



Assessing the Impact of Firm age on Bankruptcy and Financial Risk: Empirical Insights into Corporate Financial Health

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Abstract:

This study examines the relationship between firm age, bankruptcy risk and financial risk as indicators of corporate financial health within the automobile sector. Using panel data for nine years (2017-2025), the research employs a Linear Mixed-Effects Model and bootstrapped regression to assess the influence of firm age on the Altman Z-score, followed by Kendall's tau correlation to explore its association with volatility of net income. Results reveal that firm age significantly and negatively affects the Altman Z-score, suggesting that older firms face greater bankruptcy risk. Conversely, a moderate positive association between firm age and income volatility indicate that mature firms experience greater earnings fluctuation. These outcomes reflect the structural and competitive realities of the Indian automobile industry, where capital intensity, regulatory shifts and technological transitions influence long-term corporate financial health. Notably, no control variables were included, allowing firm age to be examined as an independent determinant of financial health. The study underscores the relevance of firm age as a standalone indicator in financial risk assessment and provides a foundation for further sector-specific exploration.

Keywords: Altman Z-score; Bankruptcy Risk; Bootstrapped Regression; Corporate Financial Health; Financial Risk; Firm Age; Net Income Volatility; Linear-Mixed Effects Model

Introduction:

Corporate financial health reflects a company's capacity to meet obligations, fund growth and withstand market disruptions, making it an indispensable focus in corporate governance and strategic planning. Financial health assessment helps stakeholders like investors, creditors and management to gauge the company's risk profile and operational efficiency (Rashid, Khan & Qureshi, 2023). A company's financial health plays a vital role in ensuring its long-term sustainability and growth as it reflects the organisation's capacity to withstand economic fluctuations and leverage emerging opportunities (Kamal, 2024). A financially healthy company is not only capable of withstanding economic shocks but is also better positioned to invest in innovation, expand operations and sustain employment, thereby continuing positively to the broader economy. From a stakeholder perspective, corporate financial health plays a significant role in shaping strategic decisions. Investors depend on financial performance metrics to assess risk and return potential, while lenders use them to decide creditworthiness. For management, financial analysis helps budgeting, forecasting and the identification of operational efficiencies. Moreover, regulators and policymakers monitor corporate financial health indicators to ensure financial system stability and prevent systemic risks. As corporate failures have wide-ranging implications, early detection of financial distress through financial health analysis enables timely intervention and risk mitigation.

In academic and professional research, the study of corporate financial health helps to uncover patterns, predict outcomes such as bankruptcy or turnaround and evaluate the effectiveness of management practices. Given its multidimensional relevance, the assessment of corporate financial health continues to be a vital area of inquiry across sectors and disciplines, forming the basis for informed decision-making and sustainable corporate governance.

While corporate financial health is important across sectors, its significance is amplified in capital-intensive and economically influential industries such as the automobile sector. In India, the automobile industry contributes approximately 7.1% to the national GDP and nearly 49% to the manufacturing GDP, making it a key driver of industrial growth. It also generates millions of direct and indirect jobs and supports allied sectors like steel, rubber, electronics and logistics. The government's focus on this sector is evident through initiative like Production-Linked Investment (PLI) Scheme for automobile and auto component manufacturers and the FAME II (Faster Adoption and Manufacturing of Hybrid & Electric Vehicles) scheme, which aims to promote clean mobility. However, despite its scale and potential, the sector faces financial pressures due to fluctuating demand, rising input costs, regulatory transitions and global supply chain disruptions. Therefore, assessing the financial health of automobile companies offers valuable insights into their resilience, competitiveness and long-term contribution to India's industrial economy.

