The Impact of Temperature Change on the Firm Performance: Empirical Evidence from the Indian Mining Sector

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Abstract

Irrespective of sector, fluctuations in temperature exert a noteworthy impact on the operational dynamics of businesses. The panel data used encompassed 62 publicly listed Indian companies operating in the mining sector over the period from 2011 to 2020 to verify the above in the mining sector. The primary objective is to empirically scrutinize the repercussions of temperature changes on the overall performance of the mining industry in India. Firm-specific variables are kept as control measures in this investigation and a panel quantile regression approach is employed for the analysis.

The study reveals that an escalation in the annual average temperature contributes to a decline in the profitability of mining firms. Notably, the observed negative correlation is not consistently uniform across different quantiles. Furthermore, the research establishes that working capital management does not exert a discernible influence on the profitability of mining companies. It is important to note that this empirical analysis is limited to Indian companies exclusively.

Keywords: Temperature Change, climate change, performance, mining industry, India, quantile regression.

Introduction

Global research has been concerned about climate change for a long time and the effects of these changes are causing issues worldwide. The Intergovernmental Panel on Climate Change (IPCC), whose primary goal is to 'provide scientific, technical and socioeconomic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation,' was established as early as the 1980s, demonstrating the significance of this issue [12]. Empirical evidence based on climate change is evident in many official reports and scholarly studies. Several research studies have shown that mean temperatures have risen in recent decades[1,6,20-22] and that there is an increased likelihood of severe weather conditions[1]. The weather impacts 70% of global economic activity.

There are several ways that climate change is affecting the mining sector. The construction and mining industries may suffer due to the severity and frequency of extreme climate events[21] and intensify hostility between the public and the mining sector[22]. The way that weather and rising temperatures impact the performance of enterprises remains unknown, mainly despite these evolutions and their substantial socioeconomic impact[20].

Moreover, the existing literature failed to provide evidence of how rising temperatures affect Indian mining companies' profits despite these companies are vital to any economy. More empirical data on this influence is required to assist public policies or decision-making about climate change in the mining industry.

According to the Ministry of Mines, Government of India, a significant portion of the mining sector comprises of small active mines. In India, 1319 mines were reported to produce minerals in 2021–2022 (not including fuel, atomic, or minor minerals), down from 1375 the year before. Madhya Pradesh recorded 263 of the 1319 reported mines, while Gujarat (147), Karnataka (132), Odisha (128), Chhattisgarh (114), Andhra Pradesh (108), Rajasthan (90), Tamil Nadu (88), Maharashtra (73), Jharkhand (45) and Telangana (39) followed in order of decreasing number. In 2021–2022, these 11 States collectively accounted for 93% of all mines in the nation and the mining sector contributed 1.8% of India's GDP.[18]

This research intends to fill this vacuum in the existing literature by evaluating the effect of temperature change (climate change) on business profitability using a sample of 62 listed Indian companies engaged in climate-sensitive industries such as the mining and mineral sectors. It is essential to comprehend how a temperature rise could affect these industries. India is one of the world's top mining nations; a sizable portion of the workforce lives in poverty due to their employment in mines. In most of these mines, every process step is completed by hand, with very few or no machinery other than essential tools being utilized.[9]

By using annual data from more than 62 Indian listed companies between 2011 and 2020, the study demonstrates that (1) temperature changes negatively impact company profitability and (2) the impact varies depending on the quantiles of the profitability distribution. Further, the econometric study demonstrates that the asset turnover ratio and firm size benefit the company's profitability. In contrast, the working capital and capital structure do not affect the profitability of India's mining industry.

The literature on company profitability and climate change has significantly benefited from the study's contributions. The study adds to the expanding body of research on how climate change affects micro-business. Second, the study's methodology uses the Quantile regression (QR) technique, offering several advantages over the approaches based on the mean used in earlier research. The study methodology provides more insight into the relationship between rising temperatures and corporate profitability, indicating that the effect is not as uniform as in other studies[1, 2].

