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Carbon Disclosures and Industry Environment Sensitivity on Firm Performance

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Abstract: This study was conducted to explore carbon disclosures and industry environment sensitivity on firm performance (FP). This study evaluates FP by examining both market- and accounting-based measures and how they relate to carbon disclosures. The carbon-disclosing sample is got from listed firms in China that reported their carbon emissions from 2010 to 2018. Results indicate that carbon-disclosing firms experience declined FP following carbon disclosure of 4.13% for return on assets and 4.22% for the Q ratio following disclosure compared to the non-disclosing firms, and there is a decreased FP for the control sample of carbon non-disclosing companies, an indication that environmental disclosures are linked with specific and costly risk disclosures which may castigate a company's environmental strategies over specified time periods as disclosures tend to result in accountability. We show why FP declined during the disclosure period despite prior research indicating that carbon-disclosing firms are characterized by increased FP. Despite the ever-increasing stringent measures and standards of environmental disclosures, environmentally sensitive industries are characterized by increased FP during the carbon disclosure period. We supplement the ever-expanding stream of research that evaluates the effects of carbon disclosures.

Keywords: carbon disclosures, industry environment sensitivity, firm performance, China

1. Introduction

Tackling global warming and climatic change remains as one of the critical roles which companies can adhere to considering they are the biggest sources of carbon emissions [1]. Due to the financial costs associated with improved carbon performance, questions still linger as to whether firms are honestly motivated to enhance carbon performance. This might result in management utilizing different mechanisms to justify their carbon activities without an improvement in the real carbon performance. These disclosures therefore can be deemed as legitimizing firms' carbon activities as companies may utilize such disclosures to indicate that their rules and standards are a matchup of what the society expects – which resonates with the legitimacy theory. This study depicts the effects of carbon disclosure on performance of firms by evaluating the characteristics of carbon-disclosing and non-disclosing companies while also distinguishing between environmentally sensitive firms and those which are not.

Zhao et al. [1] sought to analyze how the adoption of an Environmental Management System (EMS) in line with ISO 14001 affects economic performance through a surge in demand and a rise in productivity. They established that a firm's value is increased through EMS implementation as it results in an increase in demand and productivity – an effect which was only observed for export-oriented firms. A specific and more recent study was conducted by Siddique et al. [2] who evaluated the carbon performance impact on financial performance among US S&P 500 corporations and established that carbon performance was significant and positively related to financial performance, and firms that disclosed more carbon information reported higher financial performance.

This study evaluates firm performance (FP) by examining both market and accounting-based measures and how they relate to carbon disclosures. Measurement of this performance is essential for effective management of any organization as continuous enhancement is impossible without measuring outcomes. Performance measurement measures offer information that allows monitoring and evaluation while highlighting the shortcomings. Accounting-based measures have always been regarded as suitable profitability indicators compared to cost of capital risk-adjusted rate [3]. Market-based performance measures are future based and evaluate a company's performance over time which go a long way in motivating future performance expectations. As part of the sensitivity analysis, we employ Lu and Taylor [4] economic performance measure in establishing whether our results are robust and consistent.

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Firms that voluntarily disclosed their carbon performance status to the Carbon Disclosure Project (CDP) and a control sample of non-disclosing firms that have been matched based on the propensity of carbon disclosures were evaluated to assess whether there is a change in FP following carbon disclosure relative to the control firm and the kind of change that is discernible between environmentally sensitive and non-sensitive firms. A descriptive quantitative study was undertaken to delineate the characteristics of carbon-disclosing companies based on an unbalanced panel data of 6390 firm years for carbon-disclosing and propensity score matched carbon non-disclosing firms between 2010 and 2018.

Overall, results indicate that carbon-disclosing firms experience declined FP following disclosure compared to the non-disclosing firms and there is a decreased FP for the control sample of carbon non-disclosing companies. Aggregating the disclosure status and period, carbon-disclosing companies are characterized by a declined level of FP than the non-disclosing control firms. It is further established that environmentally sensitive industries that disclose their carbon emissions are characterized by increased FP while both state and non-state-owned companies are characterized by declined FP.

This study contributes several ideas to the existing literature on carbon disclosures and emissions. Despite the ever-increasing stringent measures and standards of environmental disclosures, environmentally sensitive industries are characterized by increased FP during the carbon disclosure period. Secondly, despite prior research indicating that carbon-disclosing firms are characterized by increased FP, performance declined during the disclosing period. This study further provides evidence on an area that has seen limited research especially in an emerging economy that is considered to be one of the highest emitters of carbon dioxide (China), with this being a concept that has continuously receiving increased attention as firms enhance the quality of their environmental and social undertakings. Novelty of the study arises from the three-wise combination of carbon disclosures, industry environment sensitivity (IES), and FP. The link between these three variables has been examined on the basis of pairwise relationships between carbon disclosures and FP or IES (classification) and FP. This study therefore sought to bridge this gap by determining the environmental industry classification (sensitivity) effect on carbon disclosures and FP among Chinese companies as they mitigate climate change through carbon emissions disclosures.

2. Literature Review

The relationship between carbon emissions disclosures and FP has continued to elicit interest among scholars due to its complex nature. Mixed results have been obtained on the existing studies conducted on the relationship between carbon emissions disclosures, environmental sensitivity classification, and financial performance. Chen and Ma [5] in a study of the four most polluting industries in the USA sought to apply the resource base view by determining whether changes in financial performance affect relative environmental performance and whether changes in relative environment performance led to changes in financial performance consistent with "it pays to be green" notion. Zhao et al. [1] sought to analyze the effects of EMS implementation in accordance with ISO 14001, through an increase in demand and an improvement in productivity on economic performance. They established that a firm's value is increased through EMS implementation as it results in an increase in demand and an improvement in productivity – an effect which was only observed

