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Does Volatility in Air Pollution Index

Affect Firm Financing Pattern?

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Abstract

Objective: This study investigates the impact of air pollution index volatility on firm financing patterns by conducting an analysis of non-financial sector enterprises of 6 Asian economies.

Methodology: To achieve the objective of our study, we employed a two-step system, the Generalized Method of Moment, to establish the regression among the variables.

Findings: The results of the estimated technique in our analysis shed light on an issue that the highly polluted firms confront environmental violation risk, urging financial institutions and stakeholders to incorporate carbon-related hazards into their investing and lending decisions. As a result, firms face tougher terms and conditions when raising funds by using both debt and equity financing. Therefore, the current analysis documents an adverse impact of the environmental pollution index on both debt and equity financing.

Implications: The findings in our analysis infer that corporate managers should consider the consequences and sensitivity of the rising air pollution index in their decision-making to ensure sustainability in financing policies.

Novelty: This research introduces new insights into the real effects of environmental pollution on firm financing patterns by introducing new arrangements of the variables.

This research relies on decision sciences fundamentals by exploring the impact of air pollution on firm financing patterns. Decision sciences intend to improve the procedures of decision-making. Moreover, our work seeks to expand such processes in the context of healthy financing decisions under high environmental hazards.

Keywords: Air Pollution Index, Firm Debt and Equity Financing, Climate Change, Environmental Risk

JEL Codes: Q53; G32

1. Introduction

Climate change due to industrialization is rapidly affecting the lives of all living things worldwide (Adnan, et al., 2022). Industrialized countries have grown substantially during the past decades and sacrificed environmental quality to achieve remarkable growth. Moreover, for this purpose, they adopted reckless behavior by disregarding the biophysical impact of economic activities on the environment. Generally, they ignore one goal to bring sustainability to another goal (Arfaoui & Yousaf, 2022; Awad, 2022). The literature regarding environmental economics (air pollution) mainly concentrates on its impact on human health, the environment, and some firm-level decisions, i.e., firm cash holding, stock prices, and firm performance (Hu, et al., 2022; Liu, et al., 2021; Tan, et al., 2021, 2022; Tan & Yan, 2021), but the liaison between air pollution index and firm financing pattern is relatively scarce and underexplored. Moreover, the air pollution index (API) may raise stakeholders' pessimistic emotions, leading to high risk. At times of high air pollution, firms try to hold more cash to confront any risky situation because of their risk aversion behavior, pessimistic emotions of financial institutions, and the general public urge firms to make daring decisions to mitigate air pollution (Gohar, et al., 2023; Liu, et al., 2020). Companies should strive to become ESG leaders from a corporate perspective, as this will bolster their resilience to economic disturbances. Additionally, conforming to ESG standards assists companies in combating climate change (Yadav, 2022). In this situation, firms face a dilemma regarding considering their financing decisions efficiently. More specifically, people are more concerned regarding intensified climate destruction driven by global warming and the greenhouse effect. Such climate destruction affects human health and economies. As a result, environmental risks rise in the shape of environmental taxes that increase default risks. These risks increase the firm's upcoming cash flows and credit risks (Chiang, et al., 2010; Tan, et al., 2022). Therefore, in this study, we try to answer how firms manage their financing needs under a high air pollution index.

Air pollution's acute mobility and negative externality have gotten the world's attention. The world's biggest economies (China and the U.S.A.) have decided to mitigate pollution emissions and want to make themselves carbon neutral by 2050. According to a survey by the World Trade Organization, 100 percent of the population of China was affected by PM 2.5 (particulate matter) during 2010-2017. Some studies have mentioned that the high air pollution index harms humans' physical and mental health (Adnan, et al, 2022; Hu, et al., 2022). It also affects the environment. The concern of the relevant authorities and the general public regarding air pollution is increasing daily, and they strictly impose ecological regulations to diminish environmental effects. Moreover, the corporate sector is considered a more powerful driver of economic development with a high producer of air pollution (Bai, et al., 2020; Nam, et al., 2019). Therefore, China has started the Blue Sky Defense campaign to ensure the sustainability of a clean environment by using different techniques and strategies, e.g., forest conservation, green building practices, environmental education, renewable energy, and recycling and waste assimilation. Undoubtedly, such methods stop the contaminating behavior of the firms by punishing them. In addition, pollution-intensive firms face high environmental violation threats (Guo, et al., 2020), and this risk may enhance the

uncertainty risk in its present and future cash flows, leading to high default risk (Jung, et al., 2018). Environmental institutions' routine and regular monitoring make environmental risk compulsory, and the creditor cannot overlook this risk while making lending decisions. In brief, how air pollution-intensive firms manage their financing needs efficiently is worthy of exploration.

