Summer 2020

Carbon Management Strategy and Carbon Disclosures: An Exploratory Study

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Recommended Citation

Dhanda, K. K., & Malik, M. (2020). Carbon management strategy and carbon disclosures: An exploratory study. *Business and Society Review, 125*(2), 225-239.

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Abstract:

Corporate Social Responsibility (CSR) is a concept aimed to ensure that corporations conduct their business in an ethical manner by taking care of their environment and human resources in addition to their economic impact. Often times, CSR refers to the steps undertaken by a corporation to measure its efforts to improve the environment and social well-being. One of the aspects of CSR pertains to the disclosure of emission information and carbon management strategy (CMS). Carbon Management refers to analyzing and focusing on those areas within the corporation where cost reductions can be made via energy reductions, waste management and reduced resource consumption. In this paper, we examine the role of an effective CMS on the emission disclosure behavior of firms. We utilize the Carbon Disclosure Project (CDP) surveys to find that firms adopting an effective CMS are more likely to disclose the information about both direct and indirect emissions.

Keywords:

Corporate Social Responsibility, Carbon Management Strategy, Carbon Disclosures, Direct Emissions

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Introduction

We are witnessing climate change on a global scale. The evidence is documented from increasing temperatures being recorded worldwide and the dramatic rise in sea levels to the melting of Artic Ice and glaciers and the extensive damage to the Coral Reef. Other alarming trends are the increase in global flooding events and the potential refugee crisis due to climate change, to name a few (Plummer and McGoogan, 2017). One of the significant factors in global climate change is the unprecedented increase in greenhouse gas emissions in the atmosphere. The concentration of carbon dioxide in the atmosphere reached the milestone of 400 parts per million for the first time in 2015 (WMO Greenhouse Gas Bulletin, 2016). A breakdown of the greenhouse gas emissions illustrates that the primary sources are: electricity production, transportation, commercial and industrial activity and farming (EPA, 2017).

Given the growing public concern around global warming and climate change, the issue of climate change has been placed on corporate radars and these stakeholders expect firms to disclose relevant GHG (greenhouse gas) emissions (Depoers, et. al., 2016). Hence, it is of upmost importance for corporations to articulate an effective carbon management strategy (CMS) in the first place and communicate levels of emission in their organizational emissions disclosures. In this specific area of research, our paper aims to analyze the effectiveness of a CMS on the disclosure of carbon emissions.

Problem Statement

A wide range of stakeholders, ranging from national governments to NGOs to the larger public concerned with health impacts, are pushing organizations to become more sustainable. In an effort to respond to these various pressures and to become more sustainable, numerous organizations are choosing to report their emissions and reduce their carbon footprints in an effort to become carbon neutral. In terms of reporting, there is a paucity of reporting agencies. One avenue is to publish emission data in annual corporate reports. However, these reports are not verified and, hence, the emissions are under-reported (Depoers, et. al. 2016). Another option for reporting is the international standard, the Global Reporting Initiative (GRI), that serves as a

broad based portal for sustainability reporting with indicators ranging from climate change to corruption to human rights (GRI, 2017). In addition, there are other international repositories such as the Kyoto Protocol (Clean Development Mechanism, Joint Implementation and Emissions Trading) and regional directories, such as, the EEA (European Environment Agency), the Canadian ECCC (Environment and Climate Change Canada, and the US EPA (Environmental Protection Agency). However, most of this reporting is done on a voluntary basis since there are no required international or national standards that firms are subject to. Yet another channel for emission disclosures is the Carbon Disclosure Project (CDP), a non-profit organization that facilitates environmental disclosures of firms with institutional investors. Every year, CDP sends out a questionnaire and collects the data from large firms across the globe, across different industrial sectors (CDP, 2017). In our study, we utilize the survey data from the CDP in order to construct a novel dataset of firms' carbon disclosures, emissions information and CMS quality. We chose to utilize the CDP database since it is considered to be the most comprehensive collection of self-reported environmental data and is widely used in academic literature (Matsioff, Noonan and O'Brien (2012), Stanny and Ely (2008), Kolk, Levy and Pinsky (2008).

