Effect of market-based regulations on corporate carbon disclosure and carbon performance: global evidence

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Abstract

Purpose – In this study, the authors examine the relationships between market-based regulations and corporate carbon disclosure and carbon performance. The authors also investigate whether these relationships vary across emission-intensive and non-emission intensive industries.

Design/methodology/approach – The study sample consists of the world's 500 largest companies across most major industries over a recent five-year period. Country-specific random effect multiple regression analysis is used to test empirical models that predict relationships between market-based regulations and carbon disclosure and carbon performance.

Findings – Results indicate that market-based regulations significantly and positively affect corporate carbon performance. However, market-based regulations do not significantly affect corporate carbon disclosure. This study also finds that the association between regulatory pressures and carbon disclosure and carbon performance varies across emission-intensive and non-emission-intensive industries.

Research limitations/implications – The findings of this study have key implications for policymakers, practitioners and future researchers in terms of understanding the factors that drive businesses to increase their carbon performance and disclosure. The study sample consists of only large firms, and future researchers can undertake similar studies with small and medium-sized firms.

Practical implications – The results of this study are expected to help business managers to identify the benefits of adopting market-based regulations. Regulators can use this study's results to evaluate if market-based regulations effectively improve corporate carbon performance and disclosure. Furthermore, stakeholders may use this study to evaluate and improve their businesses' reporting of carbon disclosure and performance.

Originality/value – In contrast to current literature that has used command and control regulations as a proxy for regulation, this study uses market-based regulations as a proxy for climate change regulations. In addition, this study uses a more comprehensive measure of carbon disclosure and carbon performance compared to the previous studies. It also uses global multi-sector data from carbon disclosure project (CDP) in contrast to most current studies that use national data from annual reports of sample firms of specific sectors.

Keywords Carbon disclosure, Carbon performance, Market-based regulations, Industry emission intensity, Regulations, Regulatory pressure

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1. Introduction

Issues in climate change have significantly attracted researchers because of their importance for the survival of human civilization. Excessive Greenhouse Gas (GHG) emissions, primarily by businesses, are the main cause of climate change (Liu *et al.*, 2015; Stern, 2006). However, businesses have played a crucial role in driving the global transition from a high to a low-carbon economy in recent years. Carbon information disclosure, also referred to as carbon disclosure, is how companies respond to climate change by providing standard information about their GHG emissions. Carbon disclosure has attracted increasing attention from scholars, stakeholders and regulators (e.g. Carvajal *et al.*, 2022; Nadeem *et al.*, 2021; Stanny, 2013; Matsumura *et al.*, 2013). Through carbon disclosure, the stakeholders, including the government and the public, can better monitor and regulate firms' carbon emissions, thus improving corporate environmental performance. Carbon disclosure includes disclosure by an organization of information such as the intensity of GHG emissions, energy use, participation in emissions trading schemes, corporate governance and strategy about climate change, performance against GHG emissions reduction targets, and risks and opportunities related to the impacts of climate change (Cotter *et al.*, 2011).

Businesses are expected to improve their carbon performance to contribute to the global fight against climate change. According to Hoffmann and Busch (2008), corporate carbon performance is indicated by a firm's carbon intensity, carbon dependency, carbon exposure and carbon risk. Carbon intensity indicates the physical carbon performance of a business. It describes the level of carbon usage by a business for a defined scope and financial year. For carbon dependency, it demonstrates the change in the physical carbon performance of a business within a given period. Regarding carbon exposure, it denotes a business's monetary carbon performance. It explains the financial implications for a business due to carbon usage for a defined scope and financial year. Concerning carbon risk, it is referred to as the change in a business's monetary carbon performance within a given period.

Against the backdrop of the increased importance of tackling climate change and businesses' roles in that objective, many countries have introduced environmental/climate change regulations (Dubash *et al.*, 2013; Iacobuta *et al.*, 2018; Eskander and Fankhauser, 2020). Environmental/climate change regulations that governments across the globe have introduced can be primarily categorized into command-and-control regulations and market-based regulations (Li and Ramanathan, 2018; Xie *et al.*, 2017). In command-and-control regulations, governments normally impose a number of emission limits and other standards/restrictions on businesses. Businesses are usually forced to follow them to reduce their impact on the environment. Businesses that cannot meet these standards are typically fined or even forced to close their businesses. In market-based regulations, although governments set limits on pollution and impose other controls and penalties on businesses, they are based on the market mechanism. Market-based regulations deploy economic instruments such as markets, prices and other economic variables to provide incentives to businesses that improve their environmental performance. Taxes, pollutant charge fees, tradable permits and refund systems are examples of instruments currently used by market-based regulations.

Unlike command-and-control regulations, market-based regulations do not force businesses to improve their environmental/carbon performance, rather they are incentivized to improve their environmental/carbon performance. Regardless of whether the regulations are command-and-control or market-based, increases in regulatory pressure are likely to affect corporate carbon disclosure and carbon performance (Wang *et al.*, 2021; Li and Ramanathan, 2018; Xie *et al.*, 2017; Yang *et al.*, 2012).

However, limited research has been done to investigate the effect of regulations on voluntary carbon disclosure and carbon performance. Some of the prominent studies in this area are Wang *et al.* (2021), Zhao *et al.* (2020), Zhang *et al.* (2017), and Pei *et al.* (2019). Existing studies that assess the impact of regulations on carbon disclosure have multiple limitations. Some of these

studies are done only in a national context, while sample periods of some other studies are quite small and old (Zaman *et al.*, 2022; Li and Ramanathan, 2018; Xie *et al.*, 2017). Some of these studies involve only one industry sector, while others use insufficient data from their annual reports (Zhao *et al.*, 2020). Most importantly, these studies only assess the impact of command-and-control regulations on carbon disclosure and carbon performance (Li and Ramanathan, 2018). Similarly, there is a lack of studies that assess the impact of regulations on corporate carbon performance. Most of these studies assess the impact of regulations on environmental performance, which is not exactly the same as carbon performance (Zhang and Wei, 2014; Zhao *et al.*, 2020; Zhang *et al.*, 2017; Pei *et al.*, 2019). These studies, as well, are predominantly done in a national context, e.g. China. Additionally, these studies measure the effect of regulation on carbon emission, which is only one of the elements of carbon performance. Moreover, the results of these studies produce conflicting and inconsistent results (Clarkson *et al.*, 2011; Freedman and Stagliano, 2008; He *et al.*, 2013; Luo, 2019; Peng *et al.*, 2015).