This study discovers the impact of air pollution on firm financing patterns. For this purpose, this study uses data from selected Asian economies, e.g., China, India, Japan, Pakistan, South Korea, and Singapore, from 2010 to 2019. For analysis, we employ a two-step system, Generalized Methods of Moment. Moreover, the findings of applied methodology highlight that a rise in the air pollution index will make financing through debt and equity more difficult due to environmental risk. It further shows an inverse liaison between the air pollution index and firm debt and equity financing. The statistical findings of this study are consistent with hypotheses and are robust to alternative metrics of tight financing patterns and air pollution. In brief, the pessimistic emotions of financial institutions and other creditors limit them from lending finance to pollution-intensive firms. Similarly, equity holders and other stakeholders consider environmental risk while investing and purchasing shares, which discloses an inverse link between the air pollution index and firm equity financing. Furthermore, firm-specific and country-specific control variables are significant determinants of tight debt financing and strong equity financing. The firms should consider the expected consequences of air pollution while making firm-level decisions, e.g., financing decisions. The findings are enough to disclose that air pollution is a significant determinant of the firm financing decisions.

This research contributes differently. Firstly, as per our best information, this is the only study that describes the broad impact of the air pollution index on firm financing patterns. Secondly, this study unveils that air pollution is a significant formal and informal determinant of healthy financing decisions. Thirdly, this study advances the literature on firm financing decisions in the presence of air pollution. It further suggests a precautionary motive for firms situated in highly polluted areas. Additionally, it enhances the literature on green finance and the primary focus of the green finance literature is to reveal environmental information and ecological investment tools, for instance, carbon pricing and green bonds (Fonseka, et al., 2019; Wang, et al., 2020). Fourthly, corporate managers may consider the sensitivity of the air pollution index while making business decisions. Moreover, this work plays a vital role in contributing to the enhancement of decision sciences. We ensure that our results contribute to the existing literature in the field by providing more reliable decisions. It further highlights the challenges and trends in decision sciences.

The remaining part of the article is managed as follows. We start the coming-up section with a literature review, discussing the development of hypotheses. In the third section, we describe the population, sample size, variables description, econometric equation, and discussion of methodology. The fourth chapter reports results (e.g., descriptive, correlation, and regression analysis). Similarly, the fifth chapter discusses the reported results in detail. The sixth section discloses the conclusion, policy recommendation, and study limitations.

2. Review of Literature

Air pollution (particulate matter) hurts individual health (Adnan, et al., 2022). Global Burden of Disease Report (GBDR) documented in 2017 that air pollution has swiftly spread among people and affected them very badly. Moreover, it is considered a more dangerous health risk factor. It causes respiratory disease and heart problems, which ultimately raise mortality rates (Franklin, et al., 2015). In addition, it adversely affects psychological well-being by increasing frustration, anxiety (Evans, et al., 1988), pessimism, minimizing happiness (Zhang, et al., 2017), lessening routine outdoor activities (Noonan, 2014), and suicidal thoughts (Lu, et al., 2018). The World Health Organization (WHO) organized research in 27 countries and found that increased air pollution lowers the quality of life (Darçın, 2014). However, air pollution disrupts the firm's external stakeholders and ultimately derails the firm's financial operations (Tan, et al., 2021). To control the expansion of air pollution, relevant authorities introduce environmental regulations. The purpose of such rules is to stem the firm's polluted operations. For instance, in the wake of the Olympic Games in Beijing 2008, the local government removed 60000 buses and taxis by the end of 2007. They also relocated 200 local factories while discontinuing production processes in the surrounding area, and after that, they noticed a substantial change in air quality. The air quality improved significantly during that period (Ma & Takeuchi, 2020). Moreover, the supply chain partners also do not want air pollution. The study by Liu, et al. (2020) noted that environmentally friendly consumers bring competition among firms to invest more in eco-friendly technology. In short, this section develops hypotheses to find a link between the air pollution index and firm financing patterns.

2.1 Air Pollution and Firm Financing Pattern

The proliferation of air pollution is increasing daily, increasing stakeholders' pessimistic expectations regarding polluted firms. Such expectations may push the government and other relevant institutions to give punishment to environmental violator firms (Pu, et al., 2019). Furthermore, it causes many diseases (Molina & Molina, 2004). The pollution emitter firms may confront a high risk of ecological violation by environmental regulatory institutions (Guo, et al., 2020). In addition, it is a transparent signal to stakeholders in circumstances of asymmetric environmental information. Moreover, firms are concerned about financial losses due to ecological violation risk because such losses may enhance the default risk of firms and the uncertainty in upcoming cash flows (Jung, et al., 2018; Zhou, et al., 2018; Demirer, et al., 2019). Generally, firms facing ecological violation risk may have high credit risk (Weber, 2012). Moreover, creditors, e.g., banks and other lending institutions, cannot overlook ecological risks regarding air pollution while making lending decisions (Thompson, 1998). The study by Tan, et al. (2021a, 2022) described that firms situated in highly polluted areas or polluted firms confront strict debt financing constraints. This further reveals a negative liaison between the air pollution index and debt financing. Jung et al. (2018) found a direct connection between firms' carbon emissions and debt financing costs. Similarly, Chen and Silva Gao (2012) surveyed the US electric utility industry and found a positive connection between carbon secretion and the cost of capital.

The abovementioned work of different scholars investigated the relationship between air pollution and firm-level decisions, e.g., cash holding decisions, firm performance, and supplier trade credit technique. Such studies, nevertheless, did not consider air pollution's impact on strong capital structure comprehensively. On the contrary, this study considers a broad range of business corporations nationwide to find the relationship between air pollution and firm financing patterns. Moreover, this study separately checks the impact of air pollution on equity financing and debt financing. It further tries to explain how different theories of environment and capital structure support the relationship between the air pollution index and firm financing pattern. Previous works have not given sufficient discussion to consider air pollution's impact on firm capital structure. This study fills this literature gap.

