Article

Linking Climate Transition Risk into Credit Risk—A Firm-level Analysis for India

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Abstract

This article explores the connection between carbon emissions (CO_2EM), climate risk ratings and firm performance in India. We analyse the environmental, social and governance (ESG) ratings and financial information provided by the Refinitiv EIKON database and information given in the Carbon Disclosure Project (CDP) of the leading 69 corporations listed on the Bombay Stock Exchange (BSE) top 200 list, from 2017 to 2022. We have also examined CRISIL's ESG ratings for 517 listed companies for 2022. We find that a firm's heightened ESG risks increase its chance of being rated lower by the credit rating agency CRISIL. Moreover, CO_2EM also have a significant adverse effect on the firm's credit rating. We find empirical support that better ESG scores significantly improve a firm's market performance as well as profitability performance. Also, a lower ESG rating and CDP disclosure quality have a significant negative impact on firm profitability. Thus, higher CO_2EM by companies diminish their export earnings. Our panel, as well as cross-sectional analysis, reveals that there is a significant association between CO_2EM, ESG ratings, and a firm's creditworthiness.

JEL Codes: G14, G20, G35

Keywords

Carbon emissions, credit risk, environmental performance, firm performance

I. Introduction

Climate risk threatens our health, livelihoods, and very existence in the foreseeable future. From the Paris Agreement in 2015 to COP29 (Conference of the Parties) in November 2024, global leaders have been engaged in constant attempts to mitigate the risk of climate change. In the Indian context too, the National Disaster Management Authority (NDMA) has issued comprehensive national guidelines for heatwave management—revised in 2019—which have enabled decentralised action through Heat Action Plans (HAPs) (Mishra, 2025). Risk arising due to changes in climate factors that affect the assets and liabilities of financial entities is defined as climate change risk. Transition risk arises when institutions need to move from conventional energy (fossil fuel-based) to green energy (renewable energy). Transition

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risk is the risk of disruption to cash flows due to dependence on highly carbon-intensive fossil fuels, and it increases when a policy shift takes place. Climate considerations are to be part of the risk framework and capital allocation process. In this regard, banks are identifying companies or sectors having potential threats to their strategic and business plans. There is a growing literature on climate risk concerns and their implications on corporations, industries and financial institutions.

Banks and financial institutions need to give importance to collecting relevant climate data and creating scenarios to examine their preparedness against climate risk. The development of efficient assessment methods to internalise climate change scenarios and understand their impact on capital and business (production cost, exposure) is critical to effectively reduce their risks.

The direct relationship between financial factors, credit ratings and climate ratings like environmental, social and governance (ESG) scores or Carbon Disclosure Project (CDP) scores at the firm-level needs to be examined by banks. In this work, we present a firm-level panel data analysis to link firms' environmental performance with financial and product market performance. In this context, we evaluate whether ESG, CDP ratings, and carbon dioxide emissions (CO_2EM) are linked with firm performance as well as firm solvency positions. This article aims to investigate if there is any linkage between firm performance and climate preparedness. Our firm-level panel data analysis is based on the CDP disclosures of Bombay Stock Exchange (BSE) 200 companies. The ESG ratings, credit ratings, and firm performance parameters are collected from the EIKON and CMIE Prowess databases. We propose to build a set of multivariate models to link firm performance with ESG, CDP performance, and CO_2EM. Banks need to factor these causal relationships into their credit rating models and examine their impact on rating slippage, increase in the delinquency rate, and overall capital requirements. The banking sector in emerging markets, like India, is making attempts to establish a linkage between credit risk, firm performance and credit risk of loans to embed climate risk in its sustainable business goals. This article is an attempt to gather empirical evidence in this direction.

This article is structured as follows. The next section reviews the existing literature, identifies the research gaps, and specifies the testable hypotheses. Section III portrays the climate risk situation in India. Section IV presents the empirical strategy and explains this study's data, variables and methodology. Section V presents the analysis and discussion of empirical results. Section VI concludes the article.

II. Review of Literature and Hypotheses Development

Within the principal-agent framework, the principal utilizes the disclosure of financial and non-financial information to mitigate agency costs resulting from information asymmetry and the separation between ownership and control (Jensen & Meckling, 1976). Specifically, the higher the level of non-financial information disclosures that take place through the ESG and CDP, the happier the principal (owner of the company) will be due to greater transparency. Similarly, the signalling theory suggests that firm managers can reduce information asymmetry by sharing voluntary information with market stakeholders, and better corporate governance can improve the overall information environment (Yekini et al., 2015). The better-managed firms will tend to disclose information about their long-term environmental sustainability initiatives as a signal of their commitment to society, the environment and stakeholders. This way, information about CO_2EM, ESG and CDP will have implications on a firm's creditworthiness and performance in the real market.

Corporate brand value is created through innovation, sustained financial performance, and ESG (Luo & Bhattacharya, 2006). Thus, investment in ESG and sustainability is likely to lead to better

performance of firms. Companies with high-quality ESG disclosures are perceived by the market as less risky and more sustainable (Lee et al., 2022). Previous researchers have also suggested that companies performing better in ESG experience a reduction in downside risk, which gets reflected in their improvement in credit ratings or reduction in credit spreads (Henisz & McGlinch, 2019).

By using a set of panel regression analyses on the largest Italian companies for 10 years, Pulino et al. (2022) found empirical evidence that there exists a positive relationship between ESG disclosures and firm performance. Veeravel et al. (2024) studied the ESG disclosure data of 167 Indian firms listed in the National Stock Exchange (NSE) from 2010 to 2020 and found a positive relationship between ESG disclosure and firm performance.

In terms of research gaps, our article specifically addresses three issues.

