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Article

The determinants and incentives of corporate greenhouse gas emission reduction

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SUMMARY

This study used hand-collected Greenhouse gas (GHG) emissions data from the Environmental Protection Agency (EPA) and aimed to understand the determinants and incentives of GHG emissions reduction. It explored how companies' financials, Chief Executive Officer (CEO) compensation, and corporate governance affected GHG emissions. Results showed that companies reporting GHG emissions were wide-spread among the 48 industries represented by two-digit Standard Industrial Classification (SIC) codes. Companies in the industries with high litigation risks and companies with higher profits tended to have lower GHG emissions. Larger property, plant, and equipment values contributed to higher GHG emissions. Furthermore, companies used compensation incentives to reduce the levels of GHG emissions as evidenced by the negative correlation between GHG emissions and executive compensation (including bonus, stock options and restricted stocks). Lastly, corporate governance affected GHG emission levels. Boards with directors of longer tenure and more female directors were more likely to curb GHG emissions. My study contributed to finding ways to incentivize companies to reduce GHG emissions.

INTRODUCTION

The purpose of this study was to investigate the determinants and incentives of corporate greenhouse gas (GHG) emission reduction. Global warming, the long-term rise in the average temperature of the Earth's climate, has attracted the attention of scientists, news media, politicians, and the public. Anthropogenic release of GHG causes global warming and changes in all components of the climate system (1, 2). Greenhouse gases, such as carbon dioxide, methane, and water vapor can cause the greenhouse effect, thereby increasing the global surface temperature. GHG emissions are perceived to have negative consequences for society at large by contributing to global warming and may cause a potential cash drain by exposing emitters to future regulatory, abatement, and compliance costs (3). GHG emitters are penalized by investors in U.S. equity markets (4, 5). Hence, reducing GHG emissions may benefit corporations, at least to some extent, by stopping the potential cash drain and reducing stock market penalization.

The classic theory suggests that the purpose of a corporation is to maximize profits for shareholders (6). However, in recent years, another school of literature suggests that corporations should consider not only profits, but also people and the planet. Corporate social responsibility (CSR) is an important aspect of business that aims to contribute to societal goals of environmental responsibility, community involvement, employee relations, diversity promotion, product quality, and corporate governance (7). With the influence of CSR, companies can expand their focus from shareholders to stakeholders, e.g., employees, suppliers, communities, and the environment. GHG emissions reduction clearly falls into the dimension of environmental responsibility and communal interests. As mentioned above, GHG emissions could be a potential cash drain due to regulatory and other related issues. For example, oil & gas companies as well as chemical companies emit large amounts of GHG and are litigation targets (8). Many companies are responding to societal pressures, thus are switching to greener business strategies. BlackRock, the largest investment management company (managing > $7 trillion assets and heavily invested in fossil fuels and greenhouse gas emitting companies), recently joined Climate Action 100+ and has pressured fossil fuel producers and consumers to show how they will reduce GHG emissions (9).

On the one hand, CSR investments are efficient from the shareholders' perspective (10). Responsible social performance, such as reducing GHG emissions, can lead companies to obtain better resources, higher-quality employees, and better marketing of products and services (11, 12). Enhanced sustainability performance can also mitigate the likelihood of negative regulatory, legislative, or fiscal action, and enhance corporate reputation. Thus, firms reducing GHG emissions may build goodwill which can lower, if not prevent, harm from negative events and dampen the potential negative consequence for firm value due to GHG emissions. On the other hand, the minimum requirements for what is perceived to be responsible social performance have been increasing (13). What may have once been perceived as exceptional practice may now be perceived as no more than the current norm. Sustainability investments disproportionately raise a firm's costs, creating a disadvantage in a competitive market, which can actually lower firms' value in the equity market (14). Despite these negative consequences, managers might pursue CSR out of self-interest or economic egoism of the organization to capture private benefits, or perhaps they have certain individual political beliefs. For these reasons this study tried to shed some light on why firms voluntarily reduce GHG emissions, and what factors are associated with GHG emission reduction to better understand firm behavior.

