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Analysis of the CAMEL ratio in Anticipating Insolvency with the Altman Z-score Model: an evaluation of Indian private sector Banks (2015-2024)

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The study aims to anticipate insolvency in Indian private sector banks using the Altman Z-score model from the perspective of the CAMEL model. The CAMEL variables analyzed include "Capital Adequacy - the Capital-to-Risk-weighted Assets ratio (CRAR), Assets Quality - Non-Performing Assets (NPA), Management Efficiency- Cost to income (BOPO), Earning Quality - Return on Assets (ROA), and Liquidity - Financial Deposit Ratio (FDR)"(Lubis et al., 2025). Secondary data obtained from 2015 to 2024 for this study from relevant banks' annual reports and the Money Control website. The study uses quantitative methods with panel data regression and linear regression with lagged variables based on annual reports from 2015 to 2024. The findings of the fixed effects model indicate that CRAR, ROA, and FDR have a significant influence on financial distress; however, NPA and BOPO are insignificant to the Altman Z-score. Additionally, linear regression with lagged variables suggests that all CAMEL variables reflect stable performance, indicating that the overall condition of selected private sector banks remains financially healthy, and some of the variables give an early warning signal of financial distress. These findings emphasize the necessity of continuous monitoring using both the CAMEL and the Altman Z-score model in order to identify and mitigate future risks in the banking sector.

Introduction

A strong financial system is essential for a country's economic growth and development. A bank is an intermediary that accepts deposits from individuals or institutions with excess funds and allocates credit to various sectors of the economy. Just as the human body cannot survive without blood, a country can not imagine sustainable growth and development without a healthy financial system. The development of the Indian banking system has experienced unpredictable changes over the past decade, reflecting the Second World War, the global financial crisis, nationalism, regulatory transformation, and the sector's adaptation to macroeconomic changes. In 2016, demonetization occurred, a merger in 2017, and the pandemic arose in 2019 and continued to impact up to 2021. It impacted the performance of the entire financial system, including public banks, private banks, foreign banks, RRBs, and NBFCs. This study covers only the selected ten banks of the Indian private sector. The first four banks- HDFC, ICICI, AXIS, and Kotak Mahindra are the top/large private sector banks selected as per market capitalisation (large capitalisation), and RBL, Federal Bank, Karnataka Bank, and South Indian Bank are mid-capitalisation. Lastly, small capitalisation, accompanied by some structural and financial changes, was observed in IDBI and Yes Bank. It is essential for internal management, investors, stakeholders, regulators, and the public as well to assess the financial solvency and stability of selected banks so that it can be easy to make important decisions. It acts as an early indicator for management to anticipate bankruptcy; it helps investors and stakeholders to make any investment decision before investing in any project; for regulators, it serves an essential function in protecting the integrity of the banking and financial system, and finally, the public who deposit savings for interest and fixed deposits to beat inflation. As a result, the study uses a reliable model for the banking industry, such as the CAMEL model, and the Atman Z-score is essential in maintaining the resilience and soundness of Indian private sector banks.

CAMEL Model

The CAMEL framework is an important model widely used in the banking industry to evaluate the overall performance of banks. It provides ratings to banks based on financial ratios. Initially, in 1970, the US federal government developed the CAMEL model. "On the recommendation of the Padmanabhan committee, in 1996, the RBI used this method in the Indian banking system. In the Indian banking industry, the CAMEL model is widely used, which provides an in-depth analysis of a bank's financial performance based on its components- Capital adequacy, Asset Quality, Management Effectiveness, Earning Quality, and Liquidity Management" (Sharma et al., 2018).

"The CAMEL model – an abbreviation for Capital Adequacy, Assets Quality, Efficient Management, Earning Quality, and Liquidity-is widely used by researchers and supervisory bodies to assess the financial performance of banks". Every component reflects a different aspect of financial performance. Capital adequacy (CRAR) measures the availability of capital in a bank, enabling it to absorb unforeseen risks and losses that may arise from market risk, operational risk, and credit risk (R & G R, 2024). Asset quality refers to the health of a bank's loan and investment portfolios. Non-Performing Assets (NPA) are a type of poor assets that are not generating income for the bank at present. Management efficiency (BOPO) is the ability to generate high returns at low cost and make important decisions to achieve organizational goals. Earning quality (ROA) represents the profit-generating capacity of banks to survive their business in the long term. The transparency in a company's reported profit is used to anticipate future cash flow and economic performance. Liquidity (FDR) of an organisation shows how easily it can meet its short-term financial liabilities, thereby mitigating liquidity risk and interest rate risk. These risks may affect the bank's reputation and performance (Lubis et al., 2025; R & G R, 2024).

