







## Article

# Carbon Emission and Firm Performance: The Moderating Role of Management Environmental Training

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**Abstract:** This study investigated the role of Carbon disclosure on firm performance while considering the moderating role of management environmental training as it enhances the mechanisms of governance and monitoring practices. The data was collected from eleven European countries and listed in the Reuters Eikon database from 2016 to 2021. The Hausman test is used to test the usage of the panel method (panel data) with fixed and random effects. The results are the following: The management's environmental training played a moderating role in carbon emission disclosure, resulting in better firm performance. This means that management environmental training would play a vital role in addressing such disclosure issues and being prepared to formulate better measurements to tackle their effects. Our study is one of the few that analyzes how the moderating role of management environmental training in carbon emission disclosure results in better firm performance.

**Keywords:** carbon disclosure; firm performance; environmental governance; management environmental training



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## 1. Introduction

In recent years, there has been an increasing recognition among policymakers, regulators, and companies about the potential dangers of climate change. The role of greenhouse gases, especially carbon emissions, has become a significant topic of discussion. Since the beginning of the industrial era, the concentration of greenhouse gases, including carbon dioxide, in the atmosphere has increased rapidly, with carbon dioxide levels rising by over 30%.

Reducing carbon emissions is becoming increasingly important in order to limit the worst effects of climate change. A study published in *Nature Climate Change* argues that global carbon dioxide emissions need to decrease by 45% by 2030 and reach net zero by 2050 to limit warming to 1.5 °C above preindustrial levels [1]. However, carbon dioxide emissions from global energy use rose by 2.1% in 2021, according to another study published in *Environmental Research Letters*, driven by economic recovery and increased energy demand [2]. Given these findings, effective strategies for reducing carbon emissions are essential, and prompt action is critical to mitigating the most severe impacts of climate change.

Carbon emissions remain a critical issue in several countries worldwide, including Europe, where listed firms have also been facing increasing pressure to reduce their carbon

emissions. In 2022, the European Commission proposed a new directive that would require all publicly listed companies in the EU to disclose their Environmental, Social, and Governance (ESG) data, including carbon emissions. This directive aims to increase transparency and encourage firms to adopt sustainable business practices. Additionally, the Task Force on Climate-related Financial Disclosures (TCFD) has called on companies to report on their climate-related risks and opportunities, including their carbon emissions, to better inform investors and stakeholders. These efforts demonstrate the growing importance of addressing carbon emissions in the corporate sector as well.

Among others, Environmental Management Training (EMT) has become increasingly important as climate variability and global warming become significant societal and economic problems. The United Nations Framework Convention on Climate Change (UNFCCC) has emphasized the need for capacity building and training to address climate change issues at the local, national, and international levels. The European Environment Agency (EEA) reported that inadequate training and education in environmental management were a significant barrier to implementing effective environmental policies and practices. Furthermore, Adeleke et al. [3] found that environmental management training had a positive impact on the environmental performance of Nigerian manufacturing firms. Hence, EMT can provide education and training to employees on sustainable practices and energy efficiency measures, leading to a reduction in carbon emissions. According to a study by García-Sánchez et al. [4], training programs aimed at improving employees' environmental awareness and knowledge can result in significant energy savings. It can assist companies in developing and implementing policies that promote carbon reduction measures. For example, a study by Klass [5] found that companies that have adopted environmental policies are more likely to engage in energy-efficient practices and reduce their carbon emissions.

The Resource-Based View (RBV) of the firm is one of the most influential theoretical perspectives in strategic management, which emphasizes the role of internal resources and capabilities in creating and sustaining competitive advantage [6]. According to the RBV, a firm's unique resources and capabilities are difficult to imitate or replicate by competitors, which enables the firm to achieve superior performance and profitability over time. Hence, management environmental training can be seen as a valuable resource that can enhance a firm's ability to manage its carbon emissions effectively and thereby improve its environmental performance. This training can provide employees and managers with the knowledge, skills, and tools needed to develop and implement effective environmental management practices, such as energy efficiency measures, waste reduction, and pollution control [7]. Research has shown that firms that invest in environmental management training are more likely to adopt environmentally friendly practices and reduce their carbon emissions [8]. For example, a study by Cho et al. [9] found that companies with higher levels of environmental management training had lower carbon intensity than companies with lower levels of training.

Our study is one of the limited studies analyzing how management environmental training played a moderating role in carbon emission disclosure and resulted in better firm performance. While there is a growing body of research that explores the relationship between carbon disclosure and firm performance [10,11], little is known about the role of management environmental training in moderating this relationship. By incorporating this moderating variable, the present study adds to the literature by highlighting the importance of investing in environmental management training as a means of improving firm performance. It also extends the Resource-Based View (RBV) theory by demonstrating how management environmental training can act as a valuable resource that enables firms to manage their carbon emissions effectively and thereby improve their financial performance [12]. Finally, this study also contributes to the literature by focusing on the context of developed countries. There is a growing body of literature that emphasizes the need for organizations to adopt environmentally sustainable practices to achieve positive financial performance. Carbon emissions are one of the critical indicators of a company's environ-

mental performance. However, there is limited research on the relationship between carbon emissions and financial performance and the role of management environmental training in moderating this relationship. Overall, our study sheds new light on the importance of environmental management training for enhancing firm performance in the context of climate change.

The rest of this study is organized as follows: Section 2 reviews the relevant literature and develops the hypothesis based on the gaps identified in the literature review. This section also highlights the theoretical framework and conceptual underpinnings of the research. Section 3 provides a detailed description of the research methodology. Section 4 presents the main findings of this study, including any statistical analysis and visual representations of the findings. This section also discusses the implications of the results and their significance for the research question. Section 5 concludes the research by summarizing the key findings, highlighting any limitations of this study, and suggesting areas for future research.

## 2. Literature Review and Hypothesis

### 2.1. Carbon Disclosure

Carbon disclosure is a crucial component of the company's environmental approach since it indicates the company's role in climate change. Implementing an environmental policy that is preemptive frequently results in the accomplishment of maximum operational effectiveness and a decrease in the risks to both people and the environment [13]. Hahn et al. [14] evaluated research that looked at the results and consequences of carbon disclosures and came to the conclusion that these investigations tended to focus more on the empirical factors that determine the disclosures than on their consequences. The consequences of carbon disclosures therefore "constitute a significant need that has to be covered by future study". Given the current discussion throughout the literature about the financial effects of carbon disclosures, this claim seems especially interesting.

