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Corporate Investing in Environmental Reservations in Emerging Markets: Uncertainty and Economic Considerations

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ABSTRACT
Environmental risks established as elevated temperatures, altered precipitation patterns, and extreme weather events, hence generating systemic risks to corporate investment operations. The study analyzes the impact of environmental risk on the expenditures of non-financial firms listed on Borsa Istanbul from 2000 to 2024. The composite environmental risk index is formulated by principal component analysis, incorporating indications of temperature, precipitation, and disasters. The results have derived from baseline regressions, two-stage least squares estimation, mediating effect models, and several robustness checks, reveal a strong negative relationship between environmental risk and corporate investment, attributed to heightened financial restrictions. The effect is most acutely experienced by state-owned corporations, firms in high-risk industries, and those receiving little government subsidies. The analysis of geographical heterogeneity indicates more pronounced negative impacts in eastern Turkiye, categorized by a highly regulated environment and a probably diminished capacity for the normal operation of financial services. Further, the study indicates that environmental risk diminishes overall investment while augmenting the scope of green investment, hence enhancing investment efficiency. In the face of climate uncertainty, focused policy interventions like environmental risk management, financial system fortification, and selective government subsidies are needed to protect investments.
Keywords: Financial constraints, corporate investment, environmental risks, Base line regression, 2SLS model, Türkiye
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1. INTRODUCTION:

The international economic and financial stability will encounter significant dangers from environmental change, whose repercussions extend beyond physical damage to encompass secondary macroeconomic and individual corporate implications. The escalating trends related to greenhouse gas emissions, temperature variability, altered precipitation patterns, and the rising frequency of extreme weather events may progressively erode the corporation's liquidity by adversely impacting asset values and reducing profits. This increases default risks in both financial and non-financial markets (Dafermos et al., 2018). Adverse environmental circumstances at the macro level can inhibit regional and national productivity. For instance, it was shown that elevated CO_2 emissions diminish industrial investment in the steel and construction sectors (Zhang & Wang, 2021). From a microeconomic perspective, environmental risks can obliterate physical assets and disrupt supply chains, heightening operational volatility. Consequently, firms adopt conservative investment strategies, establish precautionary cash reserves, and postpone or forgo capital expenditures (Ibarrar Bern, 2009; Adhikari and Safaee, 2023). Academic research has examined the relationship between environmental change and corporate performance, highlighting adverse correlations with return on assets (Secinaro et al., 2020) and effects on the risk profile of bank lending portfolios (Conlon et al., 2024). Additional studies have examined the impact of financing constraints—imposed by leverage, asset tangibility, and market conditions—on firms' responses to uncertainty through investment (Shukla & Shaw, 2020; Almeida & Campello, 2007). Nonetheless, there is scant empirical data about the influence of environmental risk events on corporate investment decisions at the micro-level, particularly through the finance constraints channel. This research examines the correlation between environmental risk and corporate investment expenditures among enterprises listed on Borsa Istanbul (Turkey) to address this gap. Utilizing principal component analysis, the study constructs a comprehensive environmental risk index that amalgamates variables of temperature, precipitation, and natural catastrophes to assess a multidimensional exposure to risk. The study has utilized employ ME regression analysis as the foundational regression, alongside two-stage least squares analysis and heterogeneity analysis, to assess the impact of environmental risk on investment behavior while controlling for potential Endogeneity. We provide three contributions. Firstly, it initially provides firm-level evidence regarding the investment implications of environmental risk in an emerging market context. Secondly, it identifies finance restrictions as a mediating factor in the interaction between the environment and investment decisions, influenced by the concept of risk. Third, it examines heterogeneity based on business ownership structure, industry classification, and regional economic conditions, with detailed policy implications. This study addresses sustainable investment strategies and the nuances of risk management by enhancing appreciative of the financial implications of environmental changes.

The structure of this study's follow-up: Section 2 describes the literature review; Section 3 describes the study methodology and data source; Section 4 examines empirical results. The following section assesses the literature and puts forth a hypothesis. Additional analysis is presented in Section 5, and policy implications are covered in the last part.