Lam, et al. (2010) introduce a novel model employing a pseudo-Bayesian method, incorporating investor biases to assign weights to stock price shocks, revealing connections between market anomalies and behavioral tendencies. Examining anomalies' dependency on these weights offers a quantitative assessment and uncovers fresh insights beyond traditional short-term underreactions and long-term overreactions in markets. Ramzan (2021) explored how currency fluctuations impact foreign investment, revealing that exchange rate volatility detrimentally affects FDI in Pakistan, particularly during crises and political stability. To attract more foreign investment, policymakers should prioritize measures promoting exchange rate stability and develop resilient investment strategies amid economic uncertainty. Rjoub, et al. (2021) delved into Turkey's carbon emissions from 1960 to 2016, exploring the impact of economic factors like growth, capital, energy use, and urbanization alongside the significant role played by financial development in moderating these emissions. It underscores the need for environmental-focused policies, suggesting ways for Turkish policymakers to mitigate carbon emissions while enhancing environmental quality through strategic interventions in financial development. Zada, et al. (2021) investigated the significance of jumps in equity market returns and volatility, discovering that emerging markets experience more frequent positive jumps. It highlights the impact of jumps on market returns, indicating that highly volatile developed and moderately volatile emerging markets tend to yield higher returns during jump periods. Additionally, it emphasizes the relevance of these findings for asset pricing models, risk management, and investment strategies in both developed and emerging markets.

Firms use the tangibility of total assets for debt financing and equity financing because banks, other financial institutions, and shareholders (stakeholders) consider firms' tangibility ratio while issuing debt financing and purchasing shares. In addition, having more tangible assets allows a firm to pay all its liabilities and, in this way, may easily win the trust of banks, financial institutions, and other stakeholders. Akbar et al. (2021) found a positive relationship between tangible assets, debt financing, and equity financing. Similarly, the firm's size is positively connected with firm debt and equity financing (Gohar, et al., 2023; Jung, et al., 2018; Imane, et al., 2023). The firm's size is calculated as a log of total sales; when sales increase, the profit will increase. The firm will be able to pay all its liabilities either in the shape of debt or in the form of dividends, which leads

to easy approachability to debt and equity financing. However, the increasing interest rate is negatively associated with debt financing and positively connected with equity financing. This is because high-interest rate charges by lending institutions discourage firms from debt financing, and firms prefer equity financing. The firms under financial development provide hefty funds on lax lending conditions, which shows a positive link between financial development and firm debt financing (Subhani, et al., 2021). In brief, the literature proved that the control variables of the current study are significant determinants of firm financing patterns.

H_1: There is a negative and significant relationship between the air pollution index and firm financing pattern.

2.2 Theory and Theorization

Theory and theorization explain how different capital structure theories confirm the connection between main explained and main explanatory variables. The agency cost theory was introduced by (Jensen & Meckling, 1976). This theory states agency conflict is a conflict between shareholders (owners) and agents (managers). Moreover, the optimal financing pattern tries to eradicate the competition between agents and shareholders while enhancing shareholder wealth. As per this study, air pollution increases a firm's environmental risk. Therefore, the firm's managers are directly involved in the firm's operations and are more concerned about the firm. They make daring decisions on a firm level, which may create information asymmetry problems between agents and shareholders. Thus, they make shareholders well aware of firms' operations (carbon risk awareness) and try to mitigate the conflict between agents and shareholders. Moreover, the information asymmetry problem will be low, and they can make rational decisions regarding firm capital structure. Similarly, trade-off theory highlights that the firms prefer more economical financing. This theory was introduced by (Modigliani & Miller, 1958). However, the pecking order theory identifies that firms should prioritize using internal funds (reserves) and then go towards external financing. This theory was introduced by (Myers & Majluf, 1984). Besides these three theories, environmental stress theory and human capital theory describe the link between main explained and explanatory variables. The environmental stress theory states suppliers and financial institutions lend less funds or supply to polluted firms or firms in highly polluted areas (Tan & Yan, 2021). Similarly, human capital theory highlights that firms acquire few laborers but invest more in firm operations due to its negative impact on air pollution. (Song, et al., 2022). Our results are consistent with our hypothesis by approving these theories.

The capital structure relevance approach states that when we change the capital structure, the cost of capital or value of the firm will change. Nevertheless, the capital structure irrelevance approach pinpoints that the change in capital structure will not change the cost of capital or the value of the firm. In addition, according to the net income approach, when firms increase the proportion of debt in capital structure, the overall cost of the debt will be low, and it is based on the assumption that the price of the debt is lower than the equity cost. In brief, according to the net income approach, the firm should enhance the proportion of debt in its capital structure to decrease the cost or increase its value. For instance, if the price of debt is 6 percent, the firm is paying an interest rate

of 6 percent, but the firm is paying equity at 10 percent. Thus, according to the net operating approach, if a firm increases the proportion of the debt in its capital structure, it becomes riskier because it has a more significant financial obligation to pay more interest. However, the traditional approach states that there is an optimal point for taking debt financing, and firms should not go beyond the optimal point; if it goes beyond the optimal point, adverse results will come. Moreover, the Modigliani and Miller (MM) model is based on a net operating income approach. The hierarchy of theories is given below.