- First, while the relationship between ESG and firm performance has received a good amount of attention from researchers, the direct relationship between ESG and credit ratings for corporates has not been addressed much in the literature.
- Second, our study examines the relationship between ESG ratings, CO_2EM and firm performance for a large emerging market economy like India.
- Third, the study also examines the impact of CO_2EM on a firm's export earnings.

In terms of the development of hypotheses, it is argued that firms with poor environmental performance have higher credit risk due to their greater exposure to potentially costly litigation, reputational losses, compliance and regulatory risk. Thus, companies with higher CO_2EM are more exposed to stricter climate-related regulations in the form of carbon taxes or entry barriers in the product market. This may also lead to more cash flow uncertainty amongst firms and adversely affect their creditworthiness (Saifullah et al., 2021). Perdichizzi et al. (2024) argued that a high level of CO_2EM indicates a high level of future environmental liabilities and a higher cost of capital for firms. Accordingly, high CO_2 emission intensity can indicate inefficiencies that ultimately harm a firm's financial performance. On the other hand, Li et al. (2022) examined the implications of ESG practices of Chinese listed firms from 2015 to 2020, and found that better ESG ratings can mitigate firms' risk of default. The main argument is that investment in ESG increases shareholder value and results in the better market value of assets of firms (Fatemi et al., 2018). Further, more socially responsible firms have better market reputations and hence better credit scores. Fuente et al. (2022) performed an empirical analysis of ESG scores and growth of values for US firms and highlighted the role of trust-enhancing, cost- and risk-reducing effects of ESG. Estimating the distance to default of companies from their market value of assets, asset volatility and bankruptcy scores, Bandyopadhyay and Kashyap (2024) found a linkage between firm-level credit risk and climate change risk (measured in terms of CO_2EM and ESG ratings). However, the direct connection between credit rating, firm performance and climate risk was not explored in detail.

Based on these arguments, the following key research hypotheses are proposed:

H_1: Climate risk (measured in terms of ESG risk rating and CO_2EM) increases firm credit risk in terms of credit risk rating.

H_2: A firm's climate risk-taking has a negative influence on its profitability as well as export performance.

By stakeholder theory, successful companies are able to align the interests of stakeholders, and, hence, are more sustainable. They focus not only on profit maximisation, but also on enhancing firm value in the interests of other stakeholders of the firms (suppliers, society, creditors and employees) (Freeman,

1984). The study by Friede et al. (2015), through a meta-analysis of more than 2000 ESG-related empirical literature, detected that approximately 90% of studies have found a positive association between ESG and firm performance. Accordingly, we test the following hypothesis:

H_3: A firm's better ESG performance has a positive impact on its performance in terms of firm value and profitability.

III. Climate Risk Situation in India

Global awareness about climate change, climate-friendly financing and carbon controls is on the rise. India is a largely populated country with immense growth potential. The corporate sector significantly contributes to India's economic growth by fostering innovation, creating employment opportunities, and driving gross domestic product (GDP) growth. However, climate change vulnerability, environmental challenges, and governance issues warrant sustainable practices for India's future growth aspirations. Climate change has been considered a critical pillar two risk by central banks, as well as by the Basel Committee on Banking Supervision (BCBS, 2020). A sustainable corporate sector growth is necessary for an overall strong economy for the nation in the near future. In May 2021, the Securities and Exchange Board of India (SEBI) mandated the Business Responsibility and Sustainability Report (BRSR) for the top 1,000 listed companies by market value of equity (MVE). This shift emphasises ESG factors as integral to corporate reporting, marking a significant step towards standardising sustainability disclosures in India. The Reserve Bank of India's (RBI, 2022) Sustainable Finance Group (SFG) has recommended that Indian banks adopt proper machinery at the top level to review and enhance climate risk management initiatives. Due to the higher growth prospects of the Indian economy, it is expected that industrial and power emissions will increase during the period 2022 to 2030 (refer to Figure 1). It is also anticipated that it may slow down as non-coal power generation steps up to meet incremental electricity growth.

The risk implications for such a shift, as well as disinvestment from fossil fuel-based assets, need due consideration. Thus, there are systemic benefits of reducing credit risk through decarbonisation or encouragement of green financing. The RBI's 2023 report has further emphasised the need for significant growth in green financing, projecting that India's green financing needs would require at least 2.5% of GDP annually until 2030 to meet the nation's climate goals (RBI, 2023).

India has spelled out its long-term goal of becoming net-zero by 2070 and fighting against climate change. The country aims to reach net-zero emissions by 2070 and to meet 50% of its electricity requirements from renewable energy sources by 2030. The Government of India recently approved a ₹20,000 crore National Green Hydrogen Mission to enhance its renewable energy production capacity, facilitate its effective usage, and reduce dependence on imported fossil fuels.

Recently, the RBI (2024) has come out with a draft climate risk disclosure framework to sensitise Indian banks to give due importance to both physical and transition risks. The draft tries to align the bank's climate policies with international standards by reporting climate exposures and risks with metrics and targets. The reporting of metrics and targets that include greenhouse gas emissions, their intensity, and financed emissions is expected to begin from the financial year (FY) 2027–2028. The latest Government of India (2025) survey has also highlighted that a strong climate adaptation strategy needs to be embedded in India's development strategy. It is of utmost importance for banks and financial institutions in India to establish a direct link between financial parameters and climate change factors and align their loan book with sustainable business goals. In this context, the present study is an empirical attempt to establish a direct link between CO_2EM, firm environmental and financial performance, and

