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Stem CEOs and financial distress: An analysis of leadership, innovation, and risk in corporate financial performance

Iman Harymawan[1+]
Santi Novita[2]
Habiburrochman[3]
Fandi Prasetya[4]
Rosyadatul Ulufiyah[5]

[1,2,3,4,5]*Department of Accounting, Faculty of Economics and Business, Universitas Airlangga, Surabaya, 60132, Indonesia.*
[1]*Email: harymawan.iman@feb.unair.ac.id*
[2]*Email: santi.novita@feb.unair.ac.id*
[3]*Email: habiburrochman@feb.unair.ac.id*
[4]*Email: fandi.prasetya@feb.unair.ac.id*
[1,5]*PUI-PT Bisnis Berkelanjutan, Universitas Airlangga, Surabaya, 60132, Indonesia.*
[5]*Email: rosyadatul.ulufiyah-2023@feb.unair.ac.id*

(+ Corresponding author)

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ABSTRACT

This paper examines whether CEOs with STEM backgrounds have a relationship with corporate financial distress, using 2022 data from Sustainalytics ESG Risk Ratings. Our findings reveal that companies led by STEM CEOs exhibit a statistically higher Altman Z-Scores, indicating a lower risk of financial distress. It shows that STEM CEOs contribute to financial resilience through structured innovation, operational efficiency, and disciplined investment strategies because of their analytical minds and long-term orientation. The study finds that STEM CEOs are more likely to adopt data-driven and future-driven decision-making frameworks, which help maintain financial stability even in volatile markets. Our heterogeneity analysis reveals that the positive impact of STEM leadership is more significant among firms in developed countries, firms led by male CEOs, smaller firms, firms with smaller boards, and firms with lower levels of innovation. These results are robust to multiple tests, including Coarsened Exact Matching (CEM), Propensity Score Matching (PSM), and Two-Stage Least Squares (2SLS) instrumental variable regression. This study contributes to the leadership and corporate finance literature by showing how a STEM CEO's educational background can impact firm-level financial outcomes. The findings also offer practical implications for corporate governance, talent selection, and policy interventions to promote financial resilience through STEM leadership.

Contribution/Originality: This study contributes to existing literature by exploring the relationship between CEOs' STEM education and corporate financial distress, using ESG-rated firms and robust techniques. It highlights the CEO's educational background as a crucial factor influencing financial stability.

1. INTRODUCTION

Corporate crises arise as a current global emergency, especially post-COVID-19, as per (World Bank, 2024) report. The report showed a 13% increase in global corporate bankruptcy in 2023, signaling deep economic uncertainty and threats to corporate survival, financial stability, and sustainable development (1). The International Monetary Fund (IMF) noted that corporate leverage in developing countries reached 87% of GDP in 2023, up from 75% in 2019 (Benediktsdottir, Danielsson, & Zoega, 2023). Economists are concerned that excessive financial pressure will reduce companies' willingness to invest in long-term sustainability solutions (Guérin, D'Espallier, & Venkatasubramanian, 2021). While investing in sustainability is a social good, it is not always a financial benefit;

therefore, companies need to have a strong social sense and responsibility (Cezarino, de Queiroz Murad, Resende, & Sales, 2020).

To fix a company's financial problems, researchers have identified factors at both macro (e.g., global economic conditions, government policies, market structure) and micro (e.g., corporate management, financial strategy, and innovation) levels. From a macro perspective, the main determinants influencing firm financial distress include national stability (Sehgal, Mishra, & Jaisawal, 2021) fiscal policy (Dumičić, 2019) financial regulation (Fernández-Gámez, Soria, Santos, & Alaminos, 2020) and government support (Sayidah & Assagaf, 2020) are the key factors that affect company financial distress. Meanwhile, from a micro viewpoint, it is found that managerial strategies (Slobodeniuk, Heidor, Velychko, Sylkina, & Kostenko, 2024), debt management (Afonso & Jalles, 2020), and operational efficiency (Jayawardena, 2020) can change financial conditions.

Other research found that economic stability and managerial strategies also impact financial distress (Apergis, Bhattacharya, & Inekwe, 2019). While current literature focuses on corporate structure and strategy, few studies have investigated CEO characteristics such as education as determinants of financial resilience. This factor is crucial for strategic decision-making during financial crises, as CEOs play a key role in navigating complex conditions and leveraging analytical expertise for data-driven solutions (Connell, 2019).

CEOs with science, technology, engineering, or mathematics (STEM) backgrounds bring a unique set of skills to the table. Those skills in risk management and sustainable innovation are able to strengthen a company's market position. What we know about managerial characteristics and their influence on operational aspects is that CEOs with a STEM education background tend to make their companies more efficient (Weerasinghe & Dissanayake, 2025), less prone to excessive risk-taking (Zhang, Xue, & Zhang, 2023), and quicker to adopt new technology (Kong, Liu, & Zhu, 2023). While there is plenty of research on how CEO traits affect firm performance, the role they play in financial recovery has not received much attention. One thing we do know is that STEM-based approaches are proven ways to drive innovation, efficiency, and risk management (Vedrenne-Gutiérrez et al., 2024).

Companies led by CEOs with STEM backgrounds tend to adopt a more data-driven approach to financial distress than their non-STEM counterparts (Alderman, Forsyth, Griffy-Brown, & Walton, 2022). That is because these CEOs have the analytical skills to excel in financial risk management and resource optimization (Jaggia & Thosar, 2021). What sets them apart is their emphasis on using data and technology to drive decisions, so that quantitative analysis, risk mitigation, and technology adoption are the keys to efficiency and long-term competitiveness (Kong et al., 2023; Rodríguez-Espíndola, Chowdhury, Dey, Albores, & Emrouznejad, 2022). This demonstrates the value of STEM CEOs in preventing financial distress and driving business sustainability (Ghardallou, 2022).

There is limited empirical evidence linking STEM CEOs to financial resilience. STEM CEOs are better at handling financial pressures because of their analytical and data-driven approach (Jaggia & Thosar, 2021), while also implementing measurable risk mitigation and technological innovations to improve efficiency and sustainability (Alderman et al., 2022). However, industry conditions, market volatility, and funding flexibility also shape financial performance (Restrepo, Uribe, & Manotas, 2020). Our findings show that companies led by STEM CEOs tend to exhibit higher financial health, but can STEM leadership truly reduce financial distress?