2. LITERATURE REVIEW

Feng et al. (2022) explored that stock exchange-listed corporations reduced capital expenditures and portfolio investment after four tropical cyclones and 33 U.S. hurricanes. Yuan and Xiang (2018) also assert that environmental regulation raises industrial production and operating costs in the long run, but its short-term implications on R&D investment are uncertain. Li and Tian (2024) show that environmental risk (or threat) is perceived by the public as a catalyst for green investment, which is primarily achieved through green technological innovation, and that maintaining an ecologically responsible image may reinforce this influence. Comprehensive environmental management reduces environmental risk, investment costs, and enhances revenues (Secinaro et al., 2020). However, smaller, less capitalized banks are at significant risk of environmental problems (Le et al., 2023). Huang and Sun (2023) also say environmental legislation uncertainty discourages company investment. Asylum (2023) emphasizes the need for reliable environmental risk exposure data to determine risk pricing and reward choices. Carbon pricing strategies minimize greenhouse gas emissions and encourage sustainable energy usage (Bento et al., 2020). Financial limits are most apparent in times of crisis. Giebel and Kraft (2024) and Albuquerque (2023) explored that financially constrained enterprises cut R&D expenditures within a crisis following a debt boom. Fahlenbrach et al. (2021) suggested that even enterprises with high debt rates and substantial liquidity and profitability balance sheets can attract investment borrowing. Barbiero et al. (2020) said debt financing decreases investment, while Krznar and Matheson (2018) indicated that the high leverage may deter owners from investing in fresh capital. Sasidharan et al. (2015) show that small and young enterprises are more vulnerable to R&D expenditures-induced cash flow shifts, supporting financing constraints. Guo et al. (2021) show that such limitations cause threshold effects on manufacturing R&D investment to be non-linear. Doruk (2023) stresses the need of internal finance for R&D initiatives, which have large fixed costs and high failure rates. Deng and Zhao (2022) and Chiu et al. (2022) find that enterprises under financial limitations prioritize cash flow in their investment decisions. Salikhova and Nikitushkina (2024) found that Russian firms' investments and liquidity are strongly correlated with cash flows, indicating continuous financial constraints, while Nicolas (2022) found that SMEs make the same investments under long-term and short-term financial constraints. The size of a corporation, cash flow from operations, Tobin Q, asset-liability ratio, returns of capital and taxes ratio, and largest shareholder ratio affect investment expenditures (Zhang & Wang, 2021). Greater firm size makes risk and budgetary constraints simpler to manage (Guo et al., 2021). Barbiero et al. (2020) found that intangible investment increases when cash flow, sales, and growth objectives rise but declines in size. Uncertainty hurts all investments, but smaller enterprises are hit worst (Rashid et al., 2022). Osegbue and Egbunike (2023) explore that tax savings boost investment expenditure as enterprises grow, whereas the efficiency and scale improve performance (Secinaro 2020). Lu et al. (2023) found that loosening monetary policy boosts investment expenditures and that small enterprises respond quicker than large firms. Panagiotidis and Printzis (2021) presented that small enterprises lose more investment in uncertain times, whereas Muhammad et al. (2024) show that larger organizations invest more in R&D. Salim and Winanto (2020) suggested that positive investment growth affects asset returns, while Ahmad et al. (2023) believe that higher asset prices and returns on total assets can enable and need additional investments. Ginglinger and Moreau (2023) suggest that environmental risk affects leverage by affecting demand and supply. Krznar and Matheson (2018) say over-borrowing can make shareholders hesitant to support capital expenditures, and Ahmad et al. (2023) explored that asymmetric knowledge limits investment. Barbiero et al. (2020) found that growth possibilities, corporate revenues, and cash flow boost intangible investments. Government expenditure may constrain aggregate demand (Parui, 2022), however in the Southern important Economic Zone of Vietnam, government investment is a driving force (Oanh et al., 2022). Shabbir et al. (2021) explored that FDI may temporarily boost growth. Rafiq et al. (2016) identified that firm’s age affects R&D expenditures and financial performance of the mining companies, where most companies tend to cut on investment activities as they grow. Pakistani financial institutions have a negative market-to-book ratio and no long-term ratio (Nadeem et al., 2024). Diana and Sriyono (2021) explained that market-to-book value and growth equities are attractive cash flows and industry uncertainty synergistically affects Norway-based aquaculture investment (Landazuri-Tveteraas et al., 2023). Wu et al. (2020) specified that companies with greater physical assets, operational cash flow, and cash balance are more likely to invest, while Dardouri et al. (2023) suggested that unemployment, inflation, and GDP effect on investment. Fatmawati (2022) and Gu (2021) provided more evidence that public sector investment decisions affect economic performance. Wei et al. (2023) explored that raising the minimum wage boosts R&D expenditures, whereas, it boosts investment in technology- and labor-intensive enterprises (Geng et al., 2022). Du et al. (2022) suggest that higher minimum salaries may increase business financial asset investments. Seok and You (2022), pay adjustments will affect employment patterns, especially low-productivity workers, but they may enhance investment if productivity improves.

3. RESEARCH METHODOLOGY

3.1 Baseline model

To investigate how environmental risk affects firm investment expenditure, the study has developed a model (1) to support research hypothesis H_{01}:

$$INE_{it} = \alpha_0 + \beta_1 ENV_{it} + \emptyset \sum Cont_{it} + \sum Y + \sum IND + \varepsilon_{it} \quad (1)$$

The random disturbance term is "ε_{it}" the fixed effect of "Y" is represented by $\sum$ Year, the fixed effect of the industry is represented by $\sum IND$, and the enterprise is represented by subscripts (i) and (t), respectively. When the value of "β_1" in model (1) is notably negative, it signifies that firm investment expenditure is significantly inhibited by environmental risk, hence supporting the validity of hypothesis "H_{01}". If not, it suggests that hypothesis "H_{01}" is incorrect.

3.2 Mediating Effect Model

The study utilized the step-by-step regression approach to examine the mediating influence. To explore the impact of environmental risk on firm investment expenditure, the study has developed models (2), (3), and (4) to test research hypothesis 1:

$$INE_{it} = \alpha_0 + \beta_1 ENV_{it} + \emptyset \sum Cont_{it} + \sum Y + \sum IND + \varepsilon_{it} \quad (2)$$

$$Intermediary_{it} = \alpha_0 + \beta_2\, ENV_{it} + \emptyset \sum Cont_{it} + \sum Y + \sum IND + \varepsilon_{it} \quad (3)$$

$$INE_{it} = \alpha_0 + \beta_3\, ENV_{it} + \beta_4\, Intermediary_{it} + \emptyset \sum Controls_{it} + \sum Y + \sum IND + \varepsilon_{it} \quad (4)$$

If the coefficient of "β_2" is positive, then the value of "β_1" in model (2) will be significantly negative. The positive coefficients of "β_3" and "β_4" suggest that environmental risk leads to a decrease in enterprise investment expenditure due to increased financing constraints. This finding supports the validity of "H_{02}". Then, it suggests that hypothesis "H_{02}" is not valid. Here is the procedure:

Step 1: As a result of building the original data matrix $(Y_{N\times q})$, the environmental risk indicators variables correspond to "N" cities/year × q.

Step 2: The second step involves standardizing the environmental risk indicator variables' data.

Step 3: Determine the original data matrix's variance-covariance matrix $(V_{q\times q})$ from $(Y_{N\times q}$

Step 4: Manipulative the eigenvalue of a matrix $\gamma_i (i = 1,2,\dots,p; \gamma_1 \ge \gamma_2 \ge, \dots, \gamma_p)$ then eigenvectors $e_1, e_2, \dots, e_p$ of alteration covariance matrix $S_{q\times q}$ by resolution the typical calculation $|\gamma I - S| = 0$.

Step 5: Scheming the amount of difference $\gamma_i / \sum_{i=1}^{q} \gamma_i$ besides the increasing percentage of difference $\sum_{i=1}^{n} \gamma_i \,/\, \sum_{i=1}^{q} \gamma_i$.

Step 6: Realize that the acquisition percentage of modification attainment active to 80% determines the amount 'n' of PCs.