The risk of litigations affects corporate decisions, which influence company policies on GHG emissions. Not only are these litigations huge cash drains, but the negative media coverage could damage the company's reputation. It is expected that many more lawsuits associated with global warming will be filed in the future targeting GHG emitters. Individuals could bring suits against state and federal governments to enforce GHG regulations against companies, and state and federal governments could also take regulatory actions against companies. In addition, shareholders who suffer financial losses due to GHG-related issues and activists who are concerned about environmental and social impact could file suits against companies with high GHG emissions. I expected GHG emitters to reduce GHG emissions if they operate in industries that face high litigation risk and therefore hypothesized that GHG emissions levels are negatively associated with litigation risks.

Of all GHG emissions in 2018, the EPA reported that the primary sources are transportation (28.2%) and electricity production (26.9%) (15). 23.78% of the sample firms in my study were in the transportation and public utilities industries. GHG emissions from transportation primarily came from burning fossil fuel for transportation vehicles and electricity comes from burning fossil fuels. I expected larger facilities with more property, plants and equipment to generate more GHG emissions. To reduce GHG emissions while maintaining sales revenue, the emitters are likely to improve the efficiency of their facilities by making large capital investments. Profitable companies are more likely to devote resources in these improvement projects to reduce GHG emissions. On the other hand, taxes on GHG emissions, increased operating costs, and regulatory compliance costs may result in reduced profit for high emission companies, signaling a negative association between GHG emission levels and profitability. Because there were opposite predictions on the relationship between GHG emissions and profitability, my hypothesis is nondirectional. Based on the above arguments, I hypothesized that GHG emission levels are positively associated with property, plant, and equipment and GHG emission levels are associated with profitability.

Compensation packages are intended to promote the growth of shareholder wealth. The structure of compensation contracts reflects the priorities in managerial actions to increase firm value (16). GHG emissions may be a source of liability which significantly affect future firm profitability and stock returns for shareholders (17). In the long run, social and environmental issues can become material financial issues of the company. Therefore, executive compensation including bonus, stock options, and restricted stocks can be designed to incentivize managers to reduce GHG emissions to maximize shareholder value (18). Incorporating GHG criteria in compensation has become a relatively recent practice in corporate governance (18). I expected that lower GHG emissions levels are associated with higher incentive compensation. This is consistent with using incentives to encourage managers to direct their efforts to long-term value creation. I thus hypothesized that GHG emission levels are negatively associated with CEO compensation.

The responsibilities of the board of directors include setting the values of the company, managing business strategies, monitoring and assessing business risks, and optimizing firm performance. As a top management body, the board of directors is involved in developing and implementing GHG policies that aim to mitigate GHG emissions, because they are closely linked to the corporate image. Shareholders groups and institutional investors have incorporated director tenure considerations into their company evaluations and voting recommendations. Directors are more powerful when they stay on the board longer, since they are more familiar with the operation of the business and have more "clout" in the operation (19). Therefore, I expected firms with higher average director tenure to have lower GHG emission levels. In addition, prior studies found that female directors influence the probability of climate change-related disclosures (20). Companies with female directors on their boards are more likely to address the emerging strategic issue of GHG emissions and communicate this action to stakeholders (21). I therefore expected GHG emissions levels to be lower if a firm has higher percentage of female directors on the board. I hypothesized that GHG emissions levels are negatively associated with the director tenure and the percentage of female directors on the board.

I found that companies reporting GHG emissions were wide-spread in 48 industries represented by two-digit SIC codes. The most prevalent industries include Electric, Gas & Sanitary Services, Oil & Gas Extraction, and Chemical & Allied Products. Based on multivariate analysis results, I found that companies in the industries with high litigation risks and companies with higher profits tended to have lower GHG emissions. Larger property, plant, and equipment contributed to higher amounts of GHG emissions. Further, companies used compensation incentives to reduce the level of GHG emissions as evidenced by the negative correlation between GHG emissions and executive compensation including bonus, stock options and restricted stocks. Lastly, I found that corporate governance affected GHG emission levels. Boards with directors having longer tenure and more female directors were more likely to curb GHG emissions. My findings contribute to finding ways to incentivize companies to reduce GHG emissions.