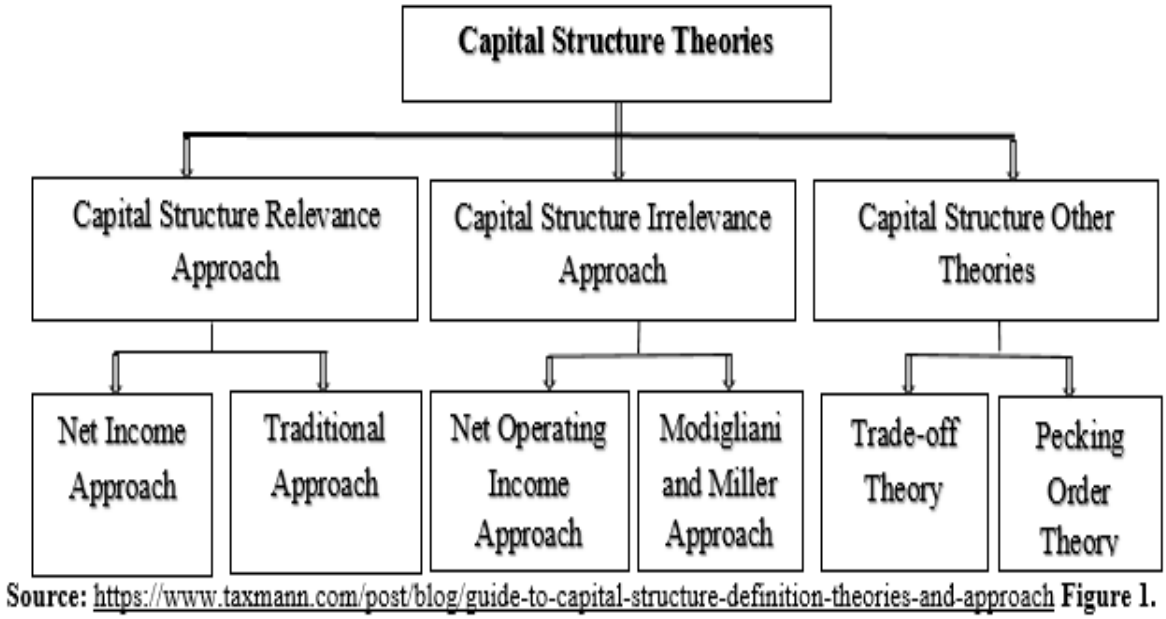

Figure 1. Capital Structure Theories Approach

Figure 2 shows the relationship between explained and explanatory variables.

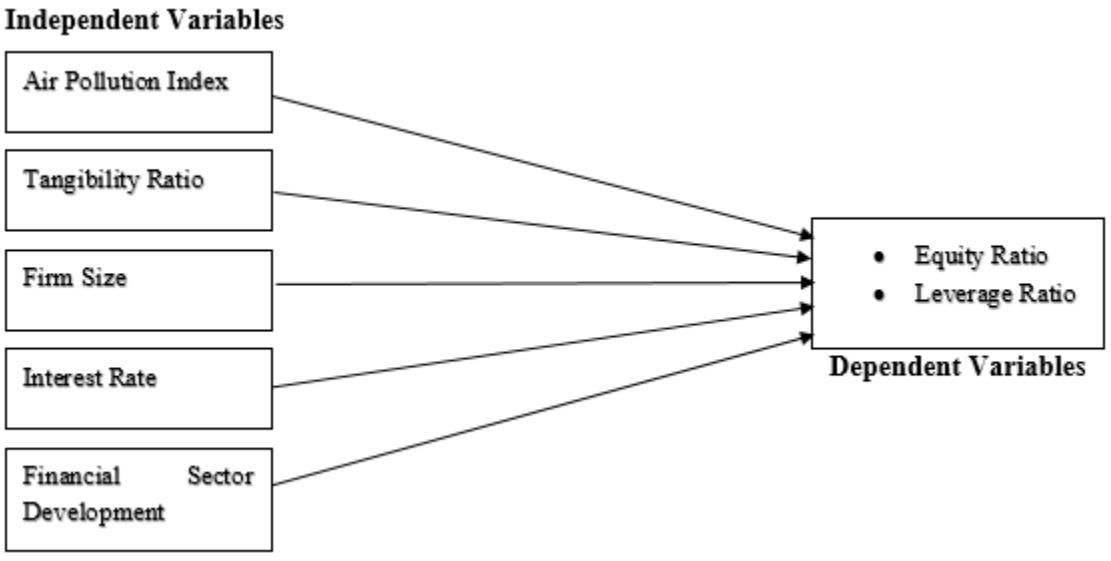

Figure 2. Conceptual Framework

3. Material and Methods

3.1 Data

We considered a sample of listed firms in China, India, Japan, Pakistan, South Korea, and Singapore from 2010-2019. For this purpose, we used Thomson Reuters Datastream for firm-specific variables, National Greenhouse and Energy Reporting, and World Development Indicators to collect data on air pollution and macroeconomic variables. Moreover, the purpose for considering this sample and period is that the under-analyzed economies are major emitters of CO2, and they have continuously emitted massive quantities of CO2 emissions in the last decade (Parker & Bhatti, 2020; Saleem & Ali, 2019; Song & Zhang, 2019). However, we excluded the firms that did not meet the following conditions: (1) financial firms, (2) firms missing five years or more than five years data, and (3) firms with delisting risk. We eventually retained 3831 firms after a transparent screening process. Finally, all variables were winsorized at the 1 percent level to eradicate the effect of very high and very low values.