Step 7: The variable star's lading is deviously determined by PCs:

$$l\big(PCs(i), Y_j\big) = \sqrt{\gamma_i}\, e_{ij}; (i = 1,2,\dots,n; j = 1,2,\dots,q) \quad (A\text{-}1)$$

Step 8: Manipulative the PCs blisters $(C_k(i))$ of respectively metropolitan k:

$$C_k(i) = e_{i1}y_1 + e_{i2}y_2 + \dots + e_{iq}y_q; (i = 1,2,3\dots,n; k = 1,2,\dots,m) \quad (B\text{-}2)$$

Step 9: The environmental risk index of each city k is calculated using Equation (B-2), and $\gamma_i / \sum_{i=1}^{n} \gamma_i$ is the primary component's weight:

$$ENV_{(k)} = \sum_{i=1}^{n} \frac{\gamma_i}{\sum_{i=1}^{n} \gamma_i} C_k(i)\,; (k = 1,2,\dots,n; I = 1,2,\dots,n) \quad (B\text{-}3)$$

Pan and Chen (2017), estimates environmental risk by consulting the literature on environmental indicator measurement approaches. There are both immediate and long-term physical risks from the environment. Long-term risks are represented by temperature, precipitation, and volatility, whereas short-term risks are measured by environmental disasters.

3.3 Data Collection

The study has conducted Winsor processing for all continuous variables at the 1% and 99% quartiles to avoid the adverse effects of outliers. Implementing these sample selection criteria results in a final dataset comprising 16520 annual observations of A-share non-financial listed companies from 2000 to 2023. The study has collected the data from Borsa Istanbul Stock Exchange "https://www.borsaistanbul.com" listed companies as the research objects. The enterprise-level and regional disaster data are sourced from the website of "https://www.kaggle.com" as sub data source of Borsa Istanbul: Turkish Stock Exchange Dataset.

4. RESULTS AND DISCUSSIONS

Table 1 represents the descriptive statistics for the primary variables. Investment expenditure (INE) has a mean value of 0.062 and a median of 0.043. The range of INE, which spans from -0.015 to 0.249, validates the variability of investment levels among various companies.

Table 1. Descriptive Statistics

Variable	N	Mean	SD	Min	Max	P25	P50	P75
INE	16520	0.062	0.045	-0.035	0.355	0.015	0.037	0.045
ENV	16520	3.395	0.715	1.24	3.795	1.903	3.045	3.453
FR	16520	-3.724	0.363	-5.315	-3.013	-3.839	-3.719	-3.562

TA	16520	24.162	1.383	19.462	37.373	31.355	31.973	24.945
ROA	16520	0.024	0.063	-0.363	0.191	0.013	0.024	0.07
DA	16520	0.563	0.183	0.073	0.837	0.307	0.623	0.713
PRO	16520	0.179	0.362	-0.639	1.963	-0.011	0.131	0.39
Phase	16520	3.113	0.713	0.783	3.243	1.709	3.197	3.709
MB	16520	0.29	0.35	0.135	1.151	0.553	0.295	0.955
POC	16520	0.063	0.073	-0.17	0.363	0.009	0.062	0.091
GDP	16520	9.317	3.453	1.3	17.7	7.9	9.5	13.1
REM	16520	10.835	0.637	9.383	13.073	10.737	11.053	11.51

ENV has a mean value of 3.087 and a standard deviation of 0.765. The ENV score varies significantly between locations, with a minimum of 1.067 and a high of 4.056, indicating the range of climatic risk that companies must contend with.

4.2 Correlations Test

Table 2 represents the results of correlation matrix with coefficients. An important association between the dependent variable, firm investment level, and environmental risk is shown by the correlation analysis. Additionally, every correlation coefficient is less than 0.5, meaning that there are no problems with Multicollinearity between the variables

Table 2. Correlation coefficient test

Variables	INE	ENV	FR	TA	ROA	DA	PRO	Phase	BM	POC	GDP	REM
INE	1											
ENV	-0.097***	1										
FR	0.053***	0.173***	1									
TA	0.129***	-0.037***	0.062***	1								
ROA	-0.009	-0.024***	0.531***	-0.247***	1							
DA	0.083***	-0.005	0.029***	0.130***	0.053***	1						
PRO	-0.243***	0.105***	0.353***	-0.139***	0.379***	-0.095***	1					
Phase	0.035***	0.005	-0.119***	0.010*	-0.124***	0.024***	-0.183***	1				
BM	-0.003	-0.019***	0.637***	-0.191***	0.383***	0.035**	0.135***	-0.139***	1			
POC	0.173***	-0.031***	0.037***	0.379***	-0.170***	0.005	-0.039***	-0.015***	-0.104***	1		
GDP	0.155***	-0.303***	-0.303***	0.055***	0.117***	0.029***	-0.097***	-0.137***	0.053***	-0.005	1	
REM	-0.051	0.079**	0.055***	0.013**	-0.015	-0.055	0.024***	-0.001	-0.063	0.019***	-0.524	1

	***	*			**	***			***		***	

The results reveal that the ENV is positively connected with PRO and FR but negatively correlated with GDP and INE. TA negatively correlates with ROA and PRO but positively with POC. ROA is positively correlated with PRO, BM, and FR, indicating a strong link between profitability, corporate valuation, and risk. PRO is favorably connected with ROA and FR but negatively correlated with INE, TA, and Phase, showing that growth, innovation, and size reduce profitability. Phase hurts FR, ROA, PRO, and BM, indicating lifecycle stage variations. BM correlates positively with FR and ROA but adversely with Phase and POC. Since POC substantially correlates with TA and adversely with ROA and BM. GDP growth is negatively associated to ENV, FR, and REM and positively related to INE and ROA.