RESULTS

My analysis was based on a sample of companies drawn from the EPA's GHG Reporting Program (GHGRP) database from the EPA (15). Approximately 8,000 facilities that emit more than 25,000 metric tons of carbon dioxide annually were

Variable	Observations	Mean	Q1	Median	Q3
Emission	1,155	5,772,810.6	97,287.5	536,550.3	4,216,791.3
logEmission	1,155	13.385	11.485	13.193	15.255
Litigation	1,155	0.107	0	0	0
ROA	1,155	0.057	0.026	0.047	0.084
NetPPE	1,155	10,462.6	1,155.4	3,735.5	11,153.4
PPE(Scaled)	1,155	0.492	0.249	0.452	0.722
Bonuses	1,155	231.8	0	0	0
logBonus	1,155	1.009	0	0	0
StockOption	1,155	1,209.1	0	208.2	1,766.7
logStockOption	1,155	3.770	0	5.343	7.477
RestrictedStock	1,155	3,431.8	980.0	2,655.4	5,000.0
logRestrictedStock	1,155	6.848	6.889	7.885	8.517
Analysts	1,155	8.466	0	6.333	15.583
logAnalysts	1,155	1.502	0	1.992	2.808
Duality	1,155	0.615	0	1	1
DirectorTenure	1,155	8.399	6.333	8.200	10.250
logDirectorTenure	1,155	2.181	1.992	2.219	2.420
FemaleDirector%	1,155	0.153	0.091	0.167	0.222
Debt	1,155	0.306	0.204	0.299	0.388
TotalAssets	1,155	31,030.1	3,328.0	9,598.0	31,269.0
Size	1,155	9.226	8.110	9.169	10.350
BTM	1,155	0.531	0.325	0.497	0.692
R&DExpenses	1,155	430.7	0	0	114.7
R&DExpenses(Scaled)	1,155	0.016	0	0	0.015
Cash&CashEquivalent	1,155	2,826.7	92.7	379.0	1,642.0
Cash (Scaled)	1,155	0.089	0.015	0.056	0.122
SalesRevenues	1,155	17,460.9	1,931.2	5,591.4	15,320.0
Sales(Scaled)	1,155	0.776	0.358	0.653	1.030

Table 1: Descriptive statistics for 24 firm characteristic and emissions metrics. The number of observations, mean, median, and first and third quartiles of variables used in all models are presented. The variable definitions are presented in the Methods section.

required to report their emissions to the EPA. The sample was further reduced by merging with financial, compensation, analyst forecast, and compensation datasets. The sample selection process biased the final sample towards larger, more established companies. One disadvantage of this was that it limited the cross-sectional variations in firm characteristics. Nevertheless, firms participating in the GHG Reporting Program constituted over an estimated 85–90% of the total U.S. GHG emissions (22) and were thus worthwhile investigating in their own right.

The mean annual GHG emission for the sample was 5.7 million tons reported to the EPA. 10.7% of sample firms were in the industries that have high litigation risks (Table 1). The average firm's Return on Investment (ROA) was 0.057. Mean annual CEO bonus, stock options, and restricted stock were 231.8 thousand dollars, 1.2 million dollars, and 3.4 million dollars, respectively. A typical sample firm had about eight analysts following. In 61.5% of firms, the CEO was also chairman of the board, and the average director tenure was 8 years. An average board consisted of 15.3% female directors. The average size of the firm, as measured by total assets, was 31 million. Average sales revenue was 12.5 million dollars. The most prevalent industries in the sample, as defined by two-digit Standard Industrial Classification (SIC) codes for GHG emission companies included Electric, Gas & Sanitary Services (22%), Oil & Gas Extraction (15%), and Chemical & Allied Products (11%) (Table 2). Results showed that companies reporting GHG emissions were wide-spread among all industries.