3.2 Variables Description

PM 2.5 air pollution means annual emissions (micrograms per cubic meter). PM stands for particulate matter, made up of solids, particles, or liquid droplets in the air. The primary source of this matter is burning and dust-generating events. Moreover, the equity ratio is measured as total shareholders' equity divided by total assets. Similarly, the tangibility ratio is computed as total fixed assets divided by total assets. The firm's size is enumerated by taking the logarithm of total sales. Real Interest rate is the lending interest rate that is adjusted for inflation. It is computed as a GDP deflator. The International Monetary Fund (IMF) developed a systematic measure of FSD and divided it into financial institutions and financial markets. The measurement of FSD is based on depth, access, and efficiency.

3.3 Econometric Models

We use two specific forms of the econometric equations in which one equation is shown in the following.

$$LR_{ijt} = \alpha_{\circ} + \alpha_1 LR_{ijt-1} + \alpha_2 API_{jt} + \beta_1 TR_{ijt} + \beta_2 FS_{ijt} + \gamma_1 IR_{jt} + \gamma_2 FSD_{jt} + \varepsilon_{jit}. \quad (1)$$

The econometric equation in (1) exhibits the liaison between explanatory variables and explained variables in which "LR_{ijt}" represents the overall ratio of debt in capital structure and it is used as the main explained variable, the subscript "i" shows industrial change and "t" shows time variations. The combination of cross-section and time-series data is called panel data. Moreover, the term "LR_{ijt-1}" describes the lagged term as an explanatory variable and is added into the econometric equation as a control variable. The term "API_{jt}" stands for air pollution index, and it is used as a main explanatory variable. The subscript "j" reveals that the data were collected from

different countries. The term "TR_{it}" shows a tangibility ratio and is used as a control variable. The term "FS_{ijt}": is firms' size and is also considered a control variable. In addition, "IR_{jt}": exhibits interest rate and is used as a country-specific control variable. The "FSD_{jt}" stands for financial sector development and is also considered a country-specific control variable. At the end of equation 1, the ε_{jit} represents the residuals. Similar work was conducted by both Farooq, et al. (2023) and Phan, et al. (2022) who explored the air pollution index on decisions regarding corporate investment in the context of BRICS economies so that they considered the following econometric equation:

$$ER_{ijt} = \alpha_{\circ} + \alpha_1 ER_{ijt-1} + \alpha_2 API_{jt} + \beta_1 TR_{ijt} + \beta_2 FS_{ijt} + \gamma_1 IR_{jt} + \gamma_2 FSD_{jt} + \varepsilon_{jit}. \quad (2)$$

The econometric equation in (2) discloses the connection between explanatory and explained variables in which "ER_{ijt-1}" shows the overall equity ratio in capital structure and it is also considered as an explained variable. The rest of the variables (independent variables) are the same as in Equation 1. A similar pattern of building econometric models was used in the study of (Farooq, et al., 2023). Table 1 shows the description of variables and relevant references.

Table 1. Portray of Variables

Variables	Short Name	Used as	Reference
Air Pollution Index	API	IV	(Tan, et al., 2021)
Equity Ratio	ER	DV	(Jung, et al., 2018)
Leverage Ratio	LR	DV	(Li, et al., 2019 ; Subhani, et al., 2023)
Tangibility Ratio	TR	CV	(Tan, et al., 2021)
Firm Size	FS	CV	(Tan & Yan, 2021)
Interest Rate	IR	CV	(Subhani, et al., 2021)
Financial Sector Development	FSD	CV	(Farooq, et al., 2020)

Note: This table discloses the short and apparent picture of variables. **Abbreviations:** ER: Equity Ratio, LR: Leverage Ratio, API: Air Pollution Index, TR: Tangibility Ratio, FS: Firm Size, IR: Interest Rate, FSD: Financial Sector Development

4. Base Line Results Reporting and Discussion

To find the impact of environmental pollution on firm financing patterns, we estimated our econometric model from Pooled Ordinary Least Square (POLS). We found the validity of the results by applying the Breusch Pagan technique, where we developed a null hypothesis which disclosed that the probability value is below 0.05, which rejected the null hypothesis. After this, we moved toward the random effect technique, where we applied the Hausman approach to examine the validity of the random effect model by developing the null hypothesis. Moreover, we

found a probability value less than 0.05, which rejected the null hypothesis, and, in this way, we accepted an alternate hypothesis, which led us toward the fixed effect technique. In brief, after Breusch Pagan and Hausman's approaches, we found that the fixed effect approach is more efficient and appropriate than POLS and random effect approaches. Before moving further, it is necessary to examine the stationarity of the data to acquire more precise and more accurate results. For this purpose, we used the unit root technique. We checked the following properties to confirm the data stationarity: (1) The mean and variance of the stationer series should be constant, but its covariance should rely on its lag value; (2) It should be time-invariant. But, here, in this case, the data was stationary. Table 2 below shows the results of the unit-root test.