In order to become carbon neutral, companies must make efforts to reduce their emissions, both direct and indirect. Carbon emissions are categorized into different groups or 'scopes' by the most widely used international accounting tool, the Greenhouse Gas (GHG) Protocol. Scope 1 emissions are direct emissions from sources that are owned and controlled by the firms and these cover production of electricity, fuel consumption or emissions from company vehicles. Scope 2 emissions are indirect emissions from consumption of purchased electricity, heat or steam (GHG, 2017). Scope 3 emissions, the toughest to measure and control, comprise of all other indirect emissions from sources not owned or controlled by firms, which include emissions from both suppliers and consumers (Carbon Trust, 2017). In this study, we focus on the direct emissions by the firm and we test the role of CMS on both Scope 1 and Scope 2 emissions.

What is the motivation behind this study? Given the growing attention in climate change and carbon emissions, we seek to investigate the factors that influence firms to disclose their emission information. Therefore, in this research, we aim to extend the literature by incorporating a new determinant of carbon disclosure, that is Carbon Management Strategy

(CMS). Prior literature has focused on various factors, such as firm size, governance, industry-specific criteria, and national culture, that influence firms' carbon disclosure behavior (Liao, Luo, and Tang, 2015; Eleftheriadis and Anagnostopoulou, 2015). We contribute to the literature by extending our understanding on the effectiveness of CMS on carbon disclosure. Luo and Tang (2016b) argue that carbon disclosure is the outcome of firms' strategic activities. The reasoning is that, as a part of its strategic activity, a firm can communicate voluntary information to its external stakeholders in order to maintain transparency. A superior quality CMS would seek to reduce the carbon emission impacts either by applying efficient technologies or setting carbon reduction targets. The CMS activity involves incorporation of the awareness and opportunities of climate change issues into core business policy. Thus, firms with an effective CMS strategy are more likely to be successful to reduce carbon footprints and disclose the relevant information to its stakeholders in order to maintain a clean corporate image. Hence, it is plausible to assume that a firm with better quality CMS intends to voluntarily disclose emissions information than the firms having no strategy or less-effective CMS. In our study, we collate information on emissions and other indicators on CMS to conclude that firms' carbon disclosure behavior is positively affected by the quality of a CMS.

Reporting and Disclosures Literature

Why do organizations choose to report and disclose their emissions, especially in the absence of regulatory requirements? One reason might be CSR and corporate governance. Chan, Watson and Woodliff (2014) find a link between corporate governance quality and CSR disclosure in company annual reports. Another reason is institutional pressures. Comyns (2016) analyzed the influence of institutional pressures on GHG reporting in multinational oil and gas companies and their results state that regulation under the EU emissions trading scheme and global reporting initiative (GRI) guidelines leads to better quality and more extensive reporting.

Legitimacy theory and impression management might also offer insights. Research indicates that voluntary environmental governance mechanisms might operate to enhance a firm's environmental legitimacy. Research by Peters and Romi (2014) indicates that the presence of an environmental committee and a Chief Sustainability Officer (CSO) are positively associated with the likelihood of GHG disclosure. Chen, Cho and Patten (2014) state that companies used

disclosure as a tool of impression management to avoid potential stakeholder mis-estimation of previously undisclosed liability exposures. A study on CSR in Latin America finds that CSR activities in certain cases from three countries, namely, Brazil, Mexico and Peru, were implemented as a way to legitimize and as a means to gain social acceptance (Benites-Lazaro and Mello-Thery, 2017).

In terms of actual performance, Dawkins and Fraas (2011) find a positive relationship between environmental performance and voluntary climate change disclosure. Another study states that companies with good environmental performance disseminate more carbon information in their disclosures (Giannarakis, et. al. 2017). Some companies are choosing to disclose information about their environmental performance in response to stakeholder demands for environmental responsibility and accountability. To this end, Jose and Shang-Mei (2007) analyze corporate websites and report the content of corporate environmental disclosures pertaining to stakeholder demands.

What about CEO characteristics and Board effectiveness? A study by Lewis et al. (2014) states that CEO characteristics such as education and tenure will influence firms' likelihood to voluntarily disclose environmental information. Another study by Walid and Mcilkenny (2015) finds a positive association between board effectiveness and the firm's decision to answer the CDP questionnaire, as well as, its carbon disclosure quality. In a follow up study, Walid et al. (2017) finds that the likelihood of voluntary climate change disclosure increases with women on boards.