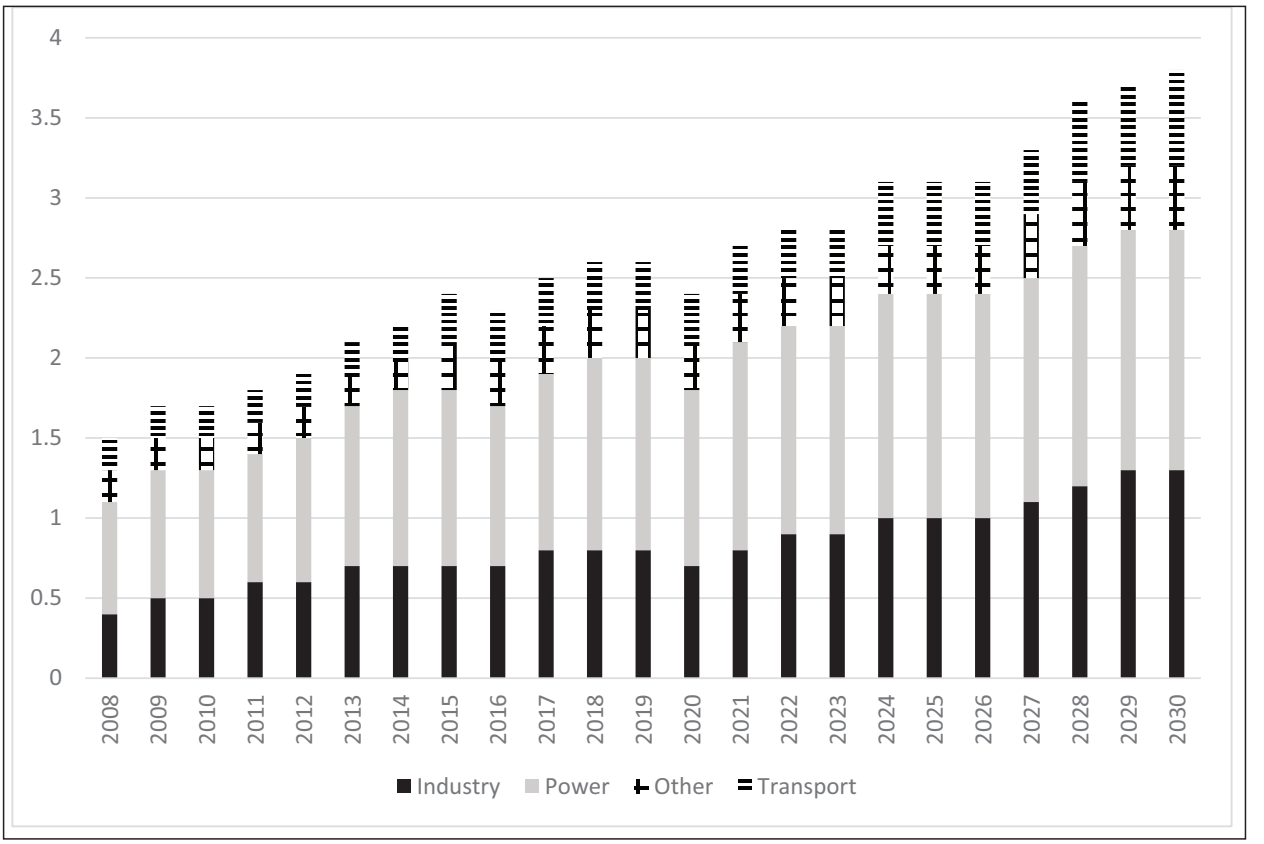

Figure 1. Sectoral Carbon Dioxide (CO_2) Emissions from Fossil Fuels-current and Projected Path in India (Units in Gigatonnes (Gt) Per Annum).

Source: Compiled from Rystad Energy's Energy Transition Solution (2023).

firm credit ratings. It highlights important aspects of ESG scores for credit risk rating and recommends key policy preparations for encouraging green finance by banks.

IV. Empirical Strategy: Data, Variables and Methodology

First, we present a firm-level panel data analysis to link ESG ratings and CO_2EM with default risk and the solvency position of selected companies. The balance sheet information for the selected top 200 BSE companies was extracted from the companies' annual reports, and CO_2EM data were obtained from the India CDP reports. We have collected disclosure scores from the CDP reports. CDP data have been widely used in the earlier empirical literature as a proxy for carbon disclosure quality. Based on the assessment by the CDP, the disclosure quality of companies was ranked in order of environmental leadership scale and coded from 1 to 9. The companies that have failed to disclose or have not submitted climate information have received the highest risk scale of nine. Similarly, the overall ESG combined score has been categorised into 10 rating scales. The best rating symbol, 'A', has received a score of 1, and the lowest rating, 'D+', has obtained a score of 10. The ESG scores and CO_2EM are obtained from the Refinitiv EIKON database. The BSE top 200 firms track the performance of the top 200 companies listed on the BSE and represent approximately 70% of the total free float MVE (i.e., available for

trading) of the BSE AllCap index. The firms were chosen in terms of MVE ranking. We included those companies with ESG disclosure data and CDP disclosure scores from the India CDP reports. It has been available since 2017. Finally, we could obtain data from 69 BSE 200 companies with climate disclosures from the year 2017 to 2022, and this gives us 414 firm years.

The leading credit rating agency of India has recently started providing ESG scores. Accordingly, we have collated 2022 ratings data for 517 companies (both listed and unlisted) to further examine their ESG scoring pattern and whether there is any linkage with sectoral as well as financial performance using the cross-sectional data.

Since we are assessing firm-specific climate and financial parameters on the discrete and the ordering nature of the dependent variable (credit rating) in this study, ordinary least squares regression would be an inappropriate model (Ederington, 1985; McKelvey & Zavoina, 1975; Yang & Raehsler, 2005). Therefore, we follow Amato and Furfine (2004) and Blume et al. (1988) by using the ordered probit model in our empirical analysis. We measured the credit risk in terms of the credit rating of a particular company using an ordered probit model and examined the role of financial and climate parameters.