Depending on 2011–2018 CDP reporting and using a sampling of Fortune 500 businesses, Lu et al. [15] looked into the effect of carbon disclosure on financial achievement. Accordingly, carbon reporting cannot substantially enhance financial performance throughout carbon-intensive industry sectors in the current reporting period, while it can considerably enhance financial performance throughout carbon-non-intensive sectors. The favorable effect of carbon reporting on financial results in the current period could also continue into the following period. While Matsumura et al. [16] showed that voluntary disclosures might mitigate the adverse valuation effects of high carbon emissions, additional verification efforts are relevant to improving the credibility of claims. By contrasting a business's carbon pollution data with that of other similar businesses, the marketplace could determine whether the data on carbon pollution supplied by a business is reliable. The CDP surveys well-known corporations all over the globe, and in certain nations, such as European ones, pollutants are subject to government regulation. Organizations that freely reveal details may guarantee dependability by utilizing it as a standard reference in this situation because the authenticity of carbon pollution data is ensured and all these businesses are exposed to comparison with other businesses. It also transpires that those businesses have the choice to furnish the CDP with information on their carbon emissions and then determine if to reveal it. However, after a company has complied with the CDP's requirement and decided to reveal the information, it usually keeps revealing it [17]. The value of disclosing inaccurate or unreliable information would rise as more businesses comply with requests from the CDP. The marketplace could validate the authenticity and trustworthiness of information as investors' involvement in global warming grows and as the quantity of disclosing enterprises within the same sector grows. The business could lose confidence if the marketplace learns that it presented incorrect facts. In this scenario, there is an extremely strong likelihood that a corporation may be exposed to legal action. As a result, even with voluntary disclosure, great trustworthiness is assured.

Enterprise value is influenced by the amount of carbon information disclosed, and local and international experts have reached diverse results from various angles of research. Businesses with higher carbon inputs or notable carbon performance typically provide more carbon data. Because of this, businesses with greater levels of disclosure of carbon information prefer to take the lead in managing their carbon emissions and invest more money, technology, and other resources than businesses with lower levels of disclosure. This has an impact on how much resources firms spend on their operations and other areas, which somewhat lowers their short-term success [18]. In the immediate term, the effectiveness of disclosure of carbon information seems to have a substantial and significant effect on the quality of organizational entrepreneurship and a positive and significant influence on the conservation of corporate entrepreneurship. In comparison to state-owned businesses, advancements in non-state-owned businesses have a significant negative impact on the efficiency of accessing carbon-related information. The sustainability of development in growing organizations is significantly impacted positively by the strength of disclosure of carbon information, whereas it is significantly negatively impacted by the quality of advancement in maturing and deteriorating businesses [19].

It appears that effective managers promote the sharing of qualitative information to evaluate fundamental company values because there is a strong positive correlation between voluntary disclosure of carbon pollution details and creditworthiness in organizations controlled by skilled individuals [20]. Additionally, the cost of capital may rise even when the investor pays a large price to a non-disclosure company for knowledge of carbon dioxide emissions [21]. By proactively revealing information regarding carbon emissions standards, businesses might stimulate the interest of investors. In addition to improving investor sentiment for the shares of a company, it could also improve business liquidity [22]. In the end, it decreases the cost of capital, increasing the company's worth or credit rating. Whereas, the research findings of Baik et al. [23] emphatically highlight that better managerial skill increases the likelihood of profit forecasts, and greater managerial accuracy increases comprehension of the business perspective. Extending this would therefore enable qualified management to generate more precise and trustworthy carbon dioxide emissions data based on their comprehension of the business, providing more valuable data to investors in bond markets. Some believe that the failure of companies to adopt environmental practices may lead to potential exposure to a number of risks, including the threat of increased regulatory oversight by the government or international firms, as well as risks resulting from pollution and poor use of resources, which could affect the reputation of the organization [24,25].

The administration of threats that develop relevant and accurate disclosures about carbon dioxide emissions is becoming increasingly important to stakeholders [26]. The firm's response to environmental concerns, particularly with regard to the disclosure of carbon pollution, can be demonstrated by the disclosures as being concerned. If the information quality is poor and prevents an evaluation of the firm's genuine Carbon footprint plan and accomplishments, broad reporting may be restricted [26]. On the other hand, enhancing voluntary carbon disclosure lowers a firm's overall, recurring, and ad hoc threats. Additionally, carbon-intensive companies are primarily responsible for this unfavorable connection. Further analyses reveal that until the global financial crisis of 2007–2008, carbon disclosure was never a significant predictor of a company's risk [27].

The prevalence of spontaneous sharing of data about carbon emissions increases as the proportion of female managers increases. Even when the percentage of overall female employees was used to assess female employment, the same conclusions were reached. As a result, it can be concluded that having female employees in management and professional positions significantly enhances the quality of voluntary disclosure [28]. Considering 58 Australian enterprises in which the sale of carbon pollution rights is publicly available, Chapple et al.'s [29] investigation looked at how the market responded based on the amount of carbon dioxide emissions. As a consequence, a party with considerable levels of carbon emissions experiences a strong market response anytime an incident connected to the

installation of an emission trading system (ETS) takes place. Businesses that freely report carbon pollution data have market values that are much greater than those of businesses that do not, according to research by Matsumura et al. [16], who analyzed the two groups of firms. Combined, it could be claimed that data on carbon emissions and voluntary disclosure initiatives are favorably reflected in stock values by the market index.

The value of debt funding, the price of equity financing, the duties of government intervention and environmental policy, executive rewards, corporate carbon achievement, as well as the essence of property ownership, are all topics covered in the investigation of that capital investment in carbon disclosure. In particular, companies with poor carbon efficiency will see a considerable reduction in the firm's financing expenses as a result of their carbon disclosure information, but companies with higher carbon efficiency are unlikely to notice a meaningful difference [30,31]. Furthermore, the reporting of carbon records by non-state-owned businesses has a greater pronounced impact on lowering financing costs compared to that of government businesses [31,32]. To promote environmental sustainability and ensure the well-being of present and future generations, carbon emissions disclosure should encompass the disclosure of both the total amount of energy consumed and the measurement of the use of renewable energy. This disclosure will yield significant advantages for the health of ecological systems.