This paper investigates the impact of CEOs with STEM backgrounds on corporate financial distress risk. Using panel data from top-rated ESG firms (Sustainalytics, 2025), the study finds that companies led by STEM CEOs exhibit lower financial distress risk. This suggests that STEM CEOs contribute positively to firms' financial stability, likely due to their structured, analytical approach and long-term strategic thinking. STEM CEOs tend to invest in innovation and operational efficiency, enhancing resilience even under economic uncertainty. The impact is strongest in firms led by male CEOs, those with engineering backgrounds, companies in developed countries, and firms with smaller boards, smaller size, and lower innovation rates. The findings hold across validation tests, including CEM, PSM, and 2SLS analyses.

This study contributes to theoretical and practical understandings of CEO leadership by highlighting double-edged implications of STEM educational backgrounds for corporate financial stability. Theoretically, this research advances the Upper Echelons literature by demonstrating that STEM-educated CEOs are often associated with innovation and operational efficiency. These findings challenge the dominant narrative of uniformly positive outcomes from STEM leadership and introduce a more balanced perspective that accounts for the complexity of strategic decision-making under uncertainty. Moreover, the heterogeneity analysis shows that this financial risk is not uniform but varies depending on firm size, innovation intensity, CEO gender, board composition, and country-level context, thus offering a more granular theoretical insight into leadership effectiveness.

Practically, this study offers several implications for multiple stakeholders. First, internal corporate governance means stronger strategic oversight and financial controls in STEM-led companies to balance innovation-driven ambition with short-term financial resilience. Second, for boards and shareholders, it provides guidance on whether the CEO's leadership style and background fit the company's risk profile and long-term strategy. Third, for policymakers and regulators, it shows the need to design regulatory environments that support innovation and introduce guardrails to mitigate systemic financial risks from high-risk executive decision-making. Finally, for external stakeholders like investors and creditors, it provides a framework to incorporate CEO background into firm-level credit and investment risk. These contributions add to the managerial literature and inform better leadership selection, performance monitoring, and risk mitigation across different institutional and national contexts.

The findings indicate that while STEM-led companies show strong performance in operational efficiency and technological innovation, they also exhibit lower financial distress risk. This can be attributed to their structured, analytical, and long-term strategies, which enhance financial resilience by aligning innovation with risk management. By offering theoretical and practical implications for promoting innovation without compromising financial stability, this study enriches the discussion on how CEO background, firm, and country characteristics influence financial performance.

The remainder of the paper is presented as follows. Section 2 discusses the institutional context and hypothesis development. Section 3 details the research design and methodology. Section 4 presents the empirical results and robustness tests. Section 5 concludes with key findings, policy implications, and future research directions.

2. INSTITUTIONAL BACKGROUND AND HYPOTHESES

2.1. A Brief Institutional Background

Corporate sustainability, particularly Environmental, Social, and Governance (ESG) measurement and reporting (Alamillos & De Mariz, 2022), is governed by standard frameworks and regulations to preserve uniformity, reduce subjectivity, and increase accountability and transparency (Barker, 2025; Rodrigues & Franco, 2019). From planning to implementation, businesses need to perform rigorous evaluations. To ensure the policy is effective, sustainability reports are audited and tracked even after they are published (Martin-Rios, Poretti, & Derchi, 2022). Businesses should also incorporate sustainability into their operations by making investments in energy efficiency, carbon reduction, and green technology to meet stakeholder expectations and be more competitive (Pedol, Biffi, & Melzi, 2021; Yang & Chen, 2024).

This paper explores Sustainalytics' role in measuring ESG risk and the relationship between ESG ratings and financial stability (Sustainalytics, 2025). To lessen financial suffering, ESG ratings promote improved governance, transparency, and risk management (Li, Zhang, & Zhao, 2022). However, companies often struggle to balance sustainability goals with short-term financial efficiency (Cupertino, Vitale, & Taticchi, 2023). In this dynamic environment, leadership experience is crucial since CEOs with STEM degrees frequently prioritize innovation and technology, which can increase productivity over the long run but may put short-term financial strain on businesses (Kong et al., 2023). Hence, this paper examines the relationship between STEM CEOs and financial distress risk using a theory-based hypothesis.

2.2. Theoretical Analysis and Research Hypotheses

The "innovation effect," which STEM CEOs produce, indicates a deep understanding of technology and data-driven decision-making (Hsieh, Kim, Wang, & Wang, 2022). Meanwhile, the risk of financial distress is determined by financial structure, operational efficiency, and investment strategy (Jouali, El Aboudi, EL AFI, & Jouali, 2024). STEM-led innovation can increase efficiency and technological competitiveness (Kong et al., 2023), and their systematic approach to capital allocation and technology investments lowers financial risk and distress (Šmejkal, Novotná, & Volek, 2022). This is particularly true for companies that can handle market uncertainty and have sufficient financing (Nguyen & Nguyen, 2022). Hence, the following hypothesis is used in this paper in accordance with the Upper Echelons theory, which holds that top management traits affect corporate decision-making:

Hypothesis 1: CEOs with a STEM educational background have a relationship with the company's financial distress.

3. RESEARCH DESIGN AND DATA

3.1. Sample Selection

Table 1 presents the sample selection process for this study involved an initial set of 1,525 listed companies identified using Sustainalytics data. From this initial pool, 550 observations were excluded due to missing financial distress data, 67 due to incomplete control variable data, 51 from the financial industry (SIC 6) to ensure analytical consistency, and one due to data duplication. After this screening, the final sample consists of 856 companies.

Table 1. Sample selection.

Description	Observations
Top companies listed firms based on Sustainalytics	1,525
Less: Missing observations for Financial Distress	(550)
Less: Missing observations for control variables	(67)
Less: Financial industry (SIC 6)	(51)
Less: Data duplicates	(1)
Final sample	**856**

Note: This table reports our sample selection procedure.

3.2. Model Specification

This paper develops a regression model to examine the relationship between CEOs with STEM backgrounds and financial distress:

$$DISTRESS_i = \beta_0 + \beta_1 STEM_i + \beta_2 BSIZE_i + \beta_3 FSIZE_i + \beta_4 RND_i + \beta_5 ROE_i + \beta_6 CASTA_i + \beta_7 RISK_i + \beta_8 TANG_i + \beta_9 LOSS_i + \beta_{10} FAGE_i + \beta_{11} LIQUIDITY_i + COUNTRY\ FE + INDUSTRY\ FE + \varepsilon_i \quad (1)$$

In the equation, $DISTRESS_i$ represents the level of financial difficulty of company i, which is used as a dependent variable in this analysis. $STEM_i$ demonstrate the CEO's background in Science, Technology, Engineering, or Mathematics. ε represents the error term, while β_0-β_{11} is a regression coefficient that reflects the relationship between each independent variable to the company's financial distress. This model controls fixed effects (FE) at the country and industry levels to capture macroeconomic factors and industry characteristics that can affect a company's financial distress.

