sell the same merchandise at prices higher than that of other suppliers.

[3] Lyon and Montgomery (2015, p. 227) define halo effect as the "inability to evaluate individual attributes apart from an overall impression." As an example, investors may learn that a company's products are organic and so also assume that the firm uses renewable energy and avoids GHG emissions.

[4] We thank an anonymous reviewer for pointing us in the direction of "greenwashing," i.e., a form of cheap talk whereby firms create the impression of responsible performance but fail to make the necessary effort or engage in only symbolic efforts potentially resulting in an error of expectations and a subsequent correction (Lyon and Montgomery, 2015).

suggest that the newly mandated EPA data have a disillusioning effect, i.e., appear to be removing some of the gloss from companies that were previously viewed positively by investors for their corporate social performance.

In other analyses, we find the fallen angel effect to hold for both more profitable and less profitable firms, for larger but not smaller firms, for both older and younger firms, and for the later years (2012–2014) but not the earlier years (2010–2011) of the EPA's GHG reporting program. We attribute this latter finding to the fact that investors have greater awareness of the negative consequence of GHG emissions in firms with high CSR scores in later years of our sample period. We also find that our results and inferences are unchanged when we conduct our analyses using a modified CSR score that excludes environmental components.

Our study contributes to the literature on the investor relevance of GHG emissions in the US in at least two ways. First, prior research on the value relevance of GHG emissions in the US has relied primarily on voluntary disclosures of emission data by companies to the CDP. As is well known, voluntary disclosures are subject to endogeneity (self-selection bias), i.e., findings with respect to the market value impact of these GHG emissions may not be generalizable to other GHG emitting companies who have chosen *not* to disclose. More specifically, CDP emissions data has been criticized for a lack of measurement consistency that limits its comparability and usefulness (Andrew and Cortese, 2011). Beginning 2010, the EPA began requiring mandatory reporting of GHG emissions by US facilities that emit more than 25 metric kilotons (i.e., 25,000 metric tons) of greenhouse gasses each year. In this study, we manually collect these GHG data for each facility and trace them back the companies owning these facilities to obtain company-level GHG emissions data. Thus, to our knowledge, our study is the first to examine the equity market value relevance of the new EPA-mandated GHG data. As noted previously, the benefit of using the EPA-mandated GHG data is that it allows us to examine more recent years as well as expand sample size (beyond the larger companies that voluntarily report GHG emissions to the CDP) by using actual – rather than model-based estimates – of GHG emissions data for smaller firms.

To elaborate, our study has 1566 firm-year observations over the 5 years 2010–2014 and includes both S&P 500 companies as well as other (smaller) firms as long as they meet the minimum 25 metric kiloton annual GHG emissions reporting requirement. By contrast, Matsumura et al. (2014) have only 550 observations over the 3 years 2006–2008 and include only S&P 500 firms. Similarly, Griffin et al. (2017) have only 1083 observations over the 5 years 2005–2009 and include only S&P 500 firms. Further, Griffin et al. (2017) suggest they select large US companies because these larger firms should be of most interest regarding the effects of climate change. However, for our sample companies we find that the total GHG emissions of 4500 metric kilotons for the smaller firms (i.e., firms smaller in size than our sample mean market value of $13 billion) is actually *higher* than the total GHG emissions of 4046 metric kilotons for firms larger than our sample mean market value. In other words, our EPA-mandated data suggest that in the aggregate smaller companies matter at least as much as larger companies in terms of their total GHG emissions and should not be excluded from accounting research studies on GHG emissions.

Second, while prior research has documented the value relevance of GHG emission data (Matsumura et al., 2014; Griffin and Sun, 2013; Griffin et al., 2017) as well as that of corporate social performance (e.g., Huang and Watson, 2015; Mishra, 2015; Chiu and Sharfman, 2011; Margolis et al., 2009; Orlitzky et al., 2003), our study is the first to examine whether the pricing of GHG emissions is impacted by a company's reputation for social performance as measured by its CSR score. Potentially, a stronger reputation for social performance (i.e., a higher CSR score) could have a halo effect and attenuate the harm to firm value associated with GHG emissions (Chakravarthy et al., 2014; Godfrey et al., 2009). Alternatively, the firm's voluntary CSR disclosures could have induced investors to hold an overly inflated view of the firm's social performance (consistent with greenwashing) which is then lowered when the GHG data become available, i.e., trigger a fallen angel effect by tarnishing a company's existing reputation for social responsibility and result in a larger than otherwise decline in its market value. Consistent with this latter expectation, our results suggest that the decline in market value associated with GHG emissions is higher for companies with a higher CSR score.

The rest of the paper proceeds as follows. Section 2 provides background information and develops our hypotheses. Section 3 discusses the research design and sample selection. Section 4 reports our empirical findings, and section 5 provides concluding comments.

2. Background and hypothesis development

2.1. Background

Under US law, the EPA has the authority to regulate firms' harmful airborne emissions to protect public health. In 2009, the EPA used this authority to begin GHGRP (the Greenhouse Gas Reporting Program) which now requires all US facilities that emit more than 25 metric kilotons of GHG in a year to report these emissions directly to the EPA. In turn, the EPA compiles the data and publishes it to advance ongoing research on the potential link between GHG emissions and global climate change. The EPA estimates that 85–90% of all US GHG emissions are reported through the GHGRP (EPA, 2013).

Notably, until the EPA's GHG reporting program, disclosures of GHG emissions by US companies were voluntary, and several (albeit the larger) companies did report the information to the CDP.[5] To the individual company emitting GHG, the emissions essentially represent an externality, i.e., any potential negative effects associated with these emissions are not borne by the company but by society at large. Further, unlike European firms, US companies are not subject to a carbon emissions cap-and-trade scheme whereby firms that emit GHG in excess of their allowances have to incur a monetary cost which may be expected to negatively impact their equity values (Clarkson et al., 2015).

[5] As noted previously (fn. 1), the CDP is the Carbon Disclosure Project which is supported by institutional investors and offers voluntarily-reported but standardized high quality environmental information for use by investors and academics.

Even under these circumstances, prior research suggests that US investors view GHG emissions negatively because, similar to traditional environmental pollutants, GHG emissions create the potential for future cash drain from the company as a result of exposure to regulatory, abatement, and compliance costs Albertini, 2013; Middleton, 2015; Matsumura et al., 2014; Clarkson et al., 2013; Griffin et al., 2017; Sinkin et al., 2008; Patten and Nance, 1998; Blacconiere and Patten, 1994). Because Matsumura et al.'s (2014) primary sample consists of firms that voluntarily supply GHG emissions data to the CDP, their findings are subject to potential self-selection bias as well as potential GHG emissions measurement bias (Andrew and Cortese, 2011). Similarly, Griffin et al. (2017) use the GHG emissions reported to the CDP by several S&P500 companies and estimate GHG emissions for S&P500 companies that do *not* report to the CDP. They find that the market-implied equity discount is similar for CDP and non-CDP disclosers.

Separately, although GHG emissions are not toxic, they are perceived to have negative consequences for society at large by contributing to potential climate change (EPA, 2015). Consistent with the notion that GHG emissions are perceived negatively, Bunge (2016) notes that Nielsen survey research indicates that two-thirds of US customers are willing to pay more for products marketed as sustainable, and relatedly that pork giant Smithfield Foods Inc. voluntarily plans to cut a quarter of its greenhouse gas emissions over the next eight years to "burnish its brand" at restaurants and grocery stores. Further, Smithfield's CEO notes that the company's emission plan is apolitical and based on business considerations rather than any regulatory pressure.[6] Although climate change is an item of information considered by MSCI KLD in computing its corporate social responsibility (CSR) scores for companies, GHG emissions *per se* are not a component of the CSR score at this time, possibly due to a lack of reliable, historical GHG emissions data (MSCI ESG Research, 2015).