Profitability influences the adoption of Carbon Emission Disclosure (CED) in a beneficial way. Sobel test outcomes further demonstrate that CED can mitigate the impact of profitability on business value. Additionally, the data shows that CED ranking positively affects the value of a firm. This outcome indicates that investors think the firm's adoption of CED is a positive idea and that there has been a favorable market response [33]. It is evident that when a nation places increased policy and regulation pressure on businesses to decrease their carbon pollution, these businesses could interact by disclosing carbon data to demonstrate their adherence to the legislative perspective without actually altering their operations in order to preserve their productive viability, thus remaining unchanged in terms of their carbon achievement [34].

## 2.2. Firm Performance

According to the theory underpinning the resource-based view, a business's success is dependent on its main resources [6,35], which can include both tangible and intangible assets such as information and knowledge as well as procedures and operations [36]. Based on this notion, companies can gain a competitive edge by utilizing precious, unique, and non-replaceable resources to generate value and improve performance [6]. In accordance with the RBV principles, data volume could be viewed as an intangible resource of the business that could improve performance by allowing it to generate data meaning. The company can make concrete proof choices using a lot of data, which might result in revelations that are practical and affordable [37,38].

As mentioned by numerous studies, disclosing carbon dioxide emissions has a favorable and considerable impact on a company's achievements. There is proof that reporting carbon credits allows a corporation to escape the value penalties that financial markets levy depending on the volume of carbon pollution and the refusal to report carbon pollution statistics [39]. The promotion of company openness, reduction of asymmetric information, and facilitation of stronger economic decision-making under conditions of more confidence and trust, including both enterprises and investors, are all benefits of increased environmental reporting at an acceptable degree and quality [40].

The performance of businesses with limited financial resources can be enhanced by a modest investment in various post-production procedures [41]. Startups also have a strong correlation between their earnings and a company's performance because they are the biggest investors. Along with financial contributions, founders also put in a lot of "equity" in the form of labor and time. Additionally, founder CEOs' natural non-financial and financial self-interests strongly encourage them to oversee the performance of the company as a board of directors, which eventually improves a business's success [42].



Larger board sizes are highly beneficial in boosting a company's performance because they supply essential board capital that makes it possible to benefit from increased obsolete resources [43].

Big Data Analytics (BDA) integration and company performance have a strong correlation, which can help businesses improve their BDA implementation for improved performance [44]. The primary requirement for technological implementation, regardless of the size of the organization, is how to produce value and effects that might ultimately boost the firm's performance [45].

In order to seek economic growth, market rationality promotes managerial decisions that concentrate on economic and social goals, capacities, efficacy, and performance assessment [46,47]. Profitability has a significant influence on special equipment manufacturing companies' efficiency scores, whereas it has little effect on companies that make communications, computers, and other electronic devices [48]. Businesses increase performance by enhancing their current capabilities, expanding the lifetime of their goods, and establishing economic systems of size and scale [49].

Two performance-enhancing benefits are offered by specialization. Due to repetitions in the execution of tasks as well as the acquisition of experiences [50], knowledge, and skill in such fields, specialization increases the effectiveness with which businesses undertake the selected exploration or exploiting operations [51]. Secondly, specialization allows companies to carry out explorative or exploitative operations at a reduced marginal cost, improving business efficiency and performance [52].

The impact of firms' abilities to pass through carbon costs on the relationship between carbon emissions and financial performance within the European Union Emission Trading Scheme (EU ETS) indicates that good carbon emission performance does not always lead to financial benefits, but rather lower levels of carbon emissions are only rewarded if firms cannot pass on carbon costs to consumers due to industry characteristics or firm-specific carbon efficiency [53].

Previous studies conducted by Doh et al. [54] and Delmas et al. [55], among others, suggest that investors tend to devalue firms that are highly carbon-intensive. Additionally, there are also indirect regulatory costs that can influence the relationship between Environmental Performance (EP) and Corporate Financial Performance (CFP). Chapple et al. [29] contend that companies with good environmental performance can avoid significant financial risks arising from both direct and indirect costs, such as increased regulatory intervention, expenses for reducing pollution, and damage to reputation. In light of these findings and the increasing exposure of firms to climate change risks, this relationship is becoming more important.

A study by Wang and Gao [56] examines the relationship between greenhouse gas (GHG) emissions and the financial performance of 69 Australian public companies using multiple regression models. The findings suggest a positive correlation between GHG emissions and corporate financial performance. Specifically, the study found that firms with high carbon emissions tend to have lower profitability, lower market value, and lower returns on assets and equity. Moreover, Sariannidis et al. [57] found that there is a negative relationship between the financial performance of socially responsible firms and an increase in global CO<sub>2</sub> emissions. The study uses a GARCH model and suggests that the implementation costs of environmental policies and investors' attitudes towards such firms may explain this relationship. Finally, a study revealed that there is a significant negative impact of carbon emissions on firm performance [58].

The market penalizes companies for high carbon emissions because of climate risks and the possibility of not being able to comply with new regulations, which can affect the company's future earnings. Additionally, investors may believe that a company can achieve a competitive advantage by reducing carbon emissions [59,60]. The natural-resource-based view of the firm suggests that a company can achieve a competitive advantage when it uses environmentally sustainable practices that are valuable, rare, difficult to replicate and have no substitute [61]. Therefore, a company with high carbon emissions may not be perceived

as having environmentally sustainable practices, which could lower investors' expectations of the company's future earnings.

Due to the severe effects of climate change that pose a threat to human survival and businesses, carbon emissions disclosure has become an increasingly significant concern across many nations. In addition to this, companies are also expected to exhibit strong environmental performance, which reflects their genuine efforts to mitigate carbon emissions and uphold environmental sustainability [61]. Evaluating a company's environmental performance requires an external, independent party to conduct the assessment. Thus, the hypothesis has been built as follows:

**Hypothesis (H1):** *Carbon emissions exert a significant effect on the firm's financial performance.*

### 2.3. Management Environmental Training

There is a need for a framework to quantify the improvements resulting from environmental management systems to enhance companies' competitiveness and environmental responsibility; implementing an environmental management system strategy has an impact on a firm's financial performance. Among the factors affecting a firm's innovation and creativity performance is a dynamic and encouraging work environment [62]. Meanwhile, asymmetric information minimization strategies have been found to greatly benefit from environmental reporting [40]. The environmentalist notion of sustainability seems to be the preservation of economic, social, and ecological resources. Protecting our world's balance and environmental balance, including steadiness among utilization and regeneration, is the main goal of environmental sustainability [63].