While extensive research has examined the determinants of corporate financial health using ratios, leverage and profitability measures, the role of firm-specific characteristics such as age and risk management has received limited empirical attention. Firm age may influence financial stability through accumulated experience, market presence and resource maturity. Younger firms often face higher uncertainty and income volatility due to weaker financial buffers, whereas older firms may demonstrate greater resilience and lower bankruptcy risk. Therefore, this study explores how firm age affects both bankruptcy risk, represented by the Altman Z score and financial risk, proxied by the volatility of net income, among automobile companies in India. The objectives of this study are as follows:

- 1) To study the relationship between firm, age and Altman Z score (proxy for bankruptcy risk)
- 2) To study the relationship between firm age and volatility of net income (proxy for financial risk)

The remainder of this paper is organised as follows: Section 2 reviews relevant literature, Section 3 describes the research methodology, Section 4 presents analysis of data, Section 5 concludes with results, discussion and conclusion and Section 6 presents the limitations of the current study and also opportunities for future research based on the same.

2. LITERATURE REVIEW:

Corporate financial health reflects the ability of the company to maintain a balance against the changing conditions of the environment and at the same time in relation to everyone participating in the business. It involves prudent financial planning, efficient resource allocation, effective cash flow management, sound risk assessment, mitigation and proactive adaptation to changing market conditions. Although the term 'financial health' is gaining traction in policy and industry discussions, it is not consistently used in academic research. Instead, terms like 'financial performance', 'financial strength', 'financial well-being' and 'financial distress prediction' are more commonly applied, despite sharing conceptual overlap with financial health. These constructs, though distinct in terminology, are conceptually aligned with the broader idea of financial health and are therefore included in this review. According to 'Corporate Distress Report' published by the Government Commercial Function (2023), corporate financial health is defined as an organisation's capacity to maintain profitability, manage liquidity and meet financial obligations sustainably, ensuring stakeholder confidence and its ability to fulfil long-term commitments without significant risk of financial distress or operational failure. Similarly, in analysing small business financial health, Everett, Onyeagoro & Davidson (2014) define a firm's

consistent profitability, ability to meet short-term and long-term liabilities, resilience to economic shocks and capacity to finance growth via debt and internal cash flow. Several other researchers have attempted to define corporate financial health in ways that broadly overlap with the definitions cited above (Osho & Omole, 2022). Abdul Rahman, Rajah, Abdul Rahman, Abdul Manaf and Masri (2025) define corporate financial health as a multidimensional construct comprising profitability, liquidity, capital structure, investment efficiency and suggest that it is positively influenced by the financial literacy of employees and managers. However, despite these efforts, there is no universally accepted definition and some use the term 'financial health' without clearly specifying what it entails (Jahangir & Sangmi, 2025; Bala, 2022) or equating the term 'financial health' with bankruptcy prediction (Ostojić, 2023) or other terms leading to inconsistent usage of terminology (Foo & Pathak, 2019; Hooda & Hooda, 2019; Zhao & Wijewardana, 2012).

Dainelli, Bet & Fabrizi (2024) conceptualise corporate financial health as a company's ability to maintain equilibrium within the financial system, dynamically linked to default risk and employ an equilibrium model to reflect the real-time interaction of credit, market and idiosyncratic risks. Their forward-looking equilibrium model underscores the need to capture multiple dimensions of financial health- an approach this study adopts by applying factor analysis to identify and aggregate key financial indicators shaping the health of India automobile companies.

As noted above, corporate financial health is particularly equated with absence of bankruptcy (Lvova, 2019). This is the reason that majority of the studies based on corporate financial health analysis employ bankruptcy prediction models in order to assess the corporate financial health. Asif, Tiwari, Saxena & Bhardwaj (2024) applied Altman Z score model to NSE listed companies in India, demonstrating its effectiveness in bankruptcy risk through five key financial ratios, while highlighting its relevance for investors and policymakers in assessing corporate financial vulnerability. Bolek & Gniadkowska-Szymanska (2022) analysed S&P 500 companies and found that Earnings Per Share (EPS) growth generally has a positive impact on financial health- as measured by the Altman Z Score- though this relationship varies with company size, with smaller firms benefiting more and medium-sized firms sometimes experiencing negative effects.