Lastly, it seems that national culture also influences disclosure behavior. A study by Luo and Tang (2016a) finds that national culture has an impact on managerial attitudes and to the extent to which managers recognize the need for emissions control and disclosure. The study finds that cultural dimensions of masculinity, power distance, and uncertainty avoidance are strongly and consistently related to carbon disclosure and that the dimensions of individualism and long-term orientation also have a significant impact.

Carbon Management Strategy Literature

Carbon management has become a strategic issue for companies today. Carbon Management Strategy (CMS), also known by Corporate Carbon Strategy or Environmental Management Strategy, generally refers to the corporate commitment to manage its overall carbon emissions. This strategy usually entails the disclosure of climate change information across its business operations (Kolk and Pinkse, 2007). Researchers are interested to know the determinants of CMS, and what makes the CMS strategically important for firms. According to the CDP Report (2010), several drivers are increasing the importance of carbon management, which includes energy costs, brand reputation, and energy supply risks. The need for effective CMS is also driven by employee and customer expectations, the risks from the physical impacts of climate change, competitive positioning and investors' pressure.

Research by Lee (2012) scrutinizes the corporate carbon strategy and analyzes the firms' priorities by looking at what resources are allocated to each of these priorities. The carbon management activities are classified into six categories: emission reduction commitment; product improvement; process and supply improvement; new market and business development; organizational involvement; and, external relationship development. In addition, the research indicates that there are six types of corporate carbon strategies: 'wait-and-see observer', 'cautious reducer', 'product enhancer', 'all-round enhancer', 'emergent explorer' and 'all-round explorer' (Lee, 2012).

The question is: Do carbon management strategies or practices actually reduce carbon emissions by corporations? A paper by Doda et al. (2016) finds scant evidence that commonly adopted management practices are reducing emissions. This could be due to lack of standardization in the reporting of corporate carbon data and management practice information. Another reason might be due to the delay between the application of corporate carbon management practices and their impact on emissions performance. Lastly, carbon management practices are usually not impact-oriented, in that there is no relationship that can be observed. However, we will also present our results from this linkage between carbon management practices and emissions. Our results indicate that an improvement in carbon management strategy results in reduced carbon emissions.

Hypotheses Development

A firm's stance on carbon management strategy (CMS) ranges from reactive initiatives, like participating in emission trading schemes and other forms of carbon emissions offsets to more proactive strategies, such as, innovative improvements to products, markets, technologies and processes with a view to achieve carbon neutrality. Hence, firms are deemed to adopt CMS when they manage carbon emissions by incorporating climate change challenges into their operational activities and functional decisions, either through reactive or proactive means.

There are various strategic options that exist for firms to address climate change and CMS. Kolk and Pinkse (2005) develop a typology of strategic options based on a firm's strategic intent and degree of interaction with other firms. According to their work, strategic intent varies between two ranges: compensation and innovation. Compensation entails the actual transfer of emissions or such activities within the firm to other firms. Innovation, on the other hand, refers to the development of processes or technologies to reduce emissions.

Another approach is offered by Weinhofer and Hoffmann (2010), who propose a framework that also classifies various carbon strategies into three types: carbon compensation, carbon reduction and carbon independence. Carbon compensation, reactive in nature, covers any actions by the firm to balance or offset its carbon emissions, for example, the purchase of carbon offsets or carbon credits. On the other hand, the two proactive actions are carbon reduction and carbon independence. The former, carbon reduction, refers to actions aimed at lowering emissions by changing the production process or products and the latter, carbon independence, is similar to carbon neutrality whereby, firms take steps to transform business operations in such a way, so as to be independent from fossil fuels (Weinhofer and Hoffmann, 2010).

With a focus on corporate responsiveness, Winn and Angell (2000) develop a greening matrix that classifies firms according to the level of policy commitment and approach in implementing corporate greening actions. According to this matrix, corporate responsiveness ranges from low commitment with passive/reactive initiatives to high commitment with active/proactive strategies. Firms in the former category are considered environmental followers and firms in the latter category are referred to as environmental innovators (Winn and Angell, 2000).

In terms of disclosure, Cormier and Magnan (1999) state that firms' environmental disclosure policies are strategic tools that result in economic benefits for firms. On the other hand, withholding carbon information may provide a signal of environmental irresponsibility and can result in potential political and economic costs to the firms. The costs can stem either from pressure by activists or from a damaged reputation among customers, employees, creditors and suppliers. Grossman (1981) and Milgrom (1981) argue that if firms withhold information, investors assume the undisclosed information is negative.

