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The Impact of Carbon Disclosure & Carbon Performance on Firm Value

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Abstract

This research aims to examine the effect of carbon management on firm value and explore how this impact varies depending on the level of environmental sensitivity within different sectors. The primary objective of this study is to understand the association between a company's carbon performance, carbon disclosure, and its overall value. To address this research question, a sample consisting of S&P 500 companies from years 2016 to 2020 is analysed, utilizing the climate change score computed by CDP—an organization representing institutional investors. A fixed effect panel regression is employed to examine this relationship. The findings reveal a positive market response to carbon disclosure and performance, with variations observed among different sectors. These results suggest that institutional investors play a pivotal role in driving market changes to mitigate climate-related risks.

JEL-Codes: G32, C23.

Keywords: CDP, Carbon Disclosure, Firm Value, Institutional Investors, Fixed effect.

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1. Introduction

This study examines the market perception of firms' carbon performance and carbon disclosure using the Carbon Disclosure Project (CDP)'s score.

As global concerns and investors' interest about climate change continue to rise, firms are pressured to prioritize non-financial aspects of their operations (Kolk & Pinkse, 2004). According to the Global Climate Risk Index, over 11,000 extreme weather events have caused the loss of almost half a million human lives since 2000 (*Global Climate Risk Index*, 2021). On this basis, businesses bear significant responsibility as they account for the majority of carbon emissions that contribute to climate change (Riley, 2017). Consequently, stakeholders have high expectations for firms to actively address climate change risk, implement necessary mitigation measures, and provide effective reporting (Wright & Nyberg, 2017). However, investments are needed in response to climate change, leading to a pivotal question: Are the required investment and resources financially justified?

This paper investigates the relationship between carbon disclosure, carbon performance and financial returns of firms in recent years, characterized by an intensified focus on climate change. Firm value represents the price that buyers are willing to pay for a company and reflects its overall appraisal at a given time (Matsumura et al., 2014). Investors' intentions are expressed in financial markets through the creation of market incentives or penalizations to firms. Consequently, if the management of environmental issues, such as carbon disclosure and high levels of carbon performance, is perceived to be crucial for a company's valuation, the market responds positively (Benkraiem et al., 2022; Hardiyansah et al., 2021; Matsumura et al., 2014; Nishitani & Kokubu, 2012; Sun et al., 2022), Conversely, if investors view these environmental considerations as burdensome costs, the market reacts negatively (Han et al., 2022; J.-H. Lee & Cho, 2021; Muhammad & Aryani, 2021). Furthermore, this relationship is influenced by the sector in which companies operate (Hardiyansah et al., 2021; Lin et al., 2015; Miralles-Quirós et al., 2018; Shen & Chang, 2009), indicating that different sectors may experience varying effects of environmental considerations on firm valuation.

Existing studies and market observations have provided conflicting findings regarding a company's carbon performance and disclosure and its financial value (Benkraiem et al., 2022; Han et al., 2022; Hardiyansah et al., 2021; J.-H. Lee & Cho, 2021; Matsumura et al., 2014; Muhammad & Aryani, 2021; Nishitani & Kokubu, 2012). This study seeks to contribute to the literature by examining the following research question: "*How does a company's carbon performance and disclosure, as assessed by CDP, relate to its value? Additionally, how each sector moderates this effect?".*

Investigating the effect of the Carbon Disclosure Project (CDP)'s score within different sectors can provide additional insights to this question, as CDP assumes the role of facilitator of collaboration among institutional investors (Cotter & Najah, 2012), a group of investors that are heavily concerned about climate change (PRI Association and UNEP Finance Initiative, 2010).

The findings of this study indicate a positive association between carbon management and the financial evaluation of companies, highlighting the importance of environmental considerations. Moreover, the extent of this effect varies based on the level of sensitivity to environmental issues exhibit by different companies.

The subsequent sections of this paper are organized as follows. Chapter 2 provides a comprehensive literature review, presenting existing academic insights on the topic, along with the formulation of the research hypotheses. Chapter 3 outlines the research methodology and empirical approach employed. The findings of the study are presented and briefly discussed in Chapter 4. Subsequently, Chapter 5 offers a detailed analysis of the results, highlighting the implications, limitations, and concluding remarks of the study.

2. Literature review

2.1. Carbon Management in the *win-win* and *win-lose* views

Carbon disclosure refers to the process of transparently reporting and disclosing a company's carbon emissions, climate-related risks, and mitigation strategies (Hahn et al., 2015). Effective carbon disclosure lead to transparency, accountability, and informed decision-making for the company itself and its stakeholders (Hess, 2007). On the other hand, carbon performance refers to a company's ability to effectively manage and diminish its carbon emissions and environmental impact. It encompasses the approaches, strategies, and results of a company's efforts to mitigate climate change and minimize its carbon footprint (Hoffmann & Busch, 2008). Carbon disclosure and carbon performance are interconnected and mutually influential. Siddique et al. (2021) and previous studies, such as Ahmad et al. (2021) and Luo & Tang (2014), have established a positive relationship between carbon performance and carbon disclosure for global firms, indicating that improved carbon performance is associated with increased levels of carbon disclosure.

Within this context, two contrasting perspectives are considered. The first perspective, known as the *win-win* approach (Porter & van der Linde, 1995), contends that shareholder value and corporate environmental strategies are not mutually exclusive, suggesting that addressing emissions and achieving profitability can be pursued concurrently, yielding positive outcomes for both. The second perspective, referred to as the *win-lose* view (Friedman, 1970), argues that voluntary actions undertaken to enhance carbon performance strategies may result in reduced profits, thereby contradicting the objective of maximizing shareholder value. This view implies that the costs associated with voluntary carbon management activities go against the interests of shareholder and can have a negative impact on firm evaluation.

The following paragraphs will provide a more comprehensive understanding of the existing academic research on carbon management activities and their implications for firm value. Firstly, the financial implications of carbon performance and disclosure will be examined. Subsequently, the study investigates the role of the Carbon Disclosure Project (CDP) in voluntary carbon disclosure and performance assessment and provide a more thorough explanation of the role of financial institution in this relationship.

2.2. The effect of Carbon Performance and Carbon Disclosure on Firm value

Multiple academic studies support the *win-win* approach, which assesses that effectively managing carbon performance can significantly influence a company's market valuation, potentially leading to financial benefits for firms with better carbon management (Benkraiem et al., 2022; Hardiyansah et al., 2021; Matsumura et al., 2014; Nishitani & Kokubu, 2012; Sun et al., 2022). For instance, Matsumura et al. (2014) conducted an analysis on S&P 500 companies from 2006 to 2008 and found that, on average, for every additional thousand metrics tons of carbon emissions, firm value decreased by $212,000. Similarly, Benkraiem et al. (2022) discovered that investors tend to reward firms with high level of carbon performance, particularly for companies with robust levels of gender diversity and innovation capacity. Furthermore, Nishitani & Kokubu (2012) found that companies reducing their greenhouse gas (GHG) emissions were more likely to enhance their firm value. Investors perceived carbon emission information as important and, if capital markets believe that carbon emissions are relevant for valuation, then also the way in which information is disclosed become crucial. Hardiyansah et al. (2021) demonstrate a positive and significant impact of carbon emission disclosure on firm value for Indonesian companies. Similarly, Matsumura et al. (2014) found that S&P 500 firms disclosing carbon emissions have a median value that is $2.3 billion higher compared to non-disclosing firms. In line with these findings, Sun et al. (2022) show that voluntary disclosure of carbon information has a positive effect on firm value, with this association being particularly pronounced in developing countries and for larger firms.

On the other hand, the *win-lose* perspective suggests that voluntary carbon management efforts have an adverse impact on firm value (Friedman, 1970). Multiple studies support this viewpoint by demonstrating a negative relationship between carbon performance, disclosure and firm value (Han et al., 2022; J.-H. Lee & Cho, 2021; Muhammad & Aryani, 2021). For instance, Lee & Cho, (2021) found a negative association between carbon performance and firm value among Korean conglomerate type of firm and Han (2022) reported a similar relationship in Taiwan firms. Furthermore, researchers have observed that market responses to voluntary carbon disclosure can sometimes be negative (S.-Y. Lee et al., 2013; Muhammad & Aryani, 2021), implying that investors may perceive carbon disclosure as unfavourable news.

2.3. Institutional investors relationship with CDP

The Carbon Disclosure Project (CDP) is a private, non-profit voluntary initiative designed to improve transparency between firms and investors and to encourage improved management of greenhouse gases by firms (Matisoff, 2013). CDP has a vast and comprehensive environmental database that is used by capital markets and purchasing organizations to make informed decisions, reward high-performing companies, and drive action. CDP is considered as the world's largest collaboration of institutional investors (Haque & Deegan, 2010) since more than 680 institutional investors holding more than US$17 trillion in assets are represented by CDP and nearly 19,000 companies, accounting for half of the global market capitalization, report their environmental data through CDP (*CDP Homepage*, 2023).

Institutional investors are professional investors who play a vital role in shaping financial markets and allocating capital (Ferreira & Matos, 2008). They manage diversified and long-term investment portfolios that mirror the composition of global capital markets (Cotter & Najah, 2012). As highlighted by the UN-backed Principles for Responsible Investment (*PRI) Association* and by the *United Nations Environment Programme (UNEP) Finance Initiative*, these portfolios inherently face growing and widespread costs resulting from environmental harm caused by corporations. Therefore, institutional investors have the potential to positively influence business practices to mitigate these externalities and reduce their overall vulnerability to such expenses. Given the long-term economic well-being and the interests of beneficiaries at stake, it is both appropriate and advisable for institutional investors to collaborate collectively, aiming to minimize financial risks associated with climate change (PRI Association and UNEP Finance Initiative, 2010).