Table 2. Unit Root Test

	Im, et al. (2003)		Dickey & Fuller (1979)	
	Statistics	**Prob.**	**Statistics**	**Prob.**
ER	-1.834***	0.033	8667.89***	0.000
LR	-7.393***	0.000	8968.84***	0.000
API	-256.630***	0.000	54051.0***	0.000
TR	-16.299***	0.000	9244.60***	0.000
FS	-23.741***	0.000	11178.7***	0.000
IR	-6.159***	0.000	7595.73***	0.000
FSD	-125.712***	0.000	31006.9***	0.000

Abbreviations: ER: Equity Ratio, LR: Leverage Ratio, API: Air Pollution Index, TR: Tangibility Ratio, FS: Firm Size, IR: Interest Rate, FSD: Financial Sector Development. **Note:** The statistics show that all variables are stationary at level I(0). **Source:** Authors own calculations

Our econometric model is a combination of firm micro-level variables (firm-specific) and macro-level variables (country-specific), and there may be chances of a relationship between residuals and independent variables. Moreover, the link between residual and independent variables may create the error of endogeneity. To identify the presence of endogeneity, we used the Wald test, and its statistics values validated the presence of endogeneity. The statistics are reported in Table 3. In Table 3, C(1), C(2), C(3),…C(6) are the restriction term for each variable of study. The statistics show that all restriction terms are linear in coefficients. Moreover, we cannot collect accurate results due to this endogeneity error. To eradicate the error of endogeneity, we employed a two-step system, the Generalized Method of Moment (GMM). Moreover, we have panel data, and GMM is a suitable approach for panel data, but it can also be used for cross-section and time series data. GMM can eradicate the problem of serial correlation, endogeneity, and heteroscedasticity. The GMM system was first introduced by Arellano and Bover (1995) and Blundell and Bond (1998) by describing that this technique is more efficient than the different GMM approaches. Moreover, the study of Bond, et al. (2001) asserted that this approach can correct unobserved country heterogeneity, calculation error, and simultaneity error. In a recent study, Farooq, et al. (2023) used this GMM technique.

Table 3. Endogeneity Identifications

Test Statistics	**Value**	**Df**	**Probability**
F-statistic	720.044	(6, 26191)	0.000
Chi-square	4320.267	6	0.000
Individual Hypothesis			
Null Hypothesis: C (1) =0, C (2) =0, C (3) =0, C (4) =0, C (5) =0, C (6) =0			
Normalized Restriction	DF		Standard Error
C (1)	-0.035		0.146
C (2)	0.041		0.010
C (3)	0.008		0.001
C (4)	0.010		0.012
C (5)	0.056		0.005
C (6)	0.011		0.001

Note: For information on C(1) C(2) C(3)…C(6) refers to the text. * Significance at 10%; ** significance at 5% level; *** significance at 1%. **Source:** Authors own calculations.

Table 4 unveils the summary of descriptive statistics for the applied approaches to finding the impact of the environmental pollution index on firm financing decisions. It further highlights the characteristics of the data set. Therefore, the mean equity ratio is 0.433, indicating that most of the sampled firms hold 43 percent equity financing in overall financing. Moreover, the mean value of the equity ratio is higher than the median value (0.425), disclosing that the listed firms have a higher level of equity financing. Similarly, the maximum and minimum statistics of the equity ratio are 0.899 and 0.000, respectively. The standard deviation value of the equity ratio is 0.170, which shows the state of the data being scattered from the mean value. However, the average leverage ratio is 0.282, meaning that average listed firms hold a 28 percent debt ratio to finance their assets. The median value of the debt ratio is 0.272. The maximum and minimum statistics are 0.900 and 0.000, respectively. The mean and median statistics of the air pollution index are 41.310 and 27.213, respectively. Moreover, the values are distributed between 11.623 and 97.599, respectively. The average levels of firm-specific and country-specific control variables are 0.356, 2.514, 2.41, and 0.694 (tangibility ratio, firm size, interest rate, and financial sector development), respectively. Moreover, the statistics regarding control variables are consistent with the prior literature (Tan, et al., 2021). In brief, Table 4 shows the basic consequence of a data set.

To explore the liaison among variables, we construct a correlation coefficient approach. Moreover, Table 5 displays the correlation coefficient between variables. Every cell in the table depicts the correlation between two variables. Quite intuitively, in column 2, the equity ratio is negatively correlated to all other variables except financial sector development (FSD). Similarly, in column 3, the leverage ratio is positively correlated to the air pollution index (API), tangibility ratio (TR), and interest rate (IR), but it is negatively correlated to firm size (FS) and financial sector development (FSD). Moreover, in column 4, the air pollution index is positively correlated to TR and IR but negatively correlated to FS and FSD. The rest of the variables show a customary picture of the correlation among variables. In short, correlation coefficients among all other explained and

explanatory variables are comparatively small and less than 0.05 percent, indicating that the regression equation does not generate serious multicollinearity error.