2.2. Hypothesis development

As noted previously, prior research on GHG emissions by US companies (Matsumura et al., 2014; Griffin and Sun, 2013; Griffin et al., 2017) suggests that investors view GHG emissions as impacting future cash flow *negatively* due to possible future regulatory, abatement, and compliance costs associated with these emissions. Consequently, the market applies a discount to the equity values of these companies in proportion to their GHG gas emissions. By contrast, prior research on corporate social responsibility (e.g., Huang and Watson, 2015; Mishra, 2015; Chiu and Sharfman, 2011; Margolis et al., 2009; Orlitzky et al., 2003) indicates that investors view a company's reputation for responsible corporate behavior as impacting future cash flow *positively* because it increases the firm's legitimacy and has the potential for attracting higher quality employees as well as loyal customers. In other words, prior CSR research suggests that investors apply a premium to the equity values of companies in proportion to their CSR scores. Hence, a pertinent question is how the negative market equity effect of GHG emissions is impacted by a company's reputation for responsible social performance as measured by its CSR score.

On the one hand, the CSR score as a metric of responsible social performance and stakeholder engagement may be expected to build goodwill (an intangible asset) and have an insulating effect by reducing if not preventing the harm from negative events such as product safety issues or an environmental accident (Chakravarthy et al., 2014; Godfrey et al., 2009). Thus, given that GHG emissions are viewed as having negative cash flow implications, any insulating properties associated with a company's CSR score could have a halo effect, i.e., could lower if not prevent the potential negative consequence for equity associated with the company's GHG emissions.[7] In other words, holding GHG emissions constant, the higher the firm's CSR score, the lower the negative effect of GHG emissions on the company's market value.

On the other hand, the firm's voluntary CSR disclosures could be associated with "greenwashing" resulting in an error of expectations, i.e., the CSR disclosures could be associated with a form of cheap talk whereby the firm created an impression of responsible social performance but failed to make the necessary effort or engaged in only symbolic efforts (Lyon and Montgomery, 2015). In other words, the voluntary CSR disclosures could have induced investors to hold an overly positive view of the firm resulting in inflated expectations of social performance. Consequently, the GHG emission disclosures could potentially trigger a correction, i.e., a downward reassessment by investors of their notions of the firm's social performance. Put differently, the new EPA-mandated GHG emissions data could potentially have a disillusioning ("fallen angel") effect, i.e., exacerbate the negative effect of GHG emissions on the value of a firm with a previous reputation for corporate social performance (as captured by the firm's CSR score).[8] Thus, firms previously perceived as socially responsible may now be perceived as less so on account of the new EPA-mandated GHG emission data. Further, the greater the firm's CSR score, the greater the original perception of the firm as an angel (i.e., a socially responsible firm), and the greater the reversal (or fall) in terms of how the firm is perceived following the disclosure of GHG emission data. In other words, holding GHG emissions constant, the higher the firm's CSR score, the greater the negative effect of GHG emissions on the company's market value. Consequently, whether the negative impact of GHG emissions on firm value is

[6] Similar sentiments are expressed by executives of other companies that are also on a lower-emissions trajectory driven in part by market forces (Olson and Sweet, 2016), and appear to be consistent with the broader notion of "enlightened value maximization" posited by Jensen (2001). Separately, an Institute of Management Accountants (IMA) survey suggests that a large fraction of their membership believes that GHG emissions have the potential for affecting companies' profitability (Cohn, 2017). The survey also suggests that 17% of US companies are currently measuring their carbon footprint.

[7] As noted previously, the halo effect refers to the tendency (pre-disposition) for a positive impression created in one area to influence an impression in another area, an inability to separate the assessment of an individual attribute from an overall impression. Thus, the more positive the original impression, the weaker the adverse impact on firm value following negative news.

[8] The fallen angel effect refers to the notion of falling off the pedestal, i.e., the more positive the original impression of the company, the greater the reversal of the original positive impression following negative news about the company. In other words, the higher the pedestal (the more positive the original impression), the further the fall or disillusioning effect following negative information and the greater the adverse impact on firm value.

alleviated or exacerbated by the firm's reputation for social performance (as reflected in the firm's CSR score) remains an open empirical question which we investigate in our study.

Our hypothesis, stated in the null form, is as follows:

H1: The equity market discount associated with GHG emissions is not affected by the company's reputation for social responsibility as measured by its CSR score.

3. Sample and model development

3.1. Sample and data

The initial sample is drawn from the EPA's GHG Reporting Program database. Starting in 2010, the EPA requires reports from all facilities in the US with annual GHG emissions exceeding 25 metric kilotons. Measurement of the emissions is done by the individual facilities and then verified by the EPA (EPA, 2013). Because the data is reported to the EPA by facility, rather than company, it is necessary to identify and aggregate the emissions for the various facilities of each parent company before conducting a financial analysis. If a facility has more than one owner, in our analysis we only include the parent company that is the majority owner (i.e., greater than 50%) as of the end of calendar year.

We obtain the parent companies' financial information from Compustat. Since the GHGRP data do not include commonly used numerical identifiers (i.e., CUSIP or CIK), the parent company names must be manually matched with the company names (*CONM*) in Compustat. In cases where we are unable to find a match, an internet search of the company's website or Bloomberg Business company profiles determines whether the parent company is a subsidiary of, or has merged with, a company that is listed in Compustat.[9] All companies that are privately or government owned are excluded from our sample.

CSR information is collected from the MSCI ESG KLD STATS Data Set.[10] This database includes data about the CSR strengths and concerns for over 2600 of the world's largest companies based on a variety of positive and negative metrics grouped by category. The six CSR categories are: environmental responsibility, community involvement, employee relations, diversity promotion, product quality, and corporate governance. The score in each category is determined by the sum of the number of strengths (i.e., positive metrics) less the sum of the number of concerns (i.e., negative metrics). The overall CSR score is then defined as the sum of the individual category scores.

During the five years 2010–2014, there are 8524 unique facilities that provide 37,394 facility-year GHG emissions reports to the EPA's GHG reporting program (GHGRP). Of these, 1771 reports are made by facilities without a majority owner (i.e., without a parent company with more than 50% ownership) and are thus excluded from our study. Another 17,228 annual emissions reports are excluded because the reporting facility cannot be matched with a Compustat company. Aggregation of the emissions from the remaining 23,589 facility-year observations result in 2800 firm-year observations for 654 unique parent companies. We exclude 562 observations with missing Compustat financial variables, 45 observations for firms operating in the financial services industry (i.e., SIC codes 6000-6999), and 627 observations with missing CSR data in the MSCI ESG KLD STATS database. Thus, our final sample consists of 1566 firm-year observations from 392 firms operating in over 20 different industries during 2010–2014.