In this context, CDP's assumes the role of a secondary stakeholder by facilitating collaborative engagement among institutional investors, thereby enhancing corporate accountability regarding climate change (Cotter & Najah, 2012). Institutional investors' demand for climate-related information induces firms to disclose information through CDP, and this is showed by the fact that firms with a higher concentration of institutional investors are associated with a greater likelihood of disclosing their climate risk information through CDP (Cohen et al., 2023, Ilhan, 2023). This study contributes to the existing literature on the impact of carbon disclosure and carbon performance on firm value. Specifically, the *CDP climate change score* is employed to assess carbon disclosure and performance (*CDP Scores Explained - 2023*), which has not been utilized in previous research. This unique approach provides valuable insights into the mixed findings regarding the *win-win* and *win-lose* perspective on carbon management, as it allows to examine this relationship using a score that is strongly influenced by institutional investors. The contribution of this study lies in understanding the extent to which institutional investors influence the effect of climate disclosure and performance on firm value.

2.4. Hypotheses Development

Extent researches indicate that capital markets take into account information on environmental disclosure and liability when evaluating a firm's ability to manage exposure to environmental risk (Barth & McNichols, 1994; Blacconiere & Patten, 1994; Campbell et al., 1998; Cormier & Magnan, 1997). Firm value is the reflection of investors' view on how the companies manage their functions (Hardiyansah et al., 2021). Therefore, as stated by Barth et al. (2001), If capital markets perceive carbon performance to be important for the valuation of a company and if performance is measured accurately enough, carbon emissions levels can have significant market-value implications.

Following the *win-win* approach, stream of literature showed that good environmental responsibility reputation can potentially bring economic benefits to firms. These benefits include increased revenues, positive perceptions of stakeholders (Simnett et al., 2009), a more talented and committed work force (Branco & Rodrigues, 2006) and fewer fines or other compliance costs (Sharfman & Fernando, 2008). Thus, even though there are no explicit costs for higher level of emissions to firms, there's evidence on the extent to which capital markets incorporate carbon disclosure and performance into firm valuation (Bolton et al., 2022; Matsumura et al., 2014). On the contrary, aligning with the *win-lose* perspective (Friedman, 1970) investors may perceive the adoption of voluntary carbon management practices as unfavourable news, particularly when competing firms exhibit a relatively low level of voluntary carbon management. In such scenarios, the voluntary disclosure of carbon-related information surpassed the mere fulfilment of government regulations, resulting in additional costs that can have negative impact on the overall value of the firms (Muhammad & Aryani, 2021). According to Lee et al., (2013), firms compelled to disclosure carbon information are recognized as heavy polluters, which influences their market value. Furthermore, Kolk et al. (2008) emphasizes that carbon information is too complex to be useful for investors to effectively assess firms' potential risk and opportunities related to climate change, thereby perceiving it as a cost.

However, as literature have shown the importance of tackling climate change for institutional investors (Clark & Hebb, 2005; Cotter & Najah, 2012; Ferreira & Matos, 2008), and as CDP operates as a facilitator of the collaboration of institutional investors (Cotter & Najah, 2012), it is expected that, as *CDP climate change score*[1] evaluates a company's carbon management in four consecutive categories (*D* category for carbon disclosure evaluation and *A*,*B*,*C* categories for carbon performance assessment), participating in CDP questionnaire would positively impact firm value, driven by institutional investors' needs. Moreover, it is expected that a higher *CDP climate change* score would have a positive and stronger impact on firm value.

The following hypothesis are tested:

Hypothesis 1. *CDP climate change scores have positive and significant impact on firm value.*

Hypothesis 2. Higher *CDP climate change scores correspond to higher positive and significant impact on firm value.*

Moreover, the effect of CDP *climate change* scores may be influenced by industry-specific factors. Industries that prioritize environmental sensitivity face substantial obligations regarding environmental and social responsibilities. Consequently, companies that exhibit a dedicated approach to corporate social responsibility (CSR) can fulfil stakeholders' expectations, gain acknowledgement, and foster positive relationships with stakeholders, thereby positively influencing their financial performance (Lin et al., 2015). On the other hand, in environmentally non-sensitive industries, the expectations from company stakeholders are less stringent. Therefore, companies that undertake CSR initiatives, such as participating in CDP questionnaires, might not necessarily receive stakeholder recognition. Moreover, as investments in CSR practices rise, these companies may not be positively evaluated by stakeholders. The increasing expenditure on CSR activities can dilute company's objectives, reduce the significance of CSR efforts and ultimately leading to a negative influence on financial performance (Shen & Chang, 2009).

[1] Elaborated information pertaining to the CDP climate change score can be accessed within the methodology section of this paper.

In other words, the needs of stakeholders regarding climate change in environmentally sensitive industries are considerably more significant compared to environmentally non-sensitive industries (Lin et al., 2015). Companies operating in environmentally sensitive sectors actively embrace CSR activities to meet stakeholder requirements, which brings them advantages and leads to improved financial performance. Conversely, companies in environmentally non-sensitive industries are not to make substantial investments in CSR activities since their stakeholders do not demand such efforts. Therefore, engaging in the *CDP climate change score* may be unnecessary for them. Moreover, if these companies significantly invest in carbon management activities, the associated costs and efforts can negatively affect their financial performance.

Based on these arguments, it is believed that industry type moderates the relationship between *CDP climate change scores* and the evaluation of firms. Specifically, for companies in environmentally sensitive industries, the effect of *CDP climate change scores* on firm valuation is expected to be more pronounced compared to companies in environmentally non-sensitive industries.

Therefore, the following hypothesis is tested:

Hypothesis 3. *The effect of CDP climate change scores on firm value is significantly stronger and positively amplified in industries that exhibit a high sensitivity to environmental factors.*

3. Methodology

3.1. Sample & Data

Based on Kim's (2022) research, this study centres on the carbon management practices of S&P 500 firms. As scholars suggested that these practices and responses are more prominent in larger firms rather than smaller or medium-sized ones (Kolk & Pinkse, 2004; Wickert, 2016), considering S&P 500 companies is a suitable sample to examine the correlation between carbon disclosure, carbon performance and firm value prediction.

The study utilizes a sample of all S&P 500 firms, spanning a five-year period from 2016 to 2020. The analysis begins in 2016 when the CDP implemented significant changes to its questionnaire to align with the *Task Force on Climate-Related Financial Disclosure*'s (TCFD) recommendations towards the end of that year (CDP – Climate Change Report 2016, 2016). While this temporal consideration may introduce certain limitations in incorporating the data collected from 2016, this year data was included to enhance the statistical robustness of the study. The decision to conclude data collection in 2020 is motivated by developments in the regulatory US landscape. In 2021, in fact, the U.S. *Securities and Exchange Commission* (SEC) initiated a proposal process aimed at establishing standardized guidelines for climate-related disclosure by organizations (Armour et al., 2021). This regulatory initiative might have impacted the way companies disclose climate-related information, thereby influencing the *CDP climate change score* assessment.

To address the potential influence of unexpected events, such as the COVID-19 pandemic, average yearly stock prices were calculated by aggregating monthly closing prices. This approach helps mitigate the impact of short-term fluctuations and provides a more stable measure of stock performance over the time considered (Salthouse & Nesselroade, 2010). However, residual effects of unexpected events may persist. The decision to include the year 2020 in the regression analysis was based on an examination of summary statistics of the average yearly stock prices per year, confirming its appropriateness (more information can be found in Table 7 in the appendix).

The CDP climate change scores for the period 2016 to 2020 were manually collected from the publicly available dataset provided by CDP (CDP data package website, 2023). CDP makes available all historical survey responses and climate *change scores* for companies that have consented to disclose this information. Researchers can access the complete historical CDP data through the CDP academic data package website (Blanco et al., 2016; *CDP data package website,* 2023.) It is worth noting that the CDP database includes the comprehensive list of S&P 500 firms, providing a comprehensive coverage of companies for analysis in the study.

Additionally, financial data of the S&P 500 companies were gathered from the financial web portal *Yahoo finance* (*Yahoo Finance - Stock Market Live, Quotes, Business & Finance News*, 2023.). Specifically, the closing stock price per month for each company were collected from 2016 to 2020, resulting in a total of 60 values per company. The overall dataset comprised a total of 28,714 values. Following the data acquisition phase, a data processing step was conducted to calculate the average yearly stock price for each individual firm within the S&P 500 firms. This resulted in a total of 2,371 yearly average stock price values.

Finally, the financial data of the S&P 500 firms was extracted from reliable sources, namely the *Income Statements* and research platforms such as *Macrotrends*. The specific variables collected and used in this study included *Return on Assets*, *GICS sectors*, *Leverage*, *Revenue*, *Basic Shares Outstanding*, *Total Current Assets, Total Non-Current Assets*, and *Total Liabilities*. These variables were chosen as they provide valuable insights into the financial performance, sector classification, leverage position, and asset and liability composition of the S&P 500 companies.