In contrast, our study aims to study the relationship between market-based regulations and corporate carbon disclosure and carbon performance of global businesses drawn from most major industries over a more recent period. Additionally, at the backdrop of lack of existing studies, we would like to assess whether the relationships between market-based regulation and carbon disclosure and carbon performance vary across emission-intensive and non-emission-intensive industries. Emission intensity of a business is determined by the nature of the business. Businesses from industry sectors such as materials, energy and utilities are considered emission-intensive. Businesses operating in these industries are regarded as high carbon emitters (Luo and Tang, 2014). We also study whether levels of carbon disclosure and carbon performance of sample companies have increased in recent years due to an increase in regulatory pressure. We use carbon disclosure and carbon performance scores reported by carbon disclosure project (CDP) as proxies for carbon disclosure and carbon performance. In contrast to the data from annual reports, CDP data are consistent for all companies and, therefore, make them internationally comparable. Most of the existing studies, for example Luo (2019), use carbon emission as a proxy for carbon performance. However, carbon emission is only one of the four indicators of carbon performance, while our measure of carbon performance includes carbon intensity, carbon dependency, carbon exposure and carbon risk.

Our study contributes to the existing literature in several ways. Firstly, in contrast to current literature that has used command and control regulations as a proxy for regulation, we use market-based regulations as a proxy for climate change regulations. As command and control regulations and market-based regulations work through different mechanisms, we can expect that the effects of these regulations on carbon disclosure and carbon performance may also be different. Secondly, we use a more comprehensive measure of carbon performance compared to the previous studies. Thirdly, in contrast to most current studies that use national data taken from annual reports of sample firms of specific sectors, we use global multi-sector data taken from CDP in our study.

Results of this study regarding the effects of market-based regulations on corporate carbon disclosure and, especially, carbon performance should be useful for both policymakers and practitioners. Our findings are expected to help business managers to identify the benefits of adopting market-based regulations. Regulators can use our results to evaluate if market-based regulations effectively improve corporate carbon performance and disclosure. Finally, different stakeholders may use this study to evaluate and improve their businesses' reporting of carbon disclosure and carbon performance. By analysing the impact of industry emission intensity on the relationship between regulations and corporate carbon disclosure and carbon performance, we provide new and critical insights into an under-researched literature. Results of our study would be useful for businesses, especially those in emission-intensive industries, to identify ways to improve their carbon performance which can lead to improvement in other forms of corporate performance.

Our full sample results suggest a positive but insignificant relationship between market-based regulations and voluntary carbon disclosure. However, we find a significant positive relationship between market-based regulations and carbon performance. These results imply that businesses from countries under market-based regulations have higher carbon performance than businesses from other countries. However, these results vary in sub-sample analysis. In non-emission intensive industries, both carbon disclosure and carbon performance are significantly positively affected by market-based regulations. However, for businesses from emission-intensive industries, we do not find any significant relationship between market-based regulations and carbon disclosure and carbon performance.

We also find that levels of carbon disclosure and carbon performance of global businesses have increased over the study period. However, the increase in carbon performance has not happened at the same pace as the increase in carbon disclosure, indicating that factors other than carbon performance can cause an increase in carbon disclosure by businesses.

By using GLS country-specific random effect models, we ensured that our results are robust against the possible presence of heteroscedasticity and autocorrelation and are devoid of any possible endogeneity. The paper is organized as follows. Section 2 reviews the current literature and develops the hypotheses of this study. Section 3 explains the research methodology, and Section 4 discusses empirical results and discussion. Section 5 presents diagnostic and other tests to validate study results, and section 6 concludes the study.

2. Theory, literature review and hypothesis development

Most existing research indicates a positive relationship between regulations and carbon disclosure (Wang *et al.*, 2021; Choi *et al.*, 2013; Hsueh, 2019; Jouvenot and Krueger, 2019; Reid and Toffel, 2009). Regulatory pressure can affect carbon disclosure directly or indirectly. For example, Choi *et al.* (2013) analyse the corporate reaction of Australia's largest 100 companies over the period of 2006–2008 when the Australian government announced a series of regulations about carbon emission disclosure. They find that, during this period, the percentage of Australian companies providing meaningful information on environmental factors, including carbon emissions, had increased substantially from 42% to 67%. Hsueh (2019) finds that businesses subject to Clean Power Plan make higher levels of carbon disclosure. Grauel and Gotthardt (2016) examine the role of effective enforcement of environmental regulations and legal origins of financial systems in clarifying the role of firms' participation in CDP climate change disclosure. Their results show that high levels of environmental regulation incentivize voluntary carbon disclosure.

Climate change regulations can cause stakeholder pressures on businesses to increase their disclosures. Business managers have more information about their businesses than external stakeholders such as shareholders and regulators (Carvajal *et al.*, 2022; Nadeem *et al.*, 2021). These stakeholders might ask for more disclosures from the management to minimize the information asymmetry problem between them and the management. As information asymmetry can cause agency problems, by doing so, the external stakeholders might be able to reduce the agency cost with the management. Some studies find that stakeholder pressure causes higher carbon disclosure (Shen *et al.*, 2020; Reid and Toffel, 2009; Stanny and Ely, 2008; Kolk *et al.*, 2008). For example, Kolk *et al.* (2008) study corporate response towards climate change related to developing reporting mechanisms for GHGs, particularly carbon disclosure. They find that institutional investor pressure on businesses causes extensive disclosure of climate change. Qian and Schaltegger (2017, p. 366) argue that, "the increasing acceptance of climate change as one of the most discussed political, societal and business issues globally, alongside the introduction of regulations to tackle the challenge of global warming we expect carbon disclosure will continue to increase". Luo *et al.* (2012) find that corporate carbon disclosure is correlated with social, economic and legal/institutional pressures.