Table 1 presents the number of observations and firms included in each industry (i.e., two-digit SIC code) classification. Approximately one-half (i.e., 48%) of our sample observations are from companies that operate in only three industries: electric, gas, and sanitary service utilities (SIC = 49), oil and gas extraction (SIC = 13), and chemicals and allied products (SIC = 28). A large portion of the remaining observations are from companies that operate in other manufacturing and production related industries. The largest GHG emitters in our sample are firms providing electricity, gas, and sanitary service utilities (SIC = 49) and petroleum refining and petroleum refining related services (SIC = 29). Notably, these two industries alone report average annual GHG emissions of over 1.1 million metric kilotons (i.e., 2.4 trillion pounds), which accounts for approximately 73% of the total GHG emissions in our sample and is roughly equivalent to the average annual emissions of 235 million passenger vehicles (EPA, 2014).[11]

3.2. Model development

To examine whether the adverse firm value impact of GHG emissions is alleviated or exacerbated by the firm's reputation for corporate social responsibility, we use a modified version of the balance sheet valuation model employed by Barth and McNichols (1994), Campbell et al. (2003), and Matsumura et al. (2014). The specific model we use is as follows:

$$\begin{aligned} Market\ Value_{it} = {} & \alpha_0 + \beta_1\ GHG\ Emissions_{it} + \beta_2\ CSR\ Score_{it} + \beta_3 (GHG\ Emissions_{it}) * (CSR\ Score_{it}) + \beta_4\ Assets_{it} + \beta_5\ Liabilities_{it} \\ & + \beta_6\ Op\ Income_{it} + \beta_7 CDP\ Report_{it} + \beta_8\ Foreign\ Ops_{it} + Industry\ Fixed\ Effects + \varepsilon_{it} \qquad (1) \end{aligned}$$

The dependent and independent variables in model (1) are defined in Appendix A. Specifically, the dependent variable $Market\ Value_{it}$ represents the firm's market value of equity at time *t* and is calculated as the company's market price per common share multiplied by

[9] Bloomberg Business company profiles are available at www.bloomberg.com.

[10] Information about MSCI ESG KLD STATS can be found in the KLD Manual at WRDS: https://wrds-web.wharton.upenn.edu/wrds.10.

[11] Our sample includes only emissions related to public parent companies that can be matched with the Compustat, MSCI ESG KLD STATS, and CDP databases. The actual total emissions for the oil and gas extraction (i.e., NAICS = 211000–211999) and utility (i.e., NAICS = 220000–229999) industries for 2014, as reported by the EPA, includes GHG emissions from all reporting facilities regardless of ownership (i.e., public, private, foreign, and governmental entities). This total, at 2.3 million metric kilotons (i.e., 4.6 trillion pounds), is considerably higher than the total for our sample.

Table 1
Industries, firm count, and GHG emissions for EPA GHGRP firms (2010–2014).

SIC code	Description	Num. of obs.	Num. of firms	Avg. GHG emissions per year *(in metric kilotons)*	Avg. GHG emissions per firm per year *(in metric kilotons)*
49	Electric, Gas, and Sanitary Services Utilities	348	79	983,112	14,100
29	Petroleum Refining and Related Industries	55	16	121,109	11,083
13	Oil and Gas Extraction	189	54	100,273	2,919
28	Chemicals and Allied Products	216	50	86,366	2,004
26	Paper and Allied Products Manufacturing	83	18	83,366	5,036
33	Primary Metal Industries	94	24	51,952	2,747
12	Bituminous Coal and Lignite Mining	20	5	16,583	4,171
20	Food Products Manufacturing	103	25	17,352	848
32	Stone, Clay, Glass, and Concrete Products	36	9	7,871	1,080
37	Transportation Equipment Manufacturing	65	16	7,298	673
10	Metal Mining	21	5	6,278	1,444
24	Lumber and Wood Products Manufacturing	9	2	5,664	2,911
36	Electronic and Other Electrical Equipment	97	26	3,957	230
14	Mining Nonmetallic Minerals	30	7	3,364	576
38	Technical Equipment Manufacturing	7	3	2,965	1,975
30	Rubber and Plastic Products Manufacturing	17	4	2,532	810
35	Machinery and Computer Manufacturing	49	13	1,847	183
45	Transportation by Air	17	4	1,668	489
73	Business Services	15	4	1,253	418
99	Other	95	28	285	200
	Total	1,566	392		

This table presents a list of industries included in our sample as well as details of the distribution of observations, firms, and GHG emissions across industries. The table is sorted in descending order, with industries representing firms with the highest average annual GHG emissions at the top. For brevity, the "Other" category in this table includes data for firms with the following two-digit SIC codes: 16, 21, 22, 25, 27, 34, 40, 44, 48, 50, 51, 55, 59, 79, 80, and 87. The average annual GHG emissions for each industry and firm are given in the last two columns of the table. The EPA measures GHG emissions by weight and reports total emissions in metric tons. For convenience, we divide the EPA's emissions data by 1000 and report our GHG emissions in metric kilotons (i.e., 1 metric kiloton equals 1 million kilograms, or 2.2 million pounds). Since our sample is drawn exclusively from facilities that are required to report to the EPA Greenhouse Gas Reporting Program (GHGRP), all of the firms represented in this table own at least one facility that emits more than 25 metric kilotons (i.e., greater than 25,000 metric tons) of GHG per year.

shares outstanding (Compustat variables: *PRCC_F * CSHO)*. The independent variables *GHG* $Emissions_{it}$ and *CSR* $Score_{it}$ represent the firm's total GHG emissions in metric kilotons (i.e., 1000 metric tons) and corporate social responsibility (CSR) score at time *t*, respectively. Based on prior research (Matsumura et al., 2014; Clarkson et al., 2015; Griffin et al., 2017; Cho et al., 2013; Huang and Watson, 2015), we expect a firm's market value to be negatively associated with GHG emissions and positively associated with the CSR score.

In model (1), the interaction variable *(GHG* $Emissions_{it}$*)*(CSR* $Score_{it}$*)* represents our main variable of interest (test variable). To the extent that the adverse firm value impact of GHG emissions is alleviated by the firm's reputation for corporate social responsibility measured by its CSR score (the halo effect), the test interaction variable is expected to be significant with a positive sign. By contrast, to the extent that the adverse firm value impact of GHG emissions is exacerbated by the firm's reputation for corporate social responsibility or its CSR score (the fallen angel effect), the test interaction variable is expected to be significant with a negative sign. In other words, a perceived dissonance between a firm's GHG emissions and its CSR score could lead to a stronger (rather than a muted) negative market value consequence associated with the GHG emissions.

In model (1), the control variables are similar to those used in Matsumura et al. (2014). $Assets_{it}$ (Compustat item *AT*) is total assets for the firm at the end of year *t* and controls for company size. $Liabilities_{it}$ (Compustat item *LT*) is total liabilities for the firm at the end of year *t*. *Op* $Income_{it}$ (Compustat item *OAIDP)* is total operating income for the firm at year *t*. Consistent with Matsumura et al. (2014), we expect $Assets_{it}$ and *Op* $Income_{it}$ ($Liabilities_{it}$) to be positively (negatively) associated with firm value. *CDP* $Report_{it}$ is a dichotomous variable equal to 1 if the firm voluntarily reports GHG emissions to the CDP in year *t*, and 0 otherwise. Similarly, *Foreign* Ops_{it} (Compustat variable *PIFO*) is a dichotomous variable equal to 1 if total foreign source income for the firm at year *t* is positive, and 0 otherwise, and is included in our model to control for foreign operations.[12] Because GHG emissions are linked to a firm's industry, we include industry dummies based on two-digit SIC code as control variables. We winsorize all continuous variables at the top and bottom 5% to minimize the effect of outliers and utilize OLS regression with robust standard errors clustered by firm and year (Cameron et al., 2011; Thompson, 2011).[13]

4. Empirical results

4.1. Descriptive statistics and pairwise correlations

Table 2 presents descriptive statistics and pairwise correlations for the variables used in our analysis. The mean (median) market value of our sample firms is $13,973 ($4497) million, and the mean (median) annual GHG emissions are 3484 (425) metric kilotons. By contrast, Matsumura et al. (2014) report a higher mean (median) market value of $33,111 ($14,323) million and a higher mean (median) annual GHG emissions of 11,455 (1068) metric kilotons for the firms in their sample. We believe that this is to be expected because the Matsumura et al. (2014) sample is composed entirely of voluntary GHG reporters (which tend to be firms with larger market caps) while our sample is composed of all US firms (not just voluntary reporters) with GHG emissions.