I first conducted univariate regression analyses where I regressed GHG emission levels on variables of interests, one at a time. GHG emissions were negatively associated

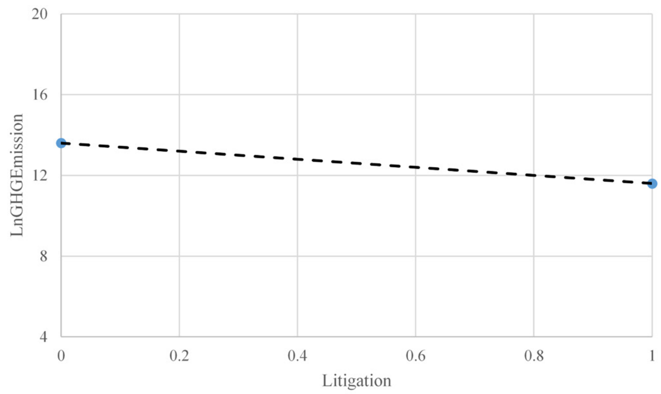

Figure 1: Correlation between GHG emissions and litigation risks. Univariate analysis results show a negative correlation between GHG emissions and litigation risks. Litigation is an indicator variable equal to one if the company is in the following industries: biotech (SIC codes 2833-2836 and 8731-8734), computer (3570-3577 and 7370-7374), electronics (3600-3674), and retail (5200-5961), and zero otherwise.

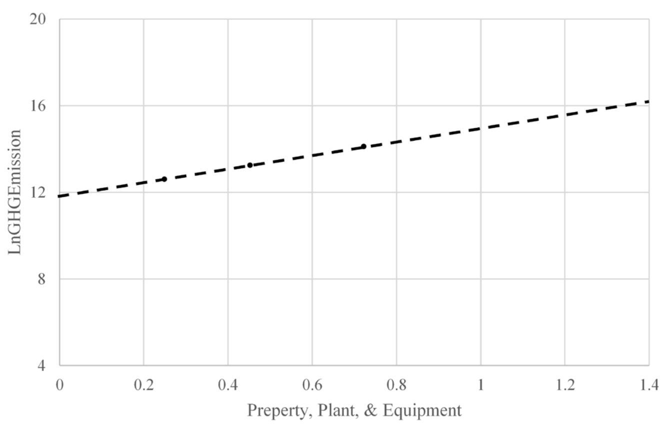

Figure 3: Correlation between GHG emissions and PP&E. Univariate analysis results show a positive correlation between GHG emissions and PP&E. PP&E is measured as net value of property, plant, and equipment divided by total assets.

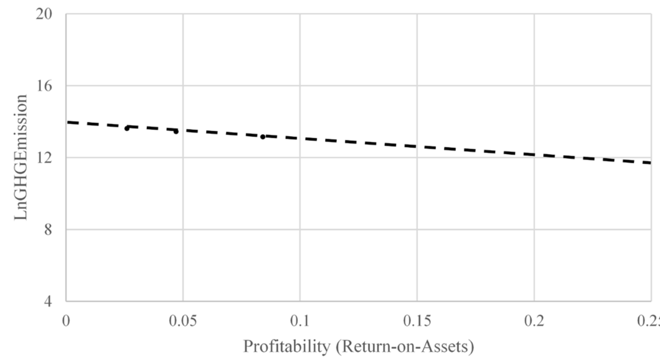

Figure 2: Correlation between GHG emissions and ROA. Univariate analysis results show a negative correlation between GHG emissions and ROA. ROA is return-on-asset ratio, calculated as net income over total assets.

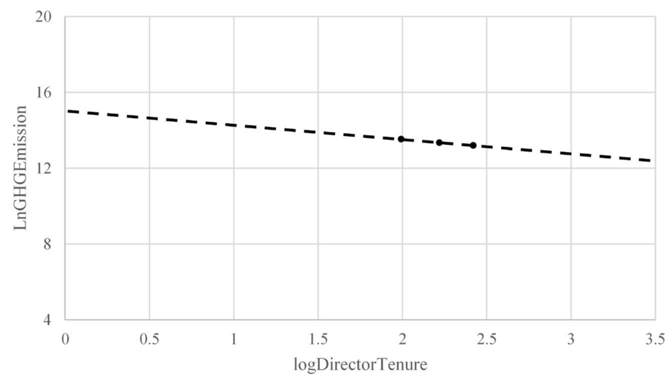

Figure 4: Correlation between GHG emissions and director tenure. Univariate analysis results show a negative correlation between GHG emissions and director tenure. Director tenure is measured as the natural logarithm of the average number of years a director has served on the board.