Review of Literature

A number of studies are evidencing the impact of temperature change (climate change) on various macroeconomic and microeconomic variables[1,5,13,15,17,21]. Increased temperature influences cow farming; this effect is not uniform across lightweight placements and heavyweight claves; according to this study, cattle farm productivity varies from winter to summer[19]. Dell et al[10] showed that increased temperature negatively affects the economic growth in economically backward countries and causes harm to the output level of the agriculture, industry and allied sectors in underdeveloped nations; there is a 1.4% drop in per capita GDP for every 1°C increase in mean temperature, by utilizing a sizable sample of countries. According to Li Sheng et al[16], most of the variables, such as precipitation and temperature deviation, will affect the profitability of aquaculture in China.

There is no significant effect of temperature change on establishment sales. Temperature shocks will impact profitability at weather-sensitive locations[21]. Temperature deviation positively affects the performance of energy firms in China. The study used panel quantile regression to test the impact of weather, saying that the effect of temperature change is heterogeneous between the quantiles[7] and Europe[2]. Liu et al[17] stated that temperature change affects the behavior of retail investors and the relation between temperature change and trading activities is U-shaped. The authors used stock brokerage data from 2012 to 2014. Climate change affects the systematic risk in the European stock market[15]. An increase in climate-related issues i.e. temperature, global warming etc. affects future growth risk[5]. Bansal and Ochoa[4] pointed out that countries nearer the equator experience slower economic growth when global temperatures rise.

Previous research has shown that the mining industry is affected by temperature change (also known as climate change) in various ways from an economic standpoint. Over the past three decades, the mining zones have seen the most significant increase in surface temperature. On the other hand, the surface temperatures in the forest areas were the lowest. Although the surface temperatures in the forested areas had increased, they were not as high as in the mining and urban regions. According to Pearce et al[21], many of the severe climate risks that have recently afflicted mines across the Canadian region, are thought to be signs of climate change. Climate change poses an extreme environmental concern and a sizeable commercial threat to the mining industry.

The vulnerability approach is used to determine and describe how susceptible the mining industry in Canada is to climate change. The study demonstrates that climate-related risks impact China's mining industry's financial performance positively and negatively and that this impact varies depending on the resource. Climate change is measured by using the following proxy indicators: the Cryogenic Freezing Index (CYFI), Typhoon Index (CYTI), High-Temperature Index (CYHI), Drought Index (CYDI) and Rain-waterlogging Index (CYRI). There is a significant negative relationship between temperature change and the mining sector's performance. Elevated temperatures created ideal conditions for the coal samples to absorb heat and encouraged the phenomenon of spontaneous coal burning[8]. According to Mavrommatis and Damigos, weather changes negatively affect the profitability of Greece's mining sector. The literature shows that there is a relationship between temperature change (climate change) and mining activities. We investigate the following research idea in light of these studies:

H_1 = There is a negative relationship between temperature change and the performance of the mining sector.

Material and Methods

We have collected data from different sources for the study. The firm-level financial data drawn from the CMIE Prowess database is a private database for Indian firms. We have used temperature change as our independent variable for the study. The temperature data come from the IMF database, an open database for climate issues. In the initial observation, we collected 138 mining companies that were selected based on firm size and reduced to 62 mining firms because of balanced panel data. We have selected data from both public and private sector firms from 2011 to 2020.

Variables Selection: With the help of extensive literature, we have considered firm performance as the dependent variable for the study. We have measured the firm's performance by using proxies like ROE (Return on Equity)[2,14] and ROA(return on Assets). The temperature change is considered the independent variable for the study; it is an outcome of the climate issues. The temperature change is measured by subtracting the average base year temperature from the average annual temperature in the country[1,4,17]. We have used the debt-to-equity ratio, the value of total assets, working capital management and asset turnover ratios, which are taken as the control variables for the study.

Methodology: In order to examine the impact of temperature change on the performance of the mining sector, a study was performed for the performance analysis of the Indian mining firms by using the profit after tax, the total amount of equity and the size of the firm.