There is a lack of studies that assess the direct impact of regulation on corporate carbon performance. Existing studies that investigate the effect of environmental regulations on carbon emission produce conflicting results. For example, studies such as Zhang and Wei (2014), Zhao *et al.* (2020), Zhang *et al.* (2017), and Pei *et al.* (2019) argue that environmental regulations can effectively curb emissions. Their findings align with Porter's hypothesis which suggests that proper environmental regulations can cause technological innovation, improve resource utilization and improve technical efficiency which can help businesses improve their environmental performance (Porter and van der Linde, 1995). However, some other studies oppose Porter's view. For example, Zhang (2016) argues that environmental regulation can dissuade carbon emissions. Sinn (2008) suggests that environmental regulations may cause an increase in CO_2 emission by decreasing CO_2 emission efficiency. Similarly, Gani (2012) suggests a significant negative correlation between the level of legal regulation and CO_2 emission. Additionally, some other studies find no significant or consistent relationship between regulations and environmental pollution/carbon emission.

Stakeholder theory suggests that managers are responsible for satisfying the expectations and demands of stakeholders (Ansoff, 1965). As climate change is such an important issue for most businesses nowadays, stakeholders will be interested to know about businesses' climate change activities. Therefore, businesses will likely increase their carbon disclosure to satisfy their stakeholders. Organizations have incentives to disclose information about their activities to respective stakeholder groups to clearly indicate that they conform to those stakeholder groups (Ullmann, 1985). However, both businesses with superior carbon performance and poor carbon performance may increase their carbon disclosure. These behaviours can be explained by the voluntary disclosure theory/signalling theory and legitimacy theory. Voluntary disclosure theory and signalling theory suggest that companies with good environmental performances are likely to make hard and high-quality verifiable disclosure to signal their good quality to investors and to differentiate themselves from companies with bad news to avoid the adverse selection problem (Clarkson *et al.*, 2008; Dye, 1985; Verrecchia, 1983).

On the other hand, legitimacy theory espouses that businesses with poor environmental performance are likely to make soft and unsupported qualitative soft disclosures regarding their environmental performance to legitimize their activities and give the impression of being socially responsible (Deegan, 2000). Therefore, we can argue that businesses might increase voluntary carbon disclosure during increased regulatory pressure to satisfy/manage various stakeholders. However, with the increase in voluntary carbon disclosure, we are not sure whether there would be a corresponding increase in carbon performance. A theory that can explain a possible effect of an increase in corporate carbon disclosure on its carbon performance is the instrumental stakeholder theory. According to this theory, "all else being equal, firms that practice in stakeholder management will perform better in profitability, stability, growth, and other conventional performance terms" (Donaldson and Preston, 1995, p. 67). In line with the proposition of this theory, we can suggest that if businesses increase their carbon disclosure as a means of satisfying/managing their stakeholders, their carbon performance, which is an important corporate performance indicator, is also likely to increase. This argument is supported by Siddique *et al.* (2021), who find that carbon disclosure positively affects carbon performance.

From the above discussion, we have two related arguments. In the first argument, we predict, as per stakeholder theory, that increase in regulatory pressure can cause businesses to increase their carbon disclosure. In the second argument, as per instrumental stakeholder theory, we predict that an increase in carbon disclosure by businesses can cause an increase in their carbon performance. As regulatory pressure positively affects carbon disclosure and carbon disclosure positively affects carbon performance, we can argue an indirect positive relationship between regulatory pressure and carbon performance. From these two arguments, we hypothesize a positive relationship between regulatory pressure and

carbon disclosure and between regulatory pressure and carbon performance. This enunciates our first hypothesis as below.

H1. Regulatory pressure positively affects both carbon disclosure and carbon performance

While there might be relationships between regulatory pressure and carbon disclosure and carbon performance, these relationships can potentially be affected by a business's industry affiliation. Industry sectors such as materials, energy and utilities are considered emission-intensive industries. Businesses operating in these industries, compared to other industries, are high carbon emitters and are regarded as emission intensive. Firms operating in emission-intensive industries are subject to more climate change legislation and regulations than other businesses (Luo and Tang, 2014). Yunus *et al.* (2016) find a significant relationship between a firm's adoption of carbon management strategy and the environmental sensitivity of the firm's industry. Therefore, we can expect that the association between regulatory pressures and carbon disclosure and carbon performance is likely to vary across emission-intensive and non-emission-intensive industries. To test these predictions, we test the following hypothesis.

H2. The association between regulatory pressures and carbon disclosure and carbon performance varies across industries

3. Research methodology

This section discusses the research methodology used to test the hypotheses, and it is structured into three sections. Section 3.1 explains the sample selection process employed in this study. Section 3.2 discusses the measurement of carbon disclosure, carbon performance, regulatory pressure and control variables used in the study. Section 3.3 shows the empirical models used in this study to test the hypotheses.