for export-oriented firms. Hermundsdottir and Aspelund [6] found that eco-innovation was more significant as a determinant of FP than non-eco-innovation and further highlighted that there was no trade-off between eco-innovation and increased financial gain since legislation stimulated eco-innovation. Tang and Luo [7], in an analysis of 336 firm-event observations (cross-sectional), found out that firms' financial results are adversely affected by carbon tax legislation-related events. He et al. [8] established that corporate carbon emissions had a negative relation with the market value of equity while disclosure of carbon management had a positive relation with the market value of equity which is stronger when there is a larger volume of carbon emissions. Alsaifi et al. [9] employed mediation path analysis technique to explore the relationship between carbon emission performance and financial performance and found out that direct corporate carbon emissions are negatively related to corporate financial performance – an indication that emissions stimulate performance of the market. Andersen and Bams [10] while exploring the four economic drivers of environmental management established that consumer-oriented firms that are visible to the public have positive relation between environmental commitment and operating performance. Nishitani et al. [11] in an analysis of Tokyo and London Stock Exchanges evaluated the relationships between social and environmental performance and integrated reporting, and found out that financial transparency and accountability is evident in companies listed in Tokyo Stock Exchanges but not London Stock Exchanges. Naeem et al. [12] established that the relationship between environmental, social, and governance performance of environmentally sensitive corporations has a positive relation with the return on equity (ROE) and Tobin's Q of the corporations with this relationship having a stronger impact in developed countries compared to emerging ones.

Due to environmental performance and disclosures being an unresolved research area in accounting, several studies [4, 7, 13] proposed use of different theories such as legitimacy theory, voluntary disclosure theory, and signaling theory to explain this relationship with the results being varied and uneven. Earlier studies on the relationship between environmental performance and environmental disclosures were largely based on the indices issued by the Council on Economic Priorities (CEP). The CEP measured the environmental performance of 50 firms from highly polluting industries (steel, oil, paper, and electric utilities) and published reports based on a 0–10 Likert scale with 10 being the worst and also based on the organizational analyses. The results varied in their depth and quality though they were considered to be the credible source available by then. While still employing the CEP measure for environmental performance, Patten [14] examined the impact of the Exxon Valdez oil spill on the environmental information disclosed in annual reports of petroleum firms. A significant increase in environmental disclosures was observed and was related to firm size and ownership in Alyeska Pipeline Service Company. Lu and Taylor [4], while testing the differences in the use of non-litigation disclosures, incorporated size-matched groups based on environmental performance (better versus worse) and industry type (environmentally sensitive industries versus non-environmentally sensitive). It was observed that worst performers and environmentally sensitive industries provided increased non-litigation environmental disclosures. Utilizing carbon mitigation and carbon intensity as measures of carbon performance, Tang and Luo [7] found a positive relationship between carbon disclosure and carbon performance consistent with the voluntary

disclosure theory and an indication that a firm's actual carbon performance can be reflected by the voluntary disclosures made to CDP. Environmentalism has been established to be low with few firms practicing voluntary environmental activities [15]. Violations as detected and punished by government were yet to cause noticeable negative effects in the stock markets. These previous studies therefore have highlighted varied expectations of firms in pollution prevention translating to mitigation of climate change. Few studies have however explored how voluntary environmental activities – specifically the carbon disclosures component – vary among environmental sensitive and non-sensitive industries and their effect on FP.

2.1. Theoretical framework

2.1.1. Voluntary disclosure theory

The foundations of the voluntary disclosure theories can be traced back to Brooks and Oikonomou [16], Roychowdhury et al. [17], and Basu et al. [18] regarding application to the environmental disclosure studies. Proprietary costs associated with non-disclosure may be difficult to interpret – an indication that there exists levels of disclosure that are increasing proprietary costs. Non-disclosure on the other hand results in investors' uncertainty about the nature of information possessed by a manager [16] which led Basu et al. [18] to posit that when faced with adverse selections, exceeding a certain threshold may result in a disclosure while those below may not. Environmental wise, companies with improved environmental performance are likely to disclose more while poorly performing companies opt for silence.

Based on the above postulations, it seems probable that managers have in their possession information that is unlikely to be accessed by the public. This concern has prompted governments to enact legislation in an effort to elicit additional environmental disclosures across a variety of concerns [19]. Despite having the legislations, disclosing companies maybe using it to bypass the questions being asked, thus ensuring that little is known about the firm despite being open in their reporting [20].

2.1.2. Legitimacy theory

Didenko et al. [21] and Giacomini et al. [22] elucidate legitimacy as socially constructed values, norms, and beliefs that guide corporate actions. This theory also insinuates the existence of a social agreement between a firm and the society at large that can either be explicitly or implicitly stated. One of the assumptions of the legitimacy theory is that the society permits organizations to continue their operations as long as they meet public expectations. To maintain legitimacy, organizations should adopt to societal changes over time. A change in public expectations about a firm should trigger a change in the operations of the latter in order to maintain legitimacy. Therefore, it is necessary to identify society's expectations in order to prevent a legitimacy gap brought on by its dynamic nature. The legitimacy theory thus postulates that companies tell the society about their actual changes through voluntary social and environmental disclosures to avoid a legitimacy gap.

2.2. Hypothesis development

2.2.1. Carbon disclosures, IES, and FP

Disclosure of environmental performance coupled with social responsibility information is done by firms to protect investors, mitigate information asymmetry, and also as a mandatory

requirement for complying with regulatory requirements. Focus has been on industries that are regarded as having a high propensity for pollution as they are always a subject of environmental regulations. Previous studies [10, 14, 23, 24] have documented that industry classification and size of the firm are factors that can result in potential public pressure regarding environmental concerns.

It is further documented that firms with poor environmental performance are also conditional to increased disclosure to stakeholders and regulatory agencies compared to firms that are performing better environmentally. TRI data have been utilized by firms to publicize names of top polluting industries as a means of attracting scrutiny and regulatory demand for reducing toxic substance [25].

Environmental stakeholders may subsequently rely on these data to target firms for legal actions and enforcement. Thus, declined environmental performance threatens company's social legitimacy – at least according to the legitimacy theory. The social–political theories (stakeholder, political economy) postulate that disclosure is a resultant of political and social pressure. The market place monitors the economic legitimacy of firms while public policies monitor social legitimacy [10, 21, 25]. Any threats to social legitimacy may lead to active participation in the public process for which disclosures are part of.