Panel B of Table 2 presents pairwise correlations for the variables in our model. *Market* $Value_{it}$ is positively and significantly correlated with *GHG* $Emissions_{it}$ as well as with *CSR* $Score_{it}$, $Assets_{it}$, $Liabilities_{it}$, *Op* $Income_{it}$, *CDP* $Report_{it}$, and *Foreign* Ops_{it}. Not surprisingly, the correlations between the variables $Assets_{it}$, $Liabilities_{it}$, and *Op* $Income_{it}$ are high but comparable to those reported by Matsumura et al. (2014). Still, in our study, our focus is on the test interaction variable *(GHG* $Emissions_{it}$*)*(CSR* $Score_{it}$*)*. In all of our analyses below, we examine variance inflation factors (VIFs) in order to address any possible issues related to multicollinearity.

4.2. Regression results: firm value effects of GHG emissions and CSR score

Table 3 presents the primary results of our tests of Hypothesis 1. In Column (1), we omit variables *CSR* $Score_{it}$ and *(GHG* $Emissions_{it}$*) * (CSR* $Score_{it}$*)* from the regression to isolate the effects of GHG emissions on firm value. Consistent with prior literature (Matsumura et al., 2014; Clarkson et al., 2015; Griffin et al., 2017), *GHG* $Emissions_{it}$ is negatively and significantly associated with firm market value (-0.170, $p < 0.01$).[14] In Column (2), we report results for the full model and find that our test interaction variable *(GHG* $Emissions_{it}$*)*(CSR* $Score_{it}$*)* is significant with a *negative* sign (-0.059, $p < 0.01$). We interpret this finding as evidence

[12] We thank an anonymous participant at the 2016 AAA annual meeting for suggesting that this variable be added to the model. Observations with missing values for *Foreign* Ops_{it} are assumed to have no foreign income.

[13] We thank an anonymous reviewer for suggesting that we cluster our standard errors by firm and year.

[14] The results reported in Table 3 Column (1) suggest a market penalty of $0.17 (based on a reported coefficient of -0.170) for every metric kiloton of GHG emissions, which translates to $170 ($0.17 × 1000) per metric ton of GHG emissions. This finding is comparable (albeit smaller) to the results of Matsumura et al. (2014) who use a model similar to ours to estimate a market penalty of $212 per metric ton of GHG emissions. Because their study employs a sample consisting of only S&P500 firms for 2006–2008, the difference between the two estimates is likely related to differences in the two samples pertaining to voluntary vs. mandatory reporters as well as firm size. Specifically, Matsumura et al. (2014) report a median market cap of $16,013 million vs. our sample median of $4497 million. Separately, Griffin et al. (2017) use a modified version of the Ohlson (1995) valuation model, to estimate an average market penalty of $78.80 per ton of GHG emissions for their sample of S&P500 firms from 2006 to 2012. Using a similar model, Clarkson et al. (2015) report an even lower market penalty of approximately $45.24 per metric ton of GHG emissions for European firms from 2006 to 2009. Put briefly, when we apply the modified Ohlson (1995) valuation model to our sample, our results suggest a market penalty of $46.76 per metric ton of GHG emissions for firms at the median of our sample. This estimate is lower than the estimate made by Griffin et al. (2017) ($78.80 per ton) but very similar to the result of Clarkson et al. (2015) ($45.24 per ton). Similar to the differences between our primary results and that of Matsumura et al. (2014), we believe that the differences between our findings and those of Griffin et al. (2017) are attributable to differences in the samples pertaining to voluntary vs. mandatory reporting requirements and firm size.

Table 2
Descriptive statistics and pairwise correlations.

Panel A: Descriptive statistics	**Full sample (*N* = *1,566*)**				
Variables	**Mean**	**SD**	**1st Q**	**Med**	**3rd Q**
Market value *(millions)*	13,973	20,734	1,741	4,497	15,441
GHG emissions *(metric kilotons)*	3,484	6,711	88	425	2,762
CSR score *(strengths-concerns)*	0.95	3.05	−1.00	0.00	3.00
Accounting quality *(abs_da) * (−1)*	−0.03	−0.02	−0.01	−0.02	−0.04
Assets *(millions)*	16,227	20,969	2,426	5,873	21,703
Liabilities *(millions)*	10,281	13,687	1,436	3,597	13,419
Op income *(millions)*	1,410	2,066	144	458	1,656
CDP report *(dummy)*	0.34	0.47	0.00	0.00	1.00
Foreign ops *(dummy)*	0.51	0.50	0.00	1.00	1.00
ROA *(net income/assets)*	0.05	0.04	0.02	0.04	0.07
Age *(years)*	35	27	12	28	56

Panel B: Pairwise correlations	**Full sample (*N* = *1,566*)**										
Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1. Market value *(millions)*		**0.252**	**0.525**	**0.161**	**0.890**	**0.834**	**0.899**	**0.585**	**0.260**	**0.328**	**0.385**
2. GHG emissions *(metric kilotons)*	**0.127**		**0.065**	**0.055**	**0.385**	**0.405**	**0.274**	**0.166**	**−0.221**	**−0.143**	**0.130**
3. CSR score *(strengths-concerns)*	**0.491**	**0.087**		**0.119**	**0.485**	**0.461**	**0.482**	**0.487**	**0.163**	**0.145**	**0.304**
4. Accounting quality *(abs_da)*(−1)*	**0.143**	**0.081**	**0.145**		**0.183**	**0.187**	**0.217**	**0.152**	0.041	0.037	**0.184**
5. Assets *(millions)*	**0.857**	**0.322**	**0.462**	**0.172**		**0.978**	**0.873**	**0.589**	**0.115**	**0.060**	**0.395**
6. Liabilities *(millions)*	**0.784**	**0.354**	**0.427**	**0.188**	**0.968**		**0.838**	**0.579**	**0.078**	−0.012	**0.388**
7. Op income *(millions)*	**0.937**	**0.186**	**0.480**	**0.165**	**0.893**	**0.836**		**0.566**	**0.237**	**0.400**	**0.390**
8. CDP report *(dummy)*	**0.537**	**0.244**	**0.505**	**0.170**	**0.533**	**0.522**	**0.531**		**0.190**	**0.132**	**0.336**
9. Foreign ops *(dummy)*	**0.310**	**−0.162**	**0.180**	0.045	**0.168**	**0.112**	**0.284**	**0.190**		**0.381**	**0.139**
10. ROA *(net income/assets)*	**0.322**	**−0.115**	**0.196**	**0.068**	**0.108**	0.043	**0.333**	**0.136**	**0.347**		**0.113**
11. Age *(years)*	**0.389**	**0.182**	**0.317**	**0.197**	**0.418**	**0.434**	**0.406**	**0.345**	**0.147**	**0.108**	

Panel A provides descriptive statistics for variables used in Table 3 of our study. In Panel B, Pearson (Spearman) correlations are shown below (above) the diagonal. Correlations in bold are significant at the $p < 0.05$ level. See Appendix A for variable definitions.