An effective and quality CMS encourages firms to provide emission information to build up community support for its relationships with various stakeholders or to enhance the firm's reputation as a credible and responsible entity. Carbon disclosure reduces information asymmetry between the management and investors. The less information asymmetry, the lower the riskiness and the cost of the firm's capital (Dhaliwal et al., 2011). Thus, to ensure the benefits of disclosures and to avoid the costs of nondisclosure, firms with high-quality CMS can consider carbon disclosures as company responsibility. The CMS activity involves not only setting targets and incentives for emission reduction, applying technologies to reduce environmental impacts and taking initiatives to adjust business operations with climate change risks, but also, maintaining transparency on environmental and emission issues between the firm and different stakeholders. Hence, the decision of carbon disclosure seems to be a part of CMS policy and it is expected that firms with better CMS are more likely to disclose carbon information than the firms having no strategy or less-effective CMS. Based on these arguments, we conjecture the positive relationship between the quality of CMS and the probability of firms' carbon disclosures. Our discussion leads to the following hypothesis:

H_1: The quality of firms' carbon management strategy (CMS) positively affects the disclosure of carbon emission information.

Research Methodology

Model Specification for Hypothesis 1

To test the study's hypothesis **(**H_1), we estimate the following logistic regression model using standard errors clustered by firms:

$$Pr\ (Emission\_Disclose)_{i\,t} = \alpha + \beta_1\, CMS\_Score_{i\,t} + \beta_2\, Firm\_Size_{i\,t} + \beta_3\, Leverage_{i\,t} + \beta_4\, Growth_{i\,t} + \beta_5\, ROE_{i\,t} + \sum \gamma_j\, Year\_Dummy + \sum \pi_k\, Industry\_Dummy + \varepsilon_t \quad (1)$$

Dependent Variable

The model's dependent variable is the firm's probability to disclose carbon emission information in the CDP survey. For the disclosure of direct and indirect emissions, we estimate two separate regression models. *Direct_Emmisions_Disclose* is a dummy variable that equals 1 if the firm discloses the quantity of direct emissions (Scope 1) in the CDP survey, and 0 otherwise. *Indirect_Emissions_Disclose* is a dummy variable that equals 1 if the firm discloses the quantity of indirect carbon emissions (Scope 2) in the CDP survey, and 0 otherwise.

Construction of the CMS Index Score

The variable, *CMS_Score*, measures the quality of the firm's carbon management strategy. According to the hypothesis H_1, a positive sign for the coefficient of the *CMS_Score* implies that the likelihood of an emission disclosure increases with the quality of the CMS.

To measure the quality of the CMS, we construct an index score based on data using corporate responses to 12 questions in the CDP's Climate Change Information Request Survey. The CDP, a non-profit organization that provides comprehensive carbon emission information of the world's largest firms measured by market capitalization, collects information on behalf of several institutional investors managing assets worth trillions of dollars. The survey is designed to produce comparable, up-to-date information for evaluating the environmental risks for firms, and the response rate is increasing every year. The CDP survey responses increased from 235 company responses in 2003 to about 3,500 responses in 2011 (Matsumura et al. 2014). Those who respond usually have top positions in the company's CSR or sustainability department. The survey's completion is supervised by the firm's Chief Sustainability Officer (or equivalent) and the accuracy of the information is approved in writing by a senior executive (Ioannou et al., 2016). Unlike environmental disclosures in annual reports and CSR or sustainability reports, which may contain other extraneous information for investors, the CDP focuses only on emission

information, which is released independently of the firm and with less confounding effects (Stanny and Ely, 2008; Wegener et al., 2013).

Used by a growing number of recent academic research projects, the CDP's Climate Change Information Request Survey covers six major areas related to an effective carbon monitoring system (CMS). These are: *corporate governance, business strategy, emission reduction target and initiatives, communication and disclosure of emission information in other reports, climate change risks, and climate change opportunities in business operations*. From these areas, we select 12 questions, including questions on whether firms have emission reduction targets; whether they provide incentives to management to meet targets; whether climate change is integrated into business strategies; where and with whom the highest level of responsibility for climate change issues lies in the organization; whether firms publish their emission information and GHG reports in other disclosures and if so, whether they are in voluntary or annual reports (or for other regulatory filings); and, whether the firms identified any climate change risks and opportunities that may result in a substantive change in their operations, revenues or expenditures. We assign numeric scores to the firms' responses and after assigning scores to each of the 12 questions, we add them to derive a value of the CMS index, which ranges from 0 to 12. A higher value indicates a better quality of CMS. Details of the survey questions, scoring criteria and index construction is provided in Appendix A.