Table 1. General Composition

Panel A: Sample selection	Firms
S&P 500 firms (5 years x 500 firms per year)	2500
Firm with missing CDP score*	(491)
Firms with missing Tobin's Q	(22)
Firms with missing Revenue	(1)
Firms with missing D/E	(62)
Total	1928

Industry Composition

Panel B: GICS sector composition	Freq.	Percent
Communication Services	60	3.11
Consumer Discretionary	245	12.71
Consumer Staples	141	7.31
Energy	95	4.93
Financials	263	13.64

Health Care	226	11.72
Industrials	269	13.95
Information Technology	269	13.95
Materials	118	6.12
Real Estate	116	6.02
Utilities	126	6.54
Total	1928	100.00

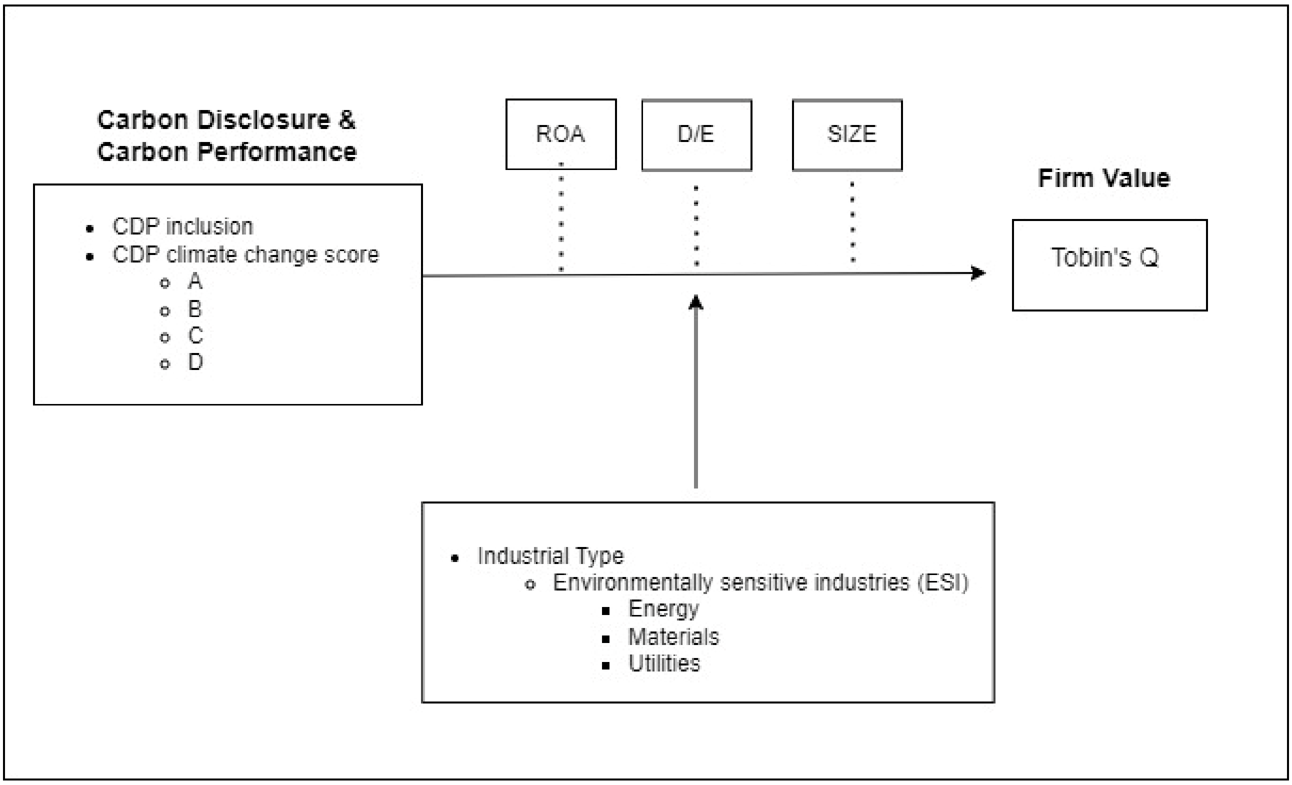
* In the context of this study, the term "missing CDP score" refers to the absence of a company's presence in the CDP database for a particular year. It should be noted that even an "F" score, indicating a company's failure to disclose information through CDP, is still considered as a score.

Table 1 details our sample. *Panel A* reveals that the sample for the S&P500 companies present in CDP database during the period of 2016-2020 consists of 1,928 firm-year observations while *Panel B* reveals that *Industrials, Information Technology* and *Consumer Discretionary* sectors have the largest number of observations: 13.95%, 13.95% and 13.64% respectively.

3.2. Operationalization

Figure 1. illustrates the operationalization of my conceptual framework based on previous literature that studied the effect of ESG scores, carbon performance and carbon disclosure on firm value (more information can be found in Table 9, 10, 11 in the appendix).

Figure 1. Empirical Model



In this study *Firm Value* is the dependent variable, while *Carbon Disclosure* and *Carbon Performance* are the independent variables of interest. Additionally, the *Industrial Type* is the moderating variable while profitability (*ROA),* leverage (*D/E),* and *size are the control variables.*

Table 2 provides a comprehensive summary of the methodology employed in the models for both the dependent and control variables and the expected effect of these variable on firm value.

Table 2. List of dependent and control variables

	Variables	Name of Variables	Measurement/Information collected from	Included in the regression based on:	Expected impact	Reference for the expected impact of the variable on Firm value:
Dependent Variable	TQ	Tobin's Q (Firm Value)	Measured as approximate Tobin's Q (Suriawinata & Nurmalita, 2022)TQ = (MVE + DEBT)/TA	(Benkraiem et al., 2022; Dalal & Thaker, 2019; Hardiyansah et al., 2021; Velte, 2017)		
Control Variables	ROA	Return on Assets	Key financial ratios collected from MacroTrends	(Benkraiem et al., 2022; Hardiyansah et al., 2021; Lee & Cho, 2021)	+	(Husna & Satria, 2019)
	D/E	Debt and Equity Ratio	Key financial ratios collected from MacroTrends. D/E = Total Debt / Total Assets	(Ahmad et al., 2021; Benkraiem et al., 2022; Dalal & Thaker, 2019; Hardiyansah et al., 2021; Lee & Cho, 2021; Muhammad & Aryani, 2021; Sun et al., 2022; Xie et al., 2018)	+	(Phương, 2011)
	SIZE	Revenue	Information collected from Income Statement. Size measured as Revenue following (Alkhazali & Zoubi, 2005)	(Ahmad et al., 2021; Benkraiem et al., 2022; Dalal & Thaker, 2019; Hardiyansah et al., 2021; Velte, 2017; Xie et al., 2018)	+	(Siahaan, 2013)

3.2.1. Dependent variable

Firm value (TQ) serves as the main dependent variable in this study. Consistent with previous research (Benkraiem et al., 2022; Dalal & Thaker, 2019; Hardiyansah et al., 2021; Nishitani & Kokubu, 2012; Velte, 2017; Xie et al., 2018), Tobin's Q is employed to evaluate the market's perception of each firm. Therefore, a modified version of the approximate Tobin's Q originally introduced by Chung and Pruitt (1994) is utilized, following the approach taken by Suriawinata & Nurmalita (2022). The specification of this measure is as follows:

$$TQ = (MVE + DEBT)/TA$$

Here, *TQ* represents Tobin's Q. *MVE* corresponds to the market value of equity, which is calculated by multiplying a firm's yearly average stock market price by the number of shares outstanding. *DEBT* refers to the book value of the total debts, while *TA* to the book value of the total assets. Tobin's Q is expected to exceed 1.0, indicating that the market value of the firm is greater than the book value of the firm represented by its total assets. Therefore, a higher Tobin's Q signifies a relatively higher firm value, while a lower Tobin's Q indicates the opposite.

3.2.2. Independent variables[2]

The Carbon Disclosure Project (CDP) is a non-profit organization that evaluates companies' commitment and progress towards climate action by collecting, aggregating, and scoring their voluntarily self-reported data through a questionnaire (*CDP Homepage*, 2023). CDP scores companies from *D-* to *A* based on their carbon performance and carbon disclosure through the information provided by the company in CDP's questionnaire. The CDP's scoring methodology is aligned with major environmental standards, and the scoring methodology provides helpful feedback for companies to reach environmental stewardship through the reflection of their performance[3] (*CDP Scores Explained*, 2023).

In the *CDP climate change program* companies are scored across four consecutive levels representing the steps a company moves through as it progress towards environmental stewardship:

- *Disclosure (D)*: the score measures the amount of data provided in response to the CDP questionnaire request and its relative importance.
- *Awareness (C)*: the score measures the comprehensiveness of a company's evaluation regarding the environmental issues interest with its business.
- *Management (B)*: the score measures the level of management for the environmental issues.

[2] All information regarding CDP climate change scores are collected from (CDP Scores Explained – CDP, 2022)
[3] For additional information about this topic, please refer to https://cdn.cdp.net/cdp-production/cms/guidance_docs/pdfs/000/000/233/original/Scoring-Introduction.pdf?

- *Leadership (A)*: companies that receive high scores across all previous levels and which disclose specific information about actions that demonstrates their leadership in environmental stewardship receive a score of *A* for leadership in CDP's evaluation.
- *Failed to disclose* (F): the score is given when a company fails to disclose through CDP.