This study employs three complementary techniques to strengthen the validity of the results and address potential methodological limitations. First, we use Coarsened Exact Matching (CEM) to reduce selection bias by matching companies with similar observable characteristics, ensuring that differences in financial distress are linked to CEO background rather than confounding variables. Second, to increase the comparability of treatment and control groups, we employ Propensity Score Matching (PSM) to match firms and estimate the probability that a firm will be led by a STEM CEO based on the variables. Third, to address endogeneity issues such as reverse causation and omitted variable bias, we employ an instrumental variable (IV) method with Two-Stage Least Squares (2SLS). We utilize the possibility that a STEM individual will become CEO as a tool to obtain exogenous variation in CEO

experience. These robustness checks ensure that our results are empirically reliable and not influenced by unobserved heterogeneity.

3.3. Variable Construction

3.3.1. Independent Variables

According to Jaggia and Thosar (2021), a STEM CEO is defined as a CEO with an educational background in Science, Technology, Engineering, or Mathematics, based on the university's academic program classification. Following prior studies, a STEM CEO is measured as a dummy variable, assigned a value of 1 if the CEO holds an academic degree in a STEM field and 0 if the CEO has a non-STEM background.

3.3.2. Key Explanatory Variables

To measure financial distress, this paper adapts the Altman Z-Score approach, which is a financial ratio-based bankruptcy prediction model that has been widely used in corporate financial literature. The financial distress indicator is calculated using a formula that combines the profitability ratio, leverage, liquidity, solvency, and operating activity of the company. Following Harymawan, Putra, Fianto, and Wan Ismail (2021), this paper uses the financial statement data of listed companies and calculates the Altman Z-Score as a proxy for the level of financial distress. The lower the score obtained, the higher the likelihood that the company will experience financial distress.

3.3.3. Control Variables

In our empirical analysis, we included the following variables as covariates: the size of the board based on the number of board members in the company (Cardoso, Peixoto, & Barboza, 2019) the size of the company measured using the natural logarithms of the company's total assets (Bozkurt & Kaya, 2023), the company's investment in research and development calculated as the ratio of R&D expenditure to total assets (Agostino, Scalera, Succurro, & Trivieri, 2022) the ratio of earnings before income and tax to total assets to reflect the profitability of the company (Kebede, Tesfaye, & Erana, 2024) the ratio of cash to equity of the company as an indicator of liquidity (Kebede et al., 2024) risk rating score based on Sustain analytics assessment to capture the level of financial risk of the company (Li, Gupta, Bu, & Kannothra, 2023) the company's asset structure calculated as the ratio of fixed assets to total assets (Balasubramanian, GS, Sridevi, & Natarajan, 2019) company losses (Friska & Pudjolaksono, 2023) natural logarithm the year of establishment of the company from the year of observation to reflect the age of the company (Balasubramanian et al., 2019), and the ratio of current liabilities to current assets to capture the company's capacity to meet its short-term obligations (Hermawan, Septiawan, & Tresnawat, 2021). All the definitions of variables used in this study are available in Table 2.

Table 2. Variable operationalization.

Variables	Definitions	Sources
Dependent Variable		
DISTRESS	Using the Altman Z-Score prediction model, calculated based on five main financial ratios that reflect the company's liquidity, profitability, operational efficiency, solvency, and leverage.	Annual Report
Independent Variable		
STEM	The dummy variable is 1 if the CEO has a STEM (Science, Technology, Engineering, and Mathematics) background, and 0 otherwise.	Annual Report
Control Variable		
BSIZE	Natural logarithm of the number of members of the board of directors and board of commissioners in the company.	Annual Report
FSIZE	Firm size is measured by the natural logarithm of total assets.	Osiris
RND	Research and development divided by total assets.	Osiris
ROE	Earnings before income and tax divided by total equity.	Osiris

Variables	Definitions	Sources
CASTA	Cash of equity divided by total assets.	Osiris
RISK	Risk rating score based on Sustainalytics assessment.	Sustainalytics
TANG	Net of Property, Plant, and Equipment divided by total assets.	Osiris
LOSS	A dummy variable equal to 1 if the firm had a loss in the prior year and 0 otherwise.	Osiris
FAGE	Natural logarithm of the number of years since the company was founded.	Annual Report
LIQUIDITY	Current LIA divided by current assets.	Osiris

Note: This table outlines all variables used in the primary analysis of this study. Additional variables employed in robustness tests and further analyses will be discussed in each respective section.

3.4. Data Collection and Description

Table 3 presents the distribution of the sample based on the Standard Industry Code (SIC) shows that 63.55% of companies are led by CEOs with a STEM background, while 36.45% are led by non-STEM CEOs. STEM CEOs are more dominant in the Agriculture, Forestry, and Fishing (100%), Public Administration (100%), and Wholesale & Retail Trade (77.30%) sectors. Conversely, the Manufacturing (51.20%) and Mining & Construction (55.56%) sectors exhibit a more balanced distribution between STEM and non-STEM CEOs. Technology and innovation-based industries tend to have a higher proportion of STEM CEOs, whereas sectors such as Health, Legal, Educational Services & Consulting, and Service Industries are more often led by non-STEM CEOs. This reflects the differing skill requirements across industries.

Table 3. Sample distribution based on standard industry code.

Standard industry code (SIC)	STEM CEO		Non-STEM CEO		Total
	N	%	N	%	
Agriculture, forestry, and fishing (0)	2	100%	0	0%	2
Mining & construction (1)	15	55.56%	12	44.44%	27
Construction industries (2)	92	73.02%	34	26.98%	126
Manufacturing (3)	171	51.20%	163	48.80%	334
Transport, communication, electric, gas, and sanitary services (4)	57	69.51%	25	30.49%	82
Wholesale & retail trade (5)	126	77.30%	37	22.70%	163
Service Industries (7)	61	66.30%	31	33.70%	92
Health, legal, and educational services & consulting (8)	18	64.29%	10	35.71%	28
Public administration (9)	2	100%	0	0%	2
Total	544	63.55%	312	36.45%	856

The sample period of this paper takes place in 2022. STEM CEO data is obtained through annual reports, while registered company data is obtained from the Sustainalytics database. For the financial distress indicator, we obtained data from the annual report. The raw data descriptions for the three variable types in the previous subsection are provided in Table 4.