The ordered probit model is expressed as:

$$R_{it}^{*} = \beta' X_{it} + \varepsilon_{it} \tag{1}$$

Where β' represents the slope coefficients of the explanatory factors X_{it}. The variable ε_{it} represents the error term. The variable R_{it} is the observed firm credit rating based on risk rankings. The ratings are given by a leading external credit rating agency in India, named CRISIL. The variable ratings are scaled from 1 to 12, while 1 means the lowest credit risk (highest credit rating) and 12 represents the highest risk of default (lowest rating).

The model parameters β and threshold parameters μ are estimated by applying the maximum likelihood technique using the log-likelihood function. In ordered probit, we are mainly examining the response probabilities of credit ratings defined as ($Ri = j|X_{it}$), where j is from 1 to 14, given the explanatory changes in the explanatory factors (X_k). This is explained in Wooldridge (2002). Through the ordered probit model, we have empirically tested if ESG risk and CO_2EM have any influence on borrowers' credit risk rating performance. We have also examined if a firm's financial performance in terms of profitability (PATTA), leverage (BORRTA) and activity (SALESTA) has implications for credit risk. We have tested this to further validate our results.

In order to study the impact of climate risk scores (in terms of ESG and CDP) and CO_2EM on company performance in terms of firm profitability and export earnings, we have run the following panel regression model:

$$\text{PERFORM}_{it} = \alpha + \beta_1 \text{FSIZE}_{it} + \beta_2 \text{ESGRisk}_{it} + \beta_3 \text{CO2EM}_{it} + \beta_4 \text{CDPRisk}_{it} + \beta_5 \text{BORRTA}_{it} + u_{it} \tag{2}$$

Where firm financial performance (PERFORM) is measured in terms of profitability (PATTA) and export earnings to total earnings (EXPINCTI). Firm size (FSIZE) variation is controlled by the variable FSIZE, which is measured by the natural log of total assets. It has been used as a control variable. The factor BORRTA captures firm leverage (borrowings to total assets). The environmental effects are captured by total CO_2EM in units of million tonnes. This information was obtained from the Scope 1, Scope 2 and Scope 3 disclosures of these companies over the FYs. The climate risk ratings are captured through the ESG and CDP risk rating scale. The error term is represented by the random variable u_{it}. The panel firm-specific fixed effects are captured through industry dummies, and year-specific effects by year dummies. We suspect panel heterogeneity is present in the regression structure since individual heterogeneity may be random. This has been further confirmed by the heteroscedasticity test, and therefore, we have presented heteroscedasticity robust coefficient results.

Table 1. Detailed Summary Statistics (Panel Data).

Variable	Observations	Mean	Std Dev	Minimum	Maximum
Credit risk rating	401	2.736	2.492	1	14
FSIZE	411	12.62	1.838	−2.30	17.73
ESG-risk	233	5.484	1.564	2	11
CDP-risk	306	4.036	1.823	1	8
PATTA	411	0.061	0.0962	−1	0.478
BORRTA	372	0.166	0.1652	0	0.853
CO_2EM	225	11.61	31.683	0.00284	305.26
SALESTA	409	0.655	0.531	0	3.09
EXPTINC	301	0.327	0.510	0.0000234	0.9812

Source: Authors' own based on audited data of listed firms, Carbon Disclosure Project (CDP) data, and EIKON database.

Note: (a) Credit risk rating: CRISIL long-term rating of borrowers, ranked in terms of ascending order of risk. (b) Firm size (FSIZE): Natural log of total assets of firms. (c) Environmental, social and governance (ESG)-risk: The overall ESG ratings are ranked in ascending order of risk as a categorical variable (2–11 scale) provided in the Refinitiv EIKON database, a higher value indicates poor ESG ratings and greater ESG risks. (d) CDP-risk: CDP ratings are arranged in increased order of risk (lowest and best 1 to riskiest 8 scale). (e) PATTA: Profitability ratio = Profit after tax to total assets. (f) BORRTA: Total borrowings to total assets. (g) CO_2EM: CO_2 emission is scaled to million tons unit capture total carbon dioxide emissions by companies (Scope 1, 2 and 3). (h) SALESTA: Asset utilisation ratio or turnover ratio. (i) EXPORTINC: Export revenue (or foreign exchange earnings) to total income ratio.

The data and variables used in setting a panel multivariate framework for selected BSE 200 firms have been summarised in Table 1. The credit risk rating notches range from the best 1 (AAA) to the worst 14 (D) classes, as reported in CRISIL rating symbols. We observed that the average borrowing rating in our sample is around 3 (i.e., AA) with a standard deviation of 2.5 notches. There are no C-rated companies in our sample. The FSIZE values are the natural logarithm of total assets, and the mean FSIZE is 12.62, with a standard deviation of 1.838. The ESG risk rating as reported by Refinitiv EIKON for our sample ranges from 2 (A) to 11 (D), with a mean rating of 5.484 (i.e., between B and B–), with a standard deviation of 1.56 notches. It means our sample covers companies with better, moderate, as well as low ESG ratings. The total amount of CO_2EM through Scope 1, 2 and 3 for our sample firms ranges from 0.00284 million tonnes to 305.26 million tonnes. The average emission level is 11.61 million tonnes with a standard deviation of 31.683. The mean profitability ratio (PATTA) is 0.061 with a standard deviation of 0.096. The mean export to income ratio is 32.7% with a standard deviation of 0.510. The mean leverage (BORRTA) is 16.6% with a standard deviation of 0.1652.