with litigation, ROA, and director tenure (Figures 1, 2, and 4) and were positively associated with PPE (Figure 3). I then ran a multivariate regression model that included all factors related to GHG emission levels including financial, compensation, and corporate governance factors. For the whole sample, Litigation was negatively associated with the level of GHG emissions (regression coefficient = -1.084, $p < 0.01$), consistent with the hypothesis that companies in the industries with high litigation risk are likely to have lower GHG emission levels (Table 3). The coefficient of ROA was negative and significant (coefficient = -4.822, $p < 0.01$), indicating that firms with higher profitability tended to have lower GHG emissions. The coefficient of Property, Plants and Equipment (PPE) was positive and significant (coefficient = 3.449, $p < 0.01$), supporting the hypothesis that firms with higher property, plant, and equity amounts are likely to have higher levels of GHG emissions. As for compensation variables, the coefficients of LogBonus and logRestrictedStocks were both negative and significant (coefficient = -0.103, $p < 0.01$; coefficient = -0.047, $p < 0.01$), indicating that managers were incentivized to reduce GHG emissions. The coefficients of logDirectorTenure and FemaleDirector% were both negative and significant (coefficient = -0.463, $p < 0.01$; coefficient = -1.370, $p < 0.01$), indicating that the board of directors impacted the level of GHG emissions. The results also indicated that other firm characteristics, such as debt to assets ratio, the size of the company, and sales revenues impacted GHG emission levels.

In additional analyses, I ran the regression on the manufacturing and transportation industries, which have the highest number of firms. The results are similar to those reported in Table 2, with the exception that stock options, rather than restricted stocks, are positively related to GHG emissions (coefficient = 0.031, $p < 0.072$). I also ran the model using the manufacturing industry only, the industry with the most firms. Again, the results did not change except that stock options, instead of restricted stocks, were statistically significant (coefficient = 0.045, $p < 0.05$).

Industries	Firms	Percentage	Industries	Firms	Percentage
A. Agriculture, Forestry, & Fishing			**E. Transportation & Public Utilities**		
01 Agricultural Production – Crops	1	0.16%	40 Railroad Transportation	1	0.16%
B. Mining			44 Water Transportation	1	0.16%
10 Metal, Mining	9	1.40%	45 Transportation by Air	4	0.62%
12 Coal Mining	11	1.71%	46 Pipelines, Except Natural Gas	2	0.31%
13 Oil & Gas Extraction	97	15.06%	48 Communications	2	0.31%
14 Nonmetallic Minerals, Except Fuels	9	1.40%	49 Electric, Gas, & Sanitary Services	143	22.20%
C. Construction			**F. Wholesale Trade**		
16 Heavy Construction, Except Building	2	0.31%	50 Wholesale Trade – Durable Goods	3	0.47%
17 Special Trade Contractors	2	0.31%	51 Wholesale Trade – Nondurable Goods	9	1.40%
D. Manufacturing			**G. Retail Trade**		
20 Food & Kindred Products	33	5.12%	55 Automative Dealers & Service Stations	1	0.16%
21 Tobacco Products	2	0.31%	58 Eating & Drinking Places	1	0.16%
22 Textile Mill Products	2	0.31%	59 Miscellaneous Retail	2	0.31%
24 Lumber & Wood Products	6	0.93%	**H. Finance, Insurance, & Real Estate**		
25 Furniture & Fixtures	2	0.31%	60 Depository Institutions	3	0.47%
26 Paper & Allied Products	24	3.73%	61 Nondepository Institutions	1	0.16%
27 Printing & Publishing	2	0.31%	62 Security & Commodity Brokers	4	0.62%
28 Chemical & Allied Products	74	11.49%	63 Insurance Carriers	2	0.31%
29 Petroleum & Coal Products	30	4.66%	65 Real Estate	1	0.16%
30 Rubber & Misc. Plastics Products	4	0.62%	67 Holding & Other Investment Offices	5	0.78%
32 Stone, Clay, & Glass Products	15	2.33%	**I. Services**		
33 Primary Metal Industries	29	4.50%	73 Business Services	6	0.93%
34 Fabricated Metal Products	5	0.78%	75 Auto Repair, Services, & Parking	1	0.16%
35 Industrial Machinery & Equipment	20	3.11%	79 Amusement & Recreation Services	2	0.31%
36 Electronic & Other Electric Equipment	31	4.81%	80 Health Services	3	0.47%
37 Transportation Equipment	26	4.04%	87 Engineering & Management Services	3	0.47%
38 Instruments & Related Products	2	0.31%	K. Nonclassifiable Establishments		
39 Miscellaneous Manufacturing Industries	1	0.16%	99 Non-Classifiable Establishments	5	0.78%
			Total Number of Companies	644	100%