A minimum score and/or the presence of a minimum number of indicators on one level will be required to be assessed on the next level. Furthermore, the scoring criteria and the relevance of the data points vary depending on the sector. Within each category, a company may receive a minus score if the provided information shows a lower level of progress in that category. For instance, to achieve a D rating rather than a D-, companies are expected to provide a more extensive range of information, similarly, a B- over a B score implies that a company is demonstrating a certain level of environmental impact management, but may not be exhibit leadership in its respective industries. Due to the low presence of minus scores, the analysis focused on the categorical representation of each score without distinguishing between scores with or without minus (more information can be consulted in Table 12 in the appendix). This approach allowed for a clearer understanding of the overall environmental performance and progress of the assessed companies, as it emphasized the broad categorization of their efforts rather than minor differences in their scores. Therefore, the analysis will focus on understanding the environmental journey of the organizations based on the four main levels: *Disclosure*, *Awareness*, *Management*, and *Leadership*.

A binary variable, denoted as *CDP inclusion*, has been constructed to indicate the participation of companies in the CDP *climate change questionnaire.* Specifically, a value of 1 has been assigned to companies receiving scores ranging from *A* to *D-*. Conversely, companies that failed to disclose information and obtained a score of *F* were assigned a value of 0. This variable provides insight into the impact of participating in the CDP questionnaire, without investigating the specific effects of different scores. Its relevance lies in understanding how the market perceived CDP.

3.2.3. Moderating variables

Investigation on whether the influence of CDP scores differs by firm characteristics have been conducted by predicting that firms belonging to environmentally sensitive industries have a stronger valuation effect of *CDP climate change score* compared to an average S&P 500 firm. To test if *CDP climate change scores* for environmentally sensitive industries have a different effect on firm value, the approach of Miralles-Quirós et al. (2018) that has also been followed by Yoon et al. (2018) was used. They argued that this hypothesis can be tested by examining the coefficient of an interaction term of the ESG scores (in this research the *CDP climate change scores*) and a dummy variable for environmentally sensitive firms. Following Lin et al. (2015), Garcia et al. (2017) and Miralles-Quiros (2018), sensitive companies that have a significant environmental impact have been identified in the *GICS* industrial sectors of *Energy*, *Materials*, and *Utilities*. The dummy variable *ESI* equals to 1 if a firm is included in one of the environmentally industries and 0 otherwise. The coefficient of the interaction variables captures the additional valuation effect of *CDP climate change scores* for environmentally sensitive industries. By investigating the significance and positivity of the coefficients, test on whether environmentally sensitive firms in the US are more rewarded for their climate change efforts can be conducted. The hypothesis is initially tested collectively for all three sectors and subsequently analysed for each sector individually. This approach allowed us to explore the potential variations in the influence of CDP scores on firm value within each sector. We expect the coefficient to be positive and significant; this would indicate a positive and significant differential effect on firm valuation of the *CDP climate change score* belonging to sensitive industries.

3.2.4. Control variables

This study incorporates several control variables that have been established as significant determinants of firm value in previous research, as outlined in Table 2 and Table 9, 10, 11 in the appendix. Firm *size* is included as a control variable, as larger firms may take advantage of economies of scale to enhance market value (Hardiyansah et al., 2021; Velte, 2017; Xie et al., 2018). Revenue, following the approach of Alkhazali & Zoubi (2005), is employed as an estimate of *firm size*. *Financial leverage*, measured by the debt-to-equity ratio, is included as a control variable, as firms with high financial leverage are more likely to lose market share and experience a negative effect on market value (Benkraiem et al., 2022; Dalal & Thaker, 2019; Hardiyansah et al., 2021; Sun et al., 2022; Xie et al., 2018). Additionally, *firm profitability*, measured by return on assets (*ROA*), is included as a control variable, given the established link between profitability and firm value in previous study (Benkraiem et al., 2022; Hardiyansah et al., 2021; J.-H. Lee & Cho, 2021).

3.3. Descriptive analysis

The validity of the models used in this study was assessed through a series of tests, the results of which are included in the tables 12, 13, and 14 in the appendix section. The conducted tests are as follows:

- Autocorrelation test (Drukker, 2003)
- Homoskedasticity test (Wooldridge, 2012)
- Hausman test (Hausman, 1978)

The correlation graph, displaying the relationships between variables, is also included in the appendix section in table 15.

Table 3. Descriptive Statistics – Total S&P500 Firms Table[4]

Variable	Obs	Mean	Std. Dev.	Min	Max
Tobin's Q	1928	2.348	1.807	.721	11.402
ROA	1928	5.978	6.461	-14.596	27.784
D/E	1928	1.116	2.87	-11.775	16.858
Size	1928	25215.883	40869.085	993.198	242155
P/S	1926	3.463	3.775	0	58.786

[4] The summary statistics in this study were computed using the *windsor2* function in Stata, which applies Windsorization to handle extreme values and calculate robust summary measures (Graham et al., 2020).

Table 4. Descriptive Statistics – S&P500 Firms that belongs to an environmentally sensitive sector (ESI_dummy = 1)

Variable	Obs	Mean	Std. Dev.	Min	Max
Tobin's Q	339	1.526	.678	.721	6.713
ROA	339	2.798	5.238	-14.596	27.784
D/E	339	1.147	1.937	-11.775	16.858
Size	339	19923.739	34180.514	993.198	242155
P/S	338	2.38	1.886	0	24.254

Table 3 presents the financial summary statistics of the *S&P 500* firms in the period 2016-2020. Comparing these statistics with the one in environmentally sensitive sectors (Table 4), notable differences are observed. The control variables show divergences between environmentally and non-environmentally sensitive industries, and the difference in Tobin's Q values indicates that firms in environmentally sensitive sectors have lower values compared to those outside these sectors. This difference suggests that the influence of *CDP climate change scores* on firm value may differ based on the sector's sensitivity to environmental factors.

Environmentally sensitive industries' descriptive statistics are further divided into their three sectors: Energy, Materials, and Utilities[5]. It appears that the low levels of Tobin's Q in environmentally sensitive industries is primarily driven by the *Energy* and *Utilities* sectors. While companies in the *Materials* sector closely align with the overall sample's average *Tobin's Q*, the *Energy* and *Utilities* ones exhibit notably lower average *Tobin's Q* values. This finding indicates that even within the environmentally sensitive sectors, different effects may exist. Therefore, further investigation will be conducted to understand the specific dynamics and factors influencing firm value within these different sectors.

Table 5. Tabulation of CDP climate change score

Panel A: Total distribution	Freq.	Percent
CDP (A)	440	22.82
CDP (B)	443	22.98
CDP (C)	371	19.24
CDP (D)	148	7.68
F	526	27.28
Total	1928	100

[5] Detailed Information can be found in tables 16, 17, and 18 in the appendix section.

Panel B: Distribution based on ESI dummy	Freq.	Percent.
ESI dummy = 1		
CDP (A)	56	16.52
CDP (B)	91	26.85
CDP (C)	46	13.57
CDP (D)	32	9.44
F	114	33.63
Total	339	100
ESI dummy = 0		
CDP (A)	384	24.17
CDP (B)	352	22.15
CDP (C)	325	20.45
CDP (D)	116	7.3
F	412	25.93
Total	1589	100

Table 5 shows the distribution of *CDP climate change* scores across the sample, providing a comprehensive overview of how the scores are spread throughout the entire dataset. *Panel A* reveals that, except for the *D* score, which represents only 7.68% of the sample, the remaining scores are evenly distributed.

Panel B illustrates the distribution of CDP *climate change scores* between companies that belongs to environmentally sensitive industries (*ESI* = 1) and companies that do not (*ESI*= 0). It can be observed that environmentally sensitive industries have a lower occurrence of *CDP climate change score A* compared to non-environmentally sensitive companies (16.52% versus 24.17%), while they have a higher frequency of score *B* (26.85% versus 22.15%). Moreover, it appears that non-environmentally sensitive industries have a higher occurrence of companies with score *C* (20.45% versus 13.57%), whereas environmentally sensitive industries have a higher frequency of companies failing to disclose information to CDP, indicated by score *F* (33.63% versus 25.93%). To delve deeper into these differences, further investigation is conducted to provide a breakdown of environmentally sensitive industries into their respective sectors in table 19 in the appendix section.

Upon conducting this comparison, a pattern emerges highlighting the significant influence of the *Energy* sector in driving a lower percentage of firms receiving the CDP *climate change* score *A*, which represents leadership in environmental stewardship in climate change. Moreover, it is worth noting that there are substantial differences within each sector regarding the percentage of companies that failed to disclose information through CDP. In the *Energy* sector, a considerable portion of companies failed to disclose, while in the *Materials* and *Utilities* sectors, the figures stand at average levels compared to the sample.

3.4. Regression Models

After conducting a *Hausman* test to assess the suitability of different panel regression methods, the fixed effects model was determined to be the most appropriate approach for the analysis (Hausman, 1978). Six fixed effects models were developed using the variables mentioned above. Additionally, alternative regression analysis will be conducted using the *Price-to-Sales* (*P/S*) ratio as the firm value dependent variable (Elliott et al., 2008) to ensure the robustness of the findings.

Fixed effects panel regression model is used to examine the relationship between CDP *climate change* scores and firm value for each S&P500 company during the period 2016-2020. The fixed effects model allows for the examination of within-firm variations in CDP scores and firm value, capturing the changes that occur within each individual company over the time considered (Wooldridge, 2012). By focusing on the within-variation, the study effectively controls for time-invariant factors that are specific to each company (Allison, 2009). This approach is crucial given the diverse nature of S&P 500 companies, which exhibit variations in management practices, organizational structures, and other firm-specific characteristics (Block, 2010). Controlling for firm-specific characteristics enhances the accuracy and validity of the analysis, providing a more robust understanding of the relationship between CDP climate change scores and firm value within the S&P500 companies.