Control Variables

In order to avoid the problem of correlated omitted variables, we include control variables that might affect the probability of carbon emission information. Research indicates that there are various firm-specific characteristics that increase the likelihood of corporate responses to the CDP questionnaire. The most common criteria is firm size followed by level of leverage. Since large firms are more exposed to regulatory pressures, the probability of their disclosure is higher than it is for smaller firms (Luo and Tang, 2016b). Therefore, we control for the size of a firm by including the variable *Firm Size*, and expect a positive coefficient for it. The variable, *Firm Size*, is calculated as the natural logarithm of the firm's total assets. To control for the effects of company leverage on the probability of emission disclosures, we include the variable *Leverage*. We also control for company growth prospects (Matsumura et al., 2014) using the variable

Growth, which is calculated as equity market value divided by equity book value. We also include another variable, *ROE*, which is measured as income before extraordinary items divided by total stockholder equity, to control for the influence of profitability on company environmental disclosures.

Sample Selection

For the data compilation, we collected the emission information and the CMS index data from the CDP's Climate Change Information Request Survey. Although the CDP collects responses from firms worldwide, we restrict our sample to U.S. firms focusing on the period 2012-2016. After collecting the emission value and disclosure information and converting the survey into a numeric CMS index, we merge the dataset with Compustat, a database of financial information of public firms in the United States.

Empirical Findings

Descriptive Statistics

The descriptive statistics of the variables used in this study are reported in Table 3. The mean value of *Direct_Emission*, the amount of direct carbon emissions in metric tons scaled by total assets, is 1,221.46 and the median value is 10.53. The large difference between the mean and median value implies that the distribution of direct emissions is highly right-skewed. Few of the firm-year observations have very large amount of direct emissions, that in turn influences the mean value, resulting in a high value. The sample is rather diverse, ranging from large manufacturing companies to smaller service companies. This diversity is also evidenced by the large value of the standard deviation value of *Direct_Emission*.

However, the sample for *Indirect_Emission* (the amount of indirect carbon emissions in metric tons scaled by total assets) is rather homogenous as evidenced by the mean and median values of is 44.01 and 19.98, respectively, and the standard deviation value is 80.30. The mean value of *CMS_Score* is 8.655 and the median value is 10. The value of the standard deviation on *CMS_Score* is 3.06. Untabulated numbers show that the *CMS_Score* ranges from 0 to 12, which implies a wide variety of CMS quality for the sample firms.

Note that there are two dummy variables used: *Direct_Emission_Disclose* and *Indirect_Emission_Disclose*. The mean value of *Direct_Emission_Disclose,* an indicator variable if the firm discloses the amount of direct emissions, zero otherwise, is 0.927 implying that around 93% of the observations disclose the amount of direct carbon emissions. The mean value of *Indirect_Emission_Disclose,* an indicator variable if the firm discloses the amount of indirect emissions, zero otherwise, is 0.677, which means 67% firm-year observations disclose the information about indirect carbon emissions.

[Table 1]

Correlation Matrix

The Pearson correlation values among the variables is reported in Table 4. Both variables *Direct_Emission* and *Indirect_Emission* are positively and significantly correlated which states that if a company has higher direct emissions, it also has higher indirect emissions. The variable *Firm_Size* has a negative correlation with both *Direct_Emission* and *Indirect_Emission* which means that large firms are emitting relatively less amount of carbon per unit of assets compared to small firms. Larger firms have more resources to take better initiatives and applying technologies to reduce the amount of carbon emissions.

The variable *CMS_Score* has a positive correlation with *Firm_Size*, which gives a univariate support that large firms have better quality CMS. However, the *CMS_Score* is not related with *Growth* and *ROE*. In addition, the variables *Growth* and *ROE* are positively correlated, which means that profitable firms have higher growth prospects. Interestingly both direct and indirect emissions are not correlated with *CMS_Score, Growth* and *ROE*. Furthermore, the variable *Firm_Size* is not correlated with *Leverage, Growth* and *ROE*.