It is therefore hypothesized that firms that are toxic pollutants do make available more disclosures beyond the mandatory requirements. In addition to this, toxic pollutants are considered to be superior environmental performers as they disclose more information that is difficult to mimic by inferior performing firms; thus, they are favorably viewed in the market. Based on this postulation, the hypotheses are formulated as:

H_{1a}: Industry environmental sensitivity is positively related to FP.
$H1_b$: Industry environmental sensitivity positively strengthens the relationship between carbon disclosures and FP.

3. Methodology

3.1. Sampling

The carbon-disclosing sample is drawn from the listed companies in China that reported their carbon emissions from 2010 to 2018. Firms' disclosure status is obtained from the CDP database, which is a non-profit organization that is a custodian of voluntarily carbon emissions by the largest companies around the world. Firms are required to have participated in the CDP survey for carbon disclosures and emissions and have data for FP and the control variables to be utilized in the analysis. Financial accounting data are obtained from the CSMAR database. The initial sample varies across the years of study as the number of Chinese companies submitting voluntary disclosures is gradually increasing. Chinese businesses that took part in the CDP survey make up the sample of this study, which is a propensity score-matched sample of companies that disclose and do not disclose their carbon emissions between 2010 and 2018 and those that did not. 2010 has been selected as the point of start since the first disclosures from Chinese companies were received during this period. Based on these provisions and procedures, a sample of 245 firms with voluntary carbon disclosures during 2010 to 2018 was obtained. Table 1 below outlines the annual distribution of carbon-disclosing companies. Few firms did disclosures in the

Table 1
Yearly distribution of carbon-disclosing companies

Year	No. of carbon-disclosing companies	Sample %
2010	4	1.63
2011	6	2.45
2012	14	5.71
2013	18	7.35
2014	32	13.06
2015	37	15.10
2016	40	16.33
2017	46	18.78
2018	48	19.59
Total	**245**	**100**

early years starting 2010 but there was a gradual increase in 2018, as depicted in Table 1.

3.2. Construction of the propensity score-matched sample

To generate a sample of carbon-disclosing companies, companies that took part in the CDP survey were obtained from the CDP database. To ensure an adequate sample of carbon-disclosing and non-disclosing companies and due to the voluntary nature of the carbon disclosures during the study period, propensity score matching is used to identify a sample of firms with a similar propensity to carbon-disclosing firms. Che et al. [26] note that this technique is vital in controlling endogenous firm characteristics that may affect the association between the relevant independent and dependent variables.

This study estimates a carbon disclosure probit model based on several factors known to be associated with carbon disclosure [4, 8, 27], growth opportunities, profit margin, unexpected earnings (UEs), environmental sensitivity, and firm size as defined in the variable definition section below. Kai and Prabhala [28] indicated that a comprehensive list of characteristics is necessary in determining the propensity scores thus the need for including several factors associated with carbon disclosure.

The next step was to match a carbon-disclosing company with a non-disclosing company that has the closest predicted value from the carbon disclosure probit model. This process is iterated until no convergence is achieved. To test for non-linearity of the carbon disclosure characteristics, the study employs the Test for Specification Error in Ramsey Regression Equations [29].

3.3. Model for testing the hypothesis

Testing hypothesis $H_{1a\ \&\ b}$, which examines the IES relationship with FP, was done using the model (1):

$$FP = \beta_0 + \beta_1 CEDI + \beta_2 POST + \beta_3 POST \times CEDI + \beta_4 IES$$
$$+ \beta_5 CEDI \times IES + \beta_6 POST \times IES + \beta_7 Controls$$
$$+ Year\ and\ ind.\ dummies + \varepsilon \tag{1}$$

Hypothesis H_{1a} will be tested by the coefficient β_4 on IES that represents the difference in FP between environmentally sensitive and non-sensitive industries. The coefficient β_5 measures the difference in change of FP between environmentally sensitive and

non-sensitive industries that disclose their carbon emissions. This also serves as the test for hypothesis H_{1b}. The coefficient β_6 measures the difference in change of FP for the matched control sample of non-disclosing companies from the assigned pre-disclosure dates to post-disclosure time period for the environmentally sensitive and non-sensitive firms.

3.3.1. Variable definition
3.3.1.1. Carbon Emissions Disclosure Index

For environmental researchers, the CDP has made it possible to access carbon emission data for more than 1550 of the largest companies in the world. CDP works with firms and shareholders to provide carbon emissions using carbon protocol as the guiding framework [30]. Carbon has long been esteemed as the most pertinent international accounting tool for business to understand, quantify, and manage carbon emissions [31]. This protocol requires companies to disclose direct and indirect emissions that are divided into three scopes: Scope I, II, and III. Scope I covers all emissions from what is owned or controlled by the organizations (direct emissions). Scope II has indirect emissions from consumption of heat and electricity while Scope III contains all other indirect emissions like outsourced activities, waste disposal, and transportation.

Carbon disclosure is a mechanism which stakeholders employ to ensure that firms establish and comply with existing environmental norms. There is a dearth of voluntary disclosure literature pertaining to companies whose carbon emissions are independently verified. Prior research has focused on cross-country voluntary disclosure incentives, incorporating a variety of different revenue variables (size and foreign sales). The usefulness of carbon disclosures depends on the relevance and valuability of the disclosures to the market in decimating information that relates to the effect of climatic change on financial performance. Despite CDP working toward ensuring that there is uniformity in providing this information, there still exists difficulty in provision of this information due to non-uniform measures of carbon measurements, thus inhibiting comparability [32].

The study proxy's carbon disclosures by an index based on the response status of a company to the invitation by the CDP to participate in their annual survey. The level of carbon disclosure is proxy by a 3 factor index constructed from companies that participated in the CDP survey. The first measure is response – which is a dichotomous value that is based on whether a company responded to the climate change survey or not.

The second one is status – which is still a binary measure that proxies whether companies submitted response to the questions on the survey or not. The third measure is score – which represents the points attained by a company after participating in the survey. This represents the ratio of the actual points awarded to a firm that participates in the survey out of the possible maximum points that can be awarded. A Carbon Emissions Disclosure Index (CEDI) is constructed as a ratio aggregate of the three measures above out of the maximum possible attainable value. The Cronbach's alpha coefficient for these measures is 0.78. Each firm year observation is therefore assigned a CEDI score, which is the outcome value of the calculated index.