Table 1
Variables description

Variables	Definition/ computation	Source
Return on Equity (ROE)	Profit after tax/ Total Equity	CMIE Prowess IQ
Return on Asset (ROA)	Profit after tax/ Total Asset	CMIE Prowess IQ
Temperature Change (TEMP 20)	Annual average temperature/ Average base year temperature	IMF database
Working Capital Management (CCC)	(Account receivable/Sales) *365 + (Clossing Stock/ Cost of goods sold) *365 + (Account Recievable)*365	CMIE Prowess IQ
Total Assets(LNTA)	Natural log of total asset	CMIE Prowess IQ
Asset Turnover Ratio (ATR 2020)	Sales/ Total Asset	CMIE Prowess IQ
Debt Equity Ratio (DE 2020)	Total long-term debt/ Total Equity	CMIE Prowess IQ

The normality of the target variable is to be tested by using the histogram. The histogram testing says that there is no normality in the target variables. Therefore, it used panel quantile regression (QR) as the methodology for the study because it discloses more about the relationship between temperature change and the performance of the mining firm. The QR technique was invented by Koenker and Bassett[13] with the following specifications in their ground breaking paper:

$$y_{i,t} = x_{i,t}\beta_\theta + u_{\theta\, i,t} \quad (1)$$

With

$$Quant_\theta(y_{i,t}|x_{i,t}) = x'_{i,t}\beta_\theta \quad (2)$$

With the following restriction

$$Quant_\theta(u_{\theta\, i,t}|\, x_{i,t}) = 0$$

where $y_{i,t}$ is the dependent variable (firm profitability), $x_{i,t}$ Is a vector of regressors, i stands for firm (i = 1,.., 62), t for time (t = 1,..,10) and β_θIs the vector of parameters to be estimated. $Quant_\theta(y_{i,t}|x_{i,t})$ represents the supplied conditional quantile of $y_{i,t}$ given $x_{i,t}$.

Results and Discussion

Summary statistic and correlation: Table 2 discloses the descriptive statistics of the variables used in the empirical analysis. The descriptive table shows that the mean of ROE and ROA are 0.036 and 0.04 respectively with standard deviations of 0.151 and 0.147. The results found that some of the mining firms had poor financial performance. Compared to the base year temperature, the average annual temperature varies between 0.365 and 1.088 degrees, with a mean change of 0.683. It says that the country's temperature is volatile throughout the study period. We can observe the excess debt ratio in the capital structure of mining firms in India. The firm's working capital management is to be measured with the cash conversion cycle, the statistics showing mismanagement in the firm's cash conversion cycle with a standard deviation of 277. Table 3 includes the Pearson correlation coefficient for the dependent and independent data used in the study. The results show a negative relationship between temperature change and financial performance (ROE and ROA). There is no correlation between the working capital management and the performance of the mining firm and there is a positive relationship between the asset turnover ratio and the performance. Moreover, the variance inflation factor (VIF) statistic was computed and presented in table 4 to examine the potential for collinearity between explanatory variables. Given that every VIF value was below 10.00 threshold limit[11], we believe that multicollinearity may be ruled out.

Empirical results: We have used a panel quantile regression model to analyze the impact of climate change on the performance of mining firms in India. Table 5 demonstrates the quantile regression results of the study. Q25, Q50 and Q75 are used for analysis. The empirical research is to be done separately for two performance proxies. It shows that temperature change negatively affects the performance of the mining firms in India. The effect varies from quantile to quantile. That means compared to the lower quantile in the upper quantile, the impact of a unit change in temperature is high (0.0383% to 0.053%) at a 1% significance.

On the other hand, the temperature change negatively impacts the ROE at 10% significance in Q25; the impact is raised in the other two quantiles, Q2 and Q3, at 1% significance. Working capital management does not affect the performance of the mining firms in India; these results contradict the results concluded in previous studies[14]. There is homogeneity in the impact of the asset turnover ratio and the firm's size on the mining sector's performance in different quantiles. This evidence shows that a unit of increase in temperature results in a 3.8% decrease in the firm's ROE in Q25 and Q50 and a 5.3% decrease in ROE in Q75.

Similarly, a unit change in temperature will affect a 2.6% decrease in the firm's ROA in Q25, 4.1% in Q50 and 2.62% in Q75. It says there is no homogeneity in the effects of temperature change in different quantiles. Hence, we failed to reject our research hypothesis, suggesting that temperature change negatively impacts the Indian Mining sector.

Table 2
Descriptive statistics of the variables used.