The two models used to test *H1* and *H2* are as follows:

(1) $TQ_{it} = \beta 0 + \beta 1\ CDP_{it} + \beta 2 ROA_{it} + \beta 3 D/E_{it} + \beta 4 SIZE_{it} + \varepsilon_{it}$

(2) $TQ_{it} = \beta 0 + \beta 1\ CDP(A)_{it} + \beta 2 CDP(B)_{it} + \beta 3 CDP(C)_{it} + \beta 4 CDP(D)_{it} + \beta 5 ROA_{it} + \beta 6 D/E_{it} + \beta 7 SIZE_{it} + \varepsilon_{it}$

Regarding *Hypothesis 3*, model (2) has been extended by including interaction terms between sector and CDP climate change score *ESI/Energy/Materials/Utilities*CDP climate change scores*. Therefore, four fixed effect panel regression models which aim to investigate the relationship between *CDP climate change scores* and firm value across environmentally sensitive sectors, have been used. The models have been constructed following Miralles-Quirós et al., (2018) and Yoon et al. (2018)

The equations used in the fixed effect models firstly uses the environmentally sensitive industries (*ESI)* as the interaction term (model 3) with each *CDP climate change score*, then the *ESI* term is substituted by *Energy* (model 4), followed by *Materials* (model 5) and finally *Utilities* (6):

(3) ESI/ (4) Energy / (5) Materials / (6) Utilities

$$TQ_{it} = \beta 0 + \beta 1\ CDP(A)_{it} + \beta 2 CDP(B)_{it} + \beta 3 CDP(C)_{it} + \beta 4 CDP(D)_{it} + +\beta 5\ ESI/Energy/Materials/Utilities * CDP(A)_{it} + \beta 6\ ESI/Energy/Materials/Utilities * CDP(B)_{it} + \beta 7\ ESI/Energy/Materials/Utilities * CDP(C)_{it} + \beta 8\ ESI/Energy/Materials/Utilities * CDP(D)_{it} + \beta 9\ ROA_{it} + \beta 10\ D/E_{it} + \beta 11\ SIZE_{it} + \varepsilon_{it}$$

4. Results

Table 6. CDP Inclusion/ CDP climate change score/ Moderating effect of Environmentally sensitive sector / Moderating effect of Energy sector / Moderating effect of Materials sector / Moderating effect of Utilities sector / Fixed Effect Regression Results

	(1) TQ	(2) TQ	(3) TQ (ESI)	(4) TQ (Energy)	(5) TQ (Materials)	(6) TQ (Utilities)
CDP	0.108***					
	(-0.041)					
CDP(A)		0.173***	0.217***	0.184***	0.191***	0.175***
		(-0.05)	(-0.05)	(-0.044)	(-0.044)	(-0.046)
CDP(B)		0.163***	0.208***	0.171***	0.185***	0.165***
		(-0.048)	(-0.046)	(-0.039)	(-0.039)	(-0.041)
CDP(C)		0.139***	0.178***	0.149***	0.156***	0.141***
		(-0.045)	(-0.044)	(-0.038)	(-0.039)	(-0.039)
CDP(D)		0.094**	0.114**	0.096**	0.104**	0.095**
		(-0.048)	(-0.047)	(-0.042)	(-0.042)	(-0.043)
Sector*CDP(A)			-0.12	-0.393	-0.174	-0.009
			(-0.101)	(-0.29)	(-0.175)	(-0.124)
Sector*CDP(B)			-0.131	-0.61	-0.244*	-0.016
			(-0.081)	(-0.139)	(-0.133)	(-0.105)
Sector*CDP(C)			-0.114	-0.119	-0.163	-0.018
			(-0.083)	(-0.16)	(-0.122)	(-0.125)
Sector*CDP(D)			-0.038	0.031	-0.103	-0.004
			(-0.096)	(-0.201)	(-0.15)	(-0.132)
ROA	0.045***	0.037***	0.038***	0.037***	0.037***	0.037***
	(-0.011)	(-0.012)	(-0.06)	(-0.006)	(-0.006)	(-0.006)
D/E	0.008	0.011	0.011	0.011	0.011	0.011
	(-0.012)	(-0.014)	(-0.009)	(-0.009)	(-0.009)	(-0.009)
SIZE	-0.057***	-0.572***	-0.57***	-0.572***	-0.571***	-0.572***
	(-0.076)	(-0.081)	(-0.035)	(-0.035)	(-0.35)	(-0.035)
Constant	5.273***	5.836***	5.801***	5.832***	5.828 ***	5.835***
	(-0.748)	(-0.748)	(-0.33)	(-0.331)	(-0.33)	(-0.33)
N	1928	1928	1928	1928	1928	1928

*This table reports estimation of the models (1), (2), (3), (4), (5) and (6) by employing periods fixed-effects panel regression using data from 2016-2020. Standard errors are reported in parentheses. The symbols ***, ** and * denote the estimated coefficients are significant at 1%,5%, and 10% levels, respectively. Notably, the variable "CDP climate change Score (F)," which signifies a company's failure to disclose information through CDP, has been excluded from the analysis as it serves as the reference variable for interpreting the coefficients of our categorical CDP climate change score dummy variables for models (1) and (2), the same has been done for the interaction term "Sector*CDP(F)" in model (3), (4), (5) and (6). The "Sector" variable included in the table should be replaced with the corresponding sector name as indicated in the parentheses in the first row for models (3), (4), (5), and (6). Robustness test have been conducted using Price to Sales ratio as the dependent variable following Elliott et al. (2008) and can be consulted in table 20 in the appendix section.

Table 6 presents the results of six fixed effects panel regression models that investigates the relationship between *CDP climate change score* and firm value among S&P 500 firms.

In model (1) the primary independent variable of interest is participation in the CDP questionnaire, represented by a binary variable (*CDP*) equals to 1 if a company has received one of the *CDP climate change scores* (*A* to *D*), while a value of 0 indicates otherwise. In terms of the level specification, the coefficient of *CDP* is positively and statistically significant (coefficient = 0.108, significance level = 0.01). This result indicates that firms that undergo evaluation through the CDP questionnaire exhibit a 10.8% higher Tobin's Q value compared to their non-participating counterparts.

In model (2), the previous model has been expanded to investigate the relationship between Tobin's Q and the individual scores assigned by CDP for climate change (ranging from *A* to *D*). The findings demonstrate that, when considering the level specification, the coefficients associated with each *CDP climate change score* are positive and exhibit statistical significance. Specifically, *CDP climate change scores A*, *B*, and *C* are significant at a 1% level, whereas score *D* is significant at a 5% level. The findings of the models demonstrate that participating in the CDP questionnaire leads to higher valuations for companies and firms with higher *CDP climate change scores* tend to exhibit higher Tobin's Q values compared to companies that do not disclose their information through CDP. Companies with a *CDP climate change* score of *A* experience a 17.3% higher Tobin's Q value compared to companies with an *F* score. The positive effect gradually decreases for companies with score of *B* (16.3%) and *C* (13.9%), and significantly diminishes for companies with a score of *D* (9.4%).

Models (3), (4), (5) and (6) explore the effect between *CDP climate change scores* and firm value across various sectors, with a specific emphasis on environmentally sensitive industries. In the analysis the focus is on examining the relationship between firm value and the interaction terms between *CDP climate change* scores and environmentally sensitive sectors. The primary independent variables of interest are the interaction terms. Initially, model (3) is designed to investigate the overall effect across all three sectors simultaneously. Subsequently, the analysis is refined by disaggregating the model into the Environmentally sensitive industries (*ESI*) dummy variable respective sectors: *Energy*, *Materials*, and *Utilities*, represented by models (4), (5), and (6) respectively. The results indicate that in all the models each CDP scores retains their statistical significance, however, the inclusion of the sector variables leads to changes in model (3) where the coefficients of all the *CDP climate change scores* have higher values compared to the other models. On the other hand, these changes are not particularly evident for each individual sectors.

Furthermore, the analysis reveals that the interaction terms between *CDP climate change* scores and environmentally sensitive industries are statistically insignificant in models (3), (4) and (6). The data do not provide strong evidence of a significant association between environmentally sensitive industries and firm value, both at the aggregate and within individual sectors level. However, despite the lack of statistical evidence, the negative coefficients indicate a potential negative relationship between environmentally sensitive industries and firm value. In Model (5), a significant negative effect has been found resulting from the interaction term between the *Materials* sector dummy variable and *CDP climate change score B*. The coefficients associated with this interaction term indicate a substantial 24.4% decrease in firm value for companies in the *Materials* sector that are scored *B* in the *CDP climate change* questionnaire compared to those that failed to provide information through CDP. This finding highlights the importance of further investigating this relationship, as it indicates that a *CDP climate change score* of *B* in the Materials sector leads to a 5% decrease in firm value.

With respect to control variables, the analysis reveals a positive and statistically significant coefficient for Return on Assets (*ROA*) in all models. As Husna & Satria (2019) showed, profitability level has a positive association with the firm value, indicating that an increase in profitability corresponds to an increase in the firm's overall value. In contrast, the *SIZE* variable, represented by the revenue level, exhibits a negative relationship with Tobin's Q. This implies that smaller firms tend to have bigger level of firm value. Additionally, all estimations are accompanied by small standard errors, indicating a higher degree of precision, and providing further confidence in the observed associations previously described.