Table 4. Descriptive statistics.

Variables	N	Mean	STD	Minimum	P25	Median	P75	Maximum
DISTRESS	856	1.831	1.079	-1.494	1.178	1.796	2.407	5.224
STEM	856	0.364	0.482	0.000	0.000	0.000	1.000	1.000
BSIZE	856	2.866	0.445	1.386	2.565	2.890	3.178	3.970
FSIZE	856	14.914	1.522	11.248	13.844	14.809	15.973	18.662
RND	856	0.021	0.038	0.000	0.000	0.000	0.026	0.192
ROE	856	0.214	0.503	-2.106	0.090	0.181	0.309	2.520
CASTA	856	0.136	0.122	0.002	0.050	0.100	0.183	0.681
RISK	856	15.314	3.162	6.900	13.300	15.600	18.000	19.900
TANG	856	0.240	0.181	0.001	0.104	0.192	0.338	0.917
LOSS	856	0.127	0.334	0.000	0.000	0.000	0.000	1.000
FAGE	856	2.849	0.961	0.000	2.398	3.045	3.367	4.762
LIQUIDITY	856	0.719	0.454	0.107	0.425	0.646	0.885	4.702

The descriptive statistics table reveals significant variation in financial distress levels among companies, ranging from -1.494 to 5.224, highlighting substantial differences in financial stability. The STEM CEO variable has an average of 0.364, indicating that 36.4% of sampled companies are led by CEOs with a STEM background. Board size (BSIZE) and firm size (FSIZE) also exhibit considerable variation, with medians of 2.890 and 14.809, respectively, reflecting diverse corporate governance structures within the sample.

The R&D intensity (RND) variable has a median of 0.000 and a maximum of 0.192, suggesting that most firms allocate minimal budgets to R&D, although some invest heavily in innovation. Return on Equity (ROE) varies widely from -2.106 to 2.520, reflecting significant differences in financial performance. The Risk Rating Score (RISK) has a median of 15.600, with values ranging from 6.900 to 19.900, indicating considerable variation in financial risk. Liquidity (LIQUIDITY) averages 0.719, with cash ratios ranging from 0.107 to 4.702, highlighting disparities in firms' cash holdings.

4. EMPIRICAL ANALYSIS

Table 5 presents the results of a two-sample independent t-test comparing companies based on CEOs' STEM backgrounds indicate that financial distress levels do not differ significantly between the groups (coefficient = -0.110, t-value = -1.431). Several control variables, however, show notable differences. Companies with STEM CEOs have higher R&D investment ($p < 0.01$), indicating a stronger focus on innovation, and a higher cash-to-asset (CASTA) ratio ($p < 0.01$), reflecting prudent cash management. Although they exhibit lower liquidity (LIQUIDITY) ($p < 0.01$), this likely reflects strategic allocation of financial resources rather than vulnerability. Additionally, these firms do not show a significantly higher likelihood of incurring losses ($p < 0.1$). Overall, the findings suggest that companies led by STEM CEOs tend to adopt sound financial practices that reduce the risk of distress and enhance long-term stability.

Table 5. Two-sample independent t-test.

Variables	Mean of STEM CEO	Mean of Non-STEM CEO	Coef.	t-value
DISTRESS	1.901	1.791	-0.110	-1.431
BSIZE	2.859	2.870	0.011	0.351
FSIZE	14.899	14.923	0.024	0.225
RND	0.033	0.014	-0.019***	-7.379
ROE	0.219	0.211	-0.008	-0.232
CASTA	0.154	0.126	-0.029***	-3.335
RISK	15.415	15.257	-0.158	-0.703
TANG	0.223	0.251	0.028**	2.157
LOSS	0.099	0.143	0.044*	1.861
FAGE	2.915	2.811	-0.103	-1.515
LIQUIDITY	0.651	0.758	0.106***	3.319

Note: * Indicates that the coefficient is statistically significant at the 10% level ($p < 0.10$).
** indicates that the coefficient is statistically significant at the 5% level ($p < 0.05$).
*** indicates that the coefficient is statistically significant at the 1% level ($p < 0.01$).

Table 6 presents the Pearson correlation matrix for the main variables in this study indicates several significant relationships. Financial distress (DISTRESS) is significantly correlated with ROE (0.334, $p < 0.01$), LOSS (-0.362, $p < 0.01$), FSIZE (-0.100, $p < 0.01$), and RND (-0.135, $p < 0.01$), reflecting the influence of profitability, company size, and R&D investment on financial performance. Although STEM CEOs do not show a significant correlation with financial distress, they are positively correlated with RND (0.245, $p < 0.01$) and CASTA (0.113, $p < 0.05$), indicating that companies led by STEM CEOs tend to invest more in innovation and maintain healthier cash reserves. These financial practices are consistent with greater financial stability and a reduced risk of bankruptcy. Liquidity is negatively correlated with CASTA (-0.419, $p < 0.01$) but positively correlated with TANG (0.268, $p < 0.01$), showing the relationship between fixed assets and liquidity management. Overall, the data show no serious multicollinearity

concerns, though the strong relationship between FSIZE and BSIZE (0.551, $p < 0.01$) warrants attention in regression analyses.