Descriptive Statistics							
	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
ROA	3.110545	-2.486174	0.624371	0.040134	0.006092	0.1516	0.023
ROE	2.393256	-1.938942	0.454314	0.035583	0.005916	0.147306	0.022
CCC	4259.499	-1940.898	2318.602	69.0777	11.18037	277.7147	77125.44
Temp 20	0.723	0.365	1.088	0.6823	0.009239	0.230044	0.053
ATR 2020	2.630876	0	2.630876	0.633936	0.017975	0.447586	0.2
DE 2020	448.097	344.6382	103.4588	-0.160587	0.883491	21.99875	483.945

Table 3
Correlation Analysis.

Correlations						
	ROA	ROE	CCC	Temp 20	ATR 2020	DE 2020
ROA	1	0.969*	-0.083**	0.000	0.259*	-0.023
ROE	0.969*	1	-0.098*	-0.009	0.265*	-0.009
CCC	-0.083**	-0.098*	1	0.004	-0.021	-0.058
Temp 20	0.000	-0.009	0.004	1	-0.162*	-0.013
ATR 2020	0.259*	0.265*	-0.021	-0.162*	1	0.005
DE 2020	-0.023	-0.009	-0.058	-0.013	0.005	1
Note: *. Correlation is significant at the 0.01 level (2-tailed). **. Correlation is significant at the 0.05 level (2-tailed).						

Table 4
Variance Inflation Factor (VIF) statistics of the explanatory variables.

Collinearity Statistics		
Variables	**VIF**	**Tolerance**
Temp 20	1.0053	0.995
CCC	1.0452	0.957
DE 2020	1.0042	0.996
ATR 2020	1.0668	0.937
LNTA 20	1.0512	0.951

Table 5
Quantile regression results.

	ROE			ROA		
	Q-0.25	**Q-0.50**	**Q-0.75**	**Q-0.25**	**Q-0.50**	**Q-0.75**
(Intercept)	-0.0466* (0.0211)	-0.0466** (0.0211)	0.11** (0.0214)	-0.0866* (0.02)	-0.0487** (0.0226)	-0.0131* (0.0295)
Temp 20	-0.0383* (0.0144)	-0.0383* (0.0144)	-0.053* (0.0174)	-0.0264*** (0.0136)	-0.0411* (0.0154)	-0.0562* (0.02)
CCC	0.000 (0000)	0.000 (0000)	0.000 (0000)	0.000 (0000)	0.000 (0000)	0.000 (0000)
ATR 2020	0.0547* (0.0076)	0.0547* (0.0076)	0.0770* (0.0092	0.0422* (0.0072)	0.059* (0.0082)	0.090* (0.0106)
DE 2020	0.000 (0000)	0.000 (0000)	0.000 (0000)	0.000 (0000)	0.000 (0000)	0.000 (0000)
LNTA 20	0.0087* (0.0018)	0.0087* (0.0018)	0.0078* (0,0022)	0.0087* (0.009)	0.001* (0.0019)	0.010* (0.0025)
Note: The dependent variables are ROE and ROA. The temp is the independent variable for the study. *, ** and *** denote the significant value at 1%, 5% and 10%. 'Q' denotes the quantiles.						

This study shows that climate change negatively affects the country's mining operations. Because we have taken temperature change as the independent variable, it impacts the performance of the mining firms. The performance of mining firms depends on their operation level. Increased temperature may affect the performance of the mining laborers and the Government's action toward environmental policies may affect the working of mines.

This empirical result follows the study concluded by Sun and others[23], that the financial performance of China's listed mining businesses is negatively impacted by hazards associated with cryogenic freezing and high temperatures.

Conclusion

Climate change is a threat to the present economy. The environmental issues from climate change are connected with the daily routine of the human being. This study examined the impact of climate change on the performance of the mining sector in India. The study has been done on the basis of secondary data. The study sample comprises of data from 62 Indian-listed mining corporations over 10 years. Return to equity and return on assets measure the firm's performance. Quantile regression calculates the impact of temperature change on different quantiles.

The study's results suggest that the impact of temperature change on the performance of mining companies is not heterogeneous in different quantiles. Still, overall, we can see the negative effect of climate change on firms' performance. Firms with higher returns have more influence from the climate change in India. This study concludes that along with firm-specific factors, climate-related issues also affect the performance of the mining industries in India. Therefore, the study suggests that temperature change is an essential factor in analyzing the performance of the mining firm. This study will benefit the firm's policymakers, household investors and management.

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