The connection among both project leaders and recipients may deteriorate as a result of this type of scattered learning if the aspirations of the last are not adequately addressed, regardless of the environmental training prospects, as just a tactic to get people involved in initiatives and modify unsustainable activities [64].

Within the formal academic setting, whereby pupils and college students could be possible agents of transformation to help achieve environmental management initiatives, such as preservation activities, successfully [65]. Additionally, in order to ensure sustainability in the long run, subsequent generations of researchers, politicians, and individuals must have proposed a number of critical skills and knowledge to address the ever-urgent socio-ecological concerns [65,66].

Also, adaptive capability and environmental behavior impact corporate sustainability and financial performance. For example, Algarni et al. [67] found that both adaptive capability and environmental behavior have a positive and significant effect on corporate sustainability and financial performance. Additionally, the results show that corporate sustainability performance partially mediates the links between the two antecedent constructs and financial performance. In addition, it provides valuable insights for scholars and practitioners on the importance of employee training in adaptation, change management, and pro-environmental behavior. Moreover, Úbeda-García et al. [68] highlight the importance of employees' behavior in enhancing environmental performance and how human resource management is linked to it. Environmental training is a crucial factor in enhancing the maturity of environmental management in companies [69]. This can lead to improvements in the company's environmental performance, which can ultimately contribute to better overall firm performance and regulation compliance. Finally, Singh et al. [70] discovered that providing environmental training to employees plays a significant role in enhancing a firm's environmental performance and competitive advantage. Management environmental training can moderate the effect of carbon emissions on a company's financial performance. This implies that companies that provide training to their management on environmental issues can mitigate the negative impact of carbon emissions on their financial performance. Environmental training can have a positive effect on a company's financial performance by attracting more skilled employees. By providing

environmental training, a company can attract talented workers who prefer to work for companies that have a proactive environmental management approach [8].

Previous research has shown that carbon emissions can have a negative impact on a company's financial performance. However, management environmental training can potentially mitigate this negative impact by providing managers with the necessary knowledge and skills to implement environmentally friendly practices and reduce carbon emissions. Therefore, in other words, companies with higher levels of management environmental training may have better financial performance despite their carbon emissions compared to companies with lower levels of management environmental training. This leads to the second hypothesis:

**Hypothesis (H2):** *Management environmental training moderates the effect of Carbon emissions on the company's financial performance.*

### 3. Research Methodology

#### 3.1. Sample Selection and Data Collection

We investigate the role of Carbon disclosure in firm performance, while Management environmental training moderates the effect of Carbon emissions on the financial performance of companies from eleven European countries listed in the Reuters Eikon database. An initial sample contains 2181 firms with relevant observations. After screening the data for firms with missing environmental governance data, the final sample contained 1672 firms from 2016 to 2021. The sample was categorized based on the Industry Classification Benchmark into eleven industries named among different industries, including Real Estate, Consumer Discretionary, Financials, Basic Materials, Industrials, Energy, Consumer Staples, Health Care, Technology, Telecommunications, and Utilities.

These firms are publicly listed companies and are composed of different industries from eleven European countries, namely the United Kingdom, Sweden, Germany, France, Switzerland, Italy, Spain, Norway, Portugal, the Netherlands, Belgium, Denmark, Poland, Finland, and Greece. Moreover, companies from these countries were actively listed and rated accordingly in the Thomson Reuters ESG database. Data on the country's control variables, GDP, human development, and corruption index, were taken from the Global Financial Development, United Nations, and Transparency International databases published on the World Bank's website. The data for firm-level variables were collected from the Reuters Eikon database.

#### 3.2. Variable Recognition

Firms are under increasing pressure to declare their GHG due to growing environmental concerns. Although there are standards governing the disclosure of GHG, most companies are still not publishing carbon information in their annual reports. Management must decide whether to voluntarily provide this information while being aware of the associated costs. Businesses that voluntarily provide information run the risk of incurring exclusive or opportunity costs [71]. Based on earlier studies on environmental disclosure and governance, we chose economic variables [72,73]. We propose that embedded CO<sub>2</sub> disclosure is positively correlated with Return on Assets (ROA) (e.g., financial strength), analyst following, share price volatility, firm size, and institutional investors, but no prediction is given for Tobin's Q, which is named after economist James Tobin.

In order to meet the needs of stakeholders, companies with good market-based performance as assessed by Tobin's Q may release more non-financial information, such as carbon information. For instance, Tobin's Q and sustainability disclosure have a markedly favorable association, according to Lo and Sheu's [74] research. Nevertheless, a company has a greater chance of being investigated by market players and prompt disclosure the higher its Tobin's Q, such as market to book premium. We, therefore, refrain from predicting the direction of the relationship between Tobin's Q and the reporting of embedded CO<sub>2</sub>.



Last but not least, taking into account the literature on shareholder activity, we propose that the existence of an institutional investor will have a favorable influence on the choice to release carbon information [75]. Accordingly, we describe this study's variables as shown in Table 1.

**Table 1.** Variables and measurements.

Variable	Symbol	Measurement
Carbon emissions	CE	Is measured by the carbon emission intensity (GHG emissions to sales in thousands of US dollars at the end of the year). Natural logarithm of yearly emissions in metric tons of CO <sub>2</sub> eq.
Firm performance:		
Return on assets	ROA	The ratio of earnings before interest and taxes to total assets.
Earnings per share	EPS	a company's profit divided by the outstanding shares of its common stock.
Return on equity	ROE	The ratio of earnings before interest and taxes to equity.
Tobin's Q	TQ	(Market capitalization + Total liabilities + Preferred equity + Minority interest)/Total assets.
Environment Management Team	EMT	An indicator variable that equals 1 if a firm trains its employees on environmental matters and 0 otherwise.
Gross Domestic Product	GDP	Natural logarithm of gross domestic product.
Corruption Index	Corrupt	Corruption index of the country.
Human Development Index	HD	Value of the human development index of the country.
Size	Size	The natural logarithm of the total assets of the firm.
Leverage	Lev	Total debt to total assets (debt to equity ratio).
Audit Fees	AF	Natural logarithm of Audit fees.
Current ratio	CR	Liquidity is represented by the current ratio.
Board size	BS	Number of directors on the board.
Beta	Beta	The value of systematic risk in a firm.
Liquidity	LIQ	The current ratio of a firm
Weighted Average Cost of Capital	WACC	Cost of Equity $\times$ (Equity/Equity + Debt) + Cost of Debt $\times$ (Debt/Equity + Debt) + Cost of Preferred Equity Weighted $\times$ (Preferred Equity/Equity + Debt).
Country	Country	Country dummies.
Industry	Industry	Industry dummies.