3.1 Sample selection

The targeted sample for this study is the largest 500 firms worldwide (referred to as Financial Times Global 500 firms) which participated in CDP during the period 2011 to 2015. Since 2003, CDP started asking more than 3,700 companies worldwide for relevant information on climate change. CDP's database is the number one database about climate change-related publicly available data (Griffin *et al.*, 2017; Matsumura *et al.*, 2013). CDP started reporting both carbon disclosure and carbon performance scores of participating companies in 2010. Before that, CDP only reported carbon disclosure scores and continued separate reporting of carbon disclosure and carbon performance scores until 2015. Starting from 2016, CDP no longer reports separate disclosure and performance scores. It now reports a combined score that has prevented us from carrying out the study for a more recent period. These 500 firms are chosen from the FTSE Global Equity Index Series as of 31 December 2015. These firms were ranked as the biggest in sales and had a market capitalization of $32,387 billion (Financial Times, 2015). There are multiple reasons for choosing G500 firms. An important reason is that these firms responded to the CDP carbon disclosure and carbon performance questionnaire during the study period of 2011–2015. Another reason for choosing G500 firms is their impact on the economies where they perform their operations (Jose and Lee, 2007). Some prior research, such as Clarkson *et al.* (2008) and Patten (2002), have identified the effect of small sample size and context on their studies' mixed results. Therefore, a large sample like G500, which includes many industries and countries, may overcome these limitations.

From G500 firms, financial firms have been excluded, as their businesses do not involve substantial carbon emissions. To be included in the sample, firms should have both carbon

disclosure score and carbon performance score available for each year between 2011 and 2015. Therefore, after excluding financial companies and companies whose carbon disclosure scores and carbon performance scores are missing in any of the years between 2011 and 2015, the final sample constitutes 189 firms. Sample firms have been classified as per the Global Industry Classification Standard (GICS). Industry–wise composition of sample firms, approximately, are consumer discretionary 14%, consumer staples 14%, energy 11%, health care 12%, industrials 16%, information technology 12%, materials 9%, telecom 7% and utilities 5%. These sample firms come from 26 countries, and the highest number of firms are from the USA (85), followed by the UK (20) and then France and Germany (12 each), followed by Japan with 11 firms. All other countries have only a few firms.

3.2 Measurement

3.2.1 Measurement of carbon disclosure and carbon performance. This study uses carbon disclosure and carbon performance scores prepared by CDP as proxies for voluntary carbon disclosure and carbon performance by sample companies. CDP collects climate change-related information from more than 8,000 businesses worldwide. CDP prepares carbon disclosure scores and carbon performance scores based on its climate change scoring methodology. The scoring methodology aims to reach a final score for carbon disclosure and carbon performance based on evaluating the responder's progress towards environmental stewardship as communicated through its CDP response. The scoring methodology assesses the level of detail and comprehensiveness in response and the company's awareness of environmental issues and its management methods.

Disclosure scores are expressed as a percentage (a number between 0 and 100). In general, the number of points allocated to each question asked in the CDP questionnaire, which the respondent companies fill in voluntarily, depends on the amount of data requested. Some questions have more than one point attached to a single piece of information where the information is of particularly high importance, e.g. the gross global Scope 1 emissions figure. Questions that allow text responses are usually judged according to how many of the required data points they achieve. At the end of scoring, the number of points a company has been awarded (the numerator) is divided by the maximum number that could have been awarded (the denominator). The fraction is then converted to a percentage by multiplying it by 100 and rounded to the nearest whole number as below:

$$(\textit{Points awarded} \,/\, \textit{points attainable})\, x\, 100 \;=\; \textit{Disclosure Score}$$

The disclosure score represents the potential quality in the completeness of disclosure, and hence it is likely usefulness to data users. The disclosure score is a matrix of comprehensiveness of the responses, good internal data management and understanding of climate change issues. It is a measure of complete transparency on climate change. However, it is important to understand that the disclosure score does not measure how green or sustainable a company is. A low disclosure score is not necessarily an indicator of poor performance, but it suggests a company has insufficient information based on which a judgement of performance can be made.

Carbon performance points are awarded when a company highlights that it is undertaking a positive climate change action. Businesses are awarded performance points when they provide evidence in their CDP response about actions considered to contribute to climate change mitigation, adaptation and transparency. Actions considered to be more fundamental to progress on combating climate change are awarded more points. External verification/assurance of emissions data is rewarded under the performance scoring, as it is considered that this potentially increases the usefulness of the information to decision makers, and can act as a pre-qualifier of the data

submitted that should be recognized when evaluating performance. The performance score is solely based on activities and positions disclosed in the CDP questionnaire, which respondent companies fill voluntarily. Therefore, it does not consider actions not mentioned in the CDP response. To receive a performance score, a company must achieve a minimum disclosure score of 50. This is to ensure that the judgement is based on sufficient information. Performance scores are converted to percentages in a similar way to the disclosure score. The percentages are then grouped into bands of A, A-, B, C, D, E, with A being the best. Letter bands are difficult to use in statistical analysis. Therefore, this study has converted them to numeric values by taking the average of the highest and lowest values of each performance band. For example, the numeric equivalent of A = 100 (highest value of A) + 86 (lowest value of A)/2 = 93. The scoring methodology of 2011 is slightly different from the 2012 to 2015 methodology. However, we use only the 2012–2015 scoring methodology to keep it simple.

Using CDP disclosure and performance scores have multiple advantages. Firstly, while supplying relevant information to CDP, all participating businesses follow a similar format and reporting guidelines provided by CDP. Secondly, since CDP uses the same methodology for all the companies, this makes the disclosure and performance scores of different companies comparable and meaningful. Thirdly, CDP provides more extensive and detailed carbon performance information than annual reports and sustainability reports of most businesses (Luo and Tang, 2014). Several previous studies, such as Siddique *et al.* (2021), Luo and Tang (2014), and Luo (2019), use CDP scores as measures for carbon performance and disclosure.

3.2.2 Measurement of industry emission intensity and market-based regulation. We have measured the emission intensity of an industry depending on the nature of the industry. Industry sectors such as materials, energy and utilities are considered emission-intensive industries. Businesses operating in these industries are regarded as high carbon emitters. Firms operating in emission-intensive industries are subject to more climate change legislation and regulations than other businesses (Luo and Tang, 2014). All other industries are considered as non-emission intensive industry.