While bankruptcy models like the Altman Z score or Ohlson O score offer useful insights into the likelihood of default, their scope is inherently limited when applied to the broader concept of financial health. These models primarily focus on identifying distress risk rather than assessing broader aspects of financial health (Horvathova, Mokrisova & Petruska, 2021). Mishra, Aithal & Tripathi (2023) analysed companies from key Nifty sectoral indices using financial ratios and found that strong credit performance- reflected in liquidity, profitability and asset efficiency- positively correlates with corporate financial health and supports broader economic growth when accompanied by sound risk management and regulatory practices. Another study by Chakraborty & Sharma (2007) explored the effectiveness of various neural network architectures- including Radial Basis Function Networks, Multi-Layer Perceptrons (with and without PCA), Self-Organising Feature Maps combined with MLP and Support Vector Machines- in classifying and predicting the financial health of firms, highlighting the growing relevance of neural networks in financial health forecasting.

To address the limitations of traditional distress models, researchers have explored alternative indicators that capture different dimensions of financial health. Net Income and its volatility over time are particularly valuable, as they reflect the consistency and predictability of firm's earnings- a crucial aspect of long-term sustainability. Barth, Beaver & Landsman (1998) examined the how the relevance of equity book value and net income changes with a firm's financial health, finding that as financial health decline, equity book value becomes more useful for valuation while the importance of net income decreases- a pattern observed consistently across industries, firm sizes and risk levels. Zarb (2018) investigated the impact of liquidity, solvency and overall financial health on profit volatility in US Airline companies, revealing that financial indicators- particularly the debt-to-equity ratio and operating profit margin- play a statistically significant role in explaining variations in operating performance.

Despite growing interest in assessing corporate financial health, empirical research rarely integrates firm-specific attributes such as age into the analysis of financial risk and stability. Most existing studies emphasize distress prediction models or isolated financial ratios, overlooking the temporal dimension of how firms evolve and mature financially. Nonetheless, a few studies do, however acknowledge that the causes of business failure may differ across the firm’s lifecycle. For instance, Thornhill & Amit (2003) found that younger firms often fail due to managerial inexperience and resource constraints, whereas older firms tend to fail because of structural rigidity and reduced adaptability to changing environments. Similarly, Kucher et al (2018) demonstrated that the determinants of corporate bankruptcy vary by firm age, with early-stage firms being more vulnerable to internal weaknesses and mature firms facing greater exposure to external and competitive pressures. Bankruptcy likelihood and earnings volatility reflect different dimensions of corporate financial health, examining their relationship with firm age provides a more nuanced understanding of corporate financial resilience. Accordingly, this study analyses a panel of S&P BSE Auto index companies over nine years to assess how firm age influences bankruptcy risk, as measured by the Altman Z score and financial risk, proxied by volatility of net income. This dual approach allows for a more comprehensive understanding of how firm maturity contributes to financial stability and long-term sustainability in the Indian automobile sector (Kaur & Rizvi, 2025).

2.1 Hypotheses of the Study:

- 1) H_{01} : There is no significant relationship between firm age and bankruptcy risk as measured by Altman Z score
 H_{11} : There is significant relationship between firm age and bankruptcy risk as measured by Altman Z score
- 2) H_{02} : There is no significant relationship between firm age and financial risk as measured by net income volatility
 H_{12} : There is significant relationship between firm age and financial risk as measured by net income volatility

3. RESEARCH METHODOLOGY:

This study adopts a quantitative, explanatory research design to investigate the relationship between firm age and corporate financial risk. The research aims to assess whether firm maturity influences bankruptcy risk and financial risk among automobile companies listed on the S&P BSE Auto Index. The analysis uses secondary panel data covering a nine-year (2017-2025) for 19 companies, collected from Capitaline Database and supplemented by information from company annual reports and company websites. Firms with incomplete data (1 company) were excluded to ensure comparability and consistency.