Overall, the findings suggest that participating in the CDP questionnaire and attain higher *CDP climate change scores* are associated with improved firm value, indicating the market's recognition of the value of climate change management, both in terms of carbon disclosure (*CDP climate change D*) and at the carbon performance level (*CDP climate change A,B,C*). Additionally, the sector-specific analysis does not reveal any variation effect across industries, showing that the market perception of the climate-related risks is similar across sectors.

5. Discussion and Conclusion

5.1. Discussion

The primary aim of this study was to conduct a comprehensive investigation into the relationship between carbon disclosure, performance, and firm value. This investigation focused on analysing the role of *CDP climate change score* in the financial market and further examining the impact of sector. This study was driven by the recognition that CDP acts as a representative of institutional investors (Cotter & Najah, 2012; Ferreira & Matos, 2008; Haque & Deegan, 2010). Consequently, it became valuable to explore how the market reacts to carbon management practices, particularly those driven by institutional investors.

The findings of the study have confirmed *Hypothesis 1* and *2* across all models, suggesting that the CDP climate change scores have positive and significant effect on firm value and that higher CDP climate change scores are associated with a greater positive impact on firm value. The result overall aligns with the *win-win* perspective in seeing carbon management as a strategic business approach that not only contributes to addressing climate change, but also enhance firm evaluation by the market (Porter & van der Linde, 1995). The results are consistent with the research conducted by Matsumura et al. (2014), as they provide empirical evidence of a positive relationship between voluntary participation in the Carbon Disclosure Project questionnaire and firm value. Conversely, the findings contradict the results of Muhammad and Aryani (2021), who identified a negative relationship between disclosing carbon information and firm value. The results suggest that the capital market perceives the act of participating in the CDP questionnaire and undergoing assessment of carbon disclosure and performance as a valuable action when evaluating firm value. This perception may be driven by the recognition that institutional investors, who deeply care about climate change, as they see it as a material risk (Cotter & Najah, 2012), view participating in CDP questionnaire as a significant factor in their investment. Therefore, the positive relationship between CDP participation and firm value could be attributed to the influence of institutional investors and their emphasis on environmental considerations. This interpretation is further supported by the observation that the higher CDP climate change score exhibits a stronger positive impact on firm value, indicating that investors recognize the importance of climate change management by the companies through carbon disclosure and performance. These findings are consistent with previous studies conducted by Benkraiem et al. (2022), Lee & Cho (2021), Matsumura et al. (2014), and Nishitani & Kokubu (2012), which have also found a positive relationship between carbon performance and firm value. Moreover, they are consistent with the findings of Hardiyansah et al. (2021) and Sun et al. (2022), who have established a positive relationship between carbon disclosure and firm value.

Regarding the moderating effect of environmentally sensitive sectors, the findings do not provide substantial evidence to either support or reject *Hypothesis 3*, which suggests a higher effect of *CDP climate change scores* on firm value for industries in environmentally sensitive industries. This might indicate that, in environmentally sensitive sectors, *CDP climate change score* does not have a significant influence. One possible explanations is that environmental practices in sensitive industries are already reflected in share prices, as indicated by Miralles-Quirós et al. (2018). In their research, the authors found that only unexpected information such as social and corporate governance practices added significant value in the financial market.

The study suggests that future research should consider expanding the scope of investigation to include other CDP's questionnaire, such as those related to water security and forests, to examine whether the observed effects extend to other environmental issues. Additionally, it is important to acknowledge the importance of considering the contextual factors that may influence the role of CDP in differential markets. Therefore, it would be valuable to investigate the relationship between carbon disclosure, performance, and firm value within the Asian market, as existing literature suggests that the impact of carbon management in this region differ from that in Western regions such as the US and Europe (Dalal & Thaker, 2019; Hardiyansah et al., 2021; J.-H. Lee & Cho, 2021; Nishitani & Kokubu, 2012; Yoon et al., 2018b).

5.2. Implications

One of the implications derived from this study is its potential to assist managers in making informed decisions regarding their participation in the Carbon Disclosure Project (CDP) questionnaire and the timing of publicly disclosing their scores and questionnaire responses. It is important for firms to recognize that mere participation in the CDP questionnaire and the subsequent public disclosure of information should not be driven solely by the anticipation of obtaining a high score. The findings of this study suggest that the market perceives the act of participating in the CDP questionnaire as valuable, indicating that firms may benefit from engaging in this process regardless of their resultant score. However, higher CDP scores are associated with higher firm value. Therefore, managers should not perceive the CDP climate change score as a standalone feature capable of automatically enhancing firm value. Instead, they should strive to improve their climate performance and disclosure levels to effectively leverage the potential benefits associated with higher CDP scores.

5.3. Limitations

Several limitations should be acknowledged when interpreting the findings of this study in conjunction with the results. The composition of the sample is an important limitation to consider in this study, as mentioned in the methodology section. It should be noted that the questionnaire used by the CDP in 2016 did not fully implement the recommendations of TCFD. Therefore, there may be slight variations in the questionnaire used across different years that might lead to inconsistencies in the data. Additionally, COVID-19 might have caused effects well beyond the stock price effect, which the control methodology employed in this research may not adequately account for. Consequently, the inclusion of data from the year 2020 might result in biased estimation, as the control method might not fully capture the multifaceted impacts of the pandemic.

When considering the operationalization of each variable, it is important to note that Tobin's Q has been calculated as an approximation of Chung & Pruitt's (2007) version. This approximation introduces some limitations and potential inaccuracies in the measurement of Tobin's Q. Additionally, the inclusion of the climate change scores with "minus" within their broader categories may restrict the availability of important information that could have been valuable for the study and consequently nuanced insights and details pertaining to minus scores may have been overlooked or lost.

5.4. Conclusion

This paper aims to make a valuable contribution to the ongoing discussion surrounding the relationship between environmental sustainability and financial performance. The study aligns with the *win-win* perspective, which emphasizes the positive synergies between carbon management practices and firm evaluation. The findings derived from the analysis provide evidence that participating in the Carbon Disclosure Project (CDP) climate change questionnaire is associated with higher financial evaluation. This positive relationship holds true for both the act of participation itself and the level of carbon disclosure and performance assessed by CDP. These results suggest that companies that prioritize and effectively manage their carbon performance and disclosure, as evaluated by CDP, experience a favourable impact on their firm value. However, environmentally sensitive sectors exhibit differential responses to carbon management strategies. While this effect may not be evident in firm valuation, it could manifest in other aspects. Further investigation is necessary to understand the nuanced dynamics at play.

This study advances the discussion on the relationship between environmental sustainability since the unique aspect of this analysis lies in the approach taken. By investigating the relationship between carbon disclosure, performance, and firm value using a score strongly influenced by institutional investors, this study demonstrates the influence of institutional investors in shaping the effect of carbon management in firm valuation.

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7. Appendix

Table 7. - Summary statistics: Average yearly stock price per Year

Year	N	mean	sd	min	max
2016	352	82.028	94.755	5.758	1346.545
2017	378	96.708	113.129	11.127	1814.539
2018	391	112.289	181.825	10.158	2742.244
2019	395	122.589	206.286	9.28	3305.723
2020	391	128.177	225.469	5.994	3653.78

Table 8. - Distribution of CDP climate change scores in the sample

CDP score	Freq.	Percent
A	145	7.52
A-	295	15.30
B	379	19.66
B-	64	3.32
C	358	18.57
C-	13	0.67
D	127	6.59
D-	21	1.09
F	526	27.28
Total	1928	100.00

ESG score	**Source**	**Summary**	**Dependent Variable**	**Independent Variables**	**Additional independent variables**	**Control variables**	**Findings**
	Yoon, B., Lee, J. H., & Byun, R. (2018). Does ESG Performance Enhance Firm Value? Evidence from Korea. *Sustainability*, *10*(10), Article 10. https://doi.org/10.3390/su10103635	Testing the valuation effect of CSR performance expecting a stronger valuation in firms that belong to environmentally sensitive industries;	-MARKET VARIABLE: Stock price of firm at the end of the year;	- ESG score;	- Sectors (1/0 variables showing if the firm is in an environmentally sensitive industry); - Firm is part of Korean Chaebol sectors (1/0 variable);	- Book value per share; - Earning per shares;	ESG score has a positive effect on firm value and this effect is weaker for environmentally sensitive industries;
	Velte, P. (2017). Does ESG performance have an impact on financial performance? Evidence from Germany. Journal of Global Responsibility, 8. https://doi.org/10.1108/JGR-11-2016-0029	Testing the effect of ESG score on accounting and market performance by breaks down ESG score into its three components;	-MARKET VARIABLE: firm value (Tobin's Q) ; - ACCOUNTING VARIABLE: Return on Assets (ROA);	-ESG score; -ESG scores separately;		-R&D expenditures; -Firm size; -Sectors;	ESG has a positive impact on ROA but no impact on Tobin's Q;
	Dalal, K. K., & Thaker, N. (2019). ESG and corporate financial performance: A panel study of Indian companies. *The IUP Journal of Corporate Governance*, *18*(1).	Examine the influence of ESG scores on the performance of Indian companies in terms of profitability and firm value;	-MARKET VARIABLE: firm value (Tobin's Q); - ACCOUNTING VARIABLE: Return on Assets (ROA);	-ESG score;		-Financial leverage (D/E ratio); -Total Revenues; -Capital Expenditures;	Higher ESG scores equals better financial performance both in terms of accounting measures than in market measures terms;