It is important to mention that both ESG and CDP, as well as credit ratings scales, are in order of their riskiness. We have used categorical variables to represent risk ratings. So, a lower rating gets a higher risk scale. Similarly, a better rating will receive a higher ranking on the risk rating scale, and its values will be lower (scale 1, 2, 3).

Table 2 reports a correlation matrix for the variables used in the multivariate analysis reported in Tables 3 and 4. As expected, CO_2EM and ESG risk ratings are positively correlated with firm leverage (BORRTA) and credit risk ratings. Further, credit risk rating is negatively correlated with the FSIZE and profitability (PATTA). Interestingly, ESG risk rating is positively associated with the level of CO_2EM, leverage (BORRTA) and CDP disclosure risk rating. Quite expectedly, the turnover ratio (SALESTA) is positively associated with the export earnings (EXPTINC) ratio. This gives us sufficient empirical

Table 2. Correlation Among Panel Variables.

	Credit Risk Rating	FSIZE	ESG-Risk	CDP-Risk	PATTA	BORRTA	CO_2 EM	SALESTA	EXPTINC
Credit risk rating	1.00								
FSIZE	−0.22***	1.00							
ESG-risk	0.13**	−0.02	1.00						
CDP-risk	0.08	−0.14**	0.32***	1.00					
PATTA	−0.18***	0.11**	−0.17***	−0.27***	1.00				
BORRTA	0.24***	−0.03	0.20***	0.28***	−0.37***	1.00			
CO_2EM	0.19**	0.21***	0.163**	0.104	−0.065	0.086	1.00		
SALESTA	−0.07	−0.16***	−0.09	−0.0002	0.511***	−0.16***	−0.051	1.00	
EXPTINC	0.004	−0.05	−0.081	−0.053	0.177***	−0.105*	−0.158**	−0.06	1.00

Source: Author's computation based on firm-level panel data.

Note: (a) For variable description, please see Table 1. (b) ***Denotes statistical significance at 1% or better. (c) **Indicates significance at 1%–5%; signifies between 5% and 10% level.

evidence among disclosing firms that there is a significant association between their environmental risk and the financial performance of firms. This is quite evident from the correlation coefficients reported in Table 2. Subsequently, we have applied a set of multivariate probit regression models to examine whether climate risk factors influence the firm's credit rating standing.

We have also assessed the pattern of CRISIL ESG scores for 517 firms for the year 2022. It represents the climate preparedness of Indian companies. The CRISIL's ESG rating is based on trends in emission intensity, use of green or alternate raw materials, green product offerings, investments, and other parameters. Using cross-sectional data, a sector-level ESG score awarded by CRISIL has been plotted in Figure 2. The mean ESG scores across 36 sectors are reported in the bar graphs. The overall ESG score for all firms together ranges between 32 and 67, with a mean score of 47.71 and a standard deviation of 5.96. Sector-wise, it varies from 36 (power) to 59 information technology (IT). Thus, there is a significant difference in the total ESG score among sectors. The industry variances are coming in terms of their preparedness towards the environment, governance and social aspects. The score is comparatively higher and adequate in IT, staffing, food and products, financial services and multibrand retail. The ESG score is relatively lower and below-average in the power, transport infra, oil and gas, and logistics sectors. Here, a higher value of ESG scores indicates better environmental performance and lower climate-related risks. Thus, firm-wise heterogeneity in the ESG combined score is present in the Indian market.

Detailed statistics about cross-sectional data of firms with CRISIL's ESG scores and their key financials are documented in Table 5. This time, we have used the CRISIL-reported ESG score of firms, along with key performance indicators like price-to-book ratio (PBR), MVE, turnover ratio (SALESTA), and firm profitability (PATTA). The mean PBR, which measures the firm's market performance, is 5.1178%, and the mean ESG score is 47.71. The average MVE is ₹12,841.74 crore.

The pairwise rank correlation estimates for the cross-section of 517 firms are presented in Table 6. Quite evidently, CRISIL's ESG scores of firms are significantly positively associated with the firm performance factors. The correlation table shows that there exists a statistically significant positive association between a company's ESG scores and its annual MVE (Spearman rank correlation coefficient