Table 2: Industry Distribution of Greenhouse Gases Emitting Firms. Industry distribution of greenhouse gases emitting firms was presented where industry was defined by two-digit SIC codes. The most prevalent industries in the sample included Electric, Gas & Sanitary Services, Oil & Gas Extraction, and Chemical & Allied Products.

To address the potential issue of multicollinearity, I applied several approaches to ensure that estimates of the regression coefficients were not biased. First, I calculated Pearson and Spearman correlations between all dependent variables. None of the pairwise correlation coefficients were greater than 0.8. Second, I calculated variance inflation factors (VIFs), a measure of the amount of multicollinearity, for the model. The highest VIF is 3.52 across all models, below the commonly accepted level of 10 at which multicollinearity is thought to be a problem (23). Third, I performed a series of stepwise

	Whole Sample		Manufacturing & Transportation		Manufacturing Only	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Intercept	6.820***	(0.000)	5.639***	(0.000)	6.624***	(0.000)
Litigation	-1.084***	(0.000)	-1.202***	(0.000)	-0.893***	(0.001)
ROA	-4.822***	(0.000)	-3.885***	(0.006)	-3.543***	(0.006)
PPE	3.449***	(0.000)	4.480***	(0.000)	5.904***	(0.000)
logBonus	-0.103***	(0.000)	-0.077**	(0.011)	-0.039	(0.227)
logStockOptions	0.005	(0.714)	0.031*	(0.072)	0.045**	(0.011)
logRestrictedStocks	-0.047**	(0.018)	-0.007	(0.753)	-0.035	(0.119)
logAnalysts	-0.178***	(0.000)	-0.132***	(0.006)	0.055	(0.312)
Duality	0.005	(0.963)	-0.089	(0.486)	-0.072	(0.600)
logDirectorTenure	-0.463***	(0.002)	-0.380**	(0.028)	-0.439***	(0.007)
FemaleDirector%	-1.370**	(0.015)	-2.750***	(0.000)	-1.247*	(0.064)
Debt	-1.220***	(0.001)	-1.255***	(0.003)	-1.654***	(0.000)
Size	0.818***	(0.000)	0.844***	(0.000)	0.672***	(0.000)
BTM	-0.151	(0.499)	0.204	(0.455)	-0.403	(0.149)
R&DExpenses	3.126	(0.257)	2.880	(0.340)	0.979	(0.712)
Cash	-0.529	(0.448)	0.365	(0.642)	0.451	(0.518)
Sales	0.426***	(0.000)	0.432***	(0.001)	0.515***	(0.000)
Year Fixed Effects						
VIF-Max	3.15		3.52		3.22	
N	1,155		921		604	
Adj. R^2	0.409		0.458		0.485	

Table 3: Determinants and Incentives of GHG Emissions. Coefficients and p-values of variables used in the OLS regression models were presented. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels (two-tailed), respectively. Variable definitions are presented in the Methods section. VIF-max = maximum variance inflation factor.

regressions (not tabulated) by adding the test variables one-by-one into the regression model, and did not observe any different results.

DISCUSSION

Beginning in 2010, the EPA began to require mandatory reporting of GHG emissions by U.S. facilities that emit more than 25 metric kilotons of greenhouse gasses each year. Measurement of the emissions is performed by the individual facilities and then verified by the EPA (24). Because the data was reported to the EPA by facilities rather than companies, I identified and aggregated emissions from all facilities for each parent company. If a facility had more than one owner, I only included the parent company that was the majority owner (i.e., greater than 50%) as of the end of the calendar year.