This study uses Cap and Trade (CAT) emission control policies as a proxy for market-based regulations. Emission trading schemes such as the European Emission Trading Scheme works on the CAT principle. In this system, a cap is imposed on the total amount of GHGs that an installation can emit. Over time, the cap is reduced to ensure total emissions fall. Within the cap, installations can buy or receive emissions allowances to trade with one another as needed (European Commission, 2017). Unlike command-and-control environmental regulations, CAT policies are market-based policies that allow installations and markets to decide how best to achieve their climate change targets through a market mechanism (Fowlie *et al.*, 2016; Teeter and Sandberg, 2017). As command-and-control climate change regulations and CAT systems work very differently, we would like to investigate whether businesses working under these systems demonstrate different levels of carbon disclosure and carbon performance.

3.2.3 Control variables. This study uses firm size, leverage, firm age, growth opportunities, capital intensity and legal origin as control variables because of their possible impact on environmental/carbon disclosure and/or environmental/carbon performance. Most voluntary disclosure studies have used firm size as a control variable (Siddique *et al.*, 2021; Xue *et al.*, 2020; Luo, 2019; Clarkson *et al.*, 2008, 2011; Deegan and Gordon, 1996; Patten, 2002). Firstly, larger firms have the resources needed to make comprehensive disclosures for non-financial information, and secondly, larger firms are subject to a high degree of public scrutiny (Liu and Anbumozhi, 2009; Stanny and Ely, 2008).

Highly leveraged firms are likely to adopt accounting and financial policies that would allow them to make detailed disclosure of their financial, environmental, and social

performance. They would do so to avoid agency costs, which their creditors might impose on them (Clarkson *et al.*, 2008). Highly leveraged firms also make detailed disclosure to keep their investors and creditors informed to avoid debt-covenants breaches (Freedman and Jaggi, 2005). Therefore, it is expected that firms with high leverage would make detailed carbon disclosure. Studies such as de Villiers *et al.* (2011), Huergo and Jaumandreu (2004), and Mohan-Neill (1995) argue that older firms are more likely to be involved in environmental management/climate change activities because older firms can do this at a lower cost as compared to new businesses. Therefore, we have used firm age as a control variable.

Growth opportunity has been used as a proxy for future growth. Porter and van der Linde (1995) use growth as a proxy for intangible assets associated with innovation. As innovation is likely to increase environmental/carbon performance, we can argue that growth is positively related to environmental/carbon performance. Businesses with higher capital spending can obtain newer and cleaner technologies, which would help them improve their carbon performance. Clarkson *et al.* (2008) argue that these businesses want to disclose information about their cleaner technologies to inform stakeholders. Therefore, businesses with higher *capital* intensity will likely make more carbon disclosure. Legal origin refers to the legal system of countries in which our sample firms operate. Some of these countries have a Common Law system, while most other countries have a Civil Law system. We use legal origin as a dummy variable to see if businesses operating under different legal systems behave differently in climate change management and disclosure. Table 1 summarizes all the variables used in this study, how these variables are measured, and their sources.

3.3 Empirical models

We use the following empirical models to test our hypotheses.

Variables	Measurement	Source
Carbon disclosure (CD)	Carbon disclosure scores reported by CDP	CDP
Carbon performance (CP)	The numeric equivalent (midpoint of carbon performance score) of the carbon performance band reported by CDP[1]: 93 for A/A-; 73 for B; 51 for C; 31 for D and 10 for E	CDP
Size	Measured as the natural logarithm of total assets	DataStream
Leverage (LEV)	Total debts divided by total assets	DataStream
Age	Measured as the natural logarithm of the age of the firm	DataStream
Growth	Measured as the ratio of market value of equity to book value of equity	
Capital intensity (CAPIN)	Measured as the ratio of capital expenditures to total sales revenue	DataStream
Cap and Trade (CAT)	Cap and Trade. It is a dummy variable that equals 1 if the firm is located in a country that uses a "Cap and Trade" policy to control greenhouse gas emission and 0 otherwise	https://icapcarbonaction.com/en/ets-map
Legal origin (LEG)	It is a dummy variable that equals 1 it the firm is in a common law country and 0 otherwise	Porta *et al.* (1998)

Note(s): [1] For the sake of simplicity, we use only the 2012–2015 scoring methodology, which is slightly different from the 2011 scoring methodology
Source(s): Table created by author

Table 1. Measurement and source of variables used in the study

3.3.1 Hypothesis 1.

$$CD_{i,tj} = \alpha + \beta_1 CAT_{i,t} + \beta_2 LEG_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 CAPIN_{i,t} + \beta_6 AGE_{i,t} + \beta_7 GROWTH_{i,t} + \gamma_t + \delta_I + \theta_j + \varepsilon i, tj \quad (1)$$

$$CP_{i,tj} = \alpha + \beta_1 CAT_{i,t} + \beta_2 LEG_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 CAPIN_{i,t} + \beta_6 AGE_{i,t} + \beta_7 GROWTH_{i,t} + \gamma_t + \delta_I + \theta_j + \varepsilon i, tj \quad (2)$$

3.3.2 Hypothesis 2. For hypothesis 1 we tested the above models in our full sample. To test hypothesis 2, following Zaman *et al.* (2021), we tested models 1 and 2 in two subsamples. Subsample 1 contains the data for businesses from emission-intensive industries, while subsample 2 contains the same data from businesses from non-emission intensive industries.

Where:

CD = CDP carbon disclosure score of a firm

CP = CDP carbon performance score of a firm

SIZE = Firm size measured as the natural log of total assets of a business

LEV = Leverage measured as total debts divided by total assets of a business

CAPIN = Capital intensity of a business measured by dividing capital spending of a business by its total revenue

AGE = Age of a business measured as the natural log of the total number of years a business has been in operation.

GROWTH = Growth opportunity of a business measured by dividing the firm's market value of equity to its book value of equity

CAT = Cap and Trade. It is a dummy variable that equals 1 if the firm is located in a country that uses a "Cap and Trade" policy to control GHG emission and 0 otherwise.