To further investigate the carbon disclosure and non-disclosure effect, the study further defines another dichotomous variable – POST. This is a variable that infers a value of 1 for the post-disclosure assigned date of matched carbon non-disclosing companies and 0 for the pre-disclosure date. This variable seeks to control the effect in FP of carbon-disclosing firms relative to

matched non-disclosing firms in order to establish the actual performance effect following carbon disclosure.

3.3.1.2. Firm performance

Measurement of FP has always been undertaken using market and accounting-based measures to evaluate how well a company is performing. Some studies have utilized accounting-based measures [33] while others have incorporated both market and accounting-based measures, that is, price earnings ratio and profitability [29]. Lu and Taylor [4] posit that using accounting-based performance metrics has its own limitation in that they focus narrowly on one aspect of a firm's economic performance. ROE, return on assets (ROA), and earnings per share (EPS) are among the most frequently utilized measures by prior studies. Given these shortcomings, the study incorporates both market and accounting-based measures to evaluate FP.

Measurements based on accounting are generally backward looking and are considered as effective indicators of company's profitability when measured against the risk-weighted average cost of capital [3]. These measures present the outcome of management actions; thus, they are preferred over market-based measures [34]. They have been criticized for being partial estimators more so regarding amortization and depreciation.

Market-based measures are generally forward looking, thus indicating the expectation of stakeholders regarding a company's performance. These include Tobin's Q, market to book value, dividends yield, and price/earnings ratio. Previous research has indicated that accounting-based measurements are used to evaluate a firm in the short term while market-based measures project the performance of a firm – an indication that integration between the two provides a better outlook of a firm. Therefore to provide a better outlook of performance, this study incorporates a combination of accounting-based and market-based measures of performance. ROA and ROE have been employed as accounting measures of FP. ROA is proxy as the net income over the total assets at the end of the year. It is a measure that evaluates the operating and financial performance of a firm by highlighting whether assets have been utilized effectively in maximizing shareholder value [35]. A positive figure is an indication of achievement of projected high performance while a negative value indicates non-achievement and declining performance. To supplement this result, ROE is utilized and is proxy as profit after tax over the total equity shares on issue by a firm.

Tobin's Q has been incorporated as the market-based measure of FP. It is determined by dividing the total of the market value of the equity and liabilities by the total of the equity and liabilities' book values. To provide an inclusive outlook of performance that is indicative of the economic performance of a firm, the measure ΔSR is utilized as it represents a more objective measure of FP since stock price holds information about a firm's future prospects for both financial and non-financial measures [4]. It is defined as a change in share price during the year scaled by year beginning price less industry median. Moreover, this metric also represents a broad measure of a firm's current period performance relative to other firms in the same industry. Choice of this measure is due to its little subjectivity and measurement errors compared to others.

3.3.1.3. Industry environmental sensitivity

Following Konadu et al. [36] approach, this study introduces a variable that assists in determining the role of environmental industry classification in the accountability process. This variable – *industry environmental sensitivity* – takes the variable of 1 if a company conducts its business in an industry that is sensitive to carbon emissions therefore prone to litigation and embargoes from regulatory bodies, and 0 if otherwise. These are industries that are in the utilities energy and materials sector and pose a risk to the environment compared to the non-energy intensive industries.

Intensive industries are further characterized by emissions of carbon dioxide at an intensity higher than the industry average, that is, they can alternatively be considered to be firms that are in pollution intensive industries. Lu and Taylor [4] postulate that the aim of taking into account this dummy variable is to do away with problems of endogeneity that might be detected between dissemination of information and firm's performance. To monitor the effect of size and industry on the analysis of environmental behavioral pattern provides the theoretical argument behind making a comparison with average performance [14].

3.3.2. Control variables
3.3.2.1. Firm size (SIZE)

Tang and Luo [7] describe size as the natural logarithm of market capitalization. Firm size has constantly been a driving factor of sustainability reporting and has been used as a control variable in the sustainability reporting research [26, 37]. The market value of common equity will be the proxy measure. Larger firms are expected to have greater incentives to disclose environmental information. Choice of size has been influenced by extant literature [38, 39, 36] which has determined a strong correlation between firm size and disclosure of information on social responsibility. It is expected that large firms are more responsive to mitigating climate change.

3.3.2.2. Unexpected earnings

Christie [40] suggests that due to the use of the industry-adjusted return measure of economic performance as FP, there is a need to control the unexpected portion of earnings. Following this approach, this measure is controlled and is proxy as the annual change in EPS scaled by the stock price at the beginning of the period.

3.3.2.3. Growth opportunities (MTB)

The proxy for growth opportunities is defined as a ratio between the market value and the book value of equity [4, 41, 42]. This ratio measures the difference between the firm's value as appraised by the market and the value aggregated from the Generally Accepted Accounting Principles transactions in the USA, e.g., relating to the research and development costs (R&D), US firms in the process of conducting research must expense this cost while some markets view it as an investment whose benefits will accrue in the future.

In a related research of South African companies, defined growth as the annual growth rate of sales and utilized it in combination with an interaction term formed by multiplying the carbon performance rating and growth. However, its shortcoming was that it was highly correlated with the individual variables being considered resulting in multicollinearity. This study therefore adopts the ratio of market value of equity to book value of equity as defined by Gaver and Gaver [41]. Market to book ratio is a variable that proxies a firm's growth opportunities and hypothesizes that firms with a higher MTB ratio are expected to

disclose increased information in order to avoid information asymmetrical problems [8]. We expect growth opportunities to be positively related to FP.

3.3.2.4. Leverage (LEV)

Leverage proxy as the debt/total asset ratio is another numerical variable that includes the state of debt as a proportion of a firm's assets. It is one of the determinants of disclosure because of the agency conflicts that are prone to arise. Previous studies [28, 42, 43] have established a positive relationship between indebtedness and quantity of information voluntarily disclosed, whereas other studies have established insignificant relationships [14, 44].

3.3.2.5. Property plant and equipment

Apart from financial resources, in order for organizations to meet their obligations to various stakeholders, tangible assets are key especially in attaining environmental goals. Presence of organizational slack in the form of surplus financial resources may stimulate innovative strategies by organizations.