Table 4. Apparent Portray of Descriptive Statistics

Variables	Mean	Median	Max.	Min.	Std. Dev.	Observation.
ER	0.433	0.425	0.899	0.000	0.179	37545
LR	0.282	0.272	0.900	0.000	0.173	37545
API	41.310	27.213	97.599	11.623	31.596	37545
TR	0.356	0.340	0.900	0.000	0.196	37545
FS	2.514	2.469	5.677	0.017	0.774	37545
IR	2.481	2.632	8.321	-5.079	2.291	37545
FSD	0.694	0.813	0.864	0.171	0.180	37545

Note: This table shows the descriptive analysis of the study variables. **Abbreviations:** ER: Equity Ratio, LR: Leverage Ratio, API: Air Pollution Index, TR: Tangibility Ratio, FS: Firm Size, IR: Interest Rate, FSD: Financial Sector Development**. Source:** Authors Own Calculations

Table 5. Apparent Portray of Correlation Analysis

Variables	ER	LR	API	TR	FS	IR	FSD
ER	1.000						
LR	-0.717	1.000					
API	-0.151	0.238	1.000				
TR	-0.095	0.339	0.147	1.000			
FS	-0.149	-0.039	-0.288	-0.060	1.000		
IR	-0.054	0.084	0.229	0.042	-0.116	1.000	
FSD	0.143	-0.215	-0.944	-0.148	0.282	-0.237	1.000

Note: This table shows the correlation analysis for variables. **Abbreviations:** ER: Equity Ratio, LR: Leverage Ratio, API: Air Pollution Index, TR: Tangibility Ratio, FS: Firm Size, IR: Interest Rate, FSD: Financial Sector Development**. Source:** Authors' Calculations

We reported our baseline regression statistics of equation 1 (leverage ratio) and equation 2 (equity ratio) in Table 6. In Table 6, LR(-1) and ER (-1) show the lag of dependent variables, which are necessary to add in the case of the GMM model. The coefficient of the API (air pollution index) is -0.008, which is significantly negative at level 1%. We can note a negative and significant relationship between the air pollution index and debt financing. This further explains that the firms situated in highly polluted areas, or the highly polluted firms, tend to save more cash for facing upcoming expected operating challenges. Moreover, the local government in highly polluted areas will face tremendous pressure, and the general public will react to this critical situation. Some relevant authorities may limit business manufacturing operations to protect the environment from becoming Hazardous, impeding firms' operations and income. Therefore, firms in highly polluted areas or highly polluted firms are subject to severe financial impediments (Li, et al., 2021; Tan, et al., 2021).

Similarly, the statistics also show an adverse liaison between the air pollution index and firm equity financing. It further means that air pollution has a material impact on the masses' emotions and decision-making. Moreover, high air pollution can make stakeholders, customers, and investors pessimistic regarding stock prices, which minimizes optimistic earnings forecasts (Tan, et al.,

2022). We further explored the idea that business managers are subject to cognitive impairments like other people. The operating cost in highly polluted areas is higher than firms in lower air pollution areas because employees in polluted areas face more physical health issues than those in less polluted areas. In line with these understandings, firms in highly polluted areas face high operating risk, high default risk, and financing constraints. In short, firms located in highly polluted areas also face high equity financing costs, and, in this way, firms do not prefer equity as a financing tool (Tan, et al., 2021).

Baseline regression statistics also reveal the liaison between the main explained variables and firm-specific and country-specific control variables. A positive connection exists between the tangibility of total assets and firm leverage ratio. This is because having more tangible assets maximizes the bankruptcy recovery ratio by mitigating creditor loss, leading to a low debt cost (Jung, et al., 2018). However, there is an inverse connection between asset tangibility and firm equity financing. The firm size and assets tangibility disrupt environmental investment, which hurts eco-friendly investors to invest, and they limit themselves to purchasing firm securities (Akbar, et al., 2021), which also highlights an inverse link between firm size and firm equity financing. Furthermore, high sales bring high profits, enabling enormous businesses to pay their liabilities easily. This also helps businesses obtain debt financing with minimum hindrance, which discloses a positive connection between firm size and firm debt financing (Subhani, et al., 2021; Wen, et al., 2021). On the other hand, results also show that the country-specific variables (real interest rate and financial development) are significant determinants of firm financing patterns. An increment in interest rate discourages corporate firms from financing debt because of high debt financing costs, and businesses prefer to do equity financing. This shows a positive link between equity financing and interest rates and a negative connection between interest rates and debt financing (Farooq, et al., 2020; Wen, et al., 2022). Furthermore, the advancement in the financial sector brings more clarity and low regulations to lend funds to firms, which urges firms to have more debt financing, demonstrating a positive connection between financial development and debt financing. In brief, the results validated the estimated methods.

The adjusted R-square statistics of both models are 0.853 and 0.872. It further shows whether an additional explanatory variable improves the model or not because the adjusted R-square is adjusted for the degree of freedom. The standard error statistics of the regression of both models are 0.066 and 0.064, respectively. It represents that the responses of under-analyzed firms are just 6.6 and 6.4 from the regression line. The statistics of Durbin Watson are 1.751 and 1.888, respectively. It negates the endogeneity problems. The values of J-statistics are 0.830 and 0.790 respectively.