Before the EPA's Greenhouse Gas Reporting Program (GHGRP), U.S. companies voluntarily disclosed their GHG emissions to the Carbon Disclosure Project (CDP). The CDP data is subject to selection bias because the emission levels were disclosed voluntarily, and the majority of disclosers were large companies. One limitation of my study is that the Execucomp database that discloses executive compensation included S&P1000 companies. Therefore, the sample firms consisted of larger firms and results from the study cannot be generalized to all the population of firms that report GHG emissions.

I also calculated the economic impact of these two variables. Moving from the 25th percentile to the 75th percentile in PP&E results in a 21.2% increase in GHG emissions, which translates to 114,001 tons of GHG emissions based on the median value. The membership in an industry that is subject to high litigation risks reduces GHG emissions by 15.89%, or 85,289 tons per year.

In this study I concluded that levels of GHG emissions were related to firm, compensation, and corporate governance characteristics. One missing factor that might potentially affect GHG emissions was CEO characteristics. The CEO's educational specializations, social background, presence on other companies' boards, religiosity, and political preferences, among others, may influence the company's GHG policies. Because these characteristics have to be collected manually from companies' proxy statements and other sources, I was not able to consider these factors in this paper. However, I examined the effect of CEO power, which was measured by whether the CEO was also the chairman of the board, in this study.

My study contributed to finding ways to incentivize companies to reduce GHG emissions. The results of my research suggested that moving forward, companies can improve GHG emission performance by prioritizing and implementing mitigation strategies such as higher energy efficiency, establishing bigger but fewer facilities, encouraging reuse and recycle practices, and committing company resources to develop new technologies and innovation. Companies can integrate GHG emission-related performance metrics in executive compensation, including bonus, stock options, and restricted stocks, to incentivize executives to engage in environmental initiatives that will increase firm value in the long run. Companies can also increase oversight by including board members in diversified boards who have experience or interest in facilitating the implementation of environmental strategies and activities to enhance the company's environmental reputation. Federal, state, and local governments can establish regulations and set up GHG standards to regulate GHG emissions. Stakeholders may pursue legal actions against companies to reduce GHG emissions and address climate change effects. The possibilities of incentivizing executives, encouraging new practices, and constructing diverse boards are an easier adaptation to the future. Legislation lags delay new policy implementation, whereas changes in the boardroom and company-level are much faster.

Government-owned and private firms deserve greater attention in climate discussions. Government-owned firms are major drivers of GHG emissions – government owned companies annually emit over 6.2 gigatons of carbon dioxide-equivalent in greenhouse gases globally (25). Unlike public firms these government-owned entities are regulated and do not rely on the board of directors to determine the organization's mission and purpose. In addition, government-owned firms depend on government funding in their low-carbon efforts. Private firms are not monitored by investors quarterly, and do not have diffuse ownership. Therefore, private firms are more likely to adopt GHG emission strategies that will create long-term firm value.

METHODS

Data

I obtained company financial information from Compustat in the Wharton Research Data Services (WRDS). Companies from the GHGRP were manually matched to companies in Compustat. In cases where a match could not

Dependent Variable	
LnEmission	Natural logarithm of Greenhouse Gas emissions in tons as reported to the EPA.
Independent Variables	
Litigation	Litigation risk. It is an indicator variable equal to one if the company is in the following industries: biotech (SIC codes 2833-2836 and 8731-8734), computer (3570-3577 and 7370-7374), electronics (3600-3674), and retail (5200-5961), and zero otherwise;
ROA	Return-on-asset ratio, calculated as net income over total assets;
PPE	Net value of property, plant, and equipment divided by the prior year total assets;
LogBonus	Natural logarithm of the CEO's current year bonus compensation;
LogStockOption	Natural logarithm of the fair value of the CEO's current year stock option grants;
LogRestrictedStock	Natural logarithm of the fair value of the CEO's current year restricted stock grants;
logAnalysts	Natural logarithm of the number of analysts following the company;
Duality	An indicator variable equal to one if the CEO is also the Chairman of the board, and zero otherwise;
logDirectorTenure	Natural logarithm of the average number of years a director has served on the board;
Female%	The percentage of female directors on the board;
Debt	The sum of short-term and long-term debts of a company divided by the prior year total assets of the company;
Size	Natural logarithm of the total assets of the company in the current year;
BTM	Book-to-Market ratio, defined as the book value of shareholder's equity divided by the market value of equity (share price*number of common shares outstanding);
R&DExpenses	Research and development expenses, defined as the R&D expenses divided by the prior year total assets of the company;
Cash	Cash and cash equivalent, defined as the cash and cash equivalent divided by the prior year total assets of the company;
Sales	Sales revenue divided by the prior year total assets of the company.