This study therefore proposes the net book value of PPE as this provides resources especially for environment sensitive industries as they seek to comply with regulation and stakeholder sustainability requirements. These firms will also find it easier to comply with sustainability requirements, thus focusing on other organizational activities. There is need for control of this variable as it is considered a determinant of disclosures. Chen and Ma [5] postulate that environmental disclosures might be influenced by firm size and incorporate the log of total assets to control their effect.

4. Empirical Results

4.1. Descriptive statistics for carbon disclosure and FP

Table 2 below indicates the descriptive statistics of the sample that was utilized in ascertaining the effect of carbon disclosure on performance of firms. This was possible by utilizing a combination of the CDP database for carbon-disclosing companies and CSMAR database for listed companies and availability of financial variables. An evaluation of the carbon disclosure proxy indicates that most of the data is inclined toward the minimum score (−0.2230), i.e., non-disclosure. The mean (−0.1390) and standard deviation (0.6232) imply that most companies do not disclose their carbon emissions. Examining the propensity score-matched control sample also indicates that most of the matched firms are inclined toward non-disclosure with a mean of (0.1930). Regarding performance, the average ROA of the firms is 7.74%. The mean of total assets in the sample was observed to be 23.168 while the minimum and maximum values were 15.7435 and 24.8095, respectively, an indication that majority of the companies in the sample have a higher value of total assets. The mean of the size of the firms in the sample as proxied by the log of market capitalization was observed to be 20.8111, which was inclined toward the minimum value of 23.168. Most firms in the sample of study did not have UEs as indicated by the mean value of 0.0009. Leverage was observed to have a mean value of 0.4617 while a number of firms in the sample were observed to be classified as environmentally sensitive industries as indicated by the mean of 0.8097 and a maximum value of 1.

Table 2
Descriptive statistics for the study sample

Total sample				
Variable	Mean	Std. Dev.	Min	Max
ROA	0.0774	0.0556	−0.0335	0.3146
ROE	0.1094	0.0847	−0.6981	0.4569
Tobin's Q	2.8524	2.2558	0.9008	14.9078
ΔSR	1.0757	0.0892	1	1.5641
CEDI	−0.1390	0.6232	−0.2230	4.4846
POST	0.1930	0.3947	0.0000	1.0000
CEDI#POST	−0.0084	0.3964	−0.2230	4.4845
NP	19.0159	1.6890	11.4370	23.6652
PPE	20.4917	1.7428	15.7435	24.8095
SIZE	23.1680	1.1961	20.8111	27.5942
UE	0.0009	0.0350	−0.2112	0.1905
LEV	0.4617	0.2136	0.0536	1.0302
IES	0.8097	0.3926	0.0000	1.0000
N = 6390				

Notes: *ROA* is calculated as the ratio of total operating income to total assets; *ROE* is calculated as net profit after tax over the total equity shares issued; *ΔSR* represents the change in share price during the year scaled by beginning year price less industry median; *CEDI* is proxied as an index of response, status, and score of firms participation in the CDP survey; *NP* is a lagged variable that represents the ratio of net profit to sales; *PPE* represents the log of net book value of total assets of a firm; *SIZE* is proxied as the log of market capitalization; *UE* is the annual change in earnings per share scaled by the stock price at the beginning of the period; *LEV* represents the debt/total asset ratio; *IES* is an indicative variable that assumes the value of 1 for environmental sensitive industries and 0 if otherwise.

Table 3 below highlights a breakdown of how the sample characteristics compare between carbon-disclosing and non-disclosing companies.

An evaluation of the means of carbon-disclosing and non-disclosing companies indicates that carbon-disclosing firms are characterized by a higher ROA (0.08842), higher profit margins (21.8324), higher value of PPE (21.6353), and are highly valued in the market (24.9177) as compared to the carbon non-disclosing companies. This observation is further cemented by the mean difference tests which are highly significant indicating there is value obtained by voluntary carbon disclosure. Carbon-disclosing companies are further observed to be highly levered (0.5599) as compared to their non-disclosing counterparts (0.4958), an indication that use of borrowed capital by disclosing companies is on the rise as compared to their non-disclosing counterparts. The UEs of carbon-disclosing companies were observed to be higher (−0.00168) as compared to their non-disclosing counterparts (−0.00316). A further analysis of the sample into environmentally sensitive and non-sensitive industries indicates that most of the carbon non-disclosing companies are environmentally sensitive (0.7981) as compared to the carbon-disclosing environmentally sensitive ones (0.7496). The ways of disclosing and non-disclosing companies are significantly different, an indication that there is a value obtained by disclosure of carbon emissions by firms.

Table 4 indicates the Pearson pairwise correlation coefficients and their respective significance levels for the variables incorporated in testing the FP – carbon disclosure relationship. To evaluate the efficacy of the independent variables on dependent ones, the interdependence between the independent variables should not be

Table 3
Mean difference tests for carbon-disclosing and non-disclosing companies.

Variable	Carbon non-disclosing companies		Carbon-disclosing companies		Mean difference test
	Mean	Median	Mean	Median	
ROA	0.0658	0.0588	0.0884	0.0689	−0.0226***
ROE	0.0811	0.0852	0.1324	0.1373	−0.0513***
Tobin's Q	2.8740	2.1176	1.8068	1.2846	1.0672***
ΔSR	1.0849	1.0496	1.0664	1.0393	0.0185***
LEV	0.4958	0.5002	0.5647	0.5599	−0.0689***
MTB	1.0515	0.6840	1.9546	1.0295	−0.9031***
ESI	0.7981	1	0.7496	1	0.0485***
UE	−0.0031	0.0003	−0.0016	0.0043	−0.0021
PPE	20.3492	20.2697	21.6353	21.5651	−1.2861***
SIZE	23.0499	22.9248	24.9177	24.8595	−1.8678***
NP	18.9394	18.9209	21.1243	21.3714	−2.1849***

Notes: *ROA* is calculated as the ratio of total operating income to total assets; *ROE* is calculated as net profit after tax over the total equity shares issued; Tobin's *Q* represents a measure of firm assets in relation to firm's market value; Δ*SR* represents the change in share price during the year scaled by beginning year price less industry median; *CEDI* is proxied as an index of response, status, and score of firms participation in the *CDP* survey; *MTB* refers to the ratio of market value of equity to book value of equity; *PPE* represents the log of total assets of a firm; *SIZE* is proxied as the log of market capitalization; *UE* is the annual change in earnings per share scaled by the stock price at the beginning of the period; *LEV* represents the debt/total asset ratio; *IES* is an indicative variable that assumes the value of 1 for environmental sensitive industries and 0 if otherwise; *, ** and *** indicate two tailed significance levels at 10%, 5%, and 1%, respectively.

significant. To test this, the variance inflation factor (VIF) and tolerance levels were estimated. Morgan et al. [45] indicate that multicollinearity problems arise when VIF has a value higher than 10 and tolerance levels less than 0.1.