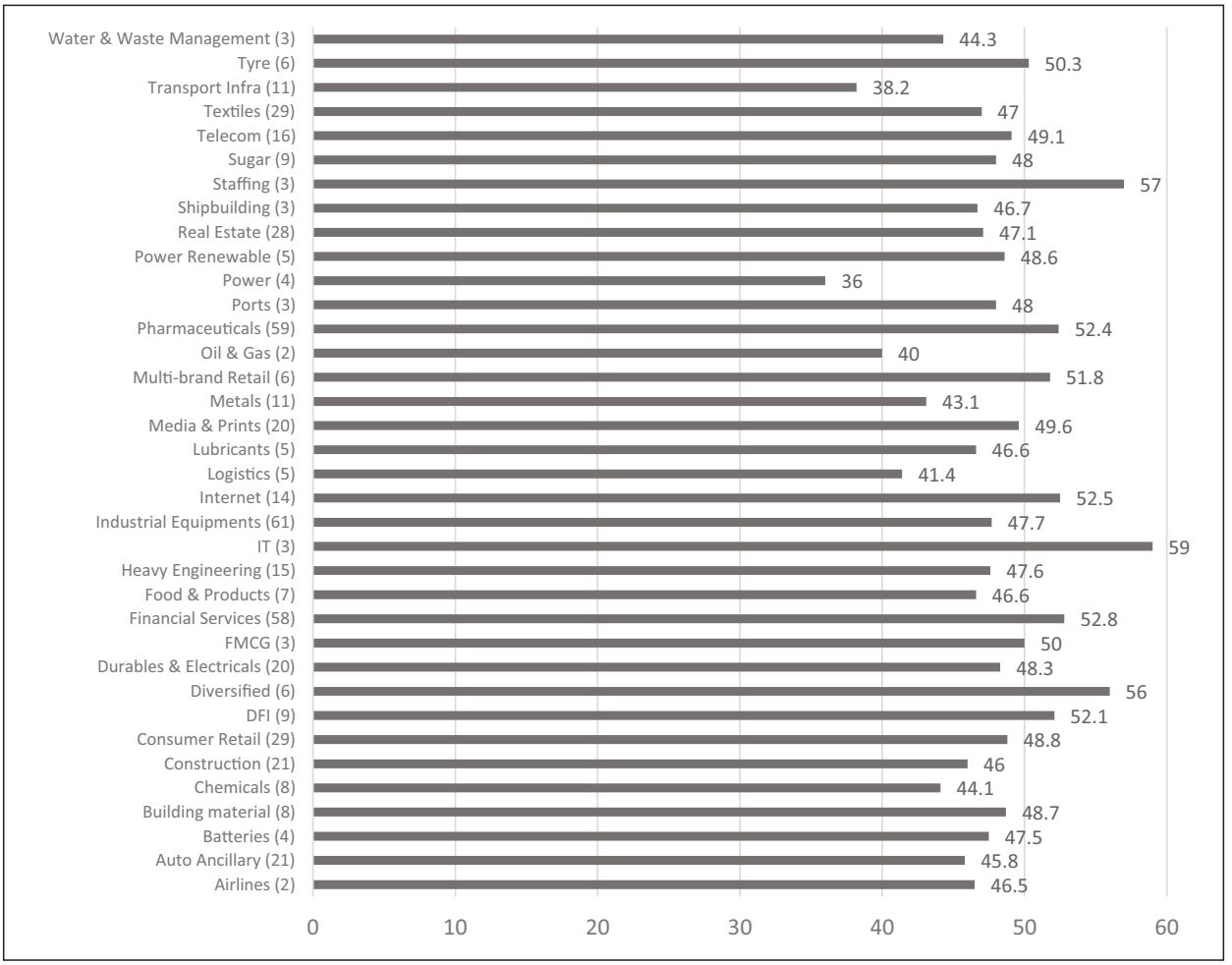

Figure 2. Sectoral Environmental, Social and Governance (ESG) Scores by CRISIL in 2022: Mean ESG Score.

Source: Author's estimation from CRISIL's ESG rating for firms.

Note: Figures in brackets adjacent to the industry name represent the number of firms in that particular industry.

between MVE and ESG = 0.444 with p value = .00). Similarly, the ESG score of a firm is significantly correlated with its PBR. The Spearman rank correlation between the PBR and ESG is 0.271 with a p value of .00. The rank correlation between financial ratios like profitability and turnover ratio, and PBR and MVE are also statistically significant. This gives us evidence that there is a statistically significant empirical relationship between climate performance and the financial or market performance of companies.

In order to study if there is any impact of ESG score on firm value and profitability, we have utilised CRISIL's cross-sectional data and framed the following cross-sectional regression model. We have used FSIZE (LTA) and turnover ratio (SALESTA) as control variables.

We utilise the following functional relationship:

$$y_i = \beta' x_i + \varepsilon_i \tag{3}$$

Where y_i is the set of dependent variables for firm i. We have used PBR and PATTA as measures of firm performance in terms of firm value and profitability. The PBR compares a firm's market price per share

to its book value. A higher ratio indicates better market performance and greater growth potential for the firm (Barclay et al., 1995). The expression x_i is the vector of explanatory variables tested in finding if there is any link between climate and firm performance. The symbol ε_i represents the error term.

V. Empirical Results

It is quite evident from Table 3 ordered probit regression results that key financial ratios like the profitability of firms (PATTA) and turnover ratios (SALESTA) have significant negative effects on credit ratings. That means better profitability and sales-to-assets, and there is a higher probability that a company will achieve better credit ratings (i.e., lower values in the risk rating scale). On the other hand, if the leverage is higher (BORRTA), a firm will most likely obtain a lower credit rating (i.e., greater values in the risk rating scale) due to higher leverage. Normally, a bank's credit rating model will factor in these relationships. We find that ESG scores by companies have a significantly positive influence on the borrower credit rating (captured in Model 2). It means that, if companies receive a lower rating (which means higher in the order of the risk scale), the likelihood that they will receive a lower rating (or a bottom rank in the risk scale) is also significantly higher. Hence, lower ESG performance causes greater credit risk in terms of a higher default risk.

Our findings will enable banks to establish a linkage between credit risk and climate change risk. Similarly, higher CO_2EM by firms increase the likelihood of obtaining lower credit ratings by agencies and hence increases their probability of default (PD). This may be because high-emitting firms face more cash flow uncertainty. Such an assessment will assist banks in adjusting their borrower-level ratings and factor in the impact of climate change on their capital, as well as business decisions.

We have also assessed the impact of CO_2EM on firm performance. To examine this relationship, we have tested the impact of CO_2EM levels on firm profitability (PATTA) and its export intensity (EXPTINC, measured in export income to total sales). The panel fixed-effects regression with heteroscedasticity robust

Table 3. Ordered Probit Model to Link Climate Risk Factors with Credit Risk.