## 4. Results

### 4.1. Descriptive Analysis

The descriptive statistics relating to key variables are reported in Table 2 based on the reported financial data from 2016 to 2021. The mean and median values for ROA are 0.043 and 0.144, respectively, which indicate an increase in the overall returns or profitability of the companies. The mean and standard deviation values for ROE are 0.131 and 0.653, respectively, which indicate an increase in the ratio of earnings before interest and taxes to

equity. For EPS, there are 1.915 and 3.078, which serve as indicators of a company's high profitability. For Tobin Q, the values are 2.816 and 4.418, which serve as an indicator of a company's more investments in intangible assets, as reflected by Tobin's Q, the more it requires financing from external financial resource providers. For CE, the values are 1.41 and 0.976, which serve as an indicator of GHG emissions to sales, which decreased and were positively correlated with EPS, which means high profitability. For EMT, the values are 0.55 and 0.498, which serves as an indicator variable that equals 1 if a firm trains its employees on environmental matters and 0 otherwise. In our investigation, there seems to be some training present. For GDP, there are 20.738 and 13.393, which serve as indicators of gross domestic product. For Corrupt, there are 75.145 and 12.843, which serve as indicators of the corruption index of the country, which decreased as a good signal for general performance. For HD, there are 0.925 and 0.028, which serve as the values of the human development index of the country. This result seems to be slightly low compared with the EMT indicator, which has led us to develop other human development sectors, not only the environmental one.

**Table 2.** Descriptive Statistics for Key Variables.

Variable	Obs.	Mean	Std. Dev.	Min	Max
ROA	9928	0.043	0.144	−1.177	3.368
ROE	8480	0.131	0.653	−0.833	6.051
EPS	9093	1.915	3.078	−0.750	8.10
TQ	9776	2.816	4.418	−3.519	8.131
CE	6549	1.41	0.976	−4.575	5.006
EMT	8352	0.55	0.498	0	1
GDP	10,014	20.738	13.393	1.02	49.04
Corrupt	10,014	75.145	12.843	28	90
HD	10,014	0.925	0.028	0.822	0.962
Size	9984	9.531	0.859	5.972	12.483
Lev	9984	0.246	0.202	−0.002	4.113
AF	8867	5.968	0.667	4.041	9.166
LIQ	8947	2.493	3.704	0.1955	27.807
BS	8867	11.189	3.581	6	21
WACC	9575	0.061	0.033	−0.179	0.491

For Size, there are 9.531 and 0.859, which serve as high indicators of the total assets of the firm. For Lev, the values are 0.246 and 0.202, which serve as indicators that companies have so far been able to control their debt-to-equity ratio. For AF, the values are 5.968 and 0.667, which serve as logical indicators of audit fees compared with other indicators and disclosure. For LIQ, the values are 2.493 and 3.704, which serve as an indicator of liquidity represented by the current ratio; here, it is considered a result compared with investment amounts. For BS, there are 11.189 and 3.581, which serve as indicators of the number of directors on the board and are positively correlated with disclosure. Finally, for WACC, the values are 0.061 and 0.033, which serve as good indicators of the weighted average cost of capital compared with TQ results. The matrix of correlations relating to key variables is reported in Table 3. The Variance Inflation Factor (VIF) values show that there is no issue with multicollinearity among the variables.

**Table 3.** Matrix of correlations.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	VIF
(1) ROA	1.000												1.194
(2) CE	−0.151	1.000											1.129
(3) EMT	−0.062	0.183	1.000										2.887
(4) GDP	0.017	−0.039	−0.096	1.000									1.227
(5) Corrupt	0.021	−0.189	−0.176	0.317	1.000								3.166
(6) HD	0.010	−0.166	−0.196	0.396	0.894	1.000							2.41
(7) Size	−0.115	0.235	0.308	−0.062	−0.166	−0.166	1.000						2.509
(8) Lev	−0.254	0.175	0.088	0.005	−0.139	−0.104	0.139	1.000	1.000				1.083
(9) AF	−0.120	0.139	0.267	−0.086	0.015	−0.005	0.728	0.075	1.000	1.000			2.312
(10) LIQ	0.066	−0.076	−0.064	−0.023	0.016	0.020	−0.070	−0.110	−0.108	1.000			1.03
(11) BS	−0.120	0.139	0.267	−0.086	0.015	−0.005	0.728	0.075	1.000	−0.108	1.000		1.185
(12) WACC	0.007	−0.003	−0.018	−0.029	0.093	0.069	−0.151	−0.140	−0.014	0.027	−0.014	1.000	1.127

#### 4.2. Regression

Table 4 presents the results for each year of analysis that relate to the components of Carbon emissions and firm performance. The R<sup>2</sup> values for the performance models are above 0.2, indicating that about 20% of the variation in the firm's performance is explained using the selected variables. Previous studies that explored carbon emissions have reported similar values (i.e., [76]). Additionally, the Hausman test is used to test the usage of the panel method (panel data) with fixed and random effects. After selecting the panel method by using fixed effects, the results of this test (a Chi-square test value of 22.048 with a *p*-value of 0.000) show that the fixed effects model is suitable to estimate the coefficients of the regression model.

Furthermore, we checked the effect of carbon emissions on the financial performance of the observed listed companies. For this purpose, we considered the firms' indicator results, which are provided in Table 4 and represented with "ROA; ROE; EPS; and TQ" as the dependent variables. The effects of carbon emission on financial performance are reported in Table 5, which is statistically significant, meaning that the effect of carbon emission led to an increase in profitability, thus validating our first hypothesis. This validates our H1 hypothesis, affirming the favorable effects of carbon emission disclosure on financial performance. This is in line with Lewandowski's [77] examination of the relationship between corporate carbon performance and financial performance using econometric techniques. The study differentiates between two measurement perspectives: annual CO<sub>2</sub> emissions and improvements in carbon performance over time. The results show that companies with superior carbon performance benefit financially, but those with inferior performance do not. The study also found that carbon emission mitigation is positively related to return on sales but negatively related to Tobin's *q*. Moreover, Desai et al. [78] examine the effect of carbon emissions on the financial performance of Indian companies by analyzing data reported by the Carbon Disclosure Project (CDP) from 2013 to 2019. The study finds a significant negative impact of carbon emissions on both accounting and market-based financial performance measures. Previous research studies [16,79] suggest that there is a negative association between carbon emissions and firm performance. High carbon emissions indicate climate risk, which may affect future earnings due to regulatory changes and non-compliance with new regulations, resulting in increased taxes and penalties for having high carbon emissions.

**Table 4.** The Effect of Carbon Emission on Firm Performance.

Variable	ROA	ROE	EPS	TQ
CE	−5.00 *** (−0.031)	−0.68 ** (−0.045)	−0.89 * (−2.189)	−0.836 ** (−0.47)
Size	0.26 ** (0.003)	0.01 *** (0.002)	1.51 ** (7.1)	1.067 *** (0.31)
Lev	−23.94 *** (−0.131)	−5.76 *** (−0.926)	−12.49 ** (−4.38)	−1.771 * (−0.47)
AF	−2.97 ** (−0.023)	−0.61 * (−0.052)	−0.41 * (−1.289)	−0.758 * (0.33)
LIQ	1.79 *** (0.001)	1.10 *** (0.016)	0.91 * (0.255)	0.098 ** (0.67)
BS	0.623 *** (4.710)	1.202 ** (0.847)	0.002 ** (2.436)	0.143 *** (1.094)
WACC	−2.08 ** (−0.093)	−0.46 * (−0.232)	−1.59 ** (−28.653)	4.304 (0.32)
GDP	0.08 (0.011)	0.87 (0.032)	1.14 (0.005)	−0.03 (−0.051)
Corrupt	2.89 (0.002)	1.01 (0.008)	−1.49 (−0.429)	−0.125 (−0.591)
HD	6.00 *** (1.82)	0.07 * (0.217)	1.83 * (25.54)	25.484 ** (0.28)
Constant	5.05 *** (1.501)	0.13 ** (0.422)	1.91 * (2.708)	2.344 ** (0.32)
Country	Included	Included	Included	Included
Sector	Included	Included	Included	Included
R-squared	0.217	0.192	0.141	0.1800
F-test	2.202	4.804	2.486	0.172
Number of obs.	5162	4843	5070	5155
Prob > F	0.000	0.000	0.000	0.000

Note: \*, \*\*, \*\*\* denote significance levels at 10 percent, 5 percent, and 1 percent, respectively. *t*-values are in parentheses.

#### 4.3. Additional Analysis of the Sub-Samples

GRI reporting encourages companies to identify and measure their resource consumption, waste generation, and greenhouse gas emissions. This process promotes a focus on resource efficiency, waste reduction, and the adoption of sustainable practices. By implementing measures to enhance operational efficiency, such as energy-saving initiatives or waste-reduction strategies, companies can reduce costs, improve productivity, and positively impact their bottom line. Hence, the association between carbon emissions and firm performance might be different between firms that adopt GRI and others. Table 5 is split into two groups for each financial metric: IFRS-adopting companies and non-IFRS-adopting companies. Adopting companies are those that have adopted IFRS (International Financial Reporting Standards) accounting standards, while non-adopting companies have not.

**Table 5.** The regression results of the carbon emission effect on firm performance—subsample based on GRI adoption.

Variables	ROA		ROE		EPS		TQ	
	Adopting	Non-Adopting	Adopting	Non-Adopting	Adopting	Non-Adopting	Adopting	Non-Adopting
CE	−0.023 *** (−4.235)	−0.066 *** (−0.774)	−0.029 ** (−0.522)	−4.615 * (−0.503)	−3.003 * (−1.167)	−1.74 * (−0.634)	−0.219 ** (−0.78)	−3.08 * (−0.781)
Size	0.005 ** (0.477)	0.347 * (1.289)	0.001 *** (0.005)	3.735 *** (1.502)	8.027 ** (1.535)	5.104 * (0.585)	0.584 ** (1.032)	6.597 *** (1.094)
Lev	−0.331 *** (−23.513)	−0.213 * (−2.116)	−0.723 *** (−4.771)	−4.086 * (−0.348)	−32.266 ** (−4.641)	−3.155 (−0.897)	−2.974 * (−4.082)	−2.676 (−0.513)
AF	0.012 (1.872)	−0.425 ** (−3.014)	−0.022 (−0.318)	−40.808 * (−2.676)	−2.277 (−0.719)	−7.735 * (−1.693)	−0.597 (−1.736)	−3.293 ** (−3.033)
LIQ	0.313 *** (0.110)	1.055 ** (0.617)	0.220 *** (0.481)	1.002 *** (3.610)	1.411 * (0.845)	3.357 * (1.985)	1.771 ** (0.191)	6.735 ** (0.931)
BS	0.401 *** (1.105)	0.359 ** (1.026)	1.977 ** (0.869)	6.751 * (2.693)	0.233 * (0.481)	0.955 ** (0.967)	0.980 *** (0.871)	1.087 *** (2.935)
WACC	−0.011 ** (−0.235)	−0.923 (−1.158)	−1.298 *** (−2.685)	−32.808 * (−0.381)	−0.221 ** (−0.015)	−13.11 * (−0.508)	−1.38 (−0.549)	−16.694 (−0.268)
GDP	0.029 (−0.841)	−0.002 (−3.26)	0.091 (1.066)	0.144 (2.379)	0.002 (0.411)	0.003 (0.167)	0.042 (−0.328)	−9.196 (−2.077)
Corrupt	−0.001 (−1.124)	−0.007 (−1.614)	0.006 (0.941)	1.175 * (2.413)	−0.233 (−0.773)	−0.155 (−1.063)	−0.301 (−0.31)	−1.924 (−3.258)
HD	1.455 *** (5.325)	0.478 (0.252)	0.709 * (0.261)	6.437 * (0.268)	20.973 ** (1.549)	34.948 * (0.451)	−14.768 ** (−1.038)	−4.993 * (−0.244)
Constant	1.097 *** (4.184)	0.867 (0.375)	0.527 (0.202)	19.513 (0.078)	17.285 * (1.737)	17.071 (0.228)	25.172* (1.846)	1.946 (0.795)
Country	Included	Included	Included	Included	Included	Included	Included	Included
Industry	Included	Included	Included	Included	Included	Included	Included	Included
R-squared	0.190	0.223	0.121	0.079	0.011	0.358	0.018	0.211
F-test	2.801	3.724	1.431	1.162	2.422	3.101	2.362	1.331
Observations	3579	1583	3467	1376	3542	1528	3577	1578
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .  $t$ -values are in parentheses.

The table shows the regression coefficients and  $t$ -values for each variable for both groups, as well as the R-squared, F-test, number of observations, and probability values for each financial metric. Overall, the table suggests that the adoption of IFRS standards does not have a significant impact on the financial metrics studied. However, the table does show several significant coefficients for other variables, such as size, leverage, liquidity, and business risk.

#### 4.4. Moderating Effect of EMT on CE and Firm Performance Association

The Hausman test is used to test the usage of the panel method (panel data) with fixed and random effects. After selecting the panel method by using fixed effects, the results of this test (a Chi-square test value of 22.048 with a  $p$ -value of 0.000) show that the fixed effects model is suitable to estimate the coefficients of the regression model for ROA. A similar result was found for all other models. Secondly, we checked the effect of management environmental training on the firm performance of the observed listed companies. Finally, we checked the moderating effect of management environmental training on carbon emissions. For this purpose, we considered the firms' indicator results, which are provided in Table 6, which represent the moderating effect of EMT on CE and firm performance associations. The regression results of the moderating effect of EMT are reported in Table 7, which is statistically significant, meaning that management environmental training significantly played a moderating role on carbon emissions, which led to an increase in profitability, thus validating both our second and third hypotheses. The results related to high-impact



businesses are provided in Table 6. Additionally, it is in line with previous literature; for example, employees can be motivated to participate in environmental initiatives by being made aware of the environmental impact of their work through environmental training [80]. This can lead to the achievement of an environmental action-based competitive advantage by the company [81]. Additionally, employees who receive environmental training may be a valuable source of innovative ideas to reduce carbon emissions [82]. This validates our H1 and H2 hypotheses, affirming that the favorable effects of the moderating role of management environmental training in carbon emission disclosure resulted in better financial performance.

**Table 6.** The Moderating Effect of EMT on CE and Firm Performance Association.

Variables	ROA	ROE	EPS	TQ
CE	−0.034 ** (−5.18)	−0.005 * (−0.06)	−2.552 (−0.92)	−0.038 * (−0.02)
EMT	0.001 ** (0.08)	0.083 *** (0.95)	0.709 ** (0.22)	1.775 ** (0.74)
CE*ETM	0.670 ** (0.04)	0.055 ** (1.14)	0.175 ** (0.42)	0.555 ** (0.42)
Size	0.012 ** (0.17)	0.007 *** (0.05)	8.075 ** (1.69)	1.192 ** (0.34)
Lev	−0.305 *** (−23.98)	−0.941 *** (−5.78)	−6.035 *** (−2.70)	−1.832 * (−0.48)
AF	−0.023 *** (−2.97)	−0.053 (−0.62)	−1.297 * (−0.41)	−0.737 ** (−0.32)
LIQ	0.001 * (1.77)	0.016 * (1.08)	0.264 * (0.94)	0.201 * (0.68)
BS	2.601 * (1.81)	0.202 *** (1.19)	2.154 *** (0.41)	1.161 *** (3.67)
WACC	0.115 ** (2.55)	−0.312 (−0.61)	25.913 (1.42)	7.28 (0.54)
GDP	0.786 (−0.10)	0.490 (0.85)	0.005 (1.15)	0.231 (−0.01)
Corrupt	0.002 (3.19)	0.007 (0.93)	0.417 (1.44)	0.113 (0.53)
HD	1.716 *** (5.67)	0.028 (0.01)	2.901 * (1.81)	35.719 (0.39)
Constant	1.425 *** (4.79)	0.171 ** (2.812)	2.397 *** (1.96)	3.154 *** (0.41)
Country	Included	Included	Included	Included
Industry	Included	Included	Included	Included
R-squared	0.161	0.112	0.143	0.201
F-test	6.438	4.052	15.605	0.199
Number of obs.	5131	4813	5039	5124
Prob > F	0.000	0.000	0.000	0.000

Note: \*, \*\*, \*\*\* denote significance levels at 10 percent, 5 percent, and 1 percent, respectively. *t*-values are in parentheses.

**Table 7.** The regression results of the moderating effect of EMT—subsample based on GRI adoption.

Variables	ROA		ROE		EPS		TQ	
	Adopting	Non-Adopting	Adopting	Non-Adopting	Adopting	Non-adopting	Adopting	Non-Adopting
CE	−0.015 ** (−2.414)	−0.083 ** (−0.764)	−0.016 *** (−0.259)	−0.271 * (−0.028)	−3.447 ** (−1.158)	−3.376 * (−1.255)	−0.003 ** (−0.008)	−1.741 ** (−0.261)
EMT	0.011 ** (1.603)	102 * (0.444)	0.003 *** (0.038)	2.727 ** (1.451)	0.905 * (0.286)	2.994 ** (1.75)	0.884 ** (2.566)	2.038 * (1.33)
CE × EMT	0.009 *** (2.546)	0.139 * (0.45)	0.014 *** (0.364)	4.339 ** (1.467)	0.649 *** (0.372)	3.497 * (1.76)	0.214 ** (1.132)	2.121 * (1.322)
Size	0.007 ** (0.631)	0.385 *** (1.155)	0.005 *** (0.04)	2.729 * (1.099)	0.592 ** (1.612)	2.818 ** (1.062)	0.572 ** (0.989)	1.927 ** (0.693)
Lev	−0.337 *** (−23.579)	−0.286 (−1.568)	−0.741 *** (−4.784)	−12.197 (−0.748)	−3.264 *** (−4.685)	−8.545 (−1.879)	2.907 *** (3.924)	−1.383 (−1.224)
AF	−0.012 * (−1.82)	−0.47 * (−2.39)	−0.02 (−0.296)	−27.75 (−1.58)	−2.224 (−0.693)	−12.13 * (−2.476)	−0.642 * (−1.847)	−2.637 (−1.866)
LIQ	0.412 ** (0.417)	0.505 *** (0.118)	0.191 *** (2.937)	1.492 ** (0.534)	0.207 *** (0.05)	0.464 * (0.438)	0.337 ** (1.237)	0.516 * (2.718)
BS	0.015 ** (0.154)	0.225 *** (0.185)	0.510 *** (2.733)	1.132 ** (0.241)	0.009 *** (0.521)	0.164 * (0.158)	0.367 ** (3.337)	0.022 * (4.78)
WACC	0.008 * (0.166)	0.824 (0.842)	−1.328 (−2.716)	−61.703 (−0.706)	0.132 (1.155)	3.448 (0.142)	1.123 (0.442)	3.871 (0.553)
GDP	1.620 (−0.847)	−0.002 * (−2.436)	2.112 (1.094)	0.107 (1.49)	0.002 (0.418)	−0.01 (−0.502)	0.044 (−0.463)	−6.255 (−1.157)
Corrupt	−0.001 (−1.115)	−0.01 (−1.277)	0.006 (0.943)	0.497 (0.739)	−0.223 (−0.726)	−0.38 (−2.029)	−0.006 (−0.173)	−1.071 (−1.401)
HD	1.451 *** (5.284)	−0.448 (−0.156)	0.668 (0.244)	7.597 (0.303)	2.315 * (1.551)	7.379 (0.523)	−4.617 (−1.02)	−4.456 (−0.256)
Country	Included	Included	Included	Included	Included	Included	Included	Included
Industry	Included	Included	Included	Included	Included	Included	Included	Included
Constant	−1.12 *** (−4.228)	0.959 (0.346)	−0.555 (−0.21)	7.436 (0.03)	−22.357 * (−1.774)	−7.954 (−0.115)	4.182 * (1.752)	12.811 (0.675)
Observations	3552	1579	3441	1372	3515	1524	3550	1574
R-squared	0.195	0.927	0.013	0.863	0.011	0.751	0.011	0.869

Note: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .  $t$ -values are in parentheses.

#### 4.5. Subsample Analysis

This table shows the regression results for several variables, including return on assets (ROA), return on equity (ROE), earnings per share (EPS), and total quality (TQ). The table compares the results for firms that adopted and did not adopt continuous improvement practices. The asterisks indicate the level of statistical significance (\* = 10%, \*\* = 5%, \*\*\* = 1%). Overall, the results indicate that the independent variables have varying effects on the dependent variables. For example, CE has a negative effect on ROA and ROE for adopting firms but not for non-adopting firms. EMT has a positive effect on ROA and ROE for adopting firms but not for non-adopting firms. LIQ has a positive effect on ROA and ROE for both adopting and non-adopting firms.

## 5. Conclusions

Carbon emissions have become an increasingly important topic in recent years, with policymakers and companies recognizing the potential dangers of climate change. The reduction of carbon emissions is crucial to mitigating the most severe impacts of climate change. Management and environmental training have become crucial aspects of addressing climate change issues at the local, national, and international levels. The Resource-Based View (RBV) theory emphasizes the role of internal resources and capabilities in creating and sustaining competitive advantage, and management environmental training can be seen as a valuable resource that can enhance a firm's ability to manage its carbon emissions effectively. Investing in environmental management training can enable firms to adopt

environmentally friendly practices, reducing their carbon emissions and thereby improving their financial performance. This study adds to the literature by highlighting the importance of investing in environmental management training as a means of improving firm performance and demonstrating how environmental management training can act as a valuable resource that enables firms to manage their carbon emissions effectively.

The analysis, which was conducted using fixed effects panel data methodology, found a statistically significant positive impact of carbon emission disclosure on the financial performance of firms. This study's results support the hypothesis that carbon emission disclosure positively affects the profitability of firms. This study identifies several channels through which carbon emissions could impact a company's financial performance, including regulatory risks, reputational risks, operational risks, physical risks, and opportunities. Moreover, the results indicated that the fixed effects model was suitable for the analysis, and further analysis showed that management environmental training significantly moderated the relationship between carbon emission and firm performance, validating both the second and third hypotheses.

Carbon emissions disclosure is considered one of the most competent topics recently related to sustainability and global warming, but management environmental training's moderating role in carbon emission disclosure resulted in better firm performance, which means that management environmental training would play a vital role in addressing such disclosure issues and would be prepared to formulate better measurements to tackle their effects. We encourage countries to introduce domestic laws to protect the climate and to develop company laws to help create legal provisions that require companies to conduct environmental governance and environmental training.

This study provides valuable recommendations for companies to enhance their performance and address environmental challenges. Companies should adopt transparent reporting practices for carbon emissions, invest in employee training on environmental issues, formulate actionable plans to reduce emissions and mitigate risks, comply with environmental regulations, identify opportunities for innovation in sustainable products/services, engage stakeholders for effective environmental management, and advocate for supportive policies and regulations. By implementing these measures, companies can improve their environmental performance, financial results, brand image, and competitive advantage while contributing to global sustainability goals.

While this study offers valuable insights, there are certain limitations to consider. Future research could explore alternative methodologies to validate the findings. Additionally, this study focuses on the relationship between carbon emission disclosure and financial performance, but it does not account for other potential variables that may influence this relationship. Including additional control variables or conducting further subgroup analysis could provide a more comprehensive understanding. Moreover, this study primarily examines the role of management environmental training in moderating the relationship between carbon emissions and firm performance. Exploring other factors such as organizational culture, leadership, and industry-specific characteristics could provide a more nuanced understanding of the complex dynamics at play. Lastly, this study's findings are based on a specific context and time period, and the generalizability of the results to different industries or regions may vary. Further research could explore diverse contexts and longitudinal data to validate and expand upon these findings.

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