From the correlation matrix, it is observed that there is no high correlation among the independent variables in this study; thus, it can be inferred that there is no multicollinearity problem. This is further cemented by the tolerance levels (1/VIF) scores whose values are not less than 0.1.

4.2. Multivariate test results

4.2.1. Carbon disclosure and FP

Table 5 indicates the results of the estimated coefficients of carbon disclosure utilizing the fixed effect approach (column I and II) of the variables being studied while incorporating both accounting (*ROA*) and market (*Tobin's* Q) based measures of FP.

Results from column I indicate that carbon disclosure (CEDI) is negative and significantly related to FP across accounting-based ROA measure of performance ($t = −2.76$ $p < 0.01$) and market-based measure, Tobin's Q ($t = −3.3$, $p < 0.01$) an indication of the declining performance of companies as the upshot of carbon disclosure.

This result was consistent to the postulations of Dionisio and de Vargas [46] who confirmed a negative relation between emissions management practices and financial performance. Examining the

control sample of carbon non-disclosing companies (*POST*) revealed a negative and significant relationship for both ROA ($t = −4.32$, $p < 0.01$) and Tobin's Q ($t = 4.57$, $p < 0.01$).

This indicates that for the propensity score-matched sample of carbon non-disclosing companies, there was a declining performance and they exhibit the same pattern as the carbon-disclosing firms. Following carbon disclosure, there is need to quantify the influence on company performance. This effect is estimated by dividing the coefficient of CEDI by the sample mean for FP measures. Results show that there is a dwindle in FP following carbon disclosure of 4.13% for ROA and 4.22% for Tobin's Q. The coefficient on CEDI#POST is negative and significant across all measures of performance, an indication that following carbon disclosure, FP of the carbon non-disclosing firms is lower (after controlling for the change in FP of the control firms during the same time period) collated to the pre-disclosure period. Further analysis of the sum of the coefficients for CEDI and CEDI#POST is significantly negative for ROA ($−0.0037 + [−0.0040] = −0.0077$, $p < 0.01$) and Tobin's Q ($−0.1779 + [−0.0753] = −0.1854$, $p < 0.01$).

This is an indication that for the carbon-disclosing firms, there is a declined FP in both the short run and the long run which can be assigned to the outcome of the management actions. This suggests that the performance measures are easier to control as managers perceive them to be within their jurisdiction [34]. Thus, in line with the provisions of the agency theory, opportunistic actions by the management regarding carbon disclosures may have resulted to declined performance while the expectation of shareholders as proxy by the market-based measures is optimism and positive performance.

Evaluating the control variables indicates that firm size is positive and significant across market-based economic measures of FP. This insinuates that large firms are more likely to make disclosures as such disclosures tend to be more manageable and there is need for such disclosures [27]. The coefficient for leverage is negative and highly significant ($p < 0.01$) across both market and accounting-based measures of FP.

This insinuates that highly leveraged firms are less likely to disclose their carbon emissions which may be attributed to the perceived decline in FP that disclosure has. The coefficient of net property and PPE is negative and significant ($p < 0.01$) which may be indicative of the investment in tangible assets and wear and tear that is associated with carbon disclosure. UEs are positive and significant across all measures of performance, an indication that an increase in FP is affiliated with higher level of UEs.

4.2.2. Carbon disclosure, industry environmental sensitivity, and FP

Table 6 indicates the results of the hypothesis testing model by including the interactions of the IES. The results in column I show that the coefficient of IES is positive and significant across both market and accounting-based measures of performance indicating that environmentally sensitive industries are characterized by a higher FP when compared to their non-sensitive counterparts which supports hypothesis H_{1a}.*****

The interaction coefficient between CEDI and IES is also positively significant across all accounting and market-based measures in column II, an indication that environmentally sensitive industries that voluntarily disclose their carbon performance are characterized by a greater FP. The positive nature of the IES coefficients and its interaction with CEDI thus supports the hypothesis H_{1b} that industry environmental sensitivity will positively moderate the carbon disclosure–FP relationship.

Table 4
Pairwise correlations, variance inflation factors, and tolerance levels

	CEDI	POST	CEDI#POST	NP	PPE	SIZE	UE	LEV	ESI	1/VIF
CEDI	1									0.53
POST	0.0786*	1								0.91
CEDI#POST	0.6682*	−0.0082	1							0.56
NP	0.2585*	0.2398*	0.1332*	1						0.31
PPE	0.1532*	0.2204*	0.0727*	0.5497*	1					0.56
SIZE	0.3074*	0.2780*	0.1664*	0.6214*	0.6448*	1				0.23
UE	0.0082	0.0035	0.0063	0.0507*	−0.0049	0.0412*	1			0.97
LEV	0.0824*	0.0818*	0.0522*	0.2125*	0.3842*	0.3617*	−0.01	1		0.71
ESI	−0.0465*	0.0365*	−0.0338*	−0.0759*	0.2395*	−0.0975*	−0.0238*	−0.0814	1	0.77

Note: Table 4 indicates the Pearson's correlations for variables utilized in testing the moderating effect of board level attributes on the relationship between firm performance and carbon disclosure. *, ** and *** indicate two-tailed significance levels at 5%, 1%, and 10%, respectively.