Table 6. Pearson correlation.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) DISTRESS	1.000					
(2) STEM	0.049 (0.153)	1.000				
(3) BSIZE	-0.078** (0.022)	-0.012 (0.726)	1.000			
(4) FSIZE	-0.100*** (0.003)	-0.008 (0.822)	0.501*** (0.000)	1.000		
(5) RND	-0.135*** (0.000)	0.245*** (0.000)	0.066* (0.052)	-0.086** (0.012)	1.000	
(6) ROE	0.334*** (0.000)	0.008 (0.816)	0.049 (0.154)	0.067** (0.048)	-0.054 (0.113)	1.000
(7) CASTA	-0.090*** (0.008)	0.113*** (0.001)	-0.106*** (0.002)	-0.212*** (0.000)	0.327*** (0.000)	-0.109*** (0.001)
(8) RISK	-0.105*** (0.002)	0.024 (0.482)	0.130*** (0.000)	-0.005 (0.894)	0.077** (0.024)	-0.079** (0.020)
(9) TANG	-0.017 (0.615)	-0.074** (0.031)	-0.023 (0.502)	0.108*** (0.002)	-0.234*** (0.000)	0.056* (0.100)
(10) LOSS	-0.362*** (0.000)	-0.064* (0.063)	0.006 (0.861)	-0.095*** (0.006)	0.124*** (0.000)	-0.289*** (0.000)
(11) FAGE	0.211*** (0.000)	0.052 (0.130)	0.123*** (0.000)	0.193*** (0.000)	0.053 (0.121)	0.067* (0.051)
(12) LIQUIDITY	-0.159*** (0.000)	-0.113*** (0.001)	0.067** (0.050)	0.183*** (0.000)	-0.177*** (0.000)	0.071** (0.038)
Variables	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
(7) CASTA	1.000					
(8) RISK	0.059* (0.084)	1.000				
(9) TANG	-0.215*** (0.000)	0.076** (0.027)	1.000			
(10) LOSS	0.031 (0.362)	0.103*** (0.003)	-0.023 (0.510)	1.000		
(11) FAGE	-0.012 (0.722)	-0.104*** (0.002)	0.002 (0.947)	-0.097*** (0.004)	1.000	
(12) LIQUIDITY	-0.419*** (0.000)	-0.024 (0.484)	0.268*** (0.000)	0.021 (0.545)	-0.097*** (0.004)	1.000

Note: * Indicates that the coefficient is statistically significant at the 10% level ($p < 0.10$).
** indicates that the coefficient is statistically significant at the 5% level ($p < 0.05$).
*** indicates that the coefficient is statistically significant at the 1% level ($p < 0.01$).

4.1. Baseline Regression

The baseline regression includes all companies with complete data from the Sustainalytics ESG Risk Rating 2022, totaling 856 observations, and examines the relationship between CEO STEM backgrounds and financial distress. As shown in columns (1) and (3) of Table 7, firms led by STEM CEOs tend to exhibit a lower risk of financial distress, supporting the hypothesis that STEM CEOs contribute to greater financial stability. This suggests that STEM CEOs influence strategic decisions by promoting innovation-driven approaches that enhance operational efficiency and long-term competitiveness, while effectively managing financial stability (Kong et al., 2023). Column (2) excludes country and industry fixed effects, while column (3) incorporates them, revealing a more pronounced relationship, likely due to industry- and country-specific factors. STEM CEOs' preference for investing in technology and innovation strengthens firms' competitive position and reduces bankruptcy risk by fostering sustainable growth and prudent financial management (Alderman et al., 2022; Hsieh et al., 2022).

Table 7. Baseline regression.

Variables	(1)	(2)	(3)
	DISTRESS	DISTRESS	DISTRESS
STEM	0.182**	0.091	0.167**
	(2.403)	(1.354)	(2.582)
BSIZE		-0.042	-0.035
		(-0.516)	(-0.391)
FSIZE		-0.122***	-0.110***
		(-4.847)	(-4.036)
RND		-3.178***	-3.477***
		(-3.017)	(-3.126)
ROE		0.536***	0.482***
		(4.667)	(4.305)
CASTA		-1.251***	-0.942***
		(-4.458)	(-3.116)
RISK		-0.008	-0.015
		(-0.834)	(-1.586)
TANG		-0.121	-0.148
		(-0.548)	(-0.679)
LOSS		-0.843***	-0.834***
		(-6.950)	(-6.907)
FAGE		0.208***	0.198***
		(6.341)	(6.073)
LIQUIDITY		-0.453***	-0.287***
		(-4.542)	(-2.975)
Constant	2.742***	3.850***	4.350***
	(6.490)	(10.760)	(9.142)
Country FE	Yes	No	Yes
Industry FE	Yes	No	Yes
R^2	0.201	0.299	0.430
Adjusted R^2	0.155	0.289	0.390
N	856	856	856

Note: * Indicates that the coefficient is statistically significant at the 10% level ($p < 0.10$).
** indicates that the coefficient is statistically significant at the 5% level ($p < 0.05$).
*** indicates that the coefficient is statistically significant at the 1% level ($p < 0.01$).

STEM leadership has an impact beyond the individual company, creating positive spillover effects across the industry. Companies with STEM CEOs set the bar for operational efficiency and financial resilience through their strategic and innovative approaches. They make smart technology investments, which others follow, creating a healthier competitive landscape. STEM CEOs' forward thinking attracts investor confidence and regulatory support and raises market expectations in a way that promotes good financial management. This can lead to more balanced decisions on leverage and capex and reduce the risk of financial distress within the company and across the industry.

4.2. Robustness Checks

4.2.1. Addressing Selection Bias with CEM

This study uses Coarsened Exact Matching (CEM) to address potential selection bias and obtain an accurate estimation of the relationship between CEO background and financial distress. CEM matches firms with similar observable characteristics so that any differences in financial distress risks are due to the CEO's background rather than other confounding factors (see Table 8).

After CEM, the results still hold: STEM CEOs have a persistent and significant positive association with financial distress. This means STEM leadership, often associated with innovation and efficiency, leads to a better financial

condition by increasing operational resilience and reducing the likelihood of financial distress, especially through prudent resource allocation to R&D and technological investment.

Moreover, CEM improves the covariate balance between the treatment and control groups (STEM vs. non-STEM CEOs), making the methodology more robust and credible. This approach also enhances the reliability of the results by reducing selection bias and providing clearer evidence on how STEM CEOs' educational backgrounds affect firm-level financial outcomes.

Table 8. Robustness test – CEM regression.

Variables	DISTRESS
STEM	0.207***
	(3.11)
BSIZE	0.063
	(0.71)
FSIZE	-0.097***
	(-3.63)
RND	-4.070***
	(-3.39)
ROE	0.500***
	(4.01)
CASTA	-0.861***
	(-2.65)
RISK	-0.015
	(-1.49)
TANG	-0.177
	(-0.75)
LOSS	-0.780***
	(-6.24)
FAGE	0.205***
	(5.98)
LIQUIDITY	-0.559***
	(-4.61)
Constant	4.461***
	(8.70)
Country FE	Yes
Industry FE	Yes
R^2	0.449
Adjusted R^2	0.404
N	758

Note: * Indicates that the coefficient is statistically significant at the 10% level ($p < 0.10$).
** indicates that the coefficient is statistically significant at the 5% level ($p < 0.05$).
*** indicates that the coefficient is statistically significant at the 1% level ($p < 0.01$).