Dependent Variable: Credit Risk Rating (CRA_Scale)	Model 1	Model 2
FSIZE	−0.285*** (−5.29)	−0.208*** (−3.61)
ESG-risk	–	0.126*** (2.37)
PATTA	−5.38*** (−3.63)	−2.93*** (−2.15)
BORRTA	1.604*** (2.87)	0.672 (1.13)
CO_2EM	0.0082** (3.54)	–
SALESTA	−0.644*** (−2.82)	−0.709*** (−3.20)
Intercept		
LR χ^2 (d.f.)	85.48 (5)***	48.75 (5)***
Pseudo R^2	0.137	0.086
Number of observations	197	201

Source: Authors' own based on audited data of 69 listed firms, Bombay Stock Exchange (BSE top 200) and Carbon Disclosure Project (CDP) data and EIKON database.

Note: (a) For variable description, please see Table 1. (b) Values in the parentheses are the estimated z values by dividing the coefficients by their respective standard errors. (c) ***Denotes significance at 1% or better and **denotes significance at 1%–5% level.

Table 4. Panel Fixed Effects Regression (with Robust Standard Errors) to Examine the Impact of Climate Risk on the Firm Performance.

Factors	Model 1 (Dependent Variable: PATTA)	Model 2 (Dependent Variable: EXPTINC)
FSIZE	−0.010*** (−3.06)	0.063* (1.85)
ESG-risk	−0.0058* (−1.86)	–
BORRTA	−0.1510*** (−4.73)	–
CDP-risk	−0.0056* (−1.84)	–
CO_2EM	–	−0.004*** (−2.68)
Intercept	0.271*** (5.78)	−0.379
No. of Obs.	164	163
Adjusted R^2	0.184	0.130
F-statistic (k, df)	11.67*** (4, 241)	3.60*** (2, 208)

Note: (a) Values in the parentheses are the estimated *t* values by dividing the coefficients by their respective standard errors. (b) ***Denotes significance at 1% or better and * denotes significance at 5%–10% level. (c) The fixed effects regression factors sectoral dummies and heteroscedasticity robust standard errors.

standard errors is reported in Table 4. In regression Model 1, we find empirical evidence that obtaining a lower ESG rating (i.e., a greater environmental risk rank) harms firm profitability in the product market. Similarly, poor climate disclosures (regarding lower-ranked CDP scores) adversely impact firm profitability. The variable CDP represents the quality of carbon disclosures. On the other hand, the higher the ESG score, the better the company's sustainable performance in terms of profitability. As per the signalling theorem of corporate finance, investors will positively respond to such news, which will ultimately increase the firm's profitability. In Model 2, we find a negative statistically significant impact of CO_2EM on a firm's export earnings (captured in a negative and statistically significant coefficient of CO_2EM). We have also checked the impact of CO_2EM scaled by the firm's total assets on its export earnings. Here, also, the coefficient is statistically significant, and the impact is negative ($CO_2EM\_TA = -3.543$ with $t = -4.65$ and $p = .00$). The industry effects in terms of environmental risk are captured through industry dummies. Three industry dummies are considered in terms of environmental risk intensities (low, high and moderate). We find strong evidence that the industry effect matters in firm performance. For example, cement, power, metal, chemicals, automobiles and petroleum products are in the high-risk category. Similarly, logistics, light manufacturing, tobacco and beverages are in the moderate risk class. On the other hand, renewable energy, telecommunications, IT, real estate, financial services and specialised services are the low environmental risk industries. We have enough firm-year observations in each industry class.

Table 7 reports cross-sectional regressions of the market performance and profitability of firms on the log of firm assets, CRISIL's ESG score and the firm's turnover ratio. A firm's market performance is measured in terms of the PBR, and profitability is measured by PAT to total assets (PATTA). The PBR has been considered a measure of a company's market value. It evaluates a company's stock price against its earnings per share and indicates the profitability prospects. We have applied robust standard errors to eliminate the problem of heteroscedasticity. Due to the cross-sectional nature, the model does not suffer from serial correlation issues.

Thus, our results provide statistical evidence that investing to deliver better ESG performance can drive value upside for a firm. It also positively boosts firm profitability. Our regression results on cross-sectional data confirm that ESG performance significantly impacts a firm's market value, captured through the PBR. This finding is in line with Ahmad et al. (2021).

Table 5. Summary Statistics for Cross-sectional Data.

Variable	Observations	Mean	Std Dev	Minimum	Maximum
ESG-SCORE	517	47.71	5.96	32	67
MVE	456	12,841.74	859	38.69	1,781,835
FSIZE	333	8.01	1.44	4.414	13.68
SALESTA	319	0.73	0.61	0.000053	4.069
Price-to-book ratio	288	5.12	5.97	0	51.96
PATTA	333	0.05	0.11	−1.08	0.54

Source: Authors' own based on audited data of listed firms and CRISIL published ratings and market capitalisation data for the financial year (FY) 2022.

Note: (a) Units in Rs. crore, others in numbers. (b) Environmental, social and governance (ESG)-SCORE: ESG score values of the credit rating agency, CRISIL, assigned on a scale of 0–100. A higher ESG score indicates better environmental, social, and governance practices followed by the firm. (c) MVE: Firm's annual market capitalisation in Rs. crore. (d) FSIZE: Firm size represented by the natural log of total assets. (e) SALESTA: Ratio of sales to total assets, representing the sales efficiency of firms. It also proxies the management quality in a firm. (f) Price-to-book ratio: Market value to book value per share of a company, equivalent to Tobin's Q. (g) PATTA: Profit after tax to total assets ratio. It proxies the profitability performance of a firm.

Table 6. Correlation Results (Cross Section Data).

	ESG-SCORE	MVE	FSIZE	SALESTA	Price-to-Book Ratio	PATTA
ESG-SCORE	1.000					
MVE	0.444***	1.000				
FSIZE	0.185***	0.572*	1.000			
SALESTA	−0.098	−0.071	−0.247***	1.000		
Price-to-book ratio	0.271***	0.484***	−0.269***	0.205***	1.000	
PATTA	0.050	0.098	−0.300***	0.475***	0.249***	1.000

Source: Authors' estimates based on firm-level cross-sectional data with CRISIL's environmental, social and governance (ESG) ratings.