Table 5
Regression results for the effect of carbon disclosures on firm performance

Independent variables	Dependent variables			
	I		II	
	ROA Coef. (*t*-statistics)	Tobin's Q Coef. (*t*-statistics)	ROA Coef. (*t*-statistics)	Tobin's Q Coef. (*t*-statistics)
CEDI	−0.0036***	−0.1205***	−0.0037***	−0.1779***
	(−3.68)	(−3.3)	(−3.18)	(−4.07)
POST	−0.0044***	−0.1924***		
	(−4.32)	(−4.57)		
CEDI#POST			−0.0040***	−0.0753**
			(−3.2)	(−1.66)
NP	0.0291***	−0.4055***	0.0292***	−0.4020***
	(55.77)	(−18.64)	(55.85)	(−18.46)
PPE	−0.0170***	−0.9419***	−0.0172***	−0.9516***
	(−22.97)	(−30.74)	(−23.32)	(−31.09)
SIZE	−0.0066***	1.9973***	−0.0070***	1.9813***
	(−7.14)	(51.81)	(−7.63)	(51.57)
UE	0.1687***	3.1160***	0.1683***	3.1128***
	(14.87)	(6.61)	(14.81)	(6.59)
LEV	−0.0239***	−2.2344***	−0.0234***	−2.2242***
	(−5.42)	(−12.18)	(−5.31)	(−12.1)
Constant	0.0359***	−15.3939***	0.0484***	−14.9376***
	(2.06)	(−21.15)	(2.8)	(−20.73)
Fixed effects				
Within regressions	Present	Present	Present	Present
R^2	0.3792	0.1966	0.3784	0.1985

Notes: *ROA* is calculated as the ratio of total operating income to total assets; Tobin's *Q* represents a measure of firm assets in relation to firm's market value; *CEDI* is proxied as an index of response, status, and score of firms participation in the *CDP* survey; *POST* is a dichotomous variable that represents 1 for post-disclosure period and 0 if otherwise; NP is a lagged variable that represents the ratio of net profit to sales; *PPE* represents the log of total assets of a firm; *SIZE* is proxied as the log of market capitalization; *UE* is the annual change in earnings per share scaled by the stock price at the beginning of the period; *LEV* represents the debt/total asset ratio; ***, ** and * indicate two-tailed significance levels at 1%, 5%, and 10%, respectively.

This is consistent with Tsang et al. [14] who established that soaring levels of toxic deploys are affiliated with increased extent of environmental disclosures. Because firms from environmentally sensitive industries already face increased publicity due to societal and political requirements, thus the need for increased disclosures. Similar findings were obtained by Sun et al. [47] in a study of the US S&P 500 EPA reporting groups which was divided into high carbon emitters and low-emitting firms. Firms that had a higher score on their probability of environmentally damaging actions are expected to disclose their carbon emissions.

The coefficient on *POST#IES* indicates the relationship between control sample of industry environmental sensitivity companies and FP in the carbon disclosure time period of the aforementioned firms. The results indicate that this coefficient is positive and significant (*t = 2.95, p < 0.01*) suggesting that there is an increased FP for environmentally sensitive industries (control sample) during the carbon post-disclosure time period.

Table 6
Regression results on the effect of IES on the relationship between carbon disclosures and firm performance.

	I		II	
	ROA Coef. (*t*-statistics)	Tobin's Q Coef. (*t*-statistics)	ROA Coef. (*t*-statistics)	Tobin's Q Coef. (*t*-statistics)
Constant	0.0275**	−0.6939	0.0371***	−0.5444
	(2.10)	(−1.27)	(2.84)	(−1.00)
CEDI	−0.0004	−0.2622***	−0.0039**	−0.2893***
	(−0.2)	(−3.09)	(−1.83)	(−3.33)
POST	0.0011	−0.0662		
	(0.77)	(−1.12)		
CEDI#POST	−0.0177***	−0.1532	−0.0300***	−0.3140*
	(−4.02)	(−0.83)	(−6.53)	(−1.65)
IES	0.0212***	0.8150***	0.0192***	0.7980***
	(14.86)	(13.38)	13.18)	(12.75)
CEDI#IES			0.0205***	0.2324*
			(7.07)	(1.90)
POST#IES			0.0043***	−0.0028
			(2.95)	(−0.04)
NP	0.0292***	−0.5059***	0.0291***	−0.5069***
	(53.91)	(−21.85)	(54.07)	(−21.89)
PPE	−0.0087***	−0.6886***	−0.0088***	−0.6908***
	(−20.09)	(−37.49)	(−20.52)	(−37.55)
SIZE	−0.0135***	1.2320***	−0.0137***	1.2276***
	(−14.12)	(30.82)	(−14.46)	(30.73)
UE	0.2280***	5.4514***	0.2255***	5.4188***
	(15.56)	(8.69)	(15.44)	(8.64)
LEV	−0.0696***	−4.1109***	−0.0675***	−4.0872***
	(−24.91)	(−34.32)	(−24.13)	(−33.92)
Fixed effects	Present	Present	Present	Present
R^2	0.4777	0.3987	0.4822	0.3990

Notes: *ROA* is calculated as the ratio of total operating income to total assets; Tobin's *Q* represents a measure of firm assets in relation to firm's market value; *CEDI* is proxied as an index of response, status, and score of firms participation in the *CDP* survey; *POST* is a dichotomous variable that represents 1 for post-disclosure period and 0 if otherwise; *IES* is a dichotomous variable that represents 1 for industry environment sensitivity and 0 if otherwise; *NP* is a lagged variable that represents the ratio of net profit to sales; *PPE* represents the log of total assets of a firm; *SIZE* is proxied as the log of market capitalization; *UE* is the annual change in earnings per share scaled by the stock price at the beginning of the period; *LEV* represents the debt/total asset ratio; ***, ** and * indicate two-tailed significance levels at 1%, 5%, and 10%, respectively.

4.3. Robustness analysis

To cement the results obtained above, robustness checks were undertaken by incorporating an alternative measure of FP. This was further necessitated by the fact that endogeneity is likely to arise between the market and accounting-based measures of performance with the independent variables that have been utilized as control variables. Therefore, to eradicate this and provide an inclusive outlook of performance that is expressive of the economic performance of a firm, the measure *ΔSR* is utilized as it represents a more objective measure of FP since stock price holds information about a firm's future prospects for both financial and non-financial measures [4]. It is proxied as change in share price during the year scaled by year beginning price less industry median. Moreover, this metric also provides a thorough evaluation of a company's performance over the most recent period in comparison to other companies operating in the same sector. In addition to that, due to the possibility of correlation of the dependent variables error terms with the independent variables, robustness was further undertaken utilizing the two-stage least squares regression analysis to evaluate the estimation coefficients and cement the results obtained as presented in Table 7.