4.2.2. Addressing Selection Bias with PSM

This study employs Propensity Score Matching (PSM) to mitigate potential selection bias in assessing the relationship between STEM CEO leadership and financial distress. To ensure that any observed variations in financial hardship are related to CEO background rather than external variables, PSM specifically compares firms with an identical chance of hiring CEOs with STEM backgrounds based on observable covariates (see Table 9).

After applying PSM, the analysis reveals a persistently positive and significant relationship. This implies that businesses with CEOs with STEM backgrounds are generally more financially secure and have a lower chance of bankruptcy, even after controlling for firm-level factors. This is mainly because of their effective innovation and long-term investment techniques.

Table 9. Robustness test – PSM regression.

Variables	(1)	(2)
	DISTRESS	DISTRESS
STEM	0.182**	0.205***
	(2.074)	(2.813)
BSIZE		-0.004
		(-0.038)
FSIZE		-0.107***
		(-3.273)
RND		-2.154*
		(-1.759)
ROE		0.602***
		(3.615)
CASTA		-1.035***
		(-2.929)
RISK		-0.015
		(-1.272)
TANG		0.176
		(0.642)
LOSS		-0.937***
		(-5.156)
FAGE		0.141***
		(3.399)
LIQUIDITY		-0.517***
		(-3.152)
Constant	2.746***	4.318***
	(6.796)	(6.537)
Country FE	Yes	Yes
Industry FE	Yes	Yes
R^2	0.260	0.493
Adjusted R^2	0.195	0.437
N	540	540

Note: * Indicates that the coefficient is statistically significant at the 10% level ($p < 0.10$).
** indicates that the coefficient is statistically significant at the 5% level ($p < 0.05$).
*** indicates that the coefficient is statistically significant at the 1% level ($p < 0.01$).

4.2.3. Addressing Endogeneity Further Using an Instrumental Variable in 2SLS

Although the baseline model addresses multiple potential endogeneity sources, there are still concerns regarding unobserved differences and possible bias in the variables. We employ an instrumental variable (IV) approach using two-stage least squares (2SLS) to address these issues. Specifically, we use the probability of an individual becoming a STEM CEO (PROB) as the IV, which captures exogenous factors influencing the selection of STEM-background CEOs and serves as an objective predictor of STEM leadership potential.

As reported in Table 10, the first-stage results show a significant relationship between PROB and STEM CEO coefficient = 0.039, $p < 0.01$, confirming the instrument's relevance and strength. In the second stage, the 2SLS regression demonstrates a positive and significant association between STEM CEO leadership and financial distress (coefficient = 0.088, $p < 0.05$), aligning closely with our baseline findings.

These results confirm that STEM CEOs contribute to improved financial stability, likely due to their innovation-driven and efficient management strategies that balance investment with risk. More importantly, the IV-2SLS estimation confirms that our core findings remain robust even after addressing potential endogeneity concerns. This strengthens the methodological validity and reinforces the causal interpretation of the relationship between CEO background and financial outcomes.

Table 10. Robustness test – 2SLS regression.

Variables	First-stage	Second-stage
	STEM	DISTRESS
PROB	0.039***	
	(11.899)	
STEM		0.088**
		(2.146)
BSIZE	0.034	-0.045
	(0.214)	(-0.490)
FSIZE	0.026	-0.111***
	(0.587)	(-4.040)
RND	7.009***	-3.764***
	(4.565)	(-3.198)
ROE	0.057	0.480***
	(0.592)	(4.286)
CASTA	0.270	-0.927***
	(0.555)	(-3.094)
RISK	0.009	-0.015
	(0.504)	(-1.573)
TANG	0.328	-0.206
	(0.969)	(-0.952)
LOSS	-0.308*	-0.825***
	(-1.783)	(-6.777)
FAGE	0.030	0.198***
	(0.492)	(6.036)
LIQUIDITY	-0.339**	-0.264***
	(-2.151)	(-2.726)
Constant	-2.054***	4.086***
	(-2.633)	(7.422)
Country FE	Yes	Yes
Industry FE	Yes	Yes
R^2	0.247	0.423
N	833	833

Note: * Indicates that the coefficient is statistically significant at the 10% level ($p < 0.10$).
** indicates that the coefficient is statistically significant at the 5% level ($p < 0.05$).
*** indicates that the coefficient is statistically significant at the 1% level ($p < 0.01$).

4.3. Heterogeneity Analyses

4.3.1. Section STEM

The leadership of STEM CEOs relates to financial distress, often driving companies toward technology-driven strategies. However, these effects vary across STEM disciplines.

Table 11 categorizes CEOs by Science, Technology, Engineering, and Mathematics (STEM) backgrounds, revealing distinct patterns. As shown in column (3), engineering CEOs have a positive association with reduced financial distress (0.126, $p < 0.1$), whereas those with Science, Technology, and Mathematics backgrounds show no significant impact.

This suggests that the technical, infrastructure-oriented approach typical of engineering CEOs may lead to investment decisions and greater financial performance. These findings highlight that not all STEM leaders exert the same relation with financial distress risk.

Table 11. Additional analysis – Section STEM.

	(1)	(2)	(3)	(4)
	DISTRESS	DISTRESS	DISTRESS	DISTRESS
Science	0.078			
	(0.689)			
Technology		0.164		
		(1.192)		
Engineering			0.126*	
			(1.807)	
Mathematic				0.090
				(0.209)
BSIZE	-0.038	-0.037	-0.033	-0.037
	(-0.412)	(-0.405)	(-0.357)	(-0.399)
FSIZE	-0.109***	-0.107***	-0.108***	-0.108***
	(-3.984)	(-3.935)	(-3.974)	(-3.950)
RND2	-3.055***	-3.083***	-3.272***	-3.046***
	(-2.739)	(-2.752)	(-2.932)	(-2.740)
ROE2	0.483***	0.484***	0.482***	0.482***
	(4.299)	(4.309)	(4.303)	(4.303)
CASTA	-0.932***	-0.935***	-0.950***	-0.930***
	(-3.094)	(-3.097)	(-3.147)	(-3.094)
RISK	-0.015	-0.015	-0.015	-0.015
	(-1.529)	(-1.539)	(-1.502)	(-1.518)
TANG	-0.142	-0.128	-0.151	-0.136
	(-0.644)	(-0.580)	(-0.688)	(-0.615)
LOSS	-0.850***	-0.847***	-0.846***	-0.854***
	(-7.057)	(-7.028)	(-7.030)	(-7.070)
FAGE	0.201***	0.201***	0.199***	0.201***
	(6.183)	(6.174)	(6.108)	(6.183)
LIQUIDITY	-0.298***	-0.300***	-0.298***	-0.300***
	(-3.055)	(-3.066)	(-3.058)	(-3.056)
_cons	4.340***	4.314***	4.326***	4.317***
	(9.174)	(9.143)	(9.173)	(9.123)
Country FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
r2	0.426	0.426	0.428	0.426
r2_a	0.385	0.385	0.387	0.385
N	856	856	856	856

Note: * Indicates that the coefficient is statistically significant at the 10% level ($p < 0.10$).
** indicates that the coefficient is statistically significant at the 5% level ($p < 0.05$).
*** indicates that the coefficient is statistically significant at the 1% level ($p < 0.01$).