Note: ***Denotes statistical significance at 1% or better; common observations (*N*) = 271. *Indicates significance at 5–10% level.

As a robustness check, we have alternatively performed a Tobit regression for the dependent variable firm profitability (PATTA), and the results about the impact of the regression factors are similar and consistent. We have derived heteroskedasticity-consistent results. We have also tested for endogeneity between the dependent (PBR) and ESG parameters in our second cross-section model. One may argue that, because of better growth, firms can invest more in ESG. To address the endogeneity issue, we have performed the Durbin–Wu–Hausman test, which confirms that there is the presence of endogeneity in Model 1 (high F value and low p value of the test statistic). To mitigate the issue, we have used the instrumental variable regression technique. The two-stage least squares (2SLS) technique was adopted using ivreg in Stata, using the market value to total assets ratio (MARKETCAPTA) as the instrumental variable. This specification is mentioned in Davidson and MacKinnon (1993) and Wooldridge (2010). We have obtained similar significant results with similar signs of the estimates, with correct standard errors. This confirms that our regression estimates are robust and the ESG score has a statistically significant positive impact on the firm's market performance. Therefore, a better ESG score awarded by the rating agency can significantly boost the firm's market performance as well as profitability.

Table 7. Environmental, Social and Governance (ESG) Scores and Market Performance Statistics: Cross Section Analysis.

Factors	Model 1 (Dependent Variable: Price-to-Book Ratio)	Model 1A (Dependent Variable: Price-to-Book Ratio—2SLS Results)	Model 2 (Dependent Variable: PATTA)	Model 2A (Dependent Variable: PATTA—Tobit Regression Results)
FSIZE	−1.043*** (−2.60)	−3.538*** (−3.98)	−0.0135** (−2.08)	−0.0178*** (−3.19)
ESG-SCORE	0.258*** (2.51)	2.176*** (4.82)	0.0025*** (3.24)	0.0025*** (2.81)
SALESTA	1.190** (2.27)	1.266 (1.02)	0.032*** (3.10)	0.0338*** (3.36)
Intercept	−0.0113 (−0.001)	−73.21*** (−4.17)	0.020 (0.37)	0.056 (1.31)
No. of Obs.	279	273	309	309
R^2	0.106	–	0.091	0.136
F-statistic	11.12***	9.94***	11.95***	13.30***

Note: (a) Values in the parenthesis are the estimated *t* values by dividing the coefficients by their respective standard errors. (b) ***Denotes significance at 1% or better and **denotes significance at 1%–5% level. (c) In Tobit regression, 57 left-censored observations at PATTA <= 0. (d) Wu–Hausman test confirms $F(1,268) = 202.82$ with prob > $F = 0.00$ indicates presence of endogeneity in Model 1. (e) The 2SLS regression estimates which are robust to heteroskedasticity, are given in Model 1 using price to book ratio as the dependent variable and market value of equity (MVE) to total assets as an instrument. Results are reported in the third column.

VI. Concluding Observations

As global concerns over climate change and sustainability grow, ESG factors have become critical in evaluating corporate practices to promote environmentally sustainable business practices. In this backdrop, our empirical research attempts to examine the consequences of CO_2EM, ESG and CDP environmental disclosures on firm performance and credit ratings.

In our analysis, we find strong empirical evidence about the linkage between the credit risk of firms recognised through credit ratings and their financial and climate performance. Our firm-level panel ordered probit regression analysis reveals that receiving lower ESG scores by companies adversely impacts their credit ratings. We also find evidence that credit rating agencies recognise climate performance in terms of financial, industry and management ratings. This finding further extends the contributions made by Capasso et al. (2020), Saifullah et al. (2021) and Li et al. (2022). Banks need to factor these types of causal relationships into their credit rating models and recalibrate them. Our panel fixed effects regression results show that ESG scores and CDP disclosure quality have significant implications for firm profitability as well as market performance. Furthermore, our panel regression results find that CO_2EM have a significant negative impact on the firm's export earnings. This gives us a new insight into the negative signalling effect due to CO_2EM on firm export earnings. Our cross-sectional regression result based on CRISIL ESG ratings provides empirical evidence that ESG performance significantly impacts a firm's market value, captured through the PBR. Better ESG performance leads to improved firm profitability. These results are also in line with the findings of Perdichizzi et al. (2024) and Veeravel et al. (2024).

Our findings are expected to enable banks, policymakers and regulators to recognise a linkage between credit risk and climate transition risk. Thus, effectively, credit portfolios could get towards a sustainable growth path. Our article contributes to the existing literature on climate change and business sustainability by providing empirical evidence on the relationship between ESG ratings, CDP ratings, CO_2EM and firm performance. Moreover, it gives proof of the influence of climate transition risk on

credit risk for firms in the Indian context. Our findings will enable banks, policymakers and regulators to establish a linkage between credit risk and climate transition risk. This will enable them to better align credit portfolios towards a sustainable growth path. Thus, the Indian banking system needs to take the lead to transition the economy to become more sustainable and resilient.

This study has certain limitations. As more companies disclose CO_2EM and ESG parameters, this research work can be further extended to a wider set of firms, along with their credit ratings and financial data. It will be interesting to see if the results obtained in our research vary across sectors, bank exposures, and investment grades versus non-investment grade firms. Further, bank-wise primary data along with their internal and external ratings, CO_2EM, fossil fuel intensity, ESG ratings and default data, may also be used to examine the climate impact on firm credit risk. All these constitute an agenda for further research.

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