4.3 Baseline Regression

Table 3 represents Baseline regression findings of environmental risk and investment expenditures. To ensure robustness, cash paid for the acquisition and building of fixed assets, intangible assets, and other long-term assets is split by total assets

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Table 3. Baseline Regression analysis

Variables	-1	-2	-3	-4
	INE1	INE1	INE2	INE2
ENV	-0.005***	-0.005***	-0.005***	-0.005***
	(-3.53)	(-3.91)	(-3.45)	(-3.97)
INE	0.010***	0.009***	0.009***	0.009***
	-19.3	-14.83	-17.97	-15.39
ROA	0.029***	0.109***	0.045***	0.113***
	-7.7	-11.39	-7.83	-11.9
DA	0.003	0.019***	0.005	0.031***
	-0.79	-5.83	-1.53	-7.73
TA	0.007***	0.007***	0.005***	0.005***
	-5.09	-5.24	-3.55	-3.83
Phase	-0.024***	-0.031***	-0.031***	-0.030***
	(-30.51)	(-39.35)	(-37.47)	(-37.45)
PRO	0.005***	0.005***	0.005***	0.005***
	-3.83	-4.8	-3.71	-5.31
MB	-0.019***	-0.017***	-0.017***	-0.017***
	(-7.37)	(-7.11)	(-7.19)	(-7.05)
POC	0.117***	0.079***	0.104***	0.073***
	-17.24	-9.73	-15.29	-7.4
GDP	0.001***	0.001***	0.001***	0.001***
	-5.62	-3.29	-5.63	-3.45
REM	-0.017***	-0.010***	-0.017***	-0.009***
	(-13.71)	(-7.31)	(-11.83)	(-7.62)
Constant	0.062***	0.009	0.045***	0.015
	-3.39	-0.51	-3.83	-0.29
Industry	NO	YES	NO	YES
Year	YES	YES	YES	YES
Observations	17,630	17,630	17,630	17,630
R-squared	0.15	0.303	0.135	0.303

Note: '***'; '**' and '*' designates two-tailed statistical significance at 1%, 5%, and 10% respectively.

egression findings have two parts: Results with year-fixed effects controlled are in Columns (1) and (3), whereas Columns (2) and (4) contain industry effects. The environmental risk regression coefficients in Columns (1) and (4) are 1% significant. This supports Hypothesis 1 that enterprises with larger environmental risks spend less.

The coefficient of enterprise age (Age) is negative, suggesting that well-established enterprises are stable and may not need major physical asset investments. Regional control factors show that enterprises in cities with greater GDP growth rates invest more. This means that economic growth and pace boost company investment. Employee pay may also reduce business investment. These data confirm the association between environmental risk and investment expenditures after controlling for control factors in regression analysis.

4.4 Instrument Investigation

Table 4 shows funding constraint mechanism exploration outcomes. Estimations using funding limitations as mediating variables are shown in Columns (1) and (2). At 1%, Column (1)'s ENV is substantial.

Table 4. The mediating impact of finance restrictions

Variable	-1	-2	-3
	SA	INV	INV
ENV	0.015***	-0.004***	-0.044***
	-4.52	(-3.70)	(-3.93)
SA		-0.014***	0.011
		(-5.92)	-1.52
SA*ENV			-0.011***
			(-3.59)
TA	0.066***	0.010***	0.010***
	-36.79	-16.56	-16.8
ROA	-0.472***	0.101***	0.101***
	(-15.73)	-10.61	-10.6
DA	-0.110***	0.017***	0.017***
	(-11.17)	-5.31	-5.33
PRO	-0.015***	0.005***	0.005***
	(-3.68)	-4.07	-3.99
Phase	-0.170***	-0.023***	-0.023***
	(-73.04)	(-27.60)	(-27.44)
Dual	-0.002	0.005***	0.005***
	(-0.61)	-4.37	-4.39
MB	-0.125***	-0.019***	-0.019***
	(-13.89)	(-6.70)	(-6.79)
POC	0.040*	0.069***	0.069***
	-1.79	-9.71	-9.71
GDP	-0.002***	0.001***	0.001***
	(-3.05)	-3.62	-3.72
REM	0.017***	-0.010***	-0.010***
	-3.78	(-7.05)	(-6.75)
Constant	-4.540***	-0.057***	0.031
	(-77.46)	(-2.64)	-0.95
Industry	YES	YES	YES
Year	YES	YES	YES
Observations	17,490	17,490	17,490
R-squared	0.508	0.205	0.206

Note: '***'; '**' and '*' designates two-tailed statistical significance at 1%, 5%, and 10% respectively.

Environmental risk significantly affects enterprise funding limitations. In particular, increasing environmental risk increases the SA index of finance restrictions, indicating a greater constraint impact. This confirms Hypothesis 2, that environmental risk increases finance restrictions and company investment. As confirmed in Column (3), the regression included the cross-multiplication term of environmental risk and funding limitations to confirm this mechanism's robustness. The cross-multiplication coefficient is notably negative at 1%. The additional result shows that environmental risk reduces investment by raising company finance limitations.

4.5 Robustness Analysis

A series of robustness tests confirms prior empirical findings that ENV and INE inversely affect business investment expenditures. Table 5 show robustness test results utilizing alternative explanatory factors in columns (1)– (5).