						-Tax rate;	
	Ahmad, N., Mobarek, A., & Roni, N. N. (2021). Revisiting the impact of ESG on financial performance of FTSE350 UK firms: Static and dynamic panel data analysis. *Cogent Business & Management*, *8*(1), 1900500. https://doi.org/10.1080/23311975.2021.1900500	Panel study on the impact of ESG scores on the financial performance of UK firms from 2002 to 2018	-MARKET VARIABLE: Market value: Share price x number of ordinary shares in issue; Earnings per Share;	-ESG score; -ESG scores separately;		-Financial leverage (D/E ratio); -Total Revenues; -Capital Expenditures; -Tax rate;	ESG score has a positive and significant impact of total on the market value and earnings per share (EPS) of firms. There are mixed results on the effect of the individual dimensions of ESG. Firm size moderates the relationship between ESG and firm financial performance;
	Xie, Jun & Nozawa, Wataru & Fujii, Hidemichi & Yagi, Michiyuki. (2018). Do Environmental, Social and Governance Activities Improve Corporate Financial Performance?. Business Strategy and the Environment. 28. 10.1002/bse.2224.	Study on the relationship between ESG score, corporate efficiency, and profitability	-MARKET VARIABLE: firm value (Tobin's Q); -ACCOUNTING VARIABLE: Return on Assets (ROA); -Corporate efficiency;	- ESG score; -ESG disclosure score;		-Sectors; -Country; -R&D expenditures; -Firm size; -Financial leverage (D/E ratio)	Corporate efficiency and ESG disclosure have a positive relationship at the middle disclosure level. ESG score have non-negative relationship with corporate efficiency, ROA and market value;

Table 9. – Literature methodology summaries on ESG rank relationship

Carbon performance	Source	Summary	Dependent Variable	Independent Variables	Additional independent variables	Control variables	Findings
	Lee, J.-H., & Cho, J.-H. (2021). Firm-Value Effects of Carbon Emissions and Carbon Disclosures—Evidence from Korea. *International Journal of Environmental Research and Public Health*, *18*(22), Article 22. https://doi.org/10.3390/ijerph182212166	Study on the association between carbon emissions, carbon disclosures, and firm value	-MARKET VARIABLE: 1)Adjusted Stock Return; -NON-FINANCIAL VARIABLE: 2) Carbon Disclosure presence (1/0 variable);	1) -Firm's Carbon Emissions/Sales; -Total Assets/Sales; -Total Liabilities/Sales; -Net Income/Sales; 2) ESG score;		-Proportion of firms disclosing CO2 in affiliated industries; -Total Assets; -Return on Assets (ROA); -Financial Leverage (D/E ratio); -Advertising Expenses/Total Assets;	Significantly positive relationship between carbon emissions and firm value but only for certain sectors; Environmental performance is positively related to the likelihood of voluntary carbon emission disclosure;
	Matsumura, E. M., Prakash, R., & Vera-Muñoz, S. C. (2014). Firm-Value Effects of Carbon Emissions and Carbon Disclosures. *The Accounting Review*, *89*(2), 695–724.	Examine the effects on firm value of carbon emissions and of the act of voluntarily disclosing carbon emissions	-MARKET VARIABLE: 1) Market value of common equity (Shares outstanding x price of share) -NON-FINANCIAL VARIABLE: 2) Carbon Disclosure	-Firm's Carbon emissions	1) -total assets; -total liabilities; 2) -proportion of firms in an industry that disclose carbon emissions to CDP; -Size; -Number of management forecasts issued	-Firm's operating income; -Sectors;	Capital markets integrate both carbon emissions and the act of voluntary disclosure carbon emissions its valuations. The market penalize all firms for their carbon emissions and firms that do

			presence (1/0 variable);		(proxy for general propensity); -Firm growth (book-to-market ratio); -Financial leverage (D/E ratio); -total foreign sales (proxy = foreign sales); -Lagged emissions indicator (1/0 variable); -Sector with GHG emissions reporting requirements (1/0 variable)		not disclose their carbon emissions face further penalizations.
	Benkraiem, R., Shuwaikh, F., Lakhal, F., & Guizani, A. (2022). Carbon performance and firm value of the World's most sustainable companies. *Economic Modelling*, *116*, 106002. https://doi.org/10.1016/j.econmod.2022.106002	Examining how carbon performance affects firm's market value and how this effect is driven by leadership, gender diversity and	-MARKET VARIABLE: firm value (Tobin's Q);	-GHG emissions (scope 1 and 2)		-Financial leverage (D/E ratio); -Capital Expenditures; -Firm's size	Carbon performance and leadership improved firm valuation. gender diversity and corporate innovation capacity may

		innovation capacity				-Firm's profitability (ROA); -Country; -R&D expenditures; -Leadership gender diversity;	moderate the value-maximizing nature of such actions;
	Nishitani, K., & Kokubu, K. (2012). Why Does the Reduction of Greenhouse Gas Emissions Enhance Firm Value? The Case of Japanese Manufacturing Firms. *Business Strategy and the Environment*, *21*(8), 517–529. https://doi.org/10.1002/bse.734	Study on the influence of firms' GHG emissions reduction on firm value	-MARKET VARIABLE: firm value (Tobin's Q);	-NON-FINANCIAL VARIABLE: -GHG reduction; -Environmental performance;		-Foreign Investors (number of stocks held by foreign investors/ total number of stocks); -Financial institution investors (number of stocks held by financial institutions divided by the total number of stocks); -Number of employess;	Firm's reduction of GHG emissions enhance firm value and this occurs where the market discipline imposed by investors is strong

						-Advertising expenditure ratio; -year of operation;	

Table 10. - Literature methodology summaries on Carbon performance relationships

Carbon disclosure	**Source**	**Summary**	**Dependent Variable**	**Independent Variables**	**Additional independent variables (moderators)**	**Control variables**	**Findings**
	HARDIYANSAH, M., AGUSTINI, A. T., & PURNAMAWATI, I. (2021). The Effect of Carbon Emission Disclosure on Firm Value: Environmental Performance and Industrial Type. The Journal of Asian Finance, Economics and Business, 8(1), 123–133. https://doi.org/10.13106/JAFEB.2021.VOL8.NO1.123	Study on the effect of carbon emission disclosure on firm value and how environmental performance and industrial type moderate this effect	-MARKET VARIABLE: firm value (Tobin's Q);	-Carbon emission disclosure ;	- Environmental performance; -Sector;	- Return on Assets (ROA); -Size; --Financial institution investors; -Financial Leverage (D/E ratio);	-Carbon emission disclosure has a positive and significant effect on firm value and environmental performance can strengthen the influence relationship of carbon emission disclosure on firm value; -Industrial type strengthens the relationship of carbon emissions disclosure on firm value.
	Muhammad, G. I., & Aryani, Y. A. (2021). The Impact of Carbon Disclosure on Firm Value with Foreign Ownership as A Moderating Variable. *Jurnal Dinamika Akuntansi Dan Bisnis*, *8*(1), 1–14. https://doi.org/10.24815/jdab.v8i1.17011	Study that analyse the effect of carbon disclosure on firm value and examine the moderation	-MARKET VARIABLE: Market Capitalization;	-Carbon emission disclosure (GRI);	**-**Foreign investors ownership;	-Profit (Net Income/Total equity); -Size;	-Carbon disclosure negatively affects firm value; -Foreign ownership

		effect of foreign ownership				-Financial Leverage (D/E ratio);	significantly impacts the relationship between carbon disclosure and firm value
	Sun, Z.-Y., Wang, S.-N., Li, D., & Li, D. (2022). The impacts of carbon emissions and voluntary carbon disclosure on firm value. *Environmental Science and Pollution Research International*, *29*(40), 60189–60197. https://doi.org/10.1007/s11356-022-20006-6	Study on the effects of voluntary carbon disclosure information and carbon emissions on firm value	-MARKET VARIABLE: outstanding common shares x market price share	1) -Carbon Emissions 2) -Disclosing carbon emissions (1/0 variable)	1) -Total Assets; -Total Liabilities; 2) Price to earning ratio	1) -Operating Income; -Financial leverage (D/E ratio);	-The increase in carbon emissions has a negative impact on firm value; -The disclosure of carbon emissions has a positive impact on firm value.

Table 11. - Literature methodology summaries on Carbon Disclosure relationships

Table 12.- Autocorrelation test - Matrix of correlations of residuals

Variables	(1)	(2)
(1) residuals	1.000	
(2) Lagged .residuals	0.957	1.000

(Drukker, 2003)

Table 13. – Homoscedasticity test Linear regression

residuals4	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
A	-.009	.051	-0.18	.853	-.11	.091	
B	-.1	.051	-1.97	.049	-.199	-.001	**
C	-.028	.052	-0.54	.589	-.129	.073	
o	0	.	.	.	.	.	
F	.041	.049	0.84	.403	-.056	.138	
log_ROA	.128	.008	15.22	0	.111	.144	***
log_DE	-.049	.012	-4.11	0	-.073	-.026	***
log_revenue	.459	.011	42.64	0	.438	.48	***
Constant	-4.502	.108	-41.54	0	-4.714	-4.289	***

Mean dependent var	-0.000	SD dependent var	0.781
R-squared	0.540	Number of obs	1928
F-test	321.994	Prob > F	0.000
Akaike crit. (AIC)	3036.411	Bayesian crit. (BIC)	3080.925

*** p<.01, ** p<.05, * p<.1

(Wooldridge, 2012)

Table 14. - Hausman (1978) specification test

	Coef.
Chi-square test value	258.007
P-value	0

(Hausman, 1978)