LEG = Legal origin. It is a dummy variable that equals 1 if the firm is located in a Common Law country and 0 otherwise

α = intercept

β = regression coefficient

ε = error term

T1 to T5 are fiscal years 2011–2015

γ_t and δ_I are year and industry effect

θ_j = random effect for country j

We have used GLS random-effects models to test our hypotheses. Because we use panel data in this study, we assume there will be significant country-level variability due to differences introduced by unmeasured control variables. Country-level variability can be accommodated by adding country-specific fixed or random effects in the model (Mundlak, 1978). In order to decide between random/fixed effects, we have used the Hausman specification test for each of our models. The Hausman

test for each of our two models favours random effect models as we fail to reject the null hypothesis of random effects. The *p*-values for model 1 and 2 are 0.9884 and 0.999, respectively.

4. Empirical results and discussion

4.1 Descriptive statistics

Table 2 shows the full sample descriptive statistics of carbon disclosure, carbon performance and the control variables for the period 2011 to 2015. The highest carbon disclosure score is 100, the lowest is 50, and the average is 85.825, with a standard deviation of 12.87. These numbers indicate that sample firms disclose a good amount of high quality and useful data about their climate change-related activities. The average carbon performance score is 66.554, with a minimum score of 10, a maximum score of 93 and a standard deviation of 21.058. This indicates that carbon performance scores have not increased much compared to carbon disclosure among the sample firms. These results also suggest that there is a large variation among sample firms in regard to their carbon performance. The average firm size is 10.680, and the mean capital intensity is 0.975. These two results are consistent with Luo (2019). The mean age of sample firms is 3.958. Our analysis (results not tabulated) shows that about 25% of sample firms are from the carbon-intensive industries (energy, materials and utilities sector), about 50% of firm-year observations are from countries with a "Cap and Trade" policy, and approximately 62% of firm-year observations are from countries that have a Common Law legal system. Our analysis also shows that Finland has the highest, and Russia has the lowest average carbon performance scores. Ireland has the highest, and the USA has the lowest average carbon disclosure scores. Table 3 shows that the utilities sector has the highest average carbon disclosure and carbon performance score. In contrast, the energy sector has the lowest average carbon disclosure and carbon performance score. Table 4 presents the Pearson correlation coefficients of dependent, independent and control variables. The results indicate a significant positive relationship between carbon disclosure and carbon performance. It also shows that capital intensity and legal origin are significantly negatively associated with carbon disclosure. Firm age and market-based regulations (proxied by cap and trade scheme) are significantly positively related to carbon disclosure. On the other hand, firm size, leverage and firm age are significantly positively related to carbon performance. Capital intensity, legal origin and market-based regulation are significantly negatively related to carbon performance.

4.2 Effect of regulatory pressure on carbon disclosure and carbon performance

Table 5 presents the relationship between carbon disclosure and carbon performance with regulatory pressure as per H1. The results reveal a positive but insignificant relationship between CAT and carbon disclosure. However, there is a significant positive relationship between CAT and carbon performance. These results imply that businesses from countries that use CAT emission control policies have higher carbon performance

	CD	CP	SIZE	LEV	CAPIN	GROWTH	AGE
Mean	85.825	66.554	10.680	0.2498	0.0975	35.398	3.958
Maximum	100.000	93.000	12.86	0.84	0.93	4139.18	5.86
Minimum	50.000	10.000	8.72	0.000	0.00	−7003.03	0.000
Std. Dev	12.870	21.058	0.768	0.13342	0.109	351.070	0.850
Firm-year Observations	945	945	945	945	945	945	945

Source(s): Table created by author

Table 2. Full sample descriptive statistics of panel data for all variables

Industry sector	N	Minimum CD score	Maximum CD score	Mean CD score	Std. Deviation
Panel A: Carbon disclosure (CD) score					
Consumer discretionary	125	51.00	100.00	86.8400	12.31666
Consumer staples	140	53.00	100.00	86.2714	12.08295
Energy	100	50.00	100.00	80.1000	13.29730
Health care	115	54.00	100.00	85.7391	12.42386
Industrials	150	50.00	100.00	86.5133	13.83107
Information technology	110	52.00	100.00	85.9818	13.29481
Materials	85	53.00	100.00	88.2941	11.94514
Telecomm services	69	54.00	100.00	84.2174	12.47453
Utilities	50	59.00	100.00	89.0600	11.91194
Panel B: Carbon performance (CP) score					
Consumer discretionary	125	31.00	93.00	67.3040	19.96134
Consumer staples	140	10.00	93.00	70.1357	19.56771
Energy	100	10.00	93.00	54.7300	20.90133
Health care	115	10.00	93.00	65.1913	19.84939
Industrials	150	10.00	93.00	68.9800	21.64865
Information technology	110	10.00	93.00	66.6455	23.43157
Materials	85	31.00	93.00	68.9294	18.81096
Telecomm Services	69	10.00	93.00	64.3768	22.14531
Utilities	50	31.00	93.00	72.8000	17.69238

Source(s): Table created by author

Table 3. Sector-wise descriptive statistics of panel data of carbon disclosure and carbon performance scores

than those without these policies. As we have used CAT as a proxy for market-based regulation, our results suggest that market-based regulations significantly positively affect carbon performance. This result supports the idea that market-based regulations incentivize businesses to increase their carbon performance. This result partially supports hypothesis 1, which suggests regulatory pressure positively affects carbon performance. Our results contradict the findings of the only existing study that assess the effects of market initiatives on carbon emission. In contrast to our findings, this study finds that market incentives appear to have little influence on carbon emission. However, Zhao *et al.* (2020) consider only market incentives and carbon emissions in their study while we consider market-based regulations and carbon performance, which are much broader than market initiatives and carbon emissions. All other existing studies that deal with the effect of regulation on carbon performance assess the impact of command and control regulations on carbon emission. Their results are very diverse. For example, Zhang *et al.* (2017) and Pei *et al.* (2019) find a positive relationship between regulations and carbon emission. However, Zhang (2016), Sinn (2008), and Gani (2012) find a negative correlation between the level of legal regulation and CO_2 emission. While Wang *et al.* (2019), Zhang (2016), and Liu *et al.* (2019) find the relationship between regulations and carbon emission as uncertain, inconsistent and nonlinear.