[Table 2]

Regression Results

The regression results of Hypothesis 1, the role of CMS on firms' disclosure of carbon emissions, are presented in Table 5. We run two models in our regression. For Model 1, the dependent variable is *Direct_Em_Disclose*. For Model 2, the dependent variable is

Indirect_Em_Disclose. In both the models, the key explanatory variable is the *CMS_Score*. Column 1 shows that the *CMS_Score* is significantly and positively associated with the variable *Direct_Em_Disclose,* and the value of the coefficient is 0.635 with a *t*-stat value of 14.447. This finding supports our hypothesis that firms with higher quality CMS are more likely to disclose direct carbon emission information on the CDP survey. The interpretation of the regression coefficient suggests that a one point increase in the CMS index score is associated with a 0.635 increase in the relative log odds of disclosing the direct emission information.

We also find a significant positive coefficient on the variable *Firm_Size*. The coefficient's value is 0.574 with a *t*-stat value of 12.776. This finding implies that larger firms are more likely to respond to CDP survey requests and to disclose the quantity of direct carbon emissions. Since large firms face transparency pressures from activists, regulators, environmentalists and from the community, they are more likely to disclose emission information to the public. However, we could not explain why smaller firms do not or are more reluctant to disclose this information. One reason might be a lack of resources to measure emissions and therefore to disclose the emission information; or, perhaps the cost of measuring and disclosing emission information outweighs the benefits of transparency. We find no association between the probability of direct emission disclosures and other firm-specific variables such as, *Leverage*, *Growth*, and *ROE*. The model's pseudo R^2 value is 29.44%.

Column 2 in Table 5 shows the regression results of the role of CMS on the disclosure of indirect emissions. The dependent variable in Model 2 is *Indirect_Em_Disclose* and the results show that there is a significant positive association between the probability of the disclosure of indirect emissions and the *CMS_Score*. The regression coefficient is 0.498 and the *t*-stat value is 13.667. This finding additionally supports the first hypothesis that a better-quality CMS influences emission disclosures positively, regardless of emissions type, direct or indirect. As for the relationship between *Firm_Size* and *Indirect_Em_Disclose,* Model 2 documents similar findings as Model 1, although the magnitude of the coefficient is much smaller in Model 2. The coefficient value is 0.06 with a *t*-stat value of 10.47. The model's pseudo R^2 value is 23.73%, and the number of observations used in both models is 545.

[Table 3]

Additional Analysis

We conduct additional analysis to check why the CMS_Score should positively affect the disclosures. If an improvement of the existing CMS brings direct benefits to the firms in terms of emission reductions, it is more likely that firms will disclose the positive information to create clean corporate image. To test this assumption, we examine how the changes in CMS_Score affect the quantity of carbon emissions. Table 4 shows the results of the multiple regressions of the relationship between the changes in the CMS_Score (Δ_CMS_Score) and the changes in the direct carbon emission (Δ_Direct_Emission). Column 1 shows that if there are positive changes in the CMS_Score, the changes in direct emissions are negative, which means that the improvement in the CMS_Score benefits the firms, which results in reduced carbon emissions. Reduction in direct emissions will influence the firms to disclose and share the information with all stakeholders. In column 2 of Table 4, we also control for the lag year's CMS_Score, to check if the result holds in case a firm's prior CMS responses has any influence on carbon reduction. We find that even after controlling the Lag_CMS_Score, the results are consistent with the findings in column 1. The adjusted R^2 in column 2 is 3.04% and the number of observations used in this model is 296.

[Table 4]

Conclusion

In this paper, we explore the effectiveness of a newly emerging corporate strategy, the CMS, and its role in carbon disclosures. By using the Carbon Disclosure Project's survey information for 2012 to 2015, we construct a novel index to measure the quality of CMS for U.S. firms. We find that firms with an effective CMS are more likely to disclose their carbon emission information than the firms with less effective or no CMS.