3.1 Variables and Measures:

Variable Type	Variable	Description
Dependent Variable	Altman Z Score	Proxy for bankruptcy risk. Higher Z score indicates lower bankruptcy likelihood
Dependent Variable	Volatility of Net Income	Proxy for financial risk or earnings instability
Independent Variable	Firm Age	Indicates firm maturity or life cycle stage

3.2 Statistical Approach:

- (a) Descriptive Statistics
- (b) Normality Testing
- (c) Linear Mixed-Model (LMM)
- (d) Bootstrapped Regression
- (e) Kendall’s Tau Correlation

4. DATA ANALYSIS:

Objective 1: To test the relationship between firm age and Altman Z score

4.1 Descriptive Statistics

Table 1: Descriptive Statistics of Age, Altman Z score and Net Income (in rs cr)

	Age	Altman Z	Net Income (in Rs cr)
Valid	171	171	171
Missing	0	0	0
Median	41.0000	6.8049	1052.9600
Mean	46.4211	8.3950	1925.2640
Std. Deviation	20.6969	6.2428	2637.2118
Coefficient of variation	0.4459	0.7436	1.3698
Skewness	-0.0169	2.3289	1.7787
Std. Error of Skewness	0.1857	0.1857	0.1857
Shapiro-Wilk	0.9394	0.8110	0.7778
P-value of Shapiro-Wilk	< .001	< .001	< .001
Minimum	8.0000	0.5312	-7289.6300
Maximum	79.0000	46.7024	13955.2000

As shown in Table 1, the descriptive statistics for firm age, Altman Z score and net income are presented. The mean firm age in the sample is approximately 46 years indicating a balanced representation of both younger and more established firms. The average Altman Z score is 8.39, suggesting that the firms generally exhibit lower bankruptcy risk. Net Income shows a mean value of ₹1925.26 crore, with substantial variation across firms, as indicated by a higher standard deviation. The Shapiro-Wilk test results ($p<.001$) indicate that all three variables deviate from normality; therefore, non-parametric or robust statistical methods are considered appropriate for further analysis.

To assess whether firm age influences bankruptcy risk, measured by the Altman Z score, a Linear Mixed-Effects Model (LMM) was employed. The panel dataset (19 firms over 9 years) involved repeated observations, making LMM suitable for accounting for within-firm correlations. As seen above, Shapiro-Wilk test indicated non-normality of the Altman Z score ($p<.001$), this model provides a robust alternative to OLS regression. Firm age was included as a fixed effect and company as a random effect.

4.2 Linear Mixed-Effects Model (LMM)							
Table 2: ANOVA Summary							
Effect		Df		F		P	
Age		1, 18.45		7.9266		0.0113	
Note. Model terms tested with Satterthwaite testMethod.							
Note. The following variable is used as a random effects grouping factor: 'Company Name'.							
Note. Type III Sum of Squares							

Table 2 shows the Linear Mixed-Effects Model results assessing the

impact of firm age on the Altman Z-score, with company included as a random effect. The analysis indicates a significant effect of firm age on the Altman Z-score, $F(1,18.45)=7.93$, $p=0.011$, suggesting that changes in firm age are associated with variations in bankruptcy risk. The LMM is appropriate given the repeated measures and non-normal distribution of the data, confirming that firm age significantly influences the chances of bankruptcy across firms.

Table 3: Fit statistics							
Deviance (REML)		log Lik.		df	AIC	BIC	
1066.6399		-533.3200		4	1074.6399		1087.2066
<i>Note. The model was fitted using restricted maximum likelihood. Please note that models with different fixed effects cannot be compared when REML is used. To use ML, switch 'Test method' to 'Likelihood ratio tests'.</i>							

The model fit statistics in Table 3 (Deviance=1066.64, AIC=1074.74, BIC=1087.21) indicates an adequately fitted model using the Restricted Maximum Likelihood (REML) estimation method. As the model was estimated under REML, these values primarily reflect the goodness of fit within the specific random-effects structure, rather than allowing for comparison across models with different fixed effects. The obtained fit indices suggest that the LMM is statistically appropriate for examining the effect of firm age on Altman Z-score across companies and years.