Table 5. Baseline regression analysis

Variables	-1	-2	-3	-4	-5	-6	-7
	INE	INE	INE	INE	INE	INE	INE
ENV_1	-0.009***						
	(-3.52)						
ENV_2		-0.010***					
		(-3.69)					
ENV_3			-0.002***				
			(-2.82)				
ENV_4				-0.001**			
				(-2.29)			
ENV_5					-0.001**		
					(-1.99)		
ENV_L						-0.004***	
						(-2.75)	
ENV_P							-0.004***
							(-2.80)
TA	0.009***	0.009***	0.009***	0.009***	0.009***	0.010***	0.010***
	-15.5	-15.51	-15.45	-15.39	-15.38	-14.6	-12.77
ROA	0.108***	0.108***	0.108***	0.108***	0.108***	0.098***	0.130***
	-11.36	-11.34	-11.38	-11.38	-11.39	-8.84	-11.02
DA	0.018***	0.018***	0.018***	0.018***	0.018***	0.014***	0.024***
	-5.85	-5.84	-5.77	-5.79	-5.79	-3.91	-6.31
PRO	0.006***	0.006***	0.006***	0.006***	0.006***	0.005***	0.005***
	-4.26	-4.26	-4.26	-4.29	-4.29	-3.35	-3.22
Phase	-0.021***	-0.021***	-0.021***	-0.021***	-0.021***	-0.018***	-0.023***
	(-28.29)	(-28.27)	(-28.17)	(-28.16)	(-28.13)	(-18.49)	(-24.51)
POC	0.005***	0.005***	0.005***	0.005***	0.005***	0.006***	0.006***
	-4.43	-4.43	-4.38	-4.42	-4.42	-4.85	-4.48
MB	-0.017***	-0.017***	-0.018***	-0.018***	-0.018***	-0.019***	-0.020***
	(-6.07)	(-6.08)	(-6.16)	(-6.14)	(-6.16)	(-5.78)	(-5.78)
FR	0.068***	0.068***	0.068***	0.068***	0.068***	0.071***	0.074***
	-9.62	-9.61	-9.58	-9.63	-9.62	-8.8	-8.48
GDP	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001*
	-3.42	-3.37	-3.94	-3.89	-3.89	-3.32	-1.87
REM	-0.010***	-0.010***	-0.011***	-0.011***	-0.011***	-0.011***	-0.008***
	(-6.62)	(-6.59)	(-7.59)	(-7.71)	(-7.65)	(-6.93)	(-3.99)
Constant	0.015	0.029	0.004	0.007	0.006	-0.001	-0.028
	-0.78	-1.5	-0.23	-0.37	-0.33	(-0.07)	(-1.09)
Industry	YES	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES	YES
Observations	17,490	17,490	17,490	17,490	17,490	13,079	12,908
R-squared	0.203	0.203	0.203	0.203	0.203	0.199	0.195

Note: '***'; '**' and '*' designates two-tailed statistical significance at 1%, 5%, and 10% respectively.

The baseline regression finding was supported by the regression results for temperature standard deviation, temperature difference, disaster incidence periods, disaster economic losses, and impacted population, which all show a 1% negative connection. Environmental risk data with a one-stage lag is used to examine resilience with regard to the time lag between environmental risk and company investment choices. Column (6) shows that environmental risk's regression coefficient on company investment expenditure is negative at 1%. As shown by column (7), the regression coefficient of environmental risk on investment expenditures is -0.004 and significant at 1%, indicating the validity of the baseline regression result. This demonstrates how reliable the benchmark regression results are. Robustness tests corroborate the inverse connection between environmental risk and corporate investment expenditures, supporting and strengthening the baseline regression.

4.6 Endogeneity Analysis

To address missing variables, the study estimated the baseline regression using two-stage least squares (2SLS). This article uses a temperature inversion as an instrumental variable based on prior investigations. The atmosphere's temperature may rise with elevation, causing a temperature inversion. Temperature inversion is substantially connected with environmental risk, meeting the "correlation" criteria for instrumental variables. Additionally, it fits the "homogeneity" condition because it is impossible to directly change firms' investment behavior. Day 1 and Day 2 are when the second and third tiers are warmer than the first. Instrumental variable-based two-stage least square regression model:

$$ENV = \beta_0 + \beta_1 Days + \emptyset Cont + \epsilon \quad (5)$$

$$INE = \gamma_0 + \gamma_1 \widehat{ENV} + \theta Cont + \epsilon \quad (6)$$

Day 1 and Day 2 are the instrumental variables of ENV in Model (5), which is the first-stage 2SLS regression model. Model (6) uses the fitted ENV value as an explanatory variable in the second step. The Two-Stage Least Squares (2SLS) regression is found in Table 6. Columns (1) and (2) record the results in terms of Days1 as the instrumental variable and columns (3) and (4) record the results in terms of Days2

Table 6. 2SLS Analysis

Variable	-1	-2	-3	-4
	First stage	Second stage	First stage	Second stage
	ENV	INE	ENV	INE
Days1	0.003***			
	-77.4			
ENV		-0.013***		
		(-5.45)		
Days3			0.005***	
			-63.83	
ENV				-0.013***
				(-5.83)
TA	0.009**	0.009***	0.011***	0.009***
	-3.63	-15.83	-3.83	-15.95
ROA	0.037	0.109***	0	0.109***
	-0.55	-11.37	0	-11.37
DA	0	0.019***	0.001	0.019***
	(-0.01)	-5.95	-0.05	-5.95
PRO	-0.017**	0.005***	-0.017*	0.005***
	(-3.11)	-5.09	(-1.95)	-5.09
Phase	0.007	-0.031***	0.007	-0.031***
	-1.24	(-39.37)	-1.17	(-39.37)
POC	-0.007	0.005***	-0.015*	0.005***
	(-0.97)	-5.37	(-1.91)	-5.37
MB	0.005	-0.017***	0.013	-0.017***
	-0.37	(-5.83)	-0.45	(-5.83)
FR	0.015	0.079***	-0.003	0.079***
	-0.24	-9.62	(-0.05)	-9.62
GDP	0.001	0.001***	0.005***	0.001***
	-0.79	-3.7	-3.79	-3.7
REM	0.153***	-0.009***	0.107***	-0.009***
	-17.24	(-7.30)	-11.83	(-7.15)
Constant	-0.083	0.009	0.329**	0.009
	(-0.95)	-0.51	-3.24	-0.5
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	17,630	17,630	17,630	17,630
R-squared	0.29	0.305	0.737	0.305

Note: '***'; '**' and '*' designates two-tailed statistical significance at 1%, 5%, and 10% respectively.