4.3.2. Developing vs Developed Country

This analysis examines the relationship between STEM CEO leadership and financial distress risk in developing and developed countries. Table 12 shows that STEM CEOs tend to make companies more financially stable and reduce bankruptcy risk across both contexts. However, the positive impact on financial performance is stronger in developed countries, where stable financial systems, robust corporate governance, and better access to funding and technology can support STEM-led firms. In developing countries, despite greater economic volatility, STEM CEOs still contribute to improving financial health, with a relatively smaller impact.

Table 12. Additional analysis – developing vs. developed countries.

	Developing	Developed
	(1)	(2)
	DISTRESS	DISTRESS
STEM	0.255	0.163**
	(1.004)	(2.447)
BSIZE	0.057	-0.066
	(0.182)	(-0.699)
FSIZE	-0.211*	-0.098***
	(-1.868)	(-3.499)
RND2	3.370	-3.937***
	(0.821)	(-3.563)
ROE2	0.622***	0.441***
	(2.821)	(3.860)
CASTA	-2.090**	-0.925***
	(-2.232)	(-2.881)
RISK	-0.072*	-0.013
	(-1.824)	(-1.267)
TANG	0.698	-0.314
	(0.760)	(-1.430)
LOSS	-0.515	-0.858***
	(-1.594)	(-6.886)
FAGE	0.223*	0.202***
	(1.730)	(5.950)
LIQUIDITY	-0.307	-0.311***
	(-0.777)	(-3.036)
_cons	7.753***	4.297***
	(4.142)	(7.419)
Country FE	Yes	Yes
Industry FE	Yes	Yes
r2	0.706	0.425
r2_a	0.519	0.390
N	73	782

Note: * Indicates that the coefficient is statistically significant at the 10% level ($p < 0.10$).
** indicates that the coefficient is statistically significant at the 5% level ($p < 0.05$).
*** indicates that the coefficient is statistically significant at the 1% level ($p < 0.01$).

4.3.3. Gender of CEO

To understand whether gender affects leadership outcomes, we examine the impact of STEM CEO gender on financial distress by splitting the sample by male and female CEOs. Table 13 shows that STEM CEOs make companies more financially stable and reduce bankruptcy risk in male-led firms (0.155, $p < 0.05$), but not in female-led firms. This suggests that male STEM CEOs may adopt a more cautious financial approach, while female STEM CEOs still lead financially healthy firms, though with slightly less emphasis on risk avoidance.

4.3.4. Board Size of Company

Table 14 indicates that STEM CEO leadership has a greater beneficial impact on increasing a company's financial stability and lowering the likelihood of bankruptcy for companies with smaller boards (0.218, $p < 0.05$). According to these results, smaller boards offer more organizational flexibility, facilitating speedier strategic choices that lessen financial hardship. This enables businesses to react to changes in the economy and modify their financial plans quickly, which improves their stability and resilience.

Table 13. Additional analysis – Gender of CEO.

	Male CEO	Female CEO
	(1)	(2)
	DISTRESS	DISTRESS
STEM	0.155**	0.110
	(2.285)	(0.473)
BSIZE	-0.058	-0.394*
	(-0.604)	(-1.747)
FSIZE	-0.102***	-0.112
	(-3.509)	(-1.521)
RND2	-3.702***	-0.304
	(-3.322)	(-0.049)
ROE2	0.449***	0.672**
	(3.849)	(2.279)
CASTA	-1.000***	-1.943
	(-3.223)	(-1.123)
RISK	-0.019*	0.064**
	(-1.784)	(2.433)
TANG	-0.053	-1.206*
	(-0.225)	(-2.011)
LOSS	-0.877***	-0.614**
	(-6.903)	(-2.213)
FAGE	0.203***	-0.034
	(5.893)	(-0.248)
LIQUIDITY	-0.312***	-0.042
	(-2.965)	(-0.180)
_cons	4.503***	1.667
	(9.135)	(1.210)
Country FE	Yes	Yes
Industry FE	Yes	Yes
r2	0.430	0.784
r2_a	0.386	0.627
N	783	72

Note: * Indicates that the coefficient is statistically significant at the 10% level ($p < 0.10$).
** indicates that the coefficient is statistically significant at the 5% level ($p < 0.05$).
*** indicates that the coefficient is statistically significant at the 1% level ($p < 0.01$).

Table 14. Additional analysis Board size of the company.

	Small board	Big board
	(1)	(2)
	DISTRESS	DISTRESS
STEM	0.218**	0.136
	(2.335)	(1.546)
FSIZE	-0.099**	-0.135***
	(-2.420)	(-4.036)
RND2	-1.376	-6.108***
	(-0.773)	(-4.286)
ROE2	0.574***	0.434***
	(3.269)	(2.998)
CASTA	-1.074***	-0.591
	(-2.623)	(-1.131)
RISK	-0.030**	0.005
	(-2.254)	(0.372)
TANG	-0.138	-0.270
	(-0.405)	(-0.968)
LOSS	-0.769***	-0.843***
	(-3.660)	(-5.714)
lnFAGE	0.146***	0.272***
	(3.103)	(6.134)
LIQUIDITY	-0.289*	-0.256*
	(-1.922)	(-1.909)

	Small board	Big board
	(1)	(2)
	DISTRESS	DISTRESS
_cons	4.057***	2.981***
	(5.089)	(4.874)
Country FE	Yes	Yes
Industry FE	Yes	Yes
r2	0.471	0.473
r2_a	0.398	0.407
N	405	451

Note: * Indicates that the coefficient is statistically significant at the 10% level (p < 0.10).
** indicates that the coefficient is statistically significant at the 5% level (p < 0.05).
*** indicates that the coefficient is statistically significant at the 1% level (p < 0.01).