Table 4: Fixed Effects Estimates							
Term		Estimate	SE	Df	t	p	
Intercept		13.1514	1.8559	18.0568	7.0864	< .001	
Age		-0.1025	0.0364	18.4479	-2.8154	0.0113	

Table 4 presents the fixed effects estimates derived from the LMM. The analysis reveals that firm age exerts a statistically significant negative influence on the Altman Z score. This indicates that as firms grow old, their bankruptcy risk, as captured by the Altman Z score, tends to decline. These findings substantiate the earlier ANOVA results, reinforcing that firm age is a significant determinant of Altman Z score within the observed sample.

Table 5: Company Name: Random Effect Estimates

Company Name	(Intercept)
Amara Raja Energy & Mobility Ltd	-1.0601
Apollo Tyres Ltd	-4.1816
Ashok Leyland Ltd	-1.4702
Bajaj Auto Ltd	1.8082
Balkrishna Industries Ltd	0.5012
Bharat Forge Ltd	-1.1942
Bosch Ltd	3.1041
Eicher Motors Ltd	6.6146
Exide Industries Ltd	0.9636
Hero Motocorp Ltd	0.0136
MRF Ltd	-2.4316
Mahindra & Mahindra Ltd	-0.1076
Maruti Suzuki India Ltd	0.0455
Samvardhana Motherson International	-0.4644
Sona BLW Precision Forgings Ltd	2.8551
TVS Motor Company Ltd	-2.8152
Tata Motors Ltd	-1.5378
Tube Investments of India Ltd	0.6865
UNO Minda Ltd	-1.3296

Table 5 represents the company-level random intercepts estimated by LMM. The results indicate notable variation across firms, with intercepts ranging from approximately -4.18 to 6.61. This variation suggests that even after accounting for firm age, substantial differences remain in baseline Altman Z scores across companies. The inclusion of random effects thus, appropriately captures firm-specific characteristics and improves model precision.

The Linear Mixed-Effects model results collectively indicate that firm age significantly influences Altman Z score while accounting for firm-level variability. To further verify the robustness of these findings and mitigate potential distributional biases, a bootstrapped regression analysis was conducted. This approach provides bias-corrected confidence intervals through repeated resampling, thereby strengthening the reliability of the estimated relationship between firm age and Altman Z score.

4.3 Bootstrapped Regression:

Table 6: Bootstrap Coefficients									
Model			Unstandardized		Bias		Standard Error		p*
H ₀	–	(Intercept)	–	8.3782	–	-0.0042	–	0.4688	< .001
H ₁	–	(Intercept)	–	13.9630	–	0.0352	–	1.3676	< .001
	–	Age	–	-0.1203	–	-0.0006	–	0.0220	< .001
Note. Bootstrapping based on 5000 replicates.									
Note. Coefficient estimate is based on the median of the bootstrap distribution.									

* Bias corrected accelerated.

The bootstrapped regression analysis as represented in Table 6, indicates that age is a significant negative predictor of Altman Z score ($B=-0.12$), suggesting that older companies tend to have lower Altman Z scores and therefore higher bankruptcy risk. The intercept ($B=13.96$) represents the predicted Altman Z when company age is zero. Bootstrapping with 5,000 replicates ensures the robustness of these estimates. Based on the findings from both Linear Mixed-Effects Model and bootstrapped regression, firm age was found to negatively influence the Altman Z-score. Hence, the null hypothesis (H_{01}), which stated that firm age has no significant relationship with bankruptcy risk, is rejected, thereby supporting the alternative hypothesis.