Table 3
Firm value effect of GHG emissions and CSR.

Model for Column 1: $Market\ Value_{it} = \alpha_0 + \beta_1 GHG\ Emissions_{it} + \beta_2 Assets_{it} + \beta_3 Liabilities_{it} + \beta_4 Op\ Income_{it} + \beta_5 CDP\ Report_{it} + \beta_6 Foreign\ Ops_{it} + Industry\ Fixed\ Effects_{it} + \varepsilon_{it}$
Model for Column 2: $Market\ Value_{it} = \alpha_0 + \beta_1 GHG\ Emissions_{it} + \beta_2 CSR\ Score_{it} + \beta_3 (GHG\ Emissions_{it})*(CSR\ Score_{it}) + \beta_4 Assets_{it} + \beta_5 Liabilities_{it} + \beta_6 Op\ Income_{it} + \beta_7 CDP\ Report_{it} + \beta_8 Foreign\ Ops_{it} + Industry\ Fixed\ Effects_{it} + \varepsilon_{it}$

Variables	Exp. sign	Coefficient		Z-stat	Coefficient		Z-stat
$GHG\ Emissions_{it}$	−	−0.17	***	−3.63	−0.103	**	−1.99
$CSR\ Score_{it}$	+				250.154	**	2.51
$(GHG\ Emissions_{it})*(CSR\ Score_{it})$	**?**				**−0.059**	***	**−3.32**
$Assets_{it}$	+	0.532	***	7.13	0.526	***	6.86
$Liabilities_{it}$	−	−0.48	***	−4.37	−0.472	***	−4.21
$Op\ Income_{it}$	+	7.01	***	14.27	6.911	***	14.41
$CDP\ Report_{it}$	+	2,494.60	***	2.75	2,254.39	**	2.32
$Foreign\ Ops_{it}$	+	−240.48		−0.48	−179.809		−0.35
Intercept		−5,817.53	***	−2.72	−5,625.99	***	−2.68
Industry Fixed Effects		Yes			Yes		
N		1,566			1,566		
R^2		0.904			0.905		

*, **, ***Indicate significance at the $p < 0.10$, $p < 0.05$, and $p < 0.01$ levels, respectively, using two-tailed tests for all variables. Results for the interaction term are reported in bold for emphasis. Reported Z-statistics are adjusted to accommodate robust standard errors clustered by firm and year (Cameron et al., 2011; Thompson, 2011). Industry fixed effects are included, but not reported for brevity. The VIFs for the variables of interest, i.e., $GHG\ Emissions_{it}$, $CSR\ Score_{it}$, $(GHG\ Emissions_{it})*(CSR\ Score_{it})$, are below 3 for all reported analyses. See Appendix A for variable definitions.

Table 4
Firm value effect of GHG emissions and CSR score: grouped by profitability, firm size, firm age, and reporting years.

Panel A: Descriptive statistics and OLS results for sample grouped by profitability

	Firms with above median ROA		Firms with below median ROA		
Variables	Mean	Median	Mean	Median	*t*-test of means
Market Value *(millions)*	20,088	7,546	7,859	3,094	0.000***
GHG Emissions *(metric kilotons)*	2,385	271	4,584	675	0.000***
CSR Score *(strengths-concerns)*	1.319	1.000	0.568	0.000	0.000***
Assets *(millions)*	18,248	6,218	14,208	5,674	0.000***
Liabilities *(millions)*	10,812	3,511	9,751	3,649	0.125
Op Income *(millions)*	2,024	748	796	263	0.000***
CDP Report *(dummy)*	0.390	0.000	0.285	0.000	0.000***
Foreign Ops *(dummy)*	0.713	1.000	0.301	0.000	0.000***
ROA *(Net Income/Total Assets)*	0.081	0.073	0.011	0.021	0.000***
Age *(years)*	37.6	34.0	33.7	25.0	0.005***
N	783		783		

		Firms with Above Median ROA			Firms with Below Median ROA			Coefficient Difference		
Variables	Exp. sign	Coefficient		Z-stat	Coefficient		Z-stat	chi2		Prob > chi2
$GHG\ Emissions_{it}$	−	−0.131		−1.07	−0.038		−1.00	0.45		0.50
$CSR\ Score_{it}$	+	132.916		1.15	176.206		1.27	0.07		0.79
$(GHG\ Emissions_{it})*(CSR\ Score_{it})$	**?**	**−0.075**	**	**−2.09**	**−0.037**	***	**−2.73**	**1.25**		0.26
$Assets_{it}$	+	0.438	***	4.13	0.944	***	5.55	4.96	**	0.03
$Liabilities_{it}$	−	−0.265	**	−2.04	−0.958	***	−5.01	9.78	***	0.00
$Op\ Income_{it}$	+	6.803	***	8.76	4.884	***	4.64	1.69		0.19
$CDP\ Report_{it}$	+	4,695.257	***	2.61	−564.548		−1.45	7.75	***	0.01
$Foreign\ Ops_{it}$	+	24.957		0.03	−910.449		−1.32	0.90		0.34
Intercept		Yes			Yes					
Industry Fixed Effects		Yes			Yes					
N		783			783					
R^2		0.913			0.886					

(*continued on next page*)

Table 4 (*continued*)

Panel B: Descriptive statistics and OLS results for sample grouped by firm size

	Firms with above median market value		Firms with below median market value		
Variables	**Mean**	**Median**	**Mean**	**Median**	***t*-test of means**
Market value *(millions)*	25,995	15,442	1,952	1,741	0.000***
GHG emissions *(metric kilotons)*	5,195	905	1,774	229	0.000***
CSR score *(strengths-concerns)*	2.424	2.000	−0.519	0.000	0.000***
Assets *(millions)*	29,016	21,412	3,439	2,556	0.000***
Liabilities *(millions)*	18,252	12,945	2,311	1,571	0.000***
Op income *(millions)*	2,610	1,656	210	155	0.000***
CDP report *(dummy)*	0.576	1.000	0.098	0.000	0.000***
Foreign Ops *(dummy)*	0.415	1.000	0.599	0.000	0.000***
ROA *(Net Income/Total Assets)*	0.059	0.052	0.033	0.031	0.000***
Age *(years)*	44.7	48.0	26.6	20.0	0.000***
N	783		783		

		Firms with Above Median Market Value		Firms with Below Median Market Value		Coefficient difference	
Variables	**Exp. sign**	**Coefficient**	**Z-stat**	**Coefficient**	**Z-stat**	**chi2**	**Prob > chi2**
GHG Emissions$_{it}$	−	−0.105	−1.34	0.001	0.38	1.79	0.18
CSR Score$_{it}$	+	210.773	1.48	45.862***	2.85	1.32	0.25
(GHG Emissions$_{it}$)*(CSR Score$_{it}$)	**?**	**−0.059*****	**−2.86**	**−0.004**	**−0.76**	**5.40****	**0.02**
Assets$_{it}$	+	0.506***	5.57	0.290***	4.77	3.36*	0.07
Liabilities$_{it}$	−	−0.392***	−2.96	−0.209**	−2.04	0.91	0.34
Op Income$_{it}$	+	6.394***	14.10	2.583***	4.71	34.29***	0.00
CDP Report$_{it}$	+	3,297.383***	2.80	−137.501	−0.82	9.23***	0.00
Foreign Ops$_{it}$	+	−15.225	−0.01	114.975	0.83	0.01	0.91
Intercept		Yes		Yes			
Industry Fixed Effects		Yes		Yes			
N		783		783			
R^2		0.873		0.561			