Days 1 and Days 2 have a considerable positive effect on ENV, as can be seen in columns 1 and 3, demonstrating that temperature inversions and environmental risk are highly correlated, with the intensity of the inversion increasing environmental risk. The environmental risk coefficient estimates in the second stage regression are significantly negative, as shown in columns (2) and (4). This supports hypothesis 1, which states that environmental risk has a negative impact on business investment expenditure. The regression findings suggest that state-owned firms have a negative environmental risk coefficient at 1%. However, environmental risk does not affect non-state-owned firms. This shows that state-owned firms are excessively affected by environmental risk on investment expenditures. State-owned firms' lower capital input to protect capital security while facing greater environmental risks, reducing investment expenditure. Non-state-owned firms with lesser capital investment may take risks for profit. Thus, environmental risk has little impact on non-state-owned firm investment. Financing limitations slow output development but boost pollution control through emission reduction subsidies and pollution preventative expenditures (Wang et al., 2024). Environmental risk negatively correlates with company investment expenditures at the 1% level in severe environmental risk industries, according to regression. In light environmental risk sectors, environmental risk does not affect investment expenditures. This shows that severe environmental concerns impact firms' investment behavior more than lower environmental threats. In the group with large government subsidies, environmental risk and investment expenditures are not significantly correlated. In the group with minimal government subsidies, environmental risk is inversely connected with investment expenditures at the 1% level, with a regression value of -0.005. This suggests that government subsidies can help businesses, lower business risks, and lessen the impact of environmental risk on investment expenditures. Wei et al. (2023) found that increasing the minimum wage significantly increases R&D expenditures.

4.7 Heterogeneity Analysis

This study uses a heterogeneity analysis on six dimensions—property rights nature, industry, government subsidies, regional differences, regional financial service level, and environmental regulation intensity—to examine how environmental risk affects different types of enterprises. The controller of a business might be state-owned or non-state-owned. Unlike private persons or firms, local governments and state-owned institutions control state-owned enterprises. Table 7 represents the results of Heterogeneity analysis findings at the firm level.

Table 7. Heterogeneity Test

Variable	Nature		Industry		Government subsidy	
	-1	-2	-3	-4	-5	-6
	State	Non-state	High	Low	High	Low
	INE	INE	INE	INE	INE	INE
ENV	-0.007***	-0.003	-0.007***	-0.003	-0.003	-0.005***
	(-3.03)	(-1.51)	(-3.79)	(-0.29)	(-1.53)	(-3.00)
INE	0.007***	0.015***	0.009***	0.013***	0.009***	0.009***
	-7.39	-10.24	-10.73	-7.83	-10.31	-6.95
ROA	0.155***	0.051***	0.079***	-0.003	0.045***	0.110***
	-9.83	-4.85	-9.5	(-0.17)	-4.85	-7.29
DA	0.024***	0.039***	0.037***	-0.013	0.013**	0.017***
	-4.8	-4.85	-7.63	(-1.35)	-3.55	-3.53
TA	0.003	0.001	0.005**	-0.003	0.009***	0.003
	-1.13	-0.37	-3.55	(-0.79)	-5.07	-1.63
Phase	-0.015***	-0.035***	-0.035***	-0.013***	-0.019***	-0.024***
	(-9.83)	(-14.83)	(-30.83)	(-4.81)	(-17.29)	(-19.15)
PRO	0.003	0.005**	0.005**	0.009**	0.007***	0.007***
	-0.7	-3.19	-3.53	-3.24	-3.97	-3.31
MB	-0.013**	-0.030***	-0.024***	-0.003	-0.013***	-0.013**
	(-3.24)	(-3.39)	(-5.83)	(-0.35)	(-3.95)	(-3.53)
POC	0.045***	0.071***	0.073***	0.109***	0.045***	0.029***
	-7.24	-5.29	-7.24	-5.45	-5.7	-5.9
GDP	0.001***	0.001**	0.001***	0.003***	0.001**	0.001*
	-3.19	-3.24	-3.95	-5.11	-1.97	-1.79
REM	-0.003**	-0.005***	-0.003***	-0.003	-0.011***	-0.015***
	(-3.53)	(-3.03)	(-3.62)	(-1.53)	(-4.80)	(-5.29)

Constant	-0.053**	-0.153***	-0.045***	-0.195***	-0.024	0.053
	(-3.30)	(-3.95)	(-3.10)	(-5.24)	(-0.95)	-1.3
Industry	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Observations	9,639	9,833	15,797	3,905	7,319	7,562
R-squared	0.179	0.11	0.135	0.107	0.315	0.3

Note: '***'; '**' and '*' designates two-tailed statistical significance at 1%, 5%, and 10% respectively.

The results reveal that only the eastern area has a 1% negative association between environmental risk and company investment expenditures, no major effect is seen in central and western areas. The greater concentration of coastal communities in the east makes them more exposed to environmental change consequences such severe temperatures, precipitation, and typhoons. Heterogeneity study shows that regional economic and environmental contexts strongly influence digital inclusive finance's environmental impacts (Wang et al., 2024). Table 8 shows that the regression coefficient of environmental risk on company investment expenditures is notably negative at 5% in places with low financial service levels.

Table 8. Test for Heterogeneity: Location, Finance, and Serviceability

Variable	Geographical region			Financial serviceability	
	-1	-2	-3	-4	-5
	East	Central	West	High	Low
	INE	INE	INE	INE	INE
ENV	-0.005***	-0.003	0.003	-0.003	-0.005**
	(-3.29)	(-0.73)	-0.53	(-1.10)	(-3.13)
INE	0.010***	0.015***	0.010***	0.013***	0.009***
	-11.79	-4.83	-3.95	-9.31	-7.4
ROA	0.062***	0.062***	0.083***	0.097***	0.035***
	-5.83	-3.62	-3.55	-5.39	-4.83
DA	0.019***	0.037***	0.024*	0.037***	0.015***
	-3.5	-3.9	-1.29	-5.45	-3.79
TA	0.005**	-0.005	0	0.001	0.005**
	-3.63	(-1.09)	-0.07	-0.53	-3.13
Phase	-0.024***	-0.024***	-0.030***	-0.024***	-0.031***
	(-19.29)	(-7.11)	(-5.83)	(-13.45)	(-16.90)
PRO	0.007***	0.001	0.001	0.005**	0.005**
	-3.19	-0.17	-0.19	-3.01	-3.24
MB	-0.017***	-0.062***	-0.005	-0.015**	-0.019***
	(-3.79)	(-5.63)	(-0.39)	(-3.19)	(-3.83)
POC	0.062***	0.095***	0.115***	0.045***	0.045***
	-4.85	-3.73	-5.01	-3.83	-6.91
GDP	0.001**	0	-0.001	0.001*	0.001***
	-3.53	-0.19	(-1.13)	-1.45	-3.35
REM	-0.015***	-0.031**	-0.001	-0.003	-0.003***
	(-5.19)	(-3.24)	(-0.83)	(-0.97)	(-3.79)
Constant	0.013	0.024	-0.083*	-0.170***	-0.063**
	-0.35	-0.24	(-1.83)	(-3.62)	(-3.35)
Industry	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Observations	11,950	3,839	3,300	7,635	9,391
R-squared	0.135	0.163	0.129	0.11	0.17

Note: '***'; '**' and '*' designates two-tailed statistical significance at 1%, 5%, and 10% respectively.