Table 15. – Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) lTobinsQ	1.000						
(2) ESI_dummy	-0.223	1.000					
(3) A	-0.022	-0.069	1.000				
(4) B	-0.073	0.042	-0.297	1.000			
(5) C	0.043	-0.066	-0.265	-0.267	1.000		
(6) D	0.032	0.031	-0.157	-0.157	-0.141	1.000	
(7) log_ROA	0.413	-0.212	0.002	-0.053	0.046	0.011	1.000
(8) log_DE	-0.102	0.054	0.093	0.062	-0.014	-0.024	-0.051
(9) log_revenue	-0.230	-0.026	0.243	0.078	-0.004	-0.061	0.027

Table 16. - Descriptive Statistics – S&P500 Firms that belong to the Energy Sector

Variable	Obs	Mean	Std. Dev.	Min	Max
Tobin's Q	95	1.373	.396	.721	2.639
ROA	95	-.128	6.906	-14.596	10.815
D/E	95	.585	1.39	-11.775	2.753
Size	95	41916.413	57782.198	993.198	242155
P/S	94	2.396	2.672	.272	24.254

Table 17. - Descriptive Statistics – S&P500 Firms that belong to the Materials Sector

Variable	Obs	Mean	Std. Dev.	Min	Max
Tobin's Q	118	1.916	.956	.767	6.713
ROA	118	5.437	4.356	-10.269	18.679
D/E	118	1.115	2.75	-11.775	16.858
Size	118	12077.434	9655.822	2531.2	49604
P/S	118	2.204	1.652	0	11.001

Table 18. - Descriptive Statistics - S&P 500 Firms that belong to the Utilities Sector

Variable	Obs	Mean	Std. Dev.	Min	Max
Tobin's Q	126	1.276	.208	.903	2.18
ROA	126	2.534	2.722	-5.759	27.784
D/E	126	1.601	1.082	-5.284	5.174
Size	126	10690.087	7029.721	2454.648	35978
P/S	126	2.531	1.292	.45	8.147

Table 19. - Tabulation of CDP climate change score for its sector (Energy, Materials, and Utilities)

Panel A: Energy	Frequency	Percenta
CDP (A)	5	5.26%
CDP (B)	20	21.95%
CDP (C)	12	12.63%
CDP (D)	11	11.58%
F	47	49.47%
Total	95	100.00%
Panel B: Materials	Frequency	Percenta
CDP (A)	30	25.42%
CDP (B)	28	23.73%
CDP (C)	21	17.80%
CDP (D)	10	8.47%
F	29	24.58%
Total	118	100.00%
Panel C: Utilities	Frequency	Percenta
CDP (A)	21	16.67%
CDP (B)	43	34.13%
CDP (C)	13	10.32%
CDP (D)	11	8.73%
F	38	30.16%
Total	126	100.00%

Table 20. - Robustness Check (Elliott et al., 2008)

Regression results – Model (1)

PSratio	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
CDPinclusion	.366	.173	2.12	.034	.027	.706	**
log_ROA	-.036	.08	-0.45	.653	-.194	.122	
log_DE	.046	.099	0.47	.638	-.148	.24	
log_revenue	-4.606	.706	-6.52	0	-5.994	-3.217	***
Constant	46.523	6.604	7.04	0	33.543	59.503	***
Mean dependent var	3.463		SD dependent var		3.775		

R-squared	0.164	Number of obs	1926
F-test	10.647	Prob > F	0.000
Akaike crit. (AIC)	7723.876	Bayesian crit. (BIC)	7746.129

*** p<.01, ** p<.05, * p<.1

Regression results – Model (2)

PSratio	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
A	1.615	.522	3.10	.002	.589	2.64	***
B	1.462	.533	2.74	.006	.415	2.509	***
C	1.136	.46	2.47	.014	.232	2.04	**
D	.805	.448	1.80	.073	-.076	1.687	*
o	0	.	.	.	.	.	
log_ROA	-.026	.079	-0.33	.739	-.183	.13	
log_DE	.033	.096	0.34	.733	-.157	.222	
log_revenue	-4.544	.699	-6.50	0	-5.917	-3.171	***
Constant	45.143	6.451	7.00	0	32.463	57.823	***

Mean dependent var	3.463	SD dependent var	3.775
R-squared	0.174	Number of obs	1926
F-test	6.692	Prob > F	0.000
Akaike crit. (AIC)	7707.631	Bayesian crit. (BIC)	7746.573

*** p<.01, ** p<.05, * p<.1

Regression results – Model (3)

PSratio	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
o	0	.	.	.	.	.	
A	2.275	.758	3.00	.003	.785	3.765	***
ESI_A	-2.247	.862	-2.61	.009	-3.94	-.553	***
B	2.062	.778	2.65	.008	.533	3.592	***
ESI_B	-1.741	.791	-2.20	.028	-3.296	-.186	**
C	1.646	.673	2.44	.015	.323	2.969	**
ESI_C	-1.391	.68	-2.04	.041	-2.727	-.054	**
D	1.167	.629	1.86	.064	-.068	2.402	*
ESI_D	-.94	.672	-1.40	.162	-2.261	.38	
o	0	.	.	.	.	.	
o	0	.	.	.	.	.	
log_ROA	-.02	.078	-0.26	.796	-.174	.134	
log_DE	.034	.096	0.36	.72	-.154	.222	
log_revenue	-4.528	.694	-6.52	0	-5.893	-3.163	***
Constant	44.76	6.396	7.00	0	32.19	57.331	***

Mean dependent var	3.463	SD dependent var	3.775
R-squared	0.179	Number of obs	1926
F-test	4.417	Prob > F	0.000
Akaike crit. (AIC)	7704.664	Bayesian crit. (BIC)	7765.860

*** p<.01, ** p<.05, * p<.1

Regression results – Model (4)

PSratio	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
o	0	.	.	.	.	.	
A	1.748	.561	3.12	.002	.645	2.85	***
Energy_A	-4.238	.74	-5.73	0	-5.693	-2.783	***
B	1.574	.577	2.73	.007	.439	2.708	***
Energy_B	-1.108	.683	-1.62	.106	-2.45	.235	
C	1.233	.499	2.47	.014	.252	2.215	**
Energy_C	-.82	.771	-1.06	.288	-2.335	.694	
D	.847	.48	1.77	.078	-.095	1.79	*
Energy_D	.096	.737	0.13	.896	-1.351	1.544	
o	0	.	.	.	.	.	
o	0	.	.	.	.	.	
log_ROA	-.029	.079	-0.37	.711	-.185	.127	
log_DE	.034	.096	0.36	.722	-.155	.224	
log_revenue	-4.536	.699	-6.49	0	-5.91	-3.162	***
Constant	45.02	6.457	6.97	0	32.328	57.713	***

Mean dependent var	3.463	SD dependent var	3.775
R-squared	0.176	Number of obs	1926
F-test	.	Prob > F	.
Akaike crit. (AIC)	7708.474	Bayesian crit. (BIC)	7764.106

*** p<.01, ** p<.05, * p<.1

Regression results – Model (5)

lTobinsQ	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
PSratio	.081	.01	8.03	0	.061	.101	***
A	.038	.034	1.13	.259	-.028	.105	
Materials_A	.057	.207	0.27	.784	-.351	.465	
B	.049	.032	1.53	.127	-.014	.112	
Materials_B	-.086	.095	-0.90	.366	-.272	.101	
C	.057	.029	1.95	.051	0	.114	*
Materials_C	-.06	.088	-0.68	.496	-.234	.114	
D	.033	.03	1.11	.269	-.026	.092	
Materials_D	-.032	.087	-0.37	.713	-.203	.139	
o	0	.	.	.	.	.	
o	0	.	.	.	.	.	
log_ROA	.039	.009	4.58	0	.022	.056	***
log_DE	.008	.008	0.93	.355	-.009	.024	
log_revenue	-.203	.063	-3.22	.001	-.327	-.079	***
Constant	2.176	.595	3.66	0	1.006	3.346	***

Mean dependent var	0.665	SD dependent var	0.595
R-squared	0.567	Number of obs	1926
F-test	13.437	Prob > F	0.000
Akaike crit. (AIC)	-1798.384	Bayesian crit. (BIC)	-1731.625

*** p<.01, ** p<.05, * p<.1

Regression results – Model (6)

PSratio	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
o	0	.	.	.	.	.	
A	1.789	.618	2.90	.004	.575	3.002	***
Utilities_A	-1.072	.673	-1.59	.112	-2.395	.252	
B	1.629	.627	2.60	.01	.397	2.861	***
Utilities_B	-1.067	.664	-1.61	.109	-2.373	.239	
C	1.283	.536	2.39	.017	.229	2.336	**
Utilities_C	-1.008	.559	-1.80	.072	-2.107	.092	*
D	.946	.517	1.83	.068	-.07	1.961	*
Utilities_D	-1.027	.669	-1.53	.126	-2.342	.289	
o	0	.	.	.	.	.	
o	0	.	.	.	.	.	
log_ROA	-.024	.079	-0.31	.76	-.18	.131	
log_DE	.033	.096	0.35	.728	-.156	.223	
log_revenue	-4.544	.699	-6.50	0	-5.917	-3.17	***
Constant	45.066	6.442	7.00	0	32.404	57.728	***

Mean dependent var	3.463	SD dependent var	3.775
R-squared	0.175	Number of obs	1926
F-test	6.327	Prob > F	0.000
Akaike crit. (AIC)	7713.526	Bayesian crit. (BIC)	7774.721

*** p<.01, ** p<.05, * p<.1