Panel C: Descriptive statistics and OLS results for sample grouped by firm age

	Firms above median age		Firms below median age		
Variables	**Mean**	**Median**	**Mean**	**Median**	***t*-test of means**
Market value *(millions)*	19,505	7,884	8,371	2,962	0.000***
GHG emissions *(metric kilotons)*	4,300	581	2,658	277	0.000***
CSR score *(strengths-concerns)*	1.824	1.000	0.071	0.000	0.000***
Assets *(millions)*	22,365	11,899	10,012	3,839	0.000***
Liabilities *(millions)*	14,355	7,069	6,156	2,549	0.000***
Op income *(millions)*	1,997	846	815	242	0.000***
CDP report *(dummy)*	0.459	0.000	0.213	0.000	0.000***
Foreign Ops *(dummy)*	0.539	1.000	0.474	0.000	0.009***
ROA *(Net Income/Total Assets)*	0.050	0.042	0.041	0.037	0.000***
Age *(years)*	58.9	56.0	12.2	12.0	0.000***
N	788		778		

		Firms Above Median Age		Firms Below Median Age		Coefficient difference	
Variables	**Exp. sign**	**Coefficient**	**Z-stat**	**Coefficient**	**Z-stat**	**chi2**	**Prob > chi2**
GHG Emissions$_{it}$	−	−0.005	−0.09	−0.194***	−2.53	3.72**	0.05
CSR Score$_{it}$	+	154.258	1.18	483.563***	3.44	2.15	0.14
(GHG Emissions$_{it}$)*(CSR Score$_{it}$)	**?**	**−0.072****	−2.42	**−0.075*****	−3.29	**0.00**	0.95
Assets$_{it}$	+	0.471***	2.73	0.699***	3.41	0.36	0.55
Liabilities$_{it}$	−	−0.434**	−2.09	−0.735**	−2.43	0.34	0.56
Op Income$_{it}$	+	7.500***	13.15	5.856***	2.87	1.54	0.21
CDP Report$_{it}$	+	775.590	0.66	4,530.140***	4.23	6.85***	0.01
Foreign Ops$_{it}$	+	834.609	1.01	−424.778	−0.91	1.60	0.21
Intercept		Yes		Yes			
Industry Fixed Effects		Yes		Yes			
N		788		778			
R^2		0.927		0.843			

(*continued on next page*)

Table 4 (*continued*)

Panel D: Descriptive statistics and OLS results for sample grouped by reporting years

Variables	Firms reporting to EPA GHGRP in years 2010–2012 Mean	Median	Firms reporting to EPA GHGRP in years 2013–2014 Mean	Median	*t*-test of means
Market value *(millions)*	12,504	3,856	16,023	5,495	0.001***
GHG emissions *(metric kilotons)*	3,536	476	3,412	388	0.717
CSR score *(strengths-concerns)*	0.636	0.000	1.394	1.000	0.000*
Assets *(millions)*	15,343	5,394	17,461	6,550	0.049**
Liabilities *(millions)*	9,767	3,356	11,040	3,945	0.063*
Op income *(millions)*	1,371	430	1,465	497	0.371
CDP report *(dummy)*	0.330	0.000	0.347	0.000	0.482
Foreign Ops *(dummy)*	0.518	1.000	0.492	0.000	0.326
ROA *(Net Income/Total Assets)*	0.048	0.041	0.043	0.038	0.031**
Age *(years)*	36.0	29.5	35.2	27.0	0.558
N	912		654		

Variables	Exp. sign	Firms Reporting to GHGRP in Years 2010–2012 Coefficient	Z-stat	Firms Reporting to GHGRP in Years 2013–2014 Coefficient	Z-stat	Coefficient difference chi2	Prob > chi2
GHG Emissions$_{it}$	−	−0.110 *	−1.93	−0.112 *	−1.86	0.00	0.96
CSR Score$_{it}$	+	240.179 ***	2.46	207.469 **	2.02	0.18	0.67
(GHG Emissions$_{it}$)* (CSR Score$_{it}$)	**?**	**−0.037**	−1.62	**−0.067** ***	−11.70	**2.99** *	0.08
Assets$_{it}$	+	0.523 ***	6.18	0.505 ***	5.83	0.04	0.84
Liabilities$_{it}$	−	−0.446 ***	−3.27	−0.508 ***	−6.26	0.43	0.51
Op Income$_{it}$	+	6.587 ***	16.11	7.604 ***	12.26	2.63	0.10
CDP Report$_{it}$	+	841.603	1.29	4,005.423 ***	5.99	38.11 ***	0.00
Foreign Ops$_{it}$	+	−284.466	−0.46	392.763	1.50	1.00	0.32
Intercept		Yes		Yes			
Industry Fixed Effects		Yes		Yes			
N		912		654			
R^2		0.920		0.905			

*, **, and *** Indicate significance at the $p < 0.10$, $p < 0.05$, and $p < 0.01$ levels, respectively, using two-tailed tests for all variables. Results for the interaction term are reported in bold for emphasis. Reported Z-statistics are adjusted to accommodate robust standard errors clustered by firm and year (Cameron et al., 2011; Thompson, 2011). Industry fixed effects are included, but not reported for brevity. The VIFs for the three variables of interest *GHG Emissions$_{it}$*, *CSR Score$_{it}$*, and *(GHG Emissions$_{it}$)*(CSR Score$_{it}$)* are below 3 for all reported analyses. See Appendix A for variable definitions.

that GHG emitters suffer an additional market penalty when they have a reputation for CSR. In other words, for a given level of GHG emissions, the higher the CSR score, the greater the negative effect of the GHG emission on firm market value. Put differently, the evidence suggests that a reputation for CSR does *not* insulate the firm from the negative value consequences associated with GHG emissions. Rather, the evidence suggests that a reputation for CSR actually exacerbates the negative value effects associated with GHG emissions. Collectively, the findings suggest a fallen angel rather than a halo effect, i.e., the market perceives a dissonance between a company's reputation for CSR and its GHG emissions and imposes an additional value penalty on GHG emitters with a reputation for social responsibility.

Table 3, Column 2 suggests that on average one metric kiloton of GHG emissions is associated with a drop in firm market value of approximately $103,000 (−0.103 × $1 million) and that this drop in market value is increased by $59,000 (−0.059 × $1million) for every step up in the firm's CSR score. Thus, for a firm with a CSR score of 1.0, the economic effect is $162,000 ($103,000 + $59,000) per metric kiloton (or $162 per ton) increase in GHG emissions. For a firm that emits the median amount of 425 metric kilotons of GHG per year, as its CSR score increases from the first quartile value of −1.00 to the third quartile value of 2.0, the firm may be expected to suffer a market penalty of $75.2 million ($59,000 × 425 × 3.00) from just the interaction of GHG emissions and CSR score. That is, for a company increasing its CSR score from the first quartile to the third quartile, absent the interaction effect, firm value may be expected to increase by $750.5 million (250.154 × 3). However, with the interaction effect, for a firm emitting the median amount of 425 metric kilotons of GHG per year, the increase in firm value is expected to be lower by $75.2 million, i.e., 10% ($75.2/$750.5) *lower than what it would be otherwise* in the absence of the interaction effect. Thus, our findings suggest that the adverse firm value impact of the EPA-mandated GHG data for socially responsible firms is economically significant.