Altman Z-score Model

A large number of studies have examined the anticipation of financial distress using diverse analytical techniques. To predict when publicly traded manufacturing companies will go bankrupt, Edward I. Altman initially published the Altman Z-score model in 1968. The original model includes five financial ratios selected from 22 indicators to measure distress zones only of public manufacturing companies (Wu et al., 2022). Afterwards, to address the limitations of the original model, Ohlson (1980), Altman (1983), and Zmijewski (1984) introduced the modified version of the Altman Z-score model specifically for service-based and private entities that were left in the original model. There were two major changes made in the updated version: the book value was given priority over market value because private firms do not have publicly traded equity, and the last ratio, sales to total assets, was completely removed for variations in differences across industries (Altman, 2000). "The value of the Z-score is calculated by multiplying its financial ratios by their particular coefficients and adding the outcomes together. The higher the score, the lower the chance of financial distress" (Lubis et al., 2025).

"The modified Z-score model includes four financial ratios: the first is the working capital ratio, which is calculated by dividing working capital by total assets of the bank. The difference between current assets and current liabilities is called working capital" (Williams et al., 2006). It is maintained to operate the day-to-day expenses. Total assets include fixed assets and current assets of the bank (Pandey, 2005). The second ratio is Retained Earnings. Retained earning is an internal fund that is ploughed back into the business to decrease leverage or debt. According to Williams et al. (2006), their study is reflected in the balance sheet's equity section. An increase in retained earnings is negatively correlated with less reliance on leverage, which directly leads to a lower probability of financial distress. The third financial ratio is Earnings before interest and taxes (EBIT), which is the total earnings of the year before paying its external liabilities, such as interest and taxes (Pandey, 2005). The last financial ratio is calculated by dividing the book value of equity (Net worth) by the total liabilities of banks. The book value of equity is used in place of the market value of equity because private and non-manufacturing companies do not consider the market value. The higher the ratio, indicates lower the risk of debt (Kaur, 2019).

Literature Review

The CAMEL model, commonly used in the banking system, is used by regulators to evaluate the overall performance and financial health by using six key variables: "capital Adequacy, asset quality, Management efficiency, earning quality, liquidity, and sensitivity to market risk"(Kayad & Hassan, 2011). This study is based on a quantitative variable, so it did not cover the sensitivity variable. When the CAMEL model is integrated with the Altman Z-score, it becomes a multidimensional financial assessment. CAMEL helps to estimate financial strength, management efficiency, and profitability, whereas the Altman Z-score predicts the likelihood of bankruptcy (Anwar & Saad, 2021). Together, they depict a strong and reliable way to forecast financial stability and sustainability, as discussed in the study (Lubis et al., 2025). The companies listed on the BSE and the NSE were found to be susceptible to bankruptcy predicted by the Altman Z-score model (Sajjan, 2016). Many of those companies fell into a state of distress. Another analysis assessed Z-score on three old public sector banks established as- Oriental bank of commerce(1943), Punjab national bank(1894) and SBI(1955)- a study reveals a significant improvement in Z-score after a change in leadership, indicating that a new CEO drives strategic improvements globally, regardless of cultural differences or corporate social responsibility (Salvi et al., 2024). "A comparative study of public and private sector banks was conducted to analyze the financial performance of the Indian banking system. The study evaluated that capital adequacy, asset quality, and earnings capacity impacted the financial performance, but had no impact on management, liquidity position, and sensitivity to market risk variables"(Singh & Makkar, 2013). A different study reveals that, according to CAMEL parameters, the overall performance of private banks significantly surpasses that of public sector banks, attributable to their initiative in digitalization and financial inclusion (Sharma et al., 2018). The consequences of financial distress on the financial strength of the institution were investigated using Tobin's Q. The study revealed that during market fluctuations, financially distressed stocks performed better than those in the grey and safe zones (Kaur, 2019). A combination of the CAMEL framework and bankruptcy model, the Altman Z-score is used to assess the overall financial health of financial institutions. Integrating the Altman Z-score with the widely used CAMEL model for banking. This study has been done in Indonesia on Islamic commercial banks to forecast insolvency utilizing the Altman Z-score with the CAMEL model. The findings revealed that the Altman Z-score is insignificant in relation to FDR, NPF, and BOPO; however, ROA and CAR influenced financial distress (Lubis et al., 2025). Some of the key areas that help banks avoid financial distress include maintaining a limited amount of external funds and regularly checking financial ratios, such as the debt ratio, net debt to EBITDA, and cash flow coverage ratio. These help banks track their ability to manage their obligations (Sethi & Mahadik, 2025). To analyze and forecast the stock market, the MLP-ANN approach is combined with the Altman Z-score. