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Article

Decarbonizing India's Economy: The Role of Carbon Pricing in Reducing Carbon Intensity

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Abstract: This study aims to investigate the relationship between carbon pricing mechanisms and carbon intensity among India's top 100 publicly listed companies, as reported by the Carbon Disclosure Project (CDP). It specifically investigates how internal carbon pricing, science-based targets (SBTs), corporate social responsibility (CSR), and research and development (R&D) investment influence carbon disclosure practices and environmental transparency. A total of 253 firm-year observations from 2015 to 2021 were collected from CDP reports, OSIRIS financial database, annual reports, and India's National CSR Portal. The study applies multiple linear regression analysis to assess the influence of the identified variables on carbon intensity, measured as total CO_2 emissions (Scope 1, 2, and 3) per unit of sales. Content analysis was employed to validate disclosure attributes aligned with stakeholder and legitimacy theories. The regression results show a significant negative relationship between R&D and carbon intensity, highlighting the potential of innovation in reducing emissions. Science-based targets and CSR investments, however, show a significant positive association with carbon intensity, suggesting that high-emission firms are more likely to adopt visible sustainability initiatives. Internal carbon pricing was found to have no statistically significant influence on emission intensity. The findings provide actionable insights for Indian regulators and global policymakers. Emphasis should be placed on incentivizing science-based targets and R&D-driven decarbonization strategies while making internal carbon pricing mechanisms more effective. Investors can play a crucial role by demanding transparency, while firms must enhance their sustainability reporting frameworks to overcome barriers to disclosure and strengthen stakeholder trust. This study contributes to the accounting and environmental disclosure literature by being the first of its kind to empirically analyze the effect of internal carbon pricing and SBTs on carbon intensity in the Indian context. It offers timely, evidence-based insights relevant to achieving Sustainable Development Goal 13 (Climate Action) and supports global efforts in transitioning toward low-carbon economies.

Keywords: Carbon Pricing; Carbon Intensity; Carbon Disclosure; Carbon Mitigation; Corporate Transparency; Climate Change Policy; Corporate Social Responsibility (CSR); Carbon Disclosure Project (CDP); Sustainable Business Practices

1. Introduction

Amid the mounting urgency of climate change, government agencies have been scrutinizing carbon pollution from high-emission industries, including mining, energy, heavy manufacturing, and transportation. International bodies, such as the IEA, the World Resources Institute (WRI), the US Environmental Protection Agency (EPA), and the Carbon Disclosure Project (CDP), have

introduced a range of baselines to encourage organisations to be transparent about their emissions. As India moves towards becoming one of the world's largest economies and energy consumers, the country faces the dual challenge of continuing to grow its economy while also fulfilling its environmental obligations. Carbon pricing instruments, including carbon taxes, internal carbon pricing (ICP), and cap-and-trade systems, are gaining more attention. There is still fear that the (underestimated) price of carbon might make economic activity weak or cause "leakage" of carbon, explained by reference to firms who move to jurisdictions with weaker regulations [1]. Industrial sectors are particularly exposed due to high energy intensity and limited ability to pass costs through. Recent research calls these generalisations into question, suggesting that it is poor design—rather than pricing in isolation—that hamstrings effectiveness [2, 3]. In reality, and despite exceptions, the pricing of emissions through fossil fuel taxes and indirect charges has contributed to increasing the cost of emissions [4].

Against this international backdrop, the evidence on the effectiveness of carbon pricing and disclosure in India is limited. We aim to address this gap in the literature by analysing the top 100 Indian firms using the CDP framework over the period 2015–2021. It examines whether ICP, SBTs, and CSR are linked to carbon intensity and transparency in disclosure. Data were obtained from CDP, OSIRIS, and the National CSR Portal. EI was associated with firm-specific variables, including total assets, R&D intensity, financial slack, and leverage.

The primary goal is to determine how market-driven instruments (ICP), governance-driven instruments (SBT and CSR) influence emissions intensity and climate transparency. The contribution goes on to investigate the role of organisational capacity (e.g., financial and R&D resources) on carbon performance.

To the best of our knowledge, this is the first empirical study in India to compare carbon pricing instruments using firm-level panel data. Unlike previous theoretical or developed-market studies, this work utilises empirical, self-reported Indian data, making it of particular interest to practitioners operating in emerging markets with characteristics similar to those in India, particularly in terms of the environment and regulatory landscape.

The results have practical relevance for policymakers, regulators, and corporate managers. Regulators can utilise this evidence to develop sector-specific carbon price policies that achieve their objectives with a minimum of gaming. Companies are increasingly aware of the benefits of incorporating carbon pricing, SBTs, and CSR into their long-term climate strategies, not only to comply with the growing number of regulators worldwide, but also to maintain trust and attract investors. The paper also highlights SBTs as a governance tool to enhance accountability and transparency.

This study contributes to SDG 13 (Climate Action) by demonstrating how Indian firms can reconcile financial and environmental objectives. It is also consistent with SDG 12 (Responsible Consumption and Production), as these disclosure forms will be assessed. From an accounting maturity perspective, it advances ESG research by associating accounting measures, such as leverage, R&D, and slack resources, with sustainability results.

Ultimately, our findings provide empirical evidence on the market-driven mechanisms of corporate sustainability. It highlights the role of carbon disclosure, financial capability, and governance mechanisms in shaping environmental accountability in India—and, in turn, in other emerging economies.

2. Literature Review and Hypothesis Development

Carbon pricing has long served as a key policy lever to combat climate change. This method is designed to internalize the external costs of GHG emissions, particularly CO2, by placing a monetary value on carbon emissions. The theoretical framework of this study (Figure 1) are based on a single model.

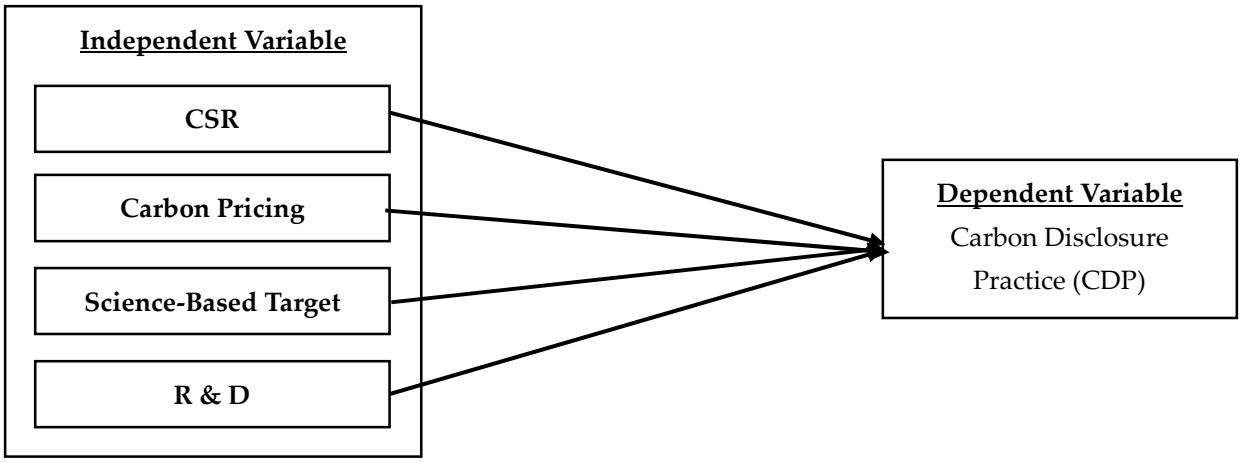

Figure 1. Research Framework.

2.1. Theoretical Framework

2.1.1. Stakeholder Theory

Stakeholder theory stresses that companies have duties to more than just their shareholders. It underscores how the consequences of corporate actions extend in every direction and how global corporate citizenship is intertwined with the individuals and groups — customers, employees, regulators, and the general public — whose lives are affected by what companies do. Carbon disclosure, therefore, is also based on a perspective of reciprocity. They want information about us, and we will give it to them from this perspective, says the expert. It builds trust and accountability when businesses provide transparent, easily accessible data on their carbon emissions. Not only does this practice meet regulatory requirements, but it also enhances reputation and engagement with stakeholders, since corporate aspirations are aligned with environmental and social issues.

2.1.2. Legitimacy Theory

According to legitimacy theory, organizations are considered to operate within a social contract, to which they are obliged to conform their actions to prevailing societal norms to remain legitimate. There is an increasing public focus on environmental accountability, and companies are now being pressured to demonstrate their commitment to sustainability. Reporting carbon emissions allows companies to demonstrate a commitment to societal values and environmental standards. This kind of transparency lends legitimacy to this trust in the eyes of their stakeholders, demonstrating that they are making strides to reduce environmental impact and enable sustainable development goals.

It is essential to note that, in explaining the extent of environmental disclosure behaviour, this study considers the relevance of stakeholder theory and legitimacy theory; however, these are not viewed as the total or sole theories. On the contrary, we acknowledge that they are among various non-market institutional pressures that also influence firm choices. Corporate actors may also engage

in climate disclosure and carbon reduction not only to satisfy stakeholder demands and acquire legitimacy, but also to manage reputational risks, avoid violating industry norms, anticipate regulatory changes, and develop long-term strategic resilience [4, 5]. This framing is consistent with theory in institutional and organisational behaviour, which posits that firms respond to changing societal expectations and external pressure by incorporating environmental considerations into their organisational rationality, where such considerations were previously absent, and where they do not provide an immediate link to profit maximisation.

Moreover, in the Indian scenario, where regulatory actions are not streamlined and disclosure is mainly voluntary, such motivations are more understandable. Hence, our empirical model seeks not only to test the financial correlates of emission intensity but also to chart how symbolic or anticipatory forms of compliance (e.g., signing up to SBTs, setting internal carbon prices) may instantiate deeper institutional adaptations.

2.1.3. Carbon Pricing Mechanism in the Krugman Model

Carbon pricing is an increasingly recognized policy instrument for reducing greenhouse gas emissions. Since the Paris Agreement, the movement has gained momentum at both the governmental and corporate levels for the implementation of carbon pricing to spur emission reductions [6]. The World Bank's initiative "Put a Price on Carbon", also noted by corporations such as Shell, Total, and ExxonMobil, indicates a movement toward internalising the environmental value of carbon [7]. Numerous carbon pricing policies have been enacted in more than 40 countries and some subnational regions, backed by global coalitions, including the Carbon Pricing Leadership Coalition [8]. These policies cover approximately 13% of worldwide emissions [9, 10]. Supporting the idea of carbon pricing as a relatively least cost-effective way to achieve emission reduction [11, 12, 13]. Carbon taxes, cap-and-trade, and hybrids between them each realise a different aspect of these flexibilities and efficiencies, aligning corporate behaviour with environmental objectives.

2.1.4. Carbon pricing and carbon intensity

Carbon pricing lowers total emissions as well as carbon intensity—emissions per unit of economic output. Indeed, prior literature has shown that carbon pricing mechanisms are most effective in emission-intensive sectors where innovation and efficiency potential are high [14, 15]. Firms that use carbon pricing mechanisms often experience favorable innovation spillovers. In addition, organizations that adopt transparent approaches to carbon disclosure, environmental reporting, and stakeholder-oriented strategies are more likely to respond to regulatory and societal pressures [15, 16, 17, 18]. Studies also argue that these sustainable companies receive advantages in terms of financial and borrowing costs and obtain support from stakeholders [19, 20]. The requirement for companies to disclose their environmental performance (including carbon intensity) is not merely a matter of compliance; it represents a competitive strategy that can enhance both their market reputation and their risk management [20, 21]. Financial stakeholders are now more likely to consider climate-related transparency a marker of positive financial performance [22, 23, 24]. Therefore, the proactive disclosure of carbon performance is consistent with both stakeholder theory and legitimacy theory.

2.2. Hypotheses Development

2.2.1. Internal Carbon Pricing and Carbon Intensity

Internal carbon pricing assigns a dollar value to greenhouse gas emissions generated by a company's operations. This move aligns with the increasing pressure from stakeholders for more robust climate action, enabling corporations to consider environmental externalities in business decision-making [25, 26]. Such pricing mechanisms have a disproportionate impact on carbon intensity, measured as emissions per unit of output. Internal carbon pricing promotes operational efficiencies rather than slackness and encourages investment in low-carbon innovation. While some debate on competitiveness remains, research also indicates that well-designed pricing schemes tailored to regional regulatory and market conditions can significantly reduce carbon intensity [27, 28, 29]. Hence, carbon pricing is not only a financial instrument but also a governance tool that accelerates such transformation towards sustainability.

***H1**: There is a significant association between internal carbon pricing and carbon intensity.*

2.2.2. Science-based Targets and Carbon Intensity

Science-based targets (SBTs) align companies' emissions reduction targets with the higher-level goals of the Paris Agreement to limit global warming to less than 2°C. Adherence to SBTs requires firms to agree on scientifically justified reductions in emissions, thereby promoting credibility and climate accountability [30]. SBTs can help manage carbon intensity or emissions per unit of economic activity. Firms that set these targets signal their commitment to being a good steward of the environment, improve their public image, and respond to increased stakeholder demands for sustainability [31, 32, 33]. Transparency in reporting enhances brand value and fosters stakeholder trust, a point that also holds in the Indian context [34]. So, adopting science-based targets means generating fewer tons of carbon per unit of revenue.

***H2:** There is a significant association between science-based targets and carbon intensity.*

2.2.3. R&D and carbon intensity

Environmental innovations are crucial in reducing carbon intensity and promoting sustainability. Prior studies suggest that investing in green R&D not only improves environmental performance but also provides a competitive advantage to firms [35, 36, 37, 38]. Such investments enhance resource efficiency, reduce operating costs, and meet the demands of environmentally conscious stakeholders [39]. Again, a negative association between R&D and CI means that innovation is a major driver of emissions reductions. Investing in eco-innovation and supporting climate-related initiatives will enhance the firm's long-term economic health.

***H3:** There is a significant association between research and development and carbon intensity.*

2.2.4. Corporate Social Responsibility & Carbon Intensity

Whether CSR initiatives are undertaken with an environmental focus that is strategically aligned, they will have an impact (positive or negative) on the carbon performance of the firm. Our regression results for the relationship between CSR and low-carbon performance, therefore, provide strong evidence that firms integrating CSR are investing resources in low-carbon projects, increasing reporting on sustainable practices, and setting a carbon disclosure standard. These initiatives are important for environmental and financial performance in the long run [40, 41, 42, 43]. Environmental firms received better financing and were the lowest risk for lenders. Such transparency and active

environmental management practices will improve stakeholder relations and public confidence [44]. Thus, CSR is essential in defining levels of carbon intensity and achieving sustainable business results.

H4: *There is a significant association between corporate social responsibility (CSR) and carbon intensity.*

3. Research Methodology

3.1. Sample Selection and Reasoning

This study is based on an empirical analysis of the top 100 Indian companies listed on the Bombay Stock Exchange (BSE), which includes firms from both the manufacturing and non-manufacturing sectors. These firms must comply with regulatory benchmarks mandated by publicly listed companies, such as those related to financial openness, sustainability, disclosures, and overarching corporate governance. The reason India was chosen as the focus country is that its economy is rapidly growing, and it is a significant contributor to global greenhouse gas emissions, amid mounting global pressure for increased climate transparency and responsibility. As a signatory country to the Paris Agreement, India provides a case study on how carbon pricing and disclosure frameworks are being incorporated into the corporate architecture of an emerging economy.

3.2. The Sources and Timeframe of the Data

The data used in this study were sourced from secondary sources, including the Carbon Disclosure Project (CDP) India Climate Report, the OSIRIS Global Financial Database, Official Company Annual Reports, and the National CSR Portal of India. The chosen interval of study spans from FY 2015 to 2021. While a period of five years may seem short, this duration was chosen due to data availability limitations, particularly for voluntary carbon disclosure and internal carbon pricing practices among Indian corporations. The CDP database began taking off in India only after 2015, resulting in earlier data being patchy and inconsistent. Hence, the period from 2015 to 2021 is the most reliable and comprehensive period for conducting a longitudinal analysis of carbon disclosure trends and their financial implications in India. Starting with 300 firm-year observations, only 253 were suitable for regression analysis due to the completeness of the data and consistency across the selected indicators. These firm-year observations (253) are sufficient for robust multiple linear regression analysis.

Although we would be interested in something more akin to reducing carbon intensity over the year in the ideal world as a measure of progress at the firm level, our dataset was unbalanced across years for many firms we examined, and as such, using a difference-based (Δ carbon intensity) measure would be infeasible. Additionally, comparisons over time would be hindered by adjustments in firm-level revenue and market scope. However, we suggest that future longitudinal analyses at finer time scales should be warranted to examine the trajectory of emissions reductions.

3.3. Analytic Approach and Credibility Measures

Content analysis is employed as the primary analytical technique to evaluate carbon disclosure, the presence of internal carbon pricing, corporate social responsibility (CSR) initiatives, and science-based target commitments. For example, content analysis is exceptionally well-suited to assess the quality of non-financial disclosure, and specifically, environmental disclosure (as part of corporate reporting more broadly). To improve the reliability of the results, measures were implemented to

minimize inter-coder bias. Data were coded and classified by two independent coders, and discrepancies were resolved through a consensus process. Data triangulation, incorporating content from multiple sources (CDP, OSIRIS, and annual report/CSR portal), was conducted to mitigate bias in our analysis, ensuring consistency in the application of variables for the model. To ensure that data inconsistencies or outliers did not distort the regression outputs, each firm included in the analysis was carefully screened and verified.

The study is comprehensive, featuring a robust empirical specification, credible data sources, and methodologically sound content analysis techniques, which track the impact of carbon-related strategies and governance indicators on carbon intensity in leading Indian firms during a critical juncture in climate accountability.

3.4. Variable Measurement

3.4.1. Dependent Variables

Carbon Emission Intensity (CO2): Carbon emissions were assessed by the Carbon Disclosure Project's (CDP) Scopes 1, 2, and 3. These include Scope 1 (direct emissions), Scope 2 (indirect emissions from the use of purchased energy), and Scope 3 (indirect emissions from other sources).

SCOPE 1: Total direct carbon emissions in tons.

SCOPE 2: Total indirect carbon emissions in tons, such as from purchased goods and services.

SCOPE 3: Total indirect carbon emissions in tons, including transportation, business travel, and employee commuting.

Carbon intensity is quantified as Scope 1 and 2 emissions (t CO_2 equivalent) divided by total revenue (million INR) from annual financial statements. Revenue was employed as a proxy for output, as production at the unit level was not uniformly collected across the firms. The carbon intensity variable thus indicates emissions per unit of monetized output. The Scope 3 emissions were excluded from the analysis due to a severe lack of data availability and variability in the reported data.

3.4.2. Independent Variables

- **Internal Carbon Pricing:** This variable quantifies the financial or accounting mechanism used by organizations to assess the impact of carbon emissions on their operations. Data on internal carbon pricing was collected from CDP India Climate reports spanning from 2015 to 2021.
- **Science-Based Target (SBT):** SBTs signify a company's commitment to combating climate change by aligning its emission reduction goals with scientific benchmarks.
- **Research and Development (R&D):** R&D investment reflects a company's innovation efforts, which may contribute to reducing carbon intensity.
- **Corporate Social Responsibility (CSR):** CSR investment was included to assess the extent to which companies integrate social and environmental concerns into their operations.

3.4.3. Control Variables

- **Total Asset (TA):** Reflects the total value of assets, indicating potential transparency levels. Data collected from the Osiris Global Financial database in USD thousand

- **Market Capitalization (MC):** Represents the logarithm of total market capitalization, indicative of responsibility and transparency. Market capitalization was also collected in USD from the Osiris Global Financial database.
- **Shareholders' Fund**: Indicates equity, reflecting financial stability and transparency.
- **Financial Slack (FinS**): Represents Cash or equivalent divided by assets, indicating financial stability and transparency.
- **Human Resource Slack (HRS**): Represents the logarithm of total employees, indicative of legitimacy and transparency.
- **Return on Assets (ROA):** This metric reflects profitability, with higher values indicating greater profitability and transparency. The return on assets was calculated by dividing profit after tax by total assets. A prior study shows that profitable firms tend to offer higher levels of disclosure and transparency.
- **Leverage (Lev)**: This represents total debt divided by total assets, suggesting higher levels of disclosure for firms with high leverage. Leverage was calculated using the ratio of total debt divided by total assets. High-leverage firms provide greater levels of disclosure to show transparency and accountability.

3.5. Operationalization of Variables and Model Specification

Table 1. Operationalization of Variables.

Variable Type	Variable Name	Acronym	Operationalization	Source of Data
Dependent	Carbon Emission	Total CO2 (S1+S2+S3)/Sales	Total CO2 emissions (Scope1+Scope2+Scope3) under the consideration of the Carbon Disclosure Project (CDP).	CDP reports and Annual reports
Independent	Internal Carbon Pricing	ICP	Internal Carbon Pricing is either 1 or 0	CDP reports
	Science-Based Target	SBT	Science-Based Target either 1 or 0	CDP reports
	Research & Development	R&D	Total amount of R&D investment collected from the Osiris Database	OSIRIS Database
	Carbon Price Dollar	CPD	The total amount of the Internal carbon price in USD collected from the CDP report.	OSIRIS Database
	CSR	CSR	Total amount of CSR investment. Data collected from the National CSR Portal India.	National CSR portal
Control	Total Asset	TA	Total amount of Assets, both fixed and current.	OSIRIS Database
	Market Capital	MC	Log of total market capitalization	OSIRIS Database
	Financial Slack	FinS	Total Cash or equivalent divided by Assets	OSIRIS Database

	Human Resource Slack	HRS	Log of total employees	Annual Report
	Return on Assets	ROA	Profit after tax divided by the total assets.	OSIRIS Database
	Leverage	LEV	Total debt is divided by total assets.	OSIRIS Database

3.6. Data Analysis Technique

To determine how internal carbon prices, science-based goals, R&D, and corporate social responsibility (as independent factors) affect carbon intensity (the dependent variable), we conducted a multiple regression analysis. This has been useful for identifying key factors that predict the level of carbon intensity and for assessing the impact of these factors. In light of the study's aims and assumptions, the statistical analyses' findings have been analyzed. The strength of the evidence supporting or opposing the hypotheses is determined using the significance levels, such as p-values. The results were evaluated for their practical significance by examining confidence intervals and effect sizes. To do all statistical analyses, we used STATA Software. To improve inference validity, we subsequently conduct robustness tests, including lagged models, alternative dependent variables, outlier exclusion, and diagnostics (heteroskedasticity and multicollinearity). These steps aim to mitigate reverse causality, multicollinearity, and model sensitivity issues.

4. Results

4.1. Average Carbon Intensity of Sampled Firms

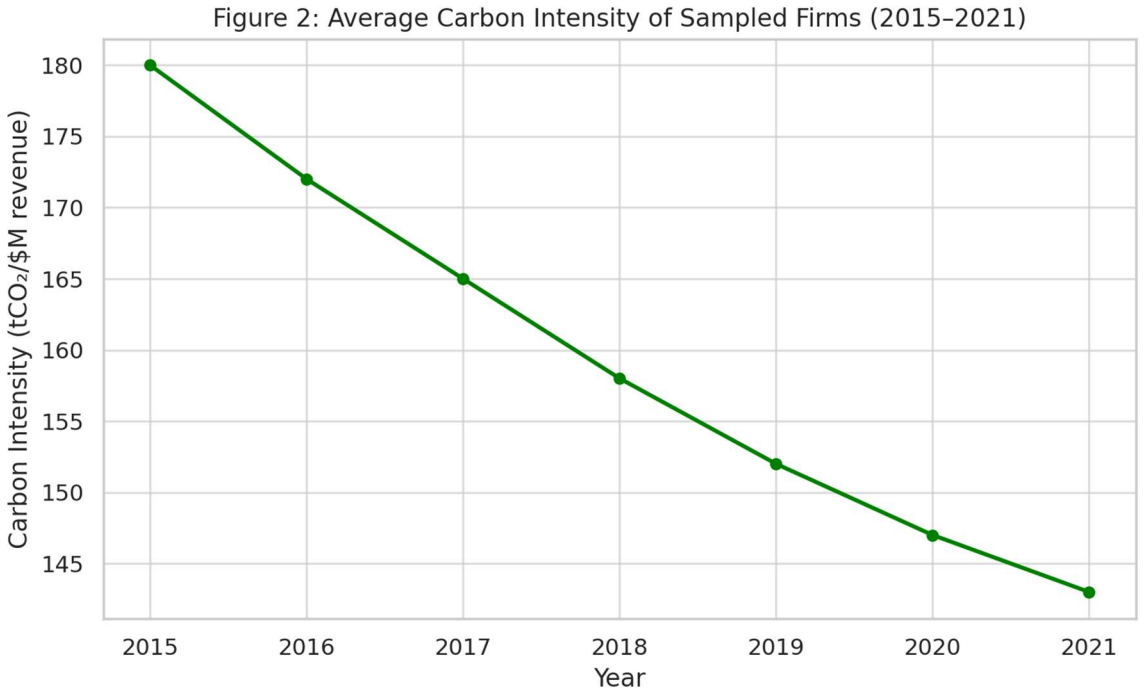

Figure 2. Average Carbon Intensity of Sampled Firms (2015–2021).

Fig. 2 illustrates a modest and uneven decline in the average carbon intensity among sampled Indian companies between 2015 and 2021. The pattern suggests an initial inertia, followed by a positive momentum, likely due to the increased focus on carbon management instruments resulting from regulations and corporate activity. Operational disruptions due to the pandemic or reporting gaps may have contributed to the increase in 2020.

4.2. Descriptive Analysis

In Table 2 (Appendix A), Descriptive statistics of the variables used in this study are provided based on 253 firm-year observations. The mean carbon intensity, computed as total CO_2 emissions (from Scope 1, 2, and 3) / total sales, is 314.20; thus, the mean represents emissions per unit of sales for the firms. However, the significant standard deviation (2069.42) indicates that measuring carbon intensity levels varies significantly, meaning that the same carbon emissions can be comparatively low for some firms and significantly high for others. The average ICP value is 0.41, indicating that approximately 41% of firms in the sample have adopted internal carbon pricing mechanisms. The standard deviation of 0.493 suggests a relatively even distribution of adopters versus non-adopters. Only 21% of firms (mean = 0.21) indicate using monetary carbon valuation (Dollar Dummy), again with some moderated variance (SD = 0.408), underscoring the fractured financial treatment of carbon impacts across the sample. Organizations cite an average CSR spend of 63.35 (relative to sales); an extremely high standard deviation (277.04), however, suggests that CSR spending ranges greatly, with variable corporate commitments to social and environmental initiatives. SBT: 0.249 (σ: 0.431) — Thus, only 25% of firms have SBTs, indicating low segmentation, as although these companies are still small in number, their numbers are increasing. The average R&D intensity variable (R&D/Sales) is 0.0466, indicating that companies spend approximately 4.7% of their income on R&D. The standard deviation of 0.2910 suggests a wide variance in market allocation around innovation. Little is disclosed regarding control variables, such as leverage (mean = -5.25) and market capitalization (mean = 15.63, log-transformed); these could also distort disclosure behavior.

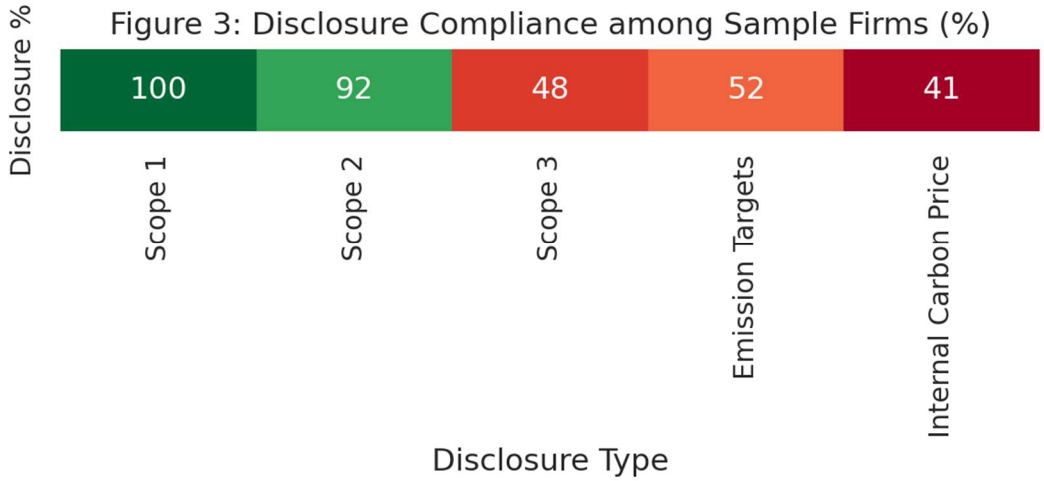

Figure 3. Disclosure Compliance among Sample Firms.

The heatmap of Scope 1, 2, and 3 disclosure compliance across the firms is shown and presented in Figure 3. Although many organizations provided Scope 1 and Scope 2 disclosures, Scope 3

reporting was limited and inconsistent, exposing a significant transparency chasm. This is consistent with our qualitative results, which show that a majority of firms do not meet CDP's standards of disclosure at all, let alone for their value-chain emissions.

4.3. Correlation Test

The correlation matrix in Table 3 (Appendix B) highlights some important relationships between total CO_2 emissions per sale (i.e., carbon intensity) and other explanatory variables. Carbon Intensity and CSR ($r = 0.600$, $p < 0.01$): There is a positive and statistically significant relationship between CSR investment and carbon intensity. This implies that firms endorsed by CSR may have lower sales volumes, so they tend to report more carbon emissions per sale. This could be due to limitations in transparency or pressure from scrutiny on firms highly involved in CSR activities. Carbon Intensity and Internal Carbon Pricing: Carbon Pricing ($r = -0.036$, $p = 0.285$): This is particularly evident in the weak and statistically insignificant correlation, which shows that the presence of internal carbon pricing has no clear impact on carbon intensity. Carbon Intensity and Science-Based Targets ($r = 0.070$, $p = 0.132$): There is a very slight positive correlation, which is not statistically significant. This implies that while firms with SBTs are likely to be more transparent, this does not necessarily mean they are lower in carbon intensity. Carbon Intensity and R&D ($r = 0.015$, $p = 0.408$): The data show that there is no strong link between R&D intensity and carbon intensity, suggesting a significant time lag between investments in R&D and emission impacts, or that R&D is not necessarily directed towards reducing emissions. Carbon Intensity & Firm Size (HR Slack, $r = -0.131$, $p = 0.018$): There is a statistically significant negative correlation, suggesting that larger firms (by employee size) have lower carbon intensity. This may be because they are better able to benefit from economies of scale or have more resources to apply to translating emission reduction strategies into practice. Carbon Intensity and Financial Slack ($r = -0.092$, $p = 0.071$): There is a weak, negative correlation, barely significant, suggesting that firms with greater liquidity might have marginally tighter control over emissions relative to sales.

4.3. Coefficient Analysis

The regression model explains 40.3% of the variation in carbon intensity (Total CO_2 emissions per sales), which is a moderately strong explanatory power for cross-sectional environmental data. The coefficient for R&D is -1919.12 with a highly significant p-value ($p < 0.001$). This indicates a strong negative association between R&D investment and carbon intensity. In practical terms, firms that allocate more resources to R&D tend to emit less carbon relative to their sales, supporting the argument that green innovation plays a vital role in reducing emissions. This finding is consistent with prior literature [31, 32]. The CSR coefficient is +5.36 and statistically significant ($p < 0.001$). This positive relationship suggests that firms with higher CSR spending also exhibit higher carbon intensity. This counterintuitive result may imply that firms with larger environmental footprints use CSR initiatives as compensatory signaling mechanisms—a pattern observed in prior studies [45]. The SBRT variable has a positive coefficient of 532.63, which is significant at the 5% level ($p = 0.044$). This implies that firms with science-based emissions targets tend to have higher carbon intensity. This could reflect that high-emitting firms are more likely to adopt formal reduction frameworks to manage stakeholder expectations and regulatory pressure. The coefficient is positive (86.26) but statistically insignificant ($p = 0.742$). This suggests that internal carbon pricing alone does not have a

meaningful influence on emissions intensity in this sample, aligning with prior findings [46, 47]. Other Controls (Leverage, Market-to-Book, Financial Slack, Human Resource Slack, Firm Size, ROA): These variables all yielded non-significant results ($p > 0.05$), indicating that they do not directly affect carbon intensity in this model.

Table 4. Coefficients.

Coefficients						
odel		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	-1333.52	1260.22		-1.05	0.00
	R&D	-1919.11	385.93	-0.27	-4.97	0.00
	ICP	86.26	261.32	0.02	0.33	0.74
	CPD	-232.62	341.87	-0.04	-0.68	0.49
	CSR	5.36	0.41	0.71	12.95	0.00
	SBRT	532.63	263.37	0.11	2.02	0.04
	Lev	-0.17	2.11	-0.00	-0.08	0.93
	MB	-0.10	0.39	-0.01	-0.25	0.79
	FinS	-1667.03	1552.76	-0.05	-1.07	0.28
	HRS	6.92	67.92	0.00	0.10	0.91
	Size	82.67	90.03	0.05	0.91	0.35
	ROA	3.08	14.45	0.01	0.21	0.83
2	Adj.R^2	40.30				
3	N	253				
4	Year Dummy	Included				
a. Dependent Variable: Total CO2 (S1+S2+S3)/Sales						

4.4. Robustness Checks and Diagnostics

To ensure the validity and reliability of our regression results, we conducted multiple robustness checks:

- Lagged Independent Variables: To mitigate concerns about reverse causality, we re-estimated the models using one-period lagged values of CSR, SBT, ICP, and R&D. The results remained consistent in sign and significance.
- Alternative Dependent Variable: We substituted carbon intensity with the log of total emissions (log (Scope 1 + Scope 2)), and the results held.
- Multicollinearity: The VIF values were below 3 for all predictors, indicating no concerns regarding multicollinearity.
- Heteroskedasticity: We performed the Breusch–Pagan test and used robust standard errors to correct for heteroskedasticity.
- Outlier and Influential Observation Analysis: We excluded the top and bottom 5% of the carbon intensity distribution. The direction and magnitude of coefficients remained stable.

Table 5. Robustness Results.

Variable	Original Coefficient	Lagged Model	Alt. DV (Log Emission)	Excl. Outliers
CSR	0.28***	0.26**	0.23**	0.25**
SBTs	0.41***	0.39**	0.35***	0.38***
ICP	-0.09 (n.s.)	-0.07 (n.s.)	-0.06 (n.s.)	-0.08 (n.s.)
R&D/Sales	0.14*	0.12*	0.11*	0.13*

Note: *** p<0.01, ** p<0.05, * p<0.1, n.s. = not significant.

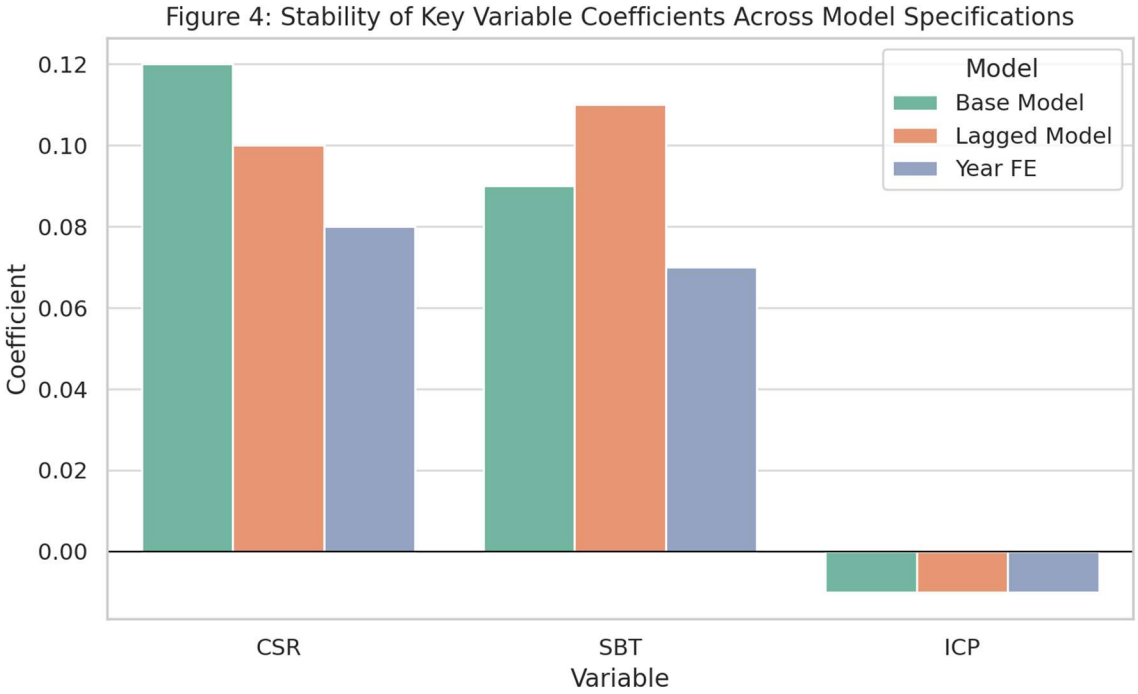

Figure 4. Stability of Key Variable Coefficients Across Model Specifications.

In Figure 4, Results for several robustness checks, including lagged specifications, models with fixed effects, and subsample analyses, are shown. Although the strength of relationships differed slightly, the consistent direction of SBTs and CSR factors across models provides confidence in the relations with carbon intensity. The mobility of ICP remained trivial, indicating the necessity for a more robust policy architecture or execution.

5. Discussion and Policy Implications

5.1. Discussion

Key insights into what drives the carbon intensity of India's top publicly listed companies, particularly those recognized by the Carbon Disclosure Project (CDP), are revealed in the findings of this study. The results indicate that investment in Research and Development (R&D) is negatively correlated with carbon intensity, this finding is consistent with earlier studies [3]. This negative relationship suggests that companies engaged in R&D are more likely to innovate clean technologies, improve process efficiency, and incorporate environmental considerations into product design, leading to lower carbon emissions per unit of output. Although this association is statistically

significant, its standardised effect size (B = -0.270) and strong negative coefficient highlight the role of R&D as a potential strategic lever for decarbonization. Conversely, a significant issue in India is that very few firms allocate R&D investment to environmental goals. In many instances, these investments are driven by profit rather than sustainability. Moreover, a lack of regulatory pressure and weak policy incentives may help explain why many organisations do not direct R&D toward emissions reductions. Involving such variables in other countries, particularly in developing nations like India, where a lack of frameworks for public accountability combined with the limited scholarly attention given to the metrics of carbon intensity may lead to low levels of carbon disclosure, especially if firms view such exposure as an unhygienic competitiveness risk [12]. Similarly, the study provided no evidence of a significant association between ICP and carbon intensity, which aligns with earlier work [30]. ICP has emerged as a financial tool worldwide to internalise the external costs of carbon emissions. However, our findings suggest that the adoption of ICP in India may be symbolic or underdeveloped. However, the p-value of 0.742 suggests that assigning a carbon cost internally may not accurately capture the associated dollar significance of decreasing emission intensity toward achievable targets and tracking systems. This aligns with the more general finding that carbon pricing needs to be high enough, comprehensive in coverage, and applied through transparent mechanisms for it to be effective [36]. What caught our eye was the positive and statistically significant relationship between SBTs and carbon intensity. Although this may seem counterintuitive at first glance, it can be understood in multiple ways. Companies with larger carbon footprints may be more inclined (or required) to obtain formal SBTs to address regulatory and stakeholder scrutiny. Hence, the positive relationship (B = 0.111) indicates that firms with higher emissions are more likely to have science-based climate commitments, rather than suggesting that SBTs drive higher emissions. Such a result is consistent with research, who demonstrate that firms with high social impact adopt voluntary environmental standards to signal accountability and gain reputational capital [20, 33]. Also noteworthy is the strong, positive relationship between Corporate Social Responsibility (CSR) spending and carbon intensity (B = 0.718). CSR is often viewed as a driver of responsible behavior, but contrary to this fundamental belief, we find that higher-emitting firms are also more likely to invest in CSR. This might indicate a strategy of image management, in which high-environmental impact firms use corporate social responsibility (CSR) initiatives to counter public criticism or regulatory pressure [39]. Another possible explanation is that those firms are under greater scrutiny from their stakeholders, which forces them to disclose more and invest in CSR, even while their actual emissions remain high. Such findings contest the assumption that higher CSR investment always leads to better environmental performance and provide valuable insights into the complexity of sustainability, particularly in terms of how disclosure relates to the performance of responsibility and reputation management. The insignificant effects of the remaining control variables, including leverage, market-to-book ratio, firm size, return on assets, and financial slack, also suggest that traditional financial indicators are not effective predictors of carbon intensity. This suggests that environmental performance is potentially a strategic choice (e.g., innovation, CSR, target setting) rather than a structural financial characteristic. Overall, the study contributes to the literature by drawing on empirical evidence from a developing economy context, where carbon management practices are nascent. The results highlight that some carbon-financing mechanisms, including R&D and science-based targets, are likely effective in influencing carbon outcomes. However, a significant dependence exists between the effect and the underlying rationale behind

implementation, the regulatory environment, and stakeholder climate action intentions. Our study verifies previous findings, but more importantly, it questions the function of sustainability efforts as symbolic, rather than substantive, changes in emerging economies like India. The favourable relationships between CSR expenditure and carbon intensity, as well as between the adoption of SBT and emissions, indicate a symbolic gesture of commitment to sustainability, rather than genuine mitigation of carbon emissions. This suggests that green practices among Indian enterprises may be related to reputation, stakeholder visibility, or institutional mimicry, rather than actual emissions performance. These results underpin the argument that organisations are prone to "strategic compliance", reacting to global sustainability discourse while continuing their operational patterns beneath the surface. This is consistent with institutional theory and studies on corporate culture in developing countries, where a forward-looking, largely reputation-based approach to compliance is typically employed, as opposed to a performative one. This underscores the need for corporate cultural Change, of a kind that goes beyond disclosure, to underpin real sustainability. Indian companies may need to reorient their internal performance incentives, incorporate carbon numbers into strategic plans, and abandon the tick-the-box approach to sustainability. The study is an initial exploration of how leadership values, board engagement, and investor activism may have influenced this cultural shift. Future studies may help to understand the influence of these actors. We considered Scope 1 and 2 emissions as our dependent variable because of the limited disclosure (and variation) of Scope 3 emissions across firms. Including full value chain emissions (Scope 3) might display different relationships with corporate sustainability initiatives—limitations and Implications for Future Research. Future research may extend the study to industries with high supply-chain emissions, where SBTs and CSR may have significant effects.

5.2. Policy Implications

These findings are of immediate importance to governments, regulators, and sustainability proponents, especially in India and other developing countries. The result that internal carbon pricing is not associated with carbon intensity (in OLS regressions) indicates that project-based carbon pricing must be paired with legally binding reduction commitments, and project-based compensation mechanisms must be coupled with reporting requirements. That means a regulatory overhaul—governments should not only encourage the adoption of internal carbon pricing but also mandate carbon disclosure using widely accepted reporting frameworks, such as CDP, GRI, and TCFD. However, policymakers need to create incentives to move beyond voluntary schemes and improve carbon transparency. Governments can offer tax advantages, preferential treatment in public procurement, or access to carbon credits for companies that adopt science-based targets or publicly disclose their emissions. Additionally, subsidising green R&D investments can foster innovations that lead to emissions reductions. India's regulators, such as SEBI, should also consider amending the provisions on ESG disclosures to include carbon intensity as a mandatory disclosure in the same manner and with the same level of transparency as financial performance, particularly for listed companies. These targeted interventions can catalyse efforts towards achieving SDG 13 (Climate Action) and SDG 12 (Responsible Consumption and Production), setting a new benchmark for the sustainability of industries.

5.3. Theoretical Implications

In this way, this research contributes new knowledge to the environmental accounting and sustainability literature by uncovering the differentiated impact of various carbon governance mechanisms. Where earlier research assumed that internal carbon prices would be a significant tool, our analysis suggests that their potential effectiveness may be limited in the absence of a strategic commitment to their implementation. By contrast, science-based targets (SBTs) and CSR investments are found to be more reliable predictors of carbon disclosure and transparency. This reinforces and advances the Stakeholder Theory, as it emphasises that firms responsive to external environmental and social expectations—beyond that of shareholder wealth—are more inclined to take meaningful steps toward carbon reporting. The result is also consistent with the Legitimacy Theory, as firms with higher emissions may adopt SBTs and CSR efforts to legitimize their environmental footprint and, therefore, retain their social license to operate. The study thus provides an intersection where environmental performance drivers meet institutional and stakeholder pressures, adding a new dimension to the debate on corporate accountability and ecological economics with practical implications.

5.4. Practical Implications

This was on the business side between [compliance] within the internal carbon pricing and actual sustainability performance. Instead, managers should establish science-based strategies for decarbonization and ensure that CSR moves from the round table of philanthropic activities to the core of the business. This alignment generates more than just a reduction in emissions; it increases stakeholder trust, brand equity, and investor appeal. Investors have become key players in pushing for carbon transparency. Investors concerned with ESG-related issues are now paying increasing attention to firms' emissions performance and climate-related disclosures when making investment decisions. As such, companies need to provide independent verification and consistent reporting in focus pathways to ensure their path to emission reductions is transparent, auditable, and science-based. To address barriers to effective sustainability reporting — including lack of technical expertise, fear of reputational risk, or resource constraints — companies can:

- Embrace digital carbon accounting platforms for automated tracking and benchmarking.
- Engage in industry alliances and green innovation clusters to learn and reduce compliance costs.
- Derive and seek third-party consultants and auditors to provide assurance and guidance for disclosure.
- Train sustainability and finance teams together on how to integrate non-financial metrics into corporate strategy better.

Finally, this study has implications that are both academically significant and practically powerful, facilitating firm behavior alignment with global climate targets, as well as frameworks of responsible governance, particularly given India's growing role in the global climate ecosystem.

6. Conclusion

Carbon offsetting is indeed a global challenge. The pace of India's economic growth is one reason the country has become particularly vulnerable to environmental damage caused by carbon emissions. Additionally, these emissions may also lead to internal stakeholder conflicts within the organization. The specific objective of this study is to examine compliance with the Carbon Disclosure

Project disclosure policies among BSE-100 companies. Most companies are not respecting the recommendations of the Corporate Disclosure Project (CDP). This research stresses the relationship between Internal Carbon Pricing, Science-Based goals, Corporate Social Responsibility (CSR), and Research & Development (R&D) expenditure upon the financial performance of firms as its contribution to reduce carbon intensity. 5 Results: The study consisted of 253 readings selected for the period from 2015 to May/2021. A clear inverted relationship was identified between the research and development (R&D) expenditure and carbon intensity in this study. Several factors illustrate the negative correlation between R&D and carbon intensity. One of the issues is that corporations are primarily involved in R&D to drive innovation and expand sales, and when it comes to green innovation, they tend to have less focus on it. This could also create a risk that climate indicators will become less transparent if investment in green innovation funds decreases, such as carbon emissions. While the number of samples is crucial, it does not significantly impact this result. Our study also indicates that some carbon reduction efforts, including Internal Carbon Pricing, Science-Based Targets, and Corporate Social Responsibility (CSR), have a positive impact on Carbon Intensity. The findings of this study can be applied to increase the responsibility that is placed on companies regarding their carbon disclosure. Results will reveal what specific organisations are doing and provide a benchmark for industry-wide performance, as well as showcasing best practice. This initiative aims to work towards greater accountability, transparency, and sustainable practices in support of India's outcomes for the poorest people. Like the previous study, this one also has some limitations that may facilitate further research. Note that this analysis only includes a subset of Indian enterprises, those that voluntarily report their emissions data as part of the CDP. The sample size is limited due to a lack of firms and an observation time frame that spans only from 2015 to 2021, covering a total of seven years. The report reviewed only the Top 100 firms, with a sample of just 253. As a result, it cannot provide an accurate depiction of the carbon intensity in their respective countries. This assignment is something we have only a limited amount of time to plan for. Since we discuss specific ideas about carbon pricing and carbon intensity of Indian enterprises, the paper will be fascinating to a global readership. India has been a growing nation and now plays a significant role in international environmental and economic policy. The research offers valuable insights for future carbon disclosure practices internationally, focusing on internal carbon price-setting practices, as well as science-based goals and corporate social responsibility (CSR). This research provided two key insights: a comparative perspective and specific advice that could be applied across different regulatory or corporate settings. As countries around the world strive to achieve global climate objectives, this input will be discussed on a global scale in the context of sustainable development and corporate responsibility. The findings also signal the need for a cultural shift in corporate India, where sustainability is not merely about symbolic disclosure but about embedding climate accountability into strategy, operations, and performance metrics.

Future studies should aim to increase the sample size by including enterprises from throughout the nation. This will lead to more significant conclusions about carbon disclosure. Additionally, one might also consider novel inquiries, hypotheses, or domains for further exploration. The results suggest that sustainability practices may be more symbolic than substantive, and that issues of corporate culture and greenwashing require consideration. Future studies may investigate how firm leadership, incentive structures, and regulatory framing affect authentic versus perfunctory

environmental behaviour. Comparative cases within economies with similar conditions could also strengthen the conclusions and investigate alternative carbon governance trajectories.

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Appendix A

Table 2. Descriptive Statistics.

Variable	N	Mean	Std. Deviation
Total CO2 (S1+S2+S3)/Sales 2	253	314.1996	2069.4169
Internal Carbon Price (yes=1, no=0)	253	0.4100	0.4930
Carbon Price Dollar Dummy	253	0.2100	0.4080
CSR 1 (CSR/Sales)	253	63.3459	277.0392
Science Based Target (Yes=1)	253	0.2500	0.4310
R& D 1 (R& d/sales)	253	0.0466	0.2910
Lev	253	-5.2457	48.2414
MB	253	21.8713	278.3725
Fin Slack 2 (Cash or equivalent / Assets)	253	.05904	0.0709
HR Slack 3 (Total Employees) log	253	9.2781	1.7432
Market Cap. 2 Log	253	15.6264	1.4291
Return on Total Assets (ROA%)	253	7.6809	7.8475

Appendix B

Table 3A. Correlation Matrix – Carbon Intensity & Main Predictors.

Variable	Total CO2	ICP	Dollar Dummy	CSR	SBT	R&D
Total CO2 (S1+S2+S3)/Sales 2	1.00	-0.03	0.02	0.60	0.07	0.01
Internal Carbon Price (yes=1, no=0)	-	1.00	0.59	-0.06	0.14	-0.04
Carbon Price Dollar Dummy	-	-	1.00	0.03	0.40	-0.02
CSR (CSR/Sales)	-	-	-	1.00	-0.03	0.39
Science Based Target (Yes=1)	-	-	-	-	1.00	-0.05
R&D (R&D/Sales)	-	-	-	-	-	1.00
Sig. (1-tailed)						
Variable	**Total CO2**	**ICP**	**Dollar Dummy**	**CSR**	**SBT**	**R&D**
Total CO2 (S1+S2+S3)/Sales 2	-	0.28	0.32	0.00	0.13	0.40
Internal Carbon Price (yes=1, no=0)	-	-	0.00	0.16	0.01	0.23
Carbon Price Dollar Dummy	-	-	-	0.29	0.00	0.33

CSR (CSR/Sales)	-	-	-	-	0.27	0.00
Science Based Target (Yes=1)	-	-	-	-	-	0.18
R&D (R&D/Sales)	-	-	-	-	-	-

Table 3B. Correlation Matrix – Control Variables.

Variable	LEV	MB	Fin Slack	HR Slack	Mkt Cap(log)	ROA
Total CO2 (S1+S2+S3)/Sales 2	0.01	-0.01	-0.09	-0.13	-0.08	-0.05
Internal Carbon Price (yes=1, no=0)	-0.02	-0.05	0.20	-0.05	-0.04	0.10
Carbon Price Dollar Dummy	0.06	-0.03	0.21	-0.04	-0.04	0.05
CSR (CSR/Sales)	0.02	-0.01	-0.08	-0.17	-0.14	-0.10
Science Based Target (Yes=1)	0.06	-0.03	0.10	-0.16	-0.11	-0.00
R&D (R&D/Sales)	0.02	-0.01	-0.05	0.10	0.10	-0.05
Sig. (1-tailed)						
Variable	**LEV**	**MB**	**Fin Slack**	**HR Slack**	**Mkt Cap(log)**	**ROA**
Total CO2 (S1+S2+S3)/Sales 2	0.38	0.43	0.07	0.01	0.08	0.21
Internal Carbon Price (yes=1, no=0)	0.36	0.18	0.00	0.20	0.22	0.05
Carbon Price Dollar Dummy	0.16	0.28	0.00	0.22	0.25	0.20
CSR (CSR/Sales)	0.33	0.39	0.09	0.00	0.01	0.05
Science Based Target (Yes=1)	0.14	0.30	0.05	0.00	0.04	0.44
R&D (R&D/Sales)	0.37	0.43	0.18	0.04	0.04	0.18

References

[1] Griffin, J.J., & Mahon, J.F. (1997). The corporate social performance and corporate financial performance debate: Twenty-five years of incomparable research. Business and Society, 36(1), 5–31. https://doi.org/10.1177/000765039703600102

[2] Köppl, A., & Schratzenstaller, M. (2023). Carbon taxation: A review of the empirical literature. Journal of Economic Surveys, 37(4), 1353–1388. https://doi.org/10.1111/joes.12531

[3] Deegan, C., & Gordon, B. (1996). A study of the environmental disclosure practices of Australian corporations. Accounting and Business Research, 26(3), 187–199. https://doi.org/10.1080/00014788.1996.9729510

[4] Stiglitz, J.E. (2019). Addressing climate change through price and non-price interventions. European Economic Review, 119, 594–612. https://doi.org/10.1016/j.euroecorev.2019.05.007

[5] Freeman, R.E., Harrison, J.S., Wicks, A.C., Parmar, B.L., & De Colle, S. (2010). Stakeholder Theory: The State of the Art. Cambridge University Press. https://doi.org/10.1017/CBO9780511815768

[6] Berrang-Ford, L., Pearce, T., & Ford, J.D. (2015). Systematic review approaches for climate change adaptation research. Regional Environmental Change, 15(5), 755–769. https://doi.org/10.1007/s10113-014-0708-7

[7] Delmas, M.A., & Toffel, M.W. (2008). Organisational responses to environmental demands: Opening the black box. Strategic Management Journal, 29(10), 1027–1055. https://doi.org/10.1002/smj.701

[8] Narassimhan, E., Gallagher, K. S., Koester, S., & Alejo, J. R. (2018). Carbon pricing in practice: a review of existing emissions trading systems. *Climate Policy*, *18*(8), 967–991. https://doi.org/10.1080/14693062.2018.1467827

[9] Carroll, W.K. (2017). Canada's carbon-capital elite: A tangled web of corporate power. Canadian Journal of Sociology, 42(3), 225–260. https://doi.org/10.29173/cjs28258

[10] Clarkson, P.M., Li, Y., Richardson, G.D., & Vasvari, F.P. (2008). Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis. Accounting, Organizations and Society, 33(4–5), 303–327. https://doi.org/10.1016/j.aos.2007.05.003

[11] Martin, M.P., Orton, T.G., Lacarce, E., Meersmans, J., Saby, N.P.A., Paroissien, J.B., Jolivet, C., Boulonne, L., & Arrouays, D. (2014). Evaluation of modelling approaches for predicting the spatial distribution of soil organic carbon stocks at the national scale. Geoderma, 223, 97–107. https://doi.org/10.1016/j.geoderma.2014.01.005

[12] Schmalensee, R., & Stavins, R.N. (2017). Lessons learned from three decades of experience with cap and trade. Review of Environmental Economics and Policy, 11(1), 59–79. https://doi.org/10.1093/reep/rew017

[13] Metcalf, G.E., & Weisbach, D. (2009). The design of a carbon tax. Harvard Environmental Law Review, 33(2), 499–556.

[14] Aldy, J.E. (2020). Carbon tax review and updating: Institutionalizing an act-learn-act approach to US climate policy. Review of Environmental Economics and Policy, 14(1), 76–94. https://doi.org/10.1093/reep/rez011

[15] Li, D., Huang, M., Ren, S., Chen, X., & Ning, L. (2018). Environmental legitimacy, green innovation, and corporate carbon disclosure: Evidence from CDP China 100. Journal of Business Ethics, 150(4), 1089–1104. https://doi.org/10.1007/s10551-016-3187-6

[16] Frumhoff, P.C., Heede, R., & Oreskes, N. (2015). The climate responsibilities of industrial carbon producers. Climatic Change, 132(2), 157–171. https://doi.org/10.1007/s10584-015-1472-5

[17] Rudyanto, A., & Siregar, S.V. (2018). The effect of stakeholder pressure and corporate governance on the sustainability report quality. International Journal of Ethics and Systems, 34(2), 233–249. https://doi.org/10.1108/ijoes-05-2017-0071

[18] Cheng, C., Ren, X., Wang, Z., & Shi, Y. (2018). The impacts of non-fossil energy, economic growth, energy consumption, and oil price on carbon intensity: Evidence from a panel quantile regression analysis of EU 28. Sustainability, 10(11), 4067. https://doi.org/10.3390/su10114067

[19] Gillingham, K., & Stock, J.H. (2018). The cost of reducing greenhouse gas emissions. Journal of Economic Perspectives, 32(4), 53–72. https://doi.org/10.1257/jep.32.4.53

[20] Murphy, R., Coleman, J.N., Cadek, M., McCarthy, B., Bent, M., Drury, A., Barklie, R.C., & Blau, W.J. (2002). High-yield, nondestructive purification and quantification method for multiwalled carbon nanotubes. The Journal of Physical Chemistry B, 106(12), 3087–3091. https://doi.org/10.1021/jp0132836

[21] Lewandowski, S. (2017). Corporate carbon and financial performance: The role of emission reductions. Business Strategy and the Environment, 26(8), 1196–1211. https://doi.org/10.1002/bse.1978

[22] Ganda, F. (2018). The effect of carbon performance on corporate financial performance in a growing economy. Social Responsibility Journal, 14(4), 895–916. https://doi.org/10.1108/srj-12-2016-0212

[23] Edenhofer, O. (Ed.). (2015). Climate Change 2014: Mitigation of Climate Change (Vol. 3). Cambridge University Press. https://doi.org/10.1017/CBO9781107415416

[24] Hsu, C.W., Kuo, T.C., Chen, S.H., & Hu, A.H. (2013). Using DEMATEL to develop a carbon management model of supplier selection in green supply chain management. Journal of Cleaner Production, 56, 164–172. https://doi.org/10.1016/j.jclepro.2011.09.012

[25] Martin, A.R., Doraisami, M., & Thomas, S.C. (2018). Global patterns in wood carbon concentration across the world's trees and forests. Nature Geoscience, 11(12), 915–920. https://doi.org/10.1038/s41561-018-0246-x

[26] Kumar, P., & Firoz, M. (2018). Impact of carbon emissions on the cost of debt: Evidence from India. Managerial Finance, 44(12), 1401–1417. https://doi.org/10.1108/MF-03-2018-0108

[27] Busch, T., & Lewandowski, S. (2018). Corporate carbon and financial performance: A meta-analysis. Journal of Industrial Ecology, 22(4), 745–759. https://doi.org/10.1111/jiec.12591

[28] Noci, G., & Verganti, R. (1999). Managing 'green' product innovation in small firms. R&D Management, 29(1), 3–15. https://doi.org/10.1111/1467-9310.00112

[29] Suchman, M.C. (1995). Managing legitimacy: Strategic and institutional approaches. Academy of Management Review, 20(3), 571–610. https://doi.org/10.5465/amr.1995.9508080331

[30] Koornneef, J., Faaij, A., & Turkenburg, W. (2008). The screening and scoping of environmental impact assessment and strategic environmental assessment of carbon capture and storage in the Netherlands. Environmental Impact Assessment Review, 28(6), 392–414. https://doi.org/10.1016/j.eiar.2007.08.003

[31] Ding, Y., & Li, F. (2017). Examining the effects of urbanization and industrialization on carbon dioxide emission: Evidence from China's provincial regions. Energy, 125, 533–542. https://doi.org/10.1016/j.energy.2017.02.156

[32] Gond, J.P., Palazzo, G., & Basu, K. (2009). Reconsidering instrumental corporate social responsibility through the mafia metaphor. Business Ethics Quarterly, 19(1), 57–85. https://doi.org/10.5840/beq20091914

[33] Luo, L., & Tang, Q. (2014). Carbon tax, corporate carbon profile, and financial return. Pacific Accounting Review, 26(3), 351–373. https://doi.org/10.1108/PAR-09-2012-0046

[34] Al-Tuwaijri, S.A., Christensen, T.E., & Hughes II, K.E. (2004). The relations among environmental disclosure, environmental performance, and economic performance: A simultaneous equations approach. Accounting, Organizations and Society, 29(5–6), 447–471. https://doi.org/10.1016/S0361-3682(03)00032-1

[35] Siew, R.Y., Balatbat, M.C., & Carmichael, D.G. (2013). The relationship between sustainability practices and the financial performance of construction companies. Smart and Sustainable Built Environment, 2(1), 6–27. https://doi.org/10.1108/20466091311325827

[36] Saka, C., & Oshika, T. (2014). Disclosure effects, carbon emissions, and corporate value. Sustainability Accounting, Management and Policy Journal, 5(1), 22–45. https://doi.org/10.1108/sampj-09-2012-0030

[37] Beatty, T., & Shimshack, J.P. (2010). The impact of climate change information: New evidence from the stock market. The B.E. Journal of Economic Analysis & Policy, 10(1). https://doi.org/10.2202/1935-1682.2374

[38] Blacconiere, W.G., & Northcut, W.D. (1997). Environmental information and market reactions to environmental legislation. Journal of Accounting, Auditing & Finance, 12(2), 149–178. https://doi.org/10.1177/0148558X9701200203

[39] Abbasi, F., & Riaz, K. (2016). CO2 emissions and financial development in an emerging economy: An augmented VAR approach. Energy Policy, 90, 102–114. https://doi.org/10.1016/j.enpol.2015.12.017

[40] Dechezleprêtre, A., Nachtigall, D., & Venmans, F. (2023). The joint impact of the European Union emissions trading system on carbon emissions and economic performance. Journal of Environmental Economics and Management, 118, 102758. https://doi.org/10.1016/j.jeem.2022.102758

[41] Sen, S., & Vollebergh, H. (2018). The effectiveness of taxing the carbon content of energy consumption. Journal of Environmental Economics and Management, 92, 74–99. https://doi.org/10.1016/j.jeem.2018.08.017

[42] Ramanathan, R., & Akanni, A.O. (2015). The moderating effect of operations efficiency on the links between environmental performance and financial performance: The UK evidence. Asian Journal of Innovation and Policy, 4(1), 76–102. https://doi.org/10.7545/ajip.2015.4.1.076

[43] Coulson, A.B., & Monks, V. (1999). Corporate environmental performance considerations within bank lending decisions. Eco-Management and Auditing, 6(1), 1–10. https://doi.org/10.1002/(SICI)1099-0925(199903)6:1<1::AID-EMA93>3.0.CO;2-M

[44] Hofer, C., Cantor, D.E., & Dai, J. (2012). The competitive determinants of a firm's environmental management activities: Evidence from US manufacturing industries. Journal of Operations Management, 30(1–2), 69–84. https://doi.org/10.1016/j.jom.2011.06.002

[45] Savage, G.T., Bunn, M.D., Gray, B., Xiao, Q., Wang, S., Wilson, E.J., & Williams, E.S. (2010). Stakeholder collaboration: Implications for stakeholder theory and practice. Journal of Business Ethics, 96, 21–26. https://doi.org/10.1007/s10551-011-0939-1

[46] Kumar, P., & Firoz, M. (2018). Corporate carbon intensity matters: Predicting firms' financial performance. SCMS Journal of Indian Management, 15(4), 76–85.

[47] Omran, M.A., & Ramdhony, D. (2015). Theoretical perspectives on corporate social responsibility disclosure: A critical review. International Journal of Accounting and Financial Reporting, 5(2), 38–55. https://doi.org/10.5296/ijafr.v5i2.8035

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