Building on the findings of Objective 1, which established a significant relationship between firm age and bankruptcy risk, the second objective examines whether a similar association exists between firm age and financial risk, represented by the volatility of net income.

Objective 2: To test the relationship between firm age and volatility of net income

4.4 Descriptive Statistics

Table 7: Descriptive Statistics for Firm Age and Volatility of Net Income

	Age	Volatility of Net Income
Valid	19	19
Missing	0	0
Mean	50.4211	1143.6409
Std. Deviation	21.0352	1326.5711
Shapiro-Wilk	0.9235	0.7031
P-value of Shapiro-Wilk	0.1314	< .001
Minimum	16.0000	186.7343
Maximum	79.0000	4621.6568

Table 7 summarises the descriptive statistics for firm age and volatility of net income. The firms average 50.42 years in age and show high variability in net income volatility. The Shapiro-Wilk test confirmed non-normality for volatility of net income ($p<.001$), supporting the use of a non-parametric correlation test for subsequent analysis.

Although the firm age satisfies the normality assumption, volatility of net income did not. Therefore, Kendall’s τ correlation test was employed to assess the strength and direction of their association. This non-parametric method is suitable when one or more variables deviate from normality and provides a robust estimate of monotonic relationships.

4.5 Kendall’s Tau-B Correlation Analysis:

Table 8: Kendall's Tau Correlations

Variable		Age	Volatility of Net Income
1. Age	Kendall's Tau B	—	
	p-value	—	

2. Volatility of Net Income	-	Kendall's Tau B	-	0.3894	-	—	—
	-	p-value	-	0.0207	-	—	—

Table 8 presents the results of Kendall’s τ correlation test examining the relationship between firm age and volatility of net income. The results reveal a significant positive correlation between the two variables, indicating that as firm age increases the volatility of net income also tends to rise. This implies that older firms exhibit relatively greater fluctuations in net income compared to younger firms. Accordingly, the null hypothesis (H_{02}) is rejected.

5. RESULTS, DISCUSSION AND CONCLUSION:

The first objective examined whether firm age significantly influences the Altman Z score serving as a proxy for bankruptcy risk. Based on the present sample, Linear Mixed-Effects Model and bootstrapped regression analyses consistently revealed a significant negative relationship between firm age and Altman Z score. This suggests that within this dataset older firms tend to exhibit lower Z scores, implying relatively higher bankruptcy risk or reduced flexibility compared to younger firms. In the context of Indian automobile sector, this may reflect the challenges faced by mature firms operating in a capital-intensive and highly competitive environment. Established firms often experience slower innovation cycles, higher fixed costs and legacy operational inefficiencies which can erode financial flexibility and elevate insolvency risk over time.

The second objective explored the relationship between firm age and volatility of net income using Kendall’s τ correlation. The results showed a moderate positive association, indicating that as firms mature, income volatility tends to increase. This could be due to cyclical demand, technological disruptions and policy changes in India’s evolving automotive landscape, where even experienced firms face earnings volatility due to regulatory reforms and shifting consumer preferences toward electric and sustainable vehicles.

Importantly, no control variables were included in this study. This was an intentional methodological choice to evaluate whether firm age alone possesses explanatory value in financial decision-making. The findings suggest that for the firms analysed, age independently contributes to understanding patterns of financial health and risk.

Overall, while these results provide meaningful insights, they are specific to the sample under study and should not be generalised without caution. Future research may incorporate larger and more diverse datasets along with control variables such as firm size, growth, leverage to build a more comprehensive understanding of how age interacts with other determinants of corporate financial health.

6. LIMITATIONS AND FUTURE RESEARCH:

The study’s findings are based on a limited dataset, which may influence the extent to which results can be generalised. While the analysis focused solely on firm age to isolate its effect on corporate financial health, future studies could expand the sample scope and incorporate additional variables such as firm size, growth, leverage and industry characteristics to provide a more comprehensive understanding of financial health determinants.

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