In the Eastern region, as well as in areas with low financial serviceability, environmental performance (ENV) has a detrimental effect on the economic dimension of innovation (INE). However, this is not the case in other regions. INE impacts other regions positively, significantly, and constructively across all financial serviceability conditions. Moreover, INE relates positively, significantly, and constructively to performance measured as return on assets (ROA) and with the debt ratio (DA) as well, with this effect being stronger in areas with high financial serviceability. In the Eastern region and in areas with poor serviceability, total assets (TA) also have positive, significant, and important impacts, albeit in other areas the impact is minimal. The Phase variable has consistently large negative impacts on all models, indicative of a phenomenon. PRO positively impacts INE in the Eastern region and in high and low financial serviceability areas, whereas the market-to-book ratio (MB) has negative impacts on INE in most scenarios. POC and GDP are significant positive and exert valuable impacts on INE, although in the Central and Western areas, GDP has lesser value. REM is a noteworthy variable, and in Eastern and

Central regions, negatively impacts INE. Table 9 represents the results of Ecological Parameter Heterogeneity test.

Table 9. Ecological Parameter Heterogeneity test

Variable	Environmental administrative regulation		Environmental and economic regulation	
	-1	-2	-3	-4
	High	Low	High	Low
	INE	INE	INE	INE
ENV	-0.015***	-0.005	-0.011***	-0.003
	(-3.63)	(-1.35)	(-5.79)	(-1.37)
INE	0.015***	0.010***	0.010***	0.009***
	-7.07	-9.63	-7.95	-9.19
ROA	0.051***	0.083***	0.079***	0.063***
	-3.91	-5.13	-5.7	-5.45
DA	0.035***	0.009	0.017**	0.024***
	-3.1	-1.24	-3.53	-5.97
TA	-0.007	0.005**	0.007**	-0.001
	(-1.62)	-3.31	-3.55	(-0.51)
Phase	-0.030***	-0.019***	-0.024***	-0.031***
	(-11.13)	(-11.62)	(-13.39)	(-15.11)
PRO	0.005	0.007***	0.005*	0.009***
	-1.05	-3.83	-1.9	-3.17
MB	-0.007	-0.013*	-0.017***	-0.013**
	(-0.70)	(-1.83)	(-3.45)	(-3.11)
POC	0.090***	0.035***	0.039***	0.083***
	-3.63	-3.79	-3.73	-7.37
GDP	0	0	0	0.003***
	(-0.10)	-0.03	-0.37	-3.29
REM	-0.013	-0.030***	-0.003	-0.003**
	(-1.53)	(-5.73)	(-1.62)	(-3.15)
Constant	-0.035	0.100**	-0.045**	-0.083***
	(-0.37)	-1.97	(-3.03)	(-3.62)
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	3,391	5,905	7,373	9,351
R-squared	0.131	0.171	0.137	0.131

Note: '***'; '**' and '*' designates two-tailed statistical significance at 1%, 5%, and 10% respectively.

The results reveal that when there is strong control of administration and regulation of the economy, ENV has a negative impact on INE. There is a positive and strong relationship on the innovation outputs INE under all scenarios, with ROA correlating even more positively under low administrative and high economic regulation. DA also positively influences the innovation outputs but even more under high regulation, while TA negatively but weakly under high administrative control and negatively under low administrative and high economic controls is a positive influence when TA are large. PRO correlates positively while the market-to-book ratio (MB) has a negative impact but all under low regulation, while control under severe administrative restriction has a positive control. POC positively influences INE across all scenarios but most strongly under heavy administrative and low economic control. GDP is mostly irrelevant but can be considerable under little economic regulation. REM negatively influences INE, especially under low administrative and economic control. Le et al. (2023) argue that the adverse effects of environmental risk on the stability of banks are more noticeable in smaller banks and those with lower capital. Financial assets include trading, buy-and-resale, derivative, investment real estate, long-term equity, hold-to-maturity, available-for-sale, loans, and advances. Table 10 represents the further regression analysis findings for environmental risk related to financial investments.

Table 10. Regression results of further analysis

Variables	-5	- 6	-7	- 8
	IE	CH	FaInv	EnvInv
ENV	-0.003**	0.009**	-0.007***	0.035**
	(-3.51)	-3.62	(-5.10)	-3.62
INE	0.001	-0.003	0.005***	-0.005
	-1.73	(-1.10)	-5.79	(-1.09)
ROA	0.010***	0.373***	-0.037**	0.039
	-3.83	-9.79	(-3.37)	-0.91

DA	0.005**	-0.313***	-0.124***	0.035
	-1.97	(-31.90)	(-35.03)	-1.24
TA	0.005***	0.003	-0.017***	-0.009
	-5.83	-0.73	(-7.73)	(-0.95)
Phase	-0.007***	-0.007***	0.037***	0.003
	(-15.37)	(-3.83)	-39.17	-0.5
PRO	0.003**	-0.005	0.003*	-0.003
	-3.15	(-1.53)	-1.29	(-0.19)
MB	-0.007***	-0.037***	-0.019***	0.01
	(-3.95)	(-5.03)	(-5.07)	-0.37
POC	0.009**	0.390***	-0.115***	-0.01
	-3	-17.07	(-7.40)	(-0.19)
GDP	0.001***	-0.001	-0.003***	-0.003
	-3.53	(-1.24)	(-5.37)	(-0.90)
REM	-0.001***	0.035***	0.024***	-0.001
	(-5.11)	-5.35	-7.45	(-0.11)
Constant	0.063***	0.195***	-0.319***	0.079
	-5.39	-3.35	(-7.17)	-0.53
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	17,630	17,630	17,630	17,630
R-squared	0.083	0.355	0.183	0.009

Note: '***'; '**' and '*' designates two-tailed statistical significance at 1%, 5%, and 10% respectively.