Corporate stance on CMS ranges from reactive strategies, such as participating in carbon offset programs, to more proactive strategies, such as innovative improvements to products and processes with a goal of carbon neutrality. In terms of disclosure, firms that provide more information have better outcomes in terms of corporate governance, firm's environmental legitimacy and impression management. Companies also choose to disclose information about their environmental performance in response to stakeholder pressures. Our findings are

important to the investors, managers, and regulators, as the results document the direct benefits, demands, and effectiveness of the CMS. We believe, our study is significant in the context of global warming and carbon emissions as the findings of our study will be of interest to corporate executives and policy makers. Reflecting the growing attention that environmentalists pay to the issue of climate change, we respond to the call for an inquiry and theoretical understanding and the needs for an effective CMS. The study also extends carbon emission literature as this study is one of the first, to the best of our knowledge, to document CMS as a determinant of carbon disclosure, an effect incremental to previously documented drivers of environmental disclosure. We also develop a novel index to measure the strength of a firm's CMS and reinforce the supports for its positive impacts on voluntary disclosures.

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Table 1

Descriptive Statistics

Variable	N	Mean	Std. Dev	Lower Quartile	Median	Upper Quartile
Direct_Emission_Disclose	545	0.927	0.261	1	1	1
Indirect_Emission_Disclose	545	0.677	0.468	0	1	1
Direct_Emission	505	1221.460	25030.450	2.569	10.529	55.540
Indirect_Emission	369	44.014	80.300	7.651	19.980	45.428
CMS_Score	545	8.655	3.068	8	10	11
Firm_Size	545	9.335	1.879	8.297	9.310	10.505
Leverage	545	0.245	0.147	0.142	0.234	0.330
Growth	545	4.571	35.005	1.767	2.906	4.709
ROE	545	0.195	1.522	0.079	0.145	0.235

This table presents the descriptive statistics of the key variables used in this study. The final sample consists of 545 firm-years observations from 2012 to 2015. The sample is restricted to U.S. public firms.
CDP started collecting data from companies in the year 2002. However, in 2011, CDP incorporated a major change in the survey methodology. Hence, we discarded the data prior to 2011 and included the results from the time period 2012-16 in order to have a consistent dataset

Table 2

Correlation Matrix

Variables	Direct_ Emission	Indirect_ Emission	CMS_ Score	Firm_Size	Leverage	Growth	ROE
Indirect_Emission	0.111**						
CMS_Score	0.016	0.001					
Firm_Size	-0.297***	-0.229***	0.397***				
Leverage	-0.077*	0.064	0.149***	0.049			
Growth	-0.006	-0.012	-0.023	-0.027	0.044		
ROE	-0.004	-0.014	-0.005	0.009	0.032	0.142***	

This table presents the Pearson correlation coefficients among the key variables used in this study. The final sample consists of 545 firm-years observations from 2012 to 2015. The sample is restricted to U.S. public firms. ***, **, and * indicates the statistical significance of the correlations among the variables at the 0.01, 0.05, and 0.10 levels, respectively, based on a two-tailed test.

Table 3

Role of CMS on the Disclosure of Direct and Indirect Emissions

Variables	Dependent Variable = Direct_Emission_Disclose	Dependent Variable = Indirect_Emission_Disclose
Intercept	-5.201*** (6.215)	-0.510*** (7.071)
CMS_Score	0.635*** (14.447)	0.498*** (13.667)
Firm_Size	0.574*** (12.776)	0.060*** (10.47)
Leverage	-1.045 (0.307)	-1.006 (0.408)
Growth	-0.011 (0.246)	0.007 (0.105)
ROE	0.226 (0.257)	-0.108 (0.065)
Industry Fixed-Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Pseudo R^2	29.44%	23.73%
N	545	545

This table presents the results of logistic regressions of CMS and firm-specific factors on the probability of disclosures of both direct and indirect emissions. The sample consists of 545 firm-year observations from 2012 to 2015. The sample is restricted to U.S. public firms. The ***, **, and * indicate the statistical significance of the regression coefficients at 0.01, 0.05, and 0.10 levels, respectively, based on a two-tailed test. The Wald Chi-Square statistics are within the parentheses below the regression coefficients. The models include industry and year fixed-effects. To conserve space, the table does not report the coefficient estimates for industry and year dummies. Definitions of the variables are given in Appendix A. Detailed construction of the CMS Index Score is given in Appendix B.