In Table 3, the coefficients on the control variables for all columns are consistent with predicted signs. Although the VIFs for variables *Assets$_{it}$* and *Liabilities$_{it}$* are predictably high (above 10), in column (1) the VIF for *GHG Emissions$_{it}$* is only 2.08. Similarly, in column (2) the VIFs for *GHG Emissions$_{it}$*, *CSR Score$_{it}$*, and *(GHG Emissions$_{it}$)*(CSR Score$_{it}$)* are only 2.97, 2.53, and 2.54, respectively. Hence, we believe that collinearity is not a significant issue in interpreting our findings. Separately (and as noted previously), the

Table 5
Sensitivity test: firm value effect of GHG emissions and accounting quality.

	Accounting Quality (Continuous Variable)			High Accounting Quality (Dummy Variable)		
Variables	**Coefficient**		**Z-stat**	**Coefficient**		**Z-stat**
GHG Emissions$_{it}$	−0.301	***	−3.69	−0.110	***	−2.77
Accounting Quality$_{it}$	3258.576		0.44			
(GHG Emissions$_{it}$)*(Accounting Quality$_{it}$)	**−5.871**	**	**−2.22**			
High AQ Dummy$_{it}$				417.909		1.25
(GHG Emissions$_{it}$)*(High AQ Dummy$_{it}$)				**−0.240**	***	**−2.77**
Assets$_{it}$	0.523	***	7.06	0.535	***	7.13
Liabilities$_{it}$	−0.467	***	−4.24	−0.479	***	−4.28
Op Income$_{it}$	7.027	***	14.39	6.985	***	14.43
CDP Report$_{it}$	2,522.985	***	2.74	2,520.005	***	2.81
Foreign Ops$_{it}$	−239.537		−0.50	−253.289		−0.52
Intercept	Yes			Yes		
Industry Fixed Effects	Yes			Yes		
N	1,566			1,566		
R^2	0.905			0.905		

*, **, ***Indicate significance at the $p < 0.10$, $p < 0.05$, and $p < 0.01$ levels, respectively, using two-tailed tests for all variables. Results for the interaction terms are reported in bold for emphasis. Reported Z-statistics are adjusted to accommodate robust standard errors clustered by firm and year (Cameron et al., 2011; Thompson, 2011). Industry fixed effects are included, but not reported for brevity. The VIFs for the variables of interest, i.e., *Accounting Quality$_{it}$*, *High AQ Dummy$_{it}$*, *(GHG Emissions$_{it}$)*(Accounting Quality$_{it}$)*, and *(GHG Emissions$_{it}$)*(High AQ Dummy$_{it}$)* are below 6 for Column 1 and below 3 for Column 2. See Appendix A for variable definitions.

environmental component of the CSR score excludes GHG emissions because the GHG data are relatively new. Still, in additional analysis (untabulated), when we modify the CSR score to exclude its environmental component our findings with respect to our variables of interest (*GHG Emissions$_{it}$*, *CSR Score$_{it}$*, and *GHG Emissions$_{it}$)*(CSR Score$_{it}$)* continue to hold.

4.3. Regression results with partitions by profitability, size, age, and reporting years

We argue that the negative coefficient on the interaction between *GHG Emissions$_{it}$* and *CSR Score$_{it}$* reported in Table 3 is evidence of a “fallen angel” effect. However, it is possible that this is the result of an underlying correlation between “angel” firms and characteristics that impact both CSR score and GHG emissions valuation. We identify several such characteristics, including profitability, size, firm age, and GHGRP reporting years, and examine whether these cause the coefficient on the interaction term to vary. Results are reported in Table 4. Overall, we find the effect to be more important for firms that are larger in size, and during the later GHGRP years.

Table 4, Panel A presents regression results for our sample partitioned by profitability, i.e., above and below the median ROA. We include this analysis because more profitable firms may be viewed more favorably by investors and a stronger interaction between GHG emissions and CSR score for these firms could possibly inform our hypothesis. The descriptive statistics show that the high and low profitability groups are significantly different in terms of market value, GHG emissions, CSR score and most of the control variables. In both partitions, the coefficient on the interaction term *(GHG Emissions$_{it}$)*(CSR Score$_{it}$)* is negative and significant; however the coefficients for the interaction term for the high and low profitability groups are not significantly different (chi2 = 1.25, prob > chi2 = 0.26).

In Table 4, Panel B we present the results of our regression when the sample is partitioned by size (as proxied by year-end market value). Firms above and below the median market value of $4.497 million are in the large and small firm groups, respectively. Though the coefficient on the interaction between GHG emissions and CSR score is negative for both groups (large = −0.059, small = −0.004), it is only significant for the large firm group. We attribute this result to the increased visibility of these firms in the market and the relative importance of voluntary emissions reporting revealed by the positive and significant coefficient on *CDP Report$_{it}$* (3279.383, $p < 0.01$).

Table 4, Panel C shows our results when the sample is partitioned by median firm age. Firms above the median age are included in the “older firm” group and firms at or below the median age are included in the “younger firm” group. The coefficient for *(GHG Emissions$_{it}$)*(CSR Score$_{it}$)* is −0.072 ($p < 0.05$) for the older firm group and −0.075 ($p < 0.01$) for the younger firm group; however, the two coefficients are not significantly different.

In Table 4, Panel D, we partition our sample into earlier (2010–2012) and later (2013–2014) years of the EPA’s mandatory GHG reporting program. The earlier- and later-years sub-samples have 912 and 654 observations, respectively. The test interaction variable *(GHG Emissions$_{it}$)*(CSR Score$_{it}$)* is negatively associated with firm market value for both sub-samples (−0.037, −0.067) albeit significant only in the later-years sub-sample. Additionally, the last column shows that the coefficient of our test interaction variable *(GHG Emissions$_{it}$)*(CSR Score$_{it}$)* is significantly different between the earlier- and later-years sub-samples. We interpret this finding as evidence that GHG emitters with a reputation for CSR suffered the additional market penalty only in the later-years when there was more awareness and/or more scrutiny of GHG emissions and CSR-related activities. For completeness, we note that collinearity does not appear to be an issue in interpreting our findings for Table 4 as the VIFs for *GHG Emissions$_{it}$*, *CSR Score$_{it}$*, and the test variable *(GHG Emissions$_{it}$) * (CSR Score$_{it}$)* are below 5 for all panels.

Table 6
Sensitivity test: non-linear relation between CSR and the impact of GHG emissions on firm value.

Variables	Coefficient		Z-stat
GHG Emissions$_{it}$	−0.084		−1.55
CSR Score$_{it}$	201.073	***	2.81
(GHG Emissions$_{it}$)*(CSR Score$_{it}$)	**−0.043**	**	**−2.41**
CSR Score$^2_{it}$	15.510		0.81
(GHG Emissions$_{it}$)*(CSR Score$^2_{it}$)	**−0.007**	*	**−1.71**
Assets$_{it}$	0.528	***	6.88
Liabilities$_{it}$	−0.471	***	−4.22
Op Income$_{it}$	6.891	***	14.22
CDP Report$_{it}$	2,245.532	**	2.30
Foreign Ops$_{it}$	−199.224		−0.39
Intercept	Yes		
Industry Fixed Effects	Yes		
N	1,566		
R^2	0.905		

*, **, ***Indicate significance at the $p < 0.10$, $p < 0.05$, and $p < 0.01$ levels, respectively, using two-tailed tests for all variables. Results for the interaction terms are reported in bold for emphasis. Reported Z-statistics are adjusted to accommodate robust standard errors clustered by firm and year (Cameron et al., 2011; Thompson, 2011). Industry fixed effects are included, but not reported for brevity. The VIFs for the variables of interest are all below 4. See Appendix A for variable definitions.