Greater involvement in environment-related activities leads to an increase in environmental expenditure and liquidity; however, it may also constrain innovation along with financial investments. The variable ENV poorly affects IE and FaInv but positively impacts CH and EnvInv. The effect of INE, while limited in other models, is small but positive and significant in the context of financial investment. The variable ROA increases IE and CH but negatively impacts FaInv. DA negatively impacts CH and FaInv, indicating that leverage reduces liquidity and investment. The variable TA increases IE but reduces FaInv. The Phase variable significantly impacts all models and, in particular, increases FaInv. MB consistently and negatively impacts IE, CH, and FaInv. POC improves IE and CH but reduces FaInv. Remittances negatively impact IE while positively stimulating CH and FaInv. In contrast, GDP growth increases IE but negatively impacts FaInv, illustrating economic paradoxes. Secinaro et al. (2020) analyze that firm-wide environmental procedures minimize environmental risks, lower investment expenditures, and boost earnings. Huang and Sun (2023) discovered that companies reduce their investment levels in response to increased uncertainties around environmental legislation.

1.9 Discussions

Enterprises in urban areas exhibiting higher GDP growth rates tend to invest more. This indicates that economic growth and acceleration enhance corporate investment. Rafiq et al. (2016) demonstrated that the age of a business moderates the relationship between R&D expenditure and financial performance in the mining sector. Investment activity is negatively influenced by firm age (Tran Thi et al., 2023). Zhang and Wang (2021) assert that operating cash flow, Tobin's Q, asset liability ratio, return on capital, and largest shareholder ratio influence investment expenditures. State-owned firms are significantly impacted by environmental risks concerning investment expenditures. State-owned enterprises reduce capital input to safeguard capital security amidst heightened environmental risks, leading to decreased investment expenditure. The negative gap between predicted market value and book value indicates that both merged and non-merged financial institutions lack a long-term market to book ratio (Nadeem et al., 2024). The market-to-book value and growth prospects enhance investment decision-making (Diana & Sriyono, 2021). Environmental risk substantially influences enterprise funding constraints and diminishes investment by increasing financial limitations for companies. Increased minimum salaries enhance investment in labor-intensive firms that exhibit greater technological innovation (Geng et al., 2022). The higher density of coastal communities in the eastern region increases their vulnerability to the impacts of environmental changes, including extreme temperatures, altered precipitation patterns, and typhoons. Landazuri-Tveteraas et al. (2023) analyzed the impact of macroeconomic and industry-specific uncertainty on investments in Norwegian aquaculture, highlighting the role of cash flows in shaping investment behaviour.

5. **Conclusions**

Businesses everywhere must closely monitor environmental conditions because they pose serious dangers. Turkey, a country with significant environmental problems, has demonstrated admirable commitment to sustainable development. Reaching strategic objectives like carbon neutrality and emission reduction requires an understanding of the investment and economic development of non-financial listed enterprises in China. This study uses data from Turkish non-financial listed firms between 2000 and 2023 to examine how environmental risk affects corporate investment levels. The objective is to furnish theoretical support for the efficient management of environmental risk by means of suitable investments. The study investigated the relationship between environmental change risk and the investment behavior of listed businesses by developing a panel data model and a mediating effects model for empirical analysis. To confirm the robustness of the findings, it also makes use of partial-sample techniques, one-stage lag, and alternative variables. To overcome Endogeneity problems, two-stage least squares estimation and instrumental variables approaches are used. The influence of environmental risk on cash holdings, investment efficiency, financial asset investment, and green investment is also examined in the study, as is the variability of these effects depending on different firm- and region-level attributes. The findings demonstrate that environmental risk has a detrimental effect on corporate investment expenditures and that it decreases corporate investment size by making firms' financing restrictions more severe. Subsequent investigation shows that higher investment efficiency, cash holdings, lower investment in financial assets, and more green investment are all related to better environmental risk that businesses confront. According to heterogeneity analysis, state-owned businesses, businesses in high-risk industries, and businesses with little government support at the company level are more likely to be negatively impacted by environmental risk when it comes to investment expenditures. At the regional level, areas with high degrees of environmental regulation, low financial service levels, and eastern regions are more likely to have a business investment expenditure inhibitory impact from environmental risk. As a result, businesses and governments must take into account the danger of environmental change and create various strategic responses to weather conditions. First, to ensure that businesses can reach the related emission reduction objectives, the government should implement stringent processes and increase monitoring. Industries take the lead in lowering environmental risks will eventually gain from it along with improving information transparency between businesses and investors, this will also help to create a more orderly and favorable market environment. This will lessen financing issues resulting from business financing constraints and encourage business innovation, transformation, and upgrading. Second, by boosting government subsidies to a specific level, the government may incentivize businesses to make tangible investments. Simultaneously, it prioritizes enhancing the quality of services provided by the regional financial sector, strengthening the capacity of financial institutions to manage environmental risks, and guaranteeing that these institutions have adequate outside funding for investment. This means that market mechanisms, in addition to legally mandated environmental regulations, should be fully utilized to control and reduce greenhouse gas emissions and enhance climate conditions.

5.1 Future Research Suggestions

This paper identifies future research opportunities in the context of de-materialization to the virtual, and the necessity of substantively evaluating the trend of financialization of business operations. Although financial investment may enable cost reduction and environmental sustainability, over financialization may divert resources needed for productive economic activities. In this regard, subsequent studies and the formulation of new policies should aim to establish balanced financial investment systems and adjust environmental regulations to reduce the accumulation of systemic financial risks. It should be remembered that as we shift to more virtual and less material operations in the business, we should find a balance. Investing in money can help businesses save and reduce their environmental impact; however, overemphasizing financial operations may dilute actual business operations. Business and regulatory agencies must collaborate to ensure that financial investments are reasonable and that environmental regulations are not overly strict, as this could expose the business to greater financial risks.

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