Our results also show that the legal system (whether the businesses are from Common Law countries or other countries) does not significantly affect businesses' carbon disclosure or carbon performance. Our results suggest a significant positive relationship between leverage and both carbon disclosure and carbon performance, implying that highly leveraged firms have better carbon performance and make more carbon disclosure compared to other

Table 4. Pearson correlation coefficients of dependent, independent, and control variables of panel data

	CD	CP	SIZE	LEV	CAPIN	GROWTH	AGE	LEG	CAT
CD	1.000								
CP	0.727**	1.000							
SIZE	0.179	0.179**	1.000						
LEV	0.160	0.101**	0.007	1.000					
CAPIN	−0.066*	−0.084**	0.011	0.157**	1.000				
GROWTH	0.051	0.027	0.179**	0.036	−0.262**	1.000			
AGE	0.071*	0.081*	0.109**	0.130**	−0.073*	−0.019	1.000		
LEG	−0.138**	−0.152**	0.036	0.105**	−0.058	0.435**	0.007	1.000	
CAT	0.086*	−0.132**	−0.018	−0.068*	0.092**	−0.124**	−0.095**	−0.515**	1.000

Note(s): ***, ** and * represent significance levels at 1%, 5 and 10%, respectively
Source(s): Table created by author

Variables	Dependent variable	
	CD	CP
C	47.741***	−6.976
CAT	4.026	11.611**
LEG	−0.404	−1.710
LEV	10.466***	13.228***
SIZE	1.698***	3.879***
CAPIN	−10.567***	−11.969*
AGE	0.844**	2.036***
GROWTH	0.000	−0.001
R-squared	0.329	0.152
F-statistic	0.3289	0.1523
Industry fixed	Yes	Yes
Country random	Yes	Yes
Year fixed effect	Yes	Yes

Note(s): ***, ** and * represent significance levels at 1%, 5 and 10%, respectively
Source(s): Table created by author

Table 5.
Effect of regulatory pressure on carbon disclosure (CD) and carbon performance (CP)

firms. This result is partially supported by Siddique *et al.* (2021), Yunus *et al.* (2016), Clarkson *et al.* (2008), and Freedman and Jaggi (2005). Results also indicate that firm size is significantly positively related to carbon disclosure and carbon performance. This supports previous studies such as Siddique *et al.* (2021), Dutta and Dutta (2020), Yunus *et al.* (2016), Liu and Anbumozhi (2009), and Stanny and Ely (2008). We also find that firm size is significantly positively related to carbon performance. To support this finding, we can argue that larger firms would have more resources to increase their carbon performance. Our results also present that firm age has a significant positive relationship with both carbon disclosure and carbon performance, implying that older firms have better carbon performance and make more carbon disclosure results supported by studies such as de Villiers *et al.* (2011), Huergo and Jaumandreu (2004), and Mohan-Neill (1995).

4.3 Effect of industry emission intensity on the association between regulatory pressure and carbon disclosure and carbon performance

Tables 6 and 7 demonstrate whether there is heterogeneity in our H1 (baseline) results across industries. Table 6 shows the results for the relationship between market-based regulations and carbon disclosure and carbon performance for emission-intensive industries. It demonstrates that, for businesses from emission-intensive industries, market-based regulations have a positive but insignificant relationship with both carbon disclosure and carbon performance. On the other hand, Table 7 demonstrates different results. It shows a positive and significant relationship between market-based regulations and both carbon disclosure and carbon performance for non-emission intensive businesses. Therefore, we can suggest that association between regulatory pressures and carbon disclosure and carbon performance varies across industries.

Figure 1 indicates that the level of carbon disclosure of sample companies consistently increased from year 1 to year 5. These results support the prediction in prior literature that businesses would continue to increase their carbon disclosure over time due to increases in regulatory pressure, ever-increasing voluntary disclosure channels and their desire to legitimize their operations. The figure also shows that the carbon performance of sample companies also increased from year 1 to year 5. However, unlike carbon disclosure, the increase in carbon performance was not always consistent. In addition, carbon performance

Variables	Dependent variable	
	CD	CP
C	38.06**	4.38
CAT	1.35	1.77
LEG	−3.65	−4.90
LEV	32.38***	29.55**
SIZE	4.08**	6.26**
CAPIN	−6.21	−12.49
AGE	−1.62*	−0.68
GROWTH	−0.03	−0.04
R-squared	0.411	0.266
F-statistic	11.01	5.72
Industry fixed	Yes	Yes
Country random	Yes	Yes
Year fixed effect	Yes	Yes

Note(s): ***, ** and * represent significance levels at 1%, 5 and 10%, respectively
Source(s): Table created by author

Table 6.
Sub-sample analysis: emission-intensive industries

Variables	Dependent variable	
	CD	CP
C	33.02***	−42.20**
CAT	4.13**	12.40***
LEG	1.27	3.19
LEV	7.28**	8.92*
SIZE	2.62***	5.95***
CAPIN	2.59	18.49*
AGE	1.43**	2.79**
GROWTH	−0.000	−0.002
R-squared	0.366	0.20
F-statistic	23.54	10.23
Industry fixed	Yes	Yes
Country random	Yes	Yes
Year fixed effect	Yes	Yes

Note(s): ***, ** and * represent significance levels at 1%, 5 and 10%, respectively
Source(s): Table created by author

Table 7.
Sub-sample analysis: non-emission intensive industries

did not always increase at the same pace as carbon disclosure. For example, the level of carbon disclosure increased consistently over the five years. Carbon performance also increased consistently from year 1–4. However, in year 5, it decreases compared to year 4. These results indicate that businesses may continue to increase their carbon disclosure because of the increase in their carbon performance and other factors such as to legitimize their activities or to satisfy their stakeholders, explanations that are suggested by legitimacy and stakeholder theory.