4.4. Sensitivity tests

As our paper (to our knowledge) is the first to observe and report on the fallen angel effect related to the interaction of GHG emissions and CSR performance, we seek to validate our findings by finding a proxy for "angel" firms. We utilize *Accounting Quality$_{it}$*, (measured as the absolute value of discretionary accruals) as a proxy for firms' *CSR score$_{it}$* in our model and find that our results (reported in Table 5) are consistent with our previous analyses. Further, when we use a dichotomous form of the *Accounting Quality$_{it}$* variable, i.e., =1 when accounting quality is high (absolute value of discretionary accruals is below median), and 0 otherwise, our results continue to hold. In Table 5, the coefficients on the interaction terms are −5.871 and −0.240 for the two models, respectively, and they are both statistically significant supporting H1.

Finally, the relation between the CSR score and the valuation impact of GHG emissions may be non-linear which could potentially impact the coefficient on the interaction term *GHG Emissions$_{it}$ * CSR Score$_{it}$*. Specifically, in examining the relationship between *Market Value* and *GHG Emission*, we find that d*Market Value$_{it}$*/d*GHG Emissions$_{it}$* is a quadratic function of *CSR Score$_{it}$* and that the curve is concave. Hence, we include *CSR Score$^2_{it}$* and *(GHG Emissions$_{it}$)*(CSR Score$^2_{it}$)* as regressors in our primary model and report the results as a sensitivity test in Table 6. Consistent with our previous inferences, in Table 6 the coefficients on both *(GHG Emissions$_{it}$)* (CSR Score$_{it}$)* and *(GHG Emissions$_{it}$)*(CSR Score$^2_{it}$)* are significantly negative (−0.043, $p < 0.05$; −0.007, $p < 0.10$).

5. Concluding remarks

Beginning in 2010, the EPA *requires* US companies to report their GHG emissions. Although GHG emissions are not toxic, they are perceived to be a negative externality, i.e., have negative consequences for society at large by contributing to potential climate change. Further, these emissions represent a potential cash drain from the firm as a result of exposure to future regulatory, abatement, and compliance costs associated with these emissions. To our knowledge, ours is the first study (1) to examine the market value effects associated with the EPA-mandated data, and (2) to utilize these data for 2010–2014 to examine whether the adverse firm value impact of GHG emissions is alleviated or exacerbated by the firm's reputation for social responsibility.

Potentially, the firm's reputation for social responsibility (as reflected in its CSR score) could have a "halo effect" that essentially insulates the firm from the adverse market value effects of the EPA-mandated GHG data. Alternatively, the firm's reputation for social responsibility (as reflected in its CSR score) could be associated with "greenwashing" and a resulting overly positive impression about the firm's social performance. Consequently, the GHG emission data could have a disillusioning (or "fallen angel" effect) that worsens the negative market value effect of these emissions by denting the firm's reputation for social responsibility.

Our findings are consistent with the fallen angel effect, i.e., we find that for any given level of GHG emissions, the higher the firm's CSR score, the greater the adverse impact on firm value. Our findings suggest that the newly EPA-mandated data remove some of the gloss from companies that were previously viewed positively by investors for their corporate social performance. Consequently, the adverse impact on the firm's equity is greater for firms with higher CSR scores, i.e., the decline in firm value captures not only the impact of the GHG emissions but also the hit to the firm's reputation for social responsibility triggered by the GHG data.

Put differently, we find that there is a dual price to pay that is associated with GHG emissions, i.e., a discount to firm value that is linked to the future negative cash flows associated with these emissions (as a result of exposure to future regulatory, abatement, and compliance costs associated with these emissions) plus an additional discount to firm value that is linked to the decline in the firm's reputation for corporate social responsibility. Other things being equal, the greater the firm's reputation (as measured by its CSR score), the greater the decline in firm value for any given level of GHG emissions. By providing scholarly evidence on the existence of a fallen angel effect, our findings suggest that corporate boards and managers of firms with a reputation for being socially responsible cannot afford to be complacent about their GHG emissions.

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Appendix A. Variable definitions

Variable	Definition
$Accounting\ Quality_{it}$	$Accounting\ Quality_{it}$ is measured by the absolute value of discretionary accruals in year t multiplied by (-1), i.e., the *higher* the metric, the *higher* the accounting quality. Discretionary accruals (*DA*) are defined as the residual from the modified Jones model with lagged *ROA* included as a regressor (Jones, 1991; DeFond and Subramanyam, 1998; Kothari et al., 2005; Kim et al., 2012). $TA_{it}/AT_{it-1} = \alpha_0(1/AT_{it-1}) + \alpha_1[(\Delta REV_{it} - \Delta REC_{it})/AT_{it-1}] + \alpha_2(PPE_{it}/AT_{it-1}) + \alpha_3(ROA_{it-1}) + \varepsilon_{it}$ where for firm i in year t: TA_{it} = total accruals calculated as the difference between net income (in millions of dollars) for year t and cash flow from operating activities (in millions of dollars) for year t ($IB_{it} - OANCF_{it}$) AT_{it-1} = total assets (in millions of dollars) at the end of year $t-1$ (AT_{it-1}) ΔREV_{it} = change in revenue (in millions of dollars) from year $t-1$ to year t ($SALE_{it}$–$SALE_{it-1}$) ΔREC_{it} = change in accounts receivable (in millions of dollars) from year $t-1$ to year t ($RECT_{it} - RECT_{it-1}$) PPE_{it} = gross property, plant, and equipment (in millions of dollars) at the end of year t ($PPEGT_{it}$) ROA_{it-1} = return on assets for year $t-1$ calculated as net income (in millions of dollars) for year $t-1$ divided by total assets (in millions of dollars) at the end of year $t-1$ (IB_{it-1}/AT_{it-1})
Age_{it}	Number of years between the firm's earliest data in the CRSP database and year t
$Assets_{it}$	Total assets (in millions of dollars) at the end of year t (AT_{it})
$CDP\ Report_{it}$	A dichotomous variable equal to 1 if the company voluntarily reports GHG emissions to the Carbon Disclosure Project (CDP) for year t, and 0 otherwise
$CSR\ Score_{it}$	Total number of strengths minus the total number of concerns in the areas of community, diversity, employee relations, environment, corporate governance, and products quality as reported in the MSCI (KLD) database for year t
$Foreign\ Ops_{it}$	A dichotomous variable equal to 1 if total pretax foreign income ($PIFO_{it}$) for year t is greater than 0; 0 otherwise
$GHG\ Emissions_{it}$	The firm's annual greenhouse gas (GHG) emissions (in metric kilotons) during year t. It is calculated by aggregating GHG emissions for all Environmental Protection Agency (EPA) Greenhouse Gas Reporting Program (GHGRP) facilities the company controls. If a GHGRP facility does not have a majority owner (i.e., greater than 50% ownership) the facility's emissions are excluded from our study. The data are available from the EPA website (www.epa.gov)
$High\ AQ\ Dummy_{it}$	A dichotomous variable equal to 1 if variable $Accounting\ Quality_{it}$ (defined previously) is above the median, 0 otherwise
$Liabilities_{it}$	Total liabilities (in millions of dollars) at the end of year t (LT_{it})
$Market\ Value_{it}$	Market price per common share multiplied by shares outstanding (in millions of dollars) at the end of year t ($PRCC\_F_{it} * CSHO_{it}$)
$Op\ Income_{it}$	Total operating income (in millions of dollars) for year t ($OIADP_{it}$)
ROA_{it}	Net income (in millions of dollars) for year t divided by total assets (in millions of dollars) at the end of year t (IB_{it}/AT_{it})

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