Consistent with the previous findings, carbon-disclosing firms are characterized by declined FP. In line with Lu and Taylor [4] proposition, despite the change in the performance metric specification, the variables of interest are consistently similar.

4.4. Discussion and summary of the findings

The results indicate that environmental industry classification (sensitive or non-sensitive) is positively related to FP suggesting that environmentally sensitive industries are characterized by increased performance as compared to their non-sensitive peers. These findings are consistent to Lu and Taylor [4] who found out that environmentally sensitive industries that are characterized by increased environmental performance (in the context of disclosures – increased disclosures) perform better as compared to their non-disclosing counterparts. The finding supports the provisions of the good news elaboration as described by the discretionary disclosure theory. Firms with a record of noble environmental performance are forthright in disclosing the information as it results to enhanced FP.

The second part of the hypothesis combined both mandatory and voluntary disclosures by examining the environmental industry

Table 7
Robustness analysis results for the effect of carbon disclosures on firm performance

Independent variables	Dependent variables ΔSR Coef. (*t*-statistics)
Constant	1.1783*** (84.08)
CED	−0.0045*** (−2.96)
NP	−0.0046*** (−6.15)
LEV	−0.0231*** (−4.67)
Wald $\chi^2(3)$	109.26
R^2	0.0147

Note: ***, ** and * indicate two-tailed significance levels at 1%, 5%, and 10%, respectively. *t-statistics* are presented in brackets.

classification effect on carbon disclosure–FP relationships. Results are positive and significant across both accounting and market-based measures indicating that there is a value that the financial market attaches to the disclosures submitted by environmentally sensitive industries and this is further enhanced by them submitting the voluntary disclosures beyond the mandatory requirements. Despite the inordinate pressure from the social and political environment that companies from environmentally sensitive industries face which ensures that disclosures are virtually mandatory for these firms, the resultant effect of additional disclosures is increased FP. Therefore, it can be concluded that more comprehensive disclosures regarding environmental sustainability will enhance FP.

These results further indicate the non-responsiveness of carbon disclosure as indicated by the negative relation across accounting, market based, and combination of both measures. This is an indication that investors are yet to attach value to the disclosures made by these firms. The findings are consistent to Alsaifi et al. [9] who established a negative relationship between corporate carbon disclosures and financial performance among environmentally sensitive FTSE 100 companies in the United Kingdom.

On the other hand, the coefficient β_3 which examined FP of the propensity score matched control sample of carbon non-disclosing companies in both the assigned dates for pre- and post-disclosure period established a consistent negative and significant coefficient across all measures of FP, indicating that FP declined during the carbon disclosure period as compared to pre-disclosure period. This finding is consistent with results obtained by Sun et al. [47] who postulated that there is a negative association between carbon emissions and firm value. These results may suggest that investors in the propensity score-matched controlled sample are yet to attach value to the information provided relative to when it was unavailable. This further suggests that information as disclosed by the companies may not be useful, corroborating the findings of Miralles-Quirós et al. [48]. Lack of interest by investors may be attributed to this as they perceive FP of these companies not to be influenced by their disclosure status. The negative association may also be an indication that voluntary disclosure of environmental performance may not be related to actual environmental performance. Whenever there is doubt in the information disclosed, stakeholders may express their doubts in the information disclosed as they think it does not meet their needs. Another possible explanation may be due to the quality of information disclosed. A peculiar observation among Chinese companies was their classification in the CDP disclosure database response score as "D" or "F" (low) – as compared to most global counterparts who were in "B" or "C" (above average) categories based on the specificities of their disclosures. Another proposition may be that increased FP

conflicts with investor interests; thus, shareholders have to finance such undertakings.

Despite the variants of the relationship that has been established between environmental disclosures and FP, this study, just like several other studies [4, 11], has established that there is value attached to voluntary carbon disclosures especially if these disclosures are made to an external body. The negative nature of this relationship is an indication that despite disclosing firms seeking to maximize their profits, there is an environmental legitimization cost that significantly affects FP.

5. Conclusion

Tackling global warming and climatic change remains as one of the critical roles which companies can adhere to considering they are the biggest sources of greenhouse gas emissions. This study sheds light on one of the most urgent and current social environmental concerns the society is facing. While previous literature has focused on carbon disclosures in the developed economies, this study examines an emerging market that is considered to be the biggest emitter of carbon in the world.

Utilizing a sample of Chinese listed firms that participate in the CDP from 2010 to 2018, as well as a control sample of propensity score matched non-disclosing companies, the findings based on the difference in difference approach indicate that carbon-disclosing companies are characterized by decreasing FP as compared to their non-disclosing counterparts. Environmental sensitive industries on the other hand are characterized by increased financial performance and so did those that disclosed their carbon emissions – an indication that despite the ever-increasing stringent requirements relating to environmental disclosures, FP is still on the rise. Generally, the findings indicate a negative association between carbon disclosure and FP. Di Vaio et al. [49] postulate that environmental disclosures are associated with specific and costly risk disclosures which may castigate a firm's environmental strategies over specified time periods as disclosures tend to result in accountability. Such actions can turn into means of competing for vital resources which is consistent with the resource dependence theory.

This study however has some limitations. The measure of carbon disclosure is subject to scrutiny as a three-factor index proxy was utilized. This proxy captures response, status, and score of firms, whereas disclosures vary and are diverse. To the knowledge of the researcher and based on the unavailability of qualified data, the measure is best placed independently to evaluate carbon-disclosing and non-disclosing companies. Future studies can consider incorporating the level and scope of emissions disclosed by companies. Future studies on the carbon emissions levels across such precincts may serve to alleviate this problem [50–57].

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data available on request from the corresponding author upon reasonable request.

Author Contribution Statement

Cyrus Isaboke: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Visualization, Project administration. **Yan Chen:** Validation, Formal analysis, Resources, Writing – review & editing, Supervision. **Amon Bagoza:** Writing – review & editing, Visualization.

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