5. Multicollinearity, endogeneity, robustness and self-selection bias

Presence of multicollinearity has been investigated in our study by analysing the pairwise correlation between the independent variables. If a correlation coefficient <0.7, there is no indication of multicollinearity (Shrestha, 2020). The correlation matrix presented in Table 8

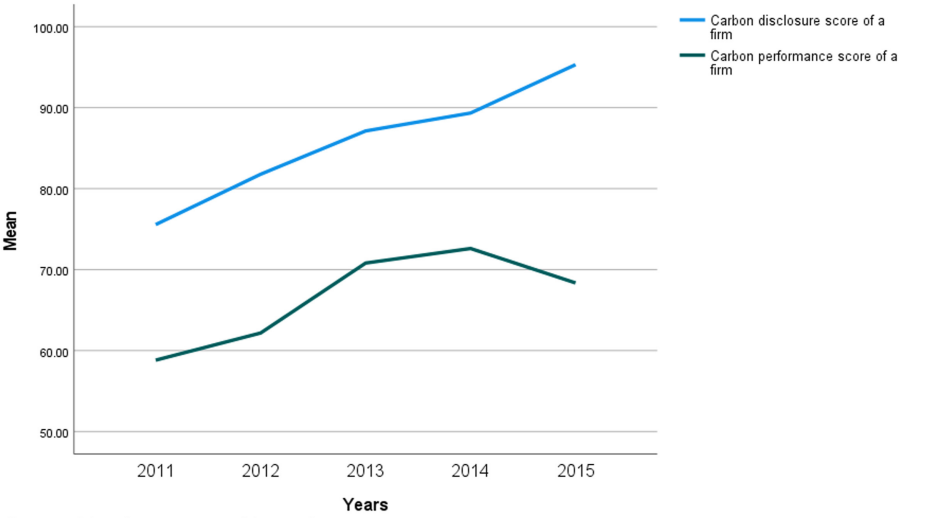

Figure 1.
Temporal effect on carbon disclosure and carbon performance

Source(s): Figure created by author

	LEV	SIZE	CAPIN	AGE	GROWTH
LEV	1				
SIZE	0.018	1			
CAPIN	0.0677	−0.0653	1		
AGE	0.1255	0.1174	−0.049	1	
GROWTH	0.0333	0.0394	−0.0432	−0.0346	1

Table 8.
The correlation matrix between the independent variables

Source(s): Table created by author

shows that pairwise correlations between the independent variables are negligible, indicating the absence of multicollinearity.

By taking country-specific random effects in the regression model, we have removed the impact of unobserved independent variables, which removes the endogeneity that might otherwise have been present in the data. GLS random-effects models used in this study adjust the standard error for heteroscedasticity and autocorrelation and consequently adjust the *p*-values for the hypothesis tests of the regression parameters. Thus, GLS provides robust standard error estimates adjusted for possible heteroscedasticity and serial correlation (Mundlak, 1978). Therefore, the hypothesis tests for the regression parameters for the models used in this paper are robust against the possible presence of heteroscedasticity and autocorrelation.

In this study, we have used balanced panel data. The initial sample size was 500 companies. However, we have not included data for all 500 companies in our final sample. Instead, we have included data for dependent, independent and control variables for only those companies whose carbon disclosure and carbon performance scores are available in each of the sample years, i.e. 2011, 2012, 2013, 2014 and 2015. Companies whose carbon disclosure or carbon performance scores are not available in any of the sample years have been excluded from the final sample. As in our sample, all the selected companies disclosed both carbon disclosure and carbon performance data for the entire study period; there should not be any self-selection bias in our data.

6. Conclusions and implications

This study examines the impact of market-based regulations on corporate carbon disclosure and carbon performance. We also assess whether the relationships between market-based regulations and carbon disclosure and carbon performance vary across emission-intensive and non-emission intensive industries. We also investigate whether voluntary carbon disclosure and carbon performance of global businesses have increased over the years. Our results suggest that market-based regulations significantly and positively affect the carbon performance of businesses. This result suggests that businesses operating under the CAT emission control system have higher carbon performance than other businesses. We do not find any significant effect of market-based regulations on corporate carbon disclosure. Our study also suggests that the association between market-based regulation and corporate carbon disclosure and carbon performance varies across industries. In emission-intensive industries, regulations do not have any significant effect on the relationship between market-based regulations and carbon disclosure and carbon performance. However, in non-emission intensive industries, market-based regulations significantly positively affect the relationship between corporate carbon disclosure and carbon performance. Our results also indicate that voluntary carbon disclosure made by global businesses has significantly and consistently increased over the years. Carbon performance has also significantly increased over the years. However, the increase in carbon performance has not always been consistent and at the same pace as the increase in carbon disclosure.

The findings of this study have key implications for policymakers, practitioners and future researchers in terms of understanding the factors that drive businesses to increase their carbon performance and disclosure. Our results demonstrate to the regulators and policymakers the critical role regulations, especially market-based regulations, play in improving corporate carbon performance. This study assures regulators from countries with the CAT system about its effectiveness. The results should encourage regulators from countries without market-based regulations to introduce similar regulations. Our findings suggest that businesses operating under the CAT Emission Scheme have higher carbon performance. However, these businesses do not always make high levels of carbon disclosure as predicted by voluntary disclosure theory and signalling theory. Future researchers may investigate this apparent contradiction between theory and practice. Our sample consists of only large firms. Future researchers can undertake similar studies but with small and medium-sized firms.

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