Table 4: Description of variables used in this analysis.

be found, an internet search of the company's website or Bloomberg Business company profiles determined whether the parent company was a subsidiary of, or had merged with, a company that was listed in Compustat. I excluded all privately or government owned companies from the sample. I also collected executive compensation data from ExecuComp, financial analyst data from Institutional Broker's Estimate System (I/B/E/S), corporate governance data from Institutional Shareholder Services (ISS), all of which are available from the WRDS.

Regression

I used multivariate analysis to investigate the impact of financial, CEO compensation, and corporate governance on firms' GHG emissions. Based on prior business literature, firm size, sales revenue, and book-to-market ratio are associated with corporate social responsibility behavior (26). Prior literature also found that R&D expenses, cash, and debt are associated with CSR expenditure (27). Expanding these findings, the following ordinary least square (OLS) regression model tests the hypotheses (Table 4).

$$\begin{aligned} LogEmission_{i,t} = {} & \alpha_0 + \beta_1 Litigation_{i,t} + \beta_2 ROA_{i,t} + \beta_3 PPE_{i,t} + \beta_4 Logbonus_{i,t} + \beta_5 LogStockOption_{i,t} + \\ & \beta_6 LogRestrictedStock_{i,t} + \beta_7 LogAnalysts_{i,t} + \beta_8 Duality_{i,t} + \beta_9 LogDirectorTenure_{i,t} + \\ & \beta_{10} FemaleDirector\%_{i,t} + \beta_{10}\, Debt_{i,t} + \beta_{12} Size_{i,t} + \beta_{13} BTM_{i,t} + + \beta_{14} R\&DExpenses_{i,t} + \\ & \beta_{15} Cash_{i,t} + \beta_{16} Sales_{i,t} + \phi YearFix + \varepsilon_{i,t} \end{aligned}$$

The dependent variable, LogEmission, is the natural logarithm of reported level of GHG emissions reported to the EPS. I used the log transformation because there were no negative numbers for this variable. The independent variables included three sets of determinants reflecting the incentives for GHG emission reduction.

Financial characteristics of the company. These variables included litigation risk (Litigation), return-on-assets (ROA) which is a profitability measure, property, plant, and equipment (PPE), number of financial analysts following the company (logAnalysts), current and long-term debt (Debt), size measured by total assets (Size), the book-to-market ratio (BTM), research and development expenses (R&DExpenses), level of cash held (Cash), and total sales revenue (Sales).

CEO compensation incentives. I included components of compensation: bonus (logBonus), stock option grants (logStockOptions), and restricted stocks (logRestrictedStock) in the model.

Corporate governance factors. These factors included whether the CEO is also the chairman of the board (Duality), board director tenure (logDirectorTenure), and percent of female directors serving on the board (FemaleDirector%).

To control for the size effect and present a cleaner comparison, I deflated most financial variables by prior year total assets and used natural logarithm transformation if the variable did not include negative values. I also included year fixed effects (YearFix) because general economic conditions may change from year to year. i,t denotes company i in year t.

To determine the relative importance of each statistically significant factor on emissions, I also standardized all variables to have zero mean and unit standard deviation. Results (not tabulated) of standardized coefficients show that the top two most important factors are litigation and PP&E (property, plant, and equipment). I did not attempt to establish causality in the relation between GHG emissions and certain factors that may be tied to GHG emission reductions. My goal was to determine how firms choose the extent to which they jointly engage in the GHG emission reductions and certain activities given that the costs of benefits of engaging in one activity potentially affect the costs and benefits of the other. This lack of a defined causal relationship and the probability that investment in one activity influences the payoff from the other suggests that the extent of engagement in each activity may be determined simultaneously. Therefore, a system of simultaneous equations can be estimated in additional to the OLS estimates.

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