Table 6. Regression Analysis (Two-step System Generalized Method of Moment)

	LR as Dependent Variable		**ER as Dependent Variable**	
Variables	**Coefficient**	**Probability**	**Coefficient**	**Probability**
Constant C	-0.935***	0.000	0.054***	0.000
Leverage Ratio (-1)	0.471***	0.000	-	-

Equity Ratio (-1)	-	-	0.935***	0.000
Air Pollution Index	-0.008***	0.000	-0.000***	0.000
Tangibility Ratio	0.110***	0.000	-0.006***	0.001
Firm Size	0.056***	0.000	0.003***	0.000
Interest Rate	-0.011***	0.000	0.002***	0.000
Financial Sector Development	0.745***	0.000	-0.010	0.013
Adjusted R-squared		0.853		0.872
Durbin-Watson Stat		1.751		1.888
S.E. of regression		0.066		0.064
J-statistic		0.830		0.790

(***) Three asterisks are required at level %, **(**)** are required at level 5 %, and **(*)** is required at level 10%. **Note:** Authors Own Calculations **Abbreviations**= ER: Equity Ratio, LR: Leverage Ratio, API: Air Pollution Index, TR: Tangibility Ratio, FS: Firm Size, IR: Interest Rate, FSD: Financial Sector Development **Source:** Authors own calculations

Table 7 discloses the results of the Robust Least Square (RLS) technique. This technique deals with normality and homoscedasticity. Moreover, RLS results validate the accuracy and reliability of the Two-step System Generalized Method of Moments results.

Table 7. Robust Least Square (RLS)

	LR as dependent Variable		**ER as the dependent variable**	
	Statistical outcomes RLS			
Variables	**Coefficients**	**Prob.**	**Coefficients**	**Prob.**
C	0.020***	0.000	0.632***	0.000
Air Pollution Index (API)	-0.001***	0.000	-0.001***	0.001
Tangibility Ratio (TA)	0.294***	0.000	0.073**	0.008
Firm Size (FZ)	0.010***	0.086	0.052***	0.002
Interest Rate (IR)	-0.002***	0.000	0.002***	0.000
Financial Sector Development (FSD)	0.122***	0.000	-0.016***	0.021
Adjusted R-square		0.648		0.670
S.E. of regression		0.160		0.173
Prob (F-statistic)		0.000		0.000

Note: ***significant at 1%, **significant at 5%, *significant at 10%, **Source:** Own calculation.

5. Conclusion

In our cohort study, we explore how an increment in the environmental pollution index affects corporate firms' financing structure by using samples of Chinese, Indian, Japanese, South Korean, and Singapore firms from 2010-2019 and by employing a two-step system, the Generalized Method of Moment (GMM), to handle the heterogeneity, endogeneity, and heteroskedasticity problems. In our analysis, we find that the coefficient values of the air pollution index in the main regression are inversely associated with both firm debt and firm equity financing. This explains the fact that the environmental violation hazard is increasing day by day across the world, and the government and other regulatory institutions are vigilant to limit environmental pollution by charging a penalty to polluted firms. Such penalties forced them to cut down their production process, negatively impacting the firm's values. Moreover, financial institutions and other stakeholders (investors996 and shareholders) consider environmental risk for lending and investing. Our empirical results further show that the main explanatory variables are significant determinants of firm financing structure. Among them, the coefficients of tangibility of total assets, financial development, and firm size are positively associated with firm debt financing. However, the interest rate is inversely associated with debt financing and positively associated with equity financing. As far as we know, this research is the first attempt in the literature to explore how an upward and downward movement of the environmental pollution index could be used to define a firm financing pattern. Such an arrangement of variables has never been a part of any research in the literature. We firmly describe that our research attaches to the interests and goals of the decision sciences.

5.1 Policy Recommendations and Limitations

The findings from the regression presented in this paper have crucial implications for corporate managers and government entities. First, it is recommended that the government implement stringent regulations regarding environmental protection policies. Simultaneously, providing resilient financing policies to corporate firms is deemed essential. Additionally, less-explored business entities should consider the sensitivity of the environmental pollution index when making decisions at the firm level. Furthermore, the government is encouraged to compel older and larger firms to allocate resources toward environmental protection processes. However, it is advised not to hinder new firms from altering or discontinuing their production processes. Incentives like financial flexibility can motivate firms to invest in environmental protection initiatives willingly. The research findings in our paper suggest that firm managers, along with conventional factors, should incorporate the environmental pollution index as a determinant in their financing decisions. In summary, the study underscores the significant impact of the environmental pollution index on firm financing patterns.

This study aimed to comprehensively investigate the influence of environmental pollution index volatility on firm financing patterns. However, certain limitations persist that could be addressed in future research endeavors. For instance, despite employing dynamic techniques, it is essential

to acknowledge some constraints associated with the available data. Firstly, the study period was confined to 10 years (2010-2019), potentially affecting the generalizability of the findings. Future research could extend the temporal scope to enhance the study's robustness. Secondly, the focus was solely on the impact of the environmental pollution index on firm financing patterns. Subsequent studies could explore the effects of other environmental degradation indicators, such as CO2 emissions, to provide a more comprehensive understanding. Additionally, relying on self-report measures for data collection introduces the possibility of recall bias effects. In summary, future research endeavors incorporating a more diverse and extended study sample size and duration would help overcome these limitations and contribute to a more thorough comprehension of the subject matter.

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