4.3.5. Size of Company

We further examine the impact of STEM CEO leadership on financial distress varies by firm size. As shown in Table 15, STEM CEOs contribute significantly to enhancing financial health and lowering bankruptcy risk in smaller firms (0.254, p < 0.05). This indicates that small firms are better positioned to capitalize on the strengths of STEM-oriented leaders, particularly in executing strategies to manage financial risks due to their greater flexibility and responsiveness to financial pressures.

Table 15. Additional analysis – Size of Company.

	Small company	Big company
	(1)	(2)
	DISTRESS	DISTRESS
STEM	0.254**	0.102
	(2.545)	(1.100)
BSIZE	-0.117	-0.174
	(-0.897)	(-1.400)
RND2	-4.876***	-1.086
	(-3.482)	(-0.774)
ROE2	0.729***	0.362***
	(3.168)	(2.933)
CASTA	-0.633	-1.170**
	(-1.601)	(-2.295)
RISK	-0.015	-0.003
	(-1.084)	(-0.201)
TANG	-0.226	-0.270
	(-0.739)	(-0.913)
LOSS	-0.711***	-0.830***
	(-3.488)	(-5.267)
FAGE	0.188***	0.169***
	(3.946)	(3.557)
LIQUIDITY	-0.143	-0.573***
	(-1.025)	(-3.619)
_cons	2.124***	3.429***
	(3.259)	(6.165)
Country FE	Yes	Yes
Industry FE	Yes	Yes
r2	0.447	0.487
r2_a	0.380	0.412
N	452	404

Note: * Indicates that the coefficient is statistically significant at the 10% level (p < 0.10).
** indicates that the coefficient is statistically significant at the 5% level (p < 0.05).
*** indicates that the coefficient is statistically significant at the 1% level (p < 0.01).

4.3.6. Company Innovation

Lastly, we evaluate the impact of STEM CEO leadership on financial distress based on firm's level of innovation. Table 16 indicates that in firms with lower innovation activity, STEM CEOs are associated with notable improvements in financial stability and a reduced likelihood of bankruptcy (0.218, $p < 0.01$). This suggests that in these firms, STEM-driven strategies, such as focused technology investment and operational restructuring, enable more efficient use of R&D resources. In turn, these improvements enhance financial stability.

Table 16. Additional analysis – Innovation company.

	Low innovation	High innovation
	(1)	(2)
	DISTRESS	DISTRESS
STEM	0.218***	0.120
	(2.990)	(0.941)
BSIZE	0.031	-0.183
	(0.321)	(-0.957)
FSIZE	-0.142***	-0.055
	(-4.164)	(-1.326)
ROE2	0.556***	0.298*
	(3.641)	(1.660)
CASTA	-0.637*	-1.557***
	(-1.867)	(-2.749)
RISK	-0.025**	-0.007
	(-2.288)	(-0.337)
TANG	-0.364	1.346***
	(-1.519)	(2.778)
LOSS	-0.582***	-1.404***
	(-3.980)	(-7.254)
FAGE	0.221***	0.131*
	(6.033)	(1.942)
LIQUIDITY	-0.343***	-0.240*
	(-3.038)	(-1.881)
_cons	4.918***	1.625**
	(9.375)	(2.240)
Country FE	Yes	Yes
Industry FE	Yes	Yes
r2	0.468	0.512
r2_a	0.417	0.430
N	618	238

Note: * Indicates that the coefficient is statistically significant at the 10% level ($p < 0.10$).
** indicates that the coefficient is statistically significant at the 5% level ($p < 0.05$).
*** indicates that the coefficient is statistically significant at the 1% level ($p < 0.01$).

5. CONCLUDING REMARKS

5.1. Key Conclusions

This paper investigates the relationship between STEM CEO leadership and financial distress risk using data from companies listed in the Sustainalytics ESG Risk Rating in 2022. The findings reveal that firms led by CEOs with a STEM background tend to be less at risk of financial distress than those led by non-STEM CEOs. This effect is particularly pronounced in smaller firms, firms with a low level of innovation, and those with fewer board members. The flexibility and resource limitations in these situations enable STEM-driven leadership to improve financial performance. Strategic investment in innovation and technology is also an important mechanism that enhances financial resilience and operational efficiency, particularly in uncertain markets. A more detailed analysis shows that the benefits of STEM leadership in reducing financial distress are more pronounced in developed countries, in male-led firms, and in industries with low innovation intensity. These findings remain robust after conducting methodological checks, including Coarsened Exact Matching (CEM), Propensity Score Matching (PSM), and instrumental variable (IV) methods using Two-Stage Least Squares (2SLS) regression. This provides valuable insights for policymakers and strategic managers on how to balance innovation and risk when choosing top leadership.

5.2. Policy Implication and Directions for Future Research

Based on this study's findings, several policy implications can enhance CEO leadership effectiveness in managing financial stability. To improve CEO leadership on financial stability, policymakers should include leadership in corporate governance guidelines as STEM CEOs drive innovation and technological investments that improve financial health and reduce bankruptcy risk. Innovation and prudent financial management need stronger board oversight, especially through audit committees and boards of directors, to ensure sound investment strategies under STEM leadership. Governments and regulators can also incentivize growth-oriented yet financially conscious strategies by providing easier access to risk-based credit or funding programs for controlled sustainable innovation and encouraging prudent financial management while reducing excessive risk-taking. Companies should also implement stronger internal governance mechanisms to ensure that CEOs' strategic decisions prioritize long-term financial stability alongside technological growth. Establishing risk assessment frameworks, investment review processes, and financial sustainability metrics can help align leadership decisions with corporate resilience.

This study opens several avenues for future research in the academic literature. First, further studies could examine the impact of specific STEM disciplines (Science, Technology, Engineering, and Mathematics) on financial decision-making and risk management. Our findings indicate that engineering CEOs have a stronger relationship with financial resilience, highlighting the need for a deeper understanding of managerial characteristics based on domain expertise. Second, future research could expand the contextual scope by considering factors such as differences in financial regulations, capital market conditions, and policy support in developing and developed countries. Third, integrating additional leadership variables, such as industry experience, leadership style, or CEO psychological traits, could further explain variations in financial risk management. Finally, with richer datasets, future studies could explore the long-term effects of STEM CEO leadership on company profitability and financial stability across extended economic cycles, offering deeper insights into how technology-driven leadership relates to corporate resilience in an increasingly digital and volatile economy.

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