Table 4

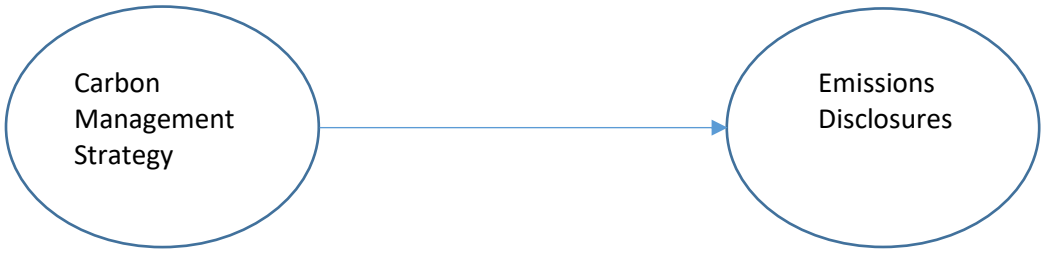
Role of CMS on Direct Carbon Emissions

Variables	**Dependent Variable = Δ_Direct_Emission**	
	(1)	**(2)**
Intercept	1.700***	1.773***
	(3.19)	(2.82)
Δ_ CMS_Score	-0.146**	-0.152*
	(-1.98)	(-1.84)
Lag_CMS_Score		-0.022
		(-0.28)
Firm_Size	-0.159*	-0.150*
	(-1.66)	(-1.65)
Leverage	0.436	0.502
	(0.39)	(0.44)
Growth	-0.001	-0.001
	(-0.15)	(-0.05)
ROE	0.016	0.012
	(0.04)	(0.03)
Year Fixed Effect	Yes	Yes
Adjusted R^2	3.82%	3.04%
N	296	296

This table presents the results of the multiple regressions of the effects of changes in CMS on the changes in direct amount of corporate carbon emissions. The sample consists of 545 firm-year observations for 2012 to 2015. The sample consists of 545 firm-years observations for the period 2012 to 2015. The sample is restricted to the U.S. public firms. The ***, **, and * indicate the statistical significance of the regression coefficients at 0.01, 0.05, and 0.10 levels, respectively, based on a two-tailed test. The t-statistics are within the parentheses below the regression coefficients. The models include industry and year fixed-effects. To conserve space, the table does not report the coefficient estimates for the industry and year dummies. Definitions of the variables are given in Appendix A. The detailed construction of the CMS Index Score in given in Appendix B.

Figure 1

The Relationship between Carbon Management Strategy (CMS) and Emissions Disclosures.



Appendix A

CMS Index Score Calculation

The CMS Index Score is based on the responses to the following 12 questions in the CDP's Climate Change Information Request Survey. The questionnaire covers six major areas related to an effective CMS: corporate governance, business strategy, emission reduction target and initiatives, communication and disclosure of emission information in other reports, climate change risks, and climate change opportunities in business operations. The scoring criteria for the CMS Index are given next to each question.

CMS Areas	Questionnaire	Index Score
Governance	Where is the highest level of direct responsibility for climate change within your company?	If any specific position = 1 No individual or committee with overall responsibility = 0 No response = 0
	Do you provide incentives for the management of climate change issues, including the attainment of targets?	Yes = 1 No = 0 No response = 0
Strategy	Please select the option that best describes your risk management procedures with regard to climate change risks and opportunities.	If any specific option = 1 No documented processes = 0 No response = 0
	Is climate change integrated into your business strategy?	Yes = 1 No = 0 No response = 0
	Please describe the process and outcomes.	If any explanation = 1 No response = 0

CMS Areas	Questionnaire	Index Score
Targets and Initiatives	Did you have an emissions reduction target that was active (ongoing or reached completion) in the reporting year?	Absolute or Intensity target = 1 No target = 0 No response = 0
	Please provide details of your absolute target.	Any information about absolute target = 1 No information = 0
	Please provide details of your intensity target.	Any information about intensity target = 1 No information = 0
	Please also indicate what change in absolute emissions this intensity target reflects.	Any information = 1 No information = 0
Communications	Have you published information about your company's response to climate change and GHG emissions performance for this reporting year in other places than in your CDP response?	Voluntary, annual report, other regulatory filing = 1 No = 0 No response = 0
Climate Change Risks	Have you identified any climate change risks (current or future) that have the potential to generate a substantive change in your business operations, revenue or expenditure?	Any response = 1 No = 0 No Response = 0
Climate Change Opportunities	Have you identified any climate change opportunities (current or future) that have the potential to generate a substantive change in your business operations, revenue or expenditure?	Any response = 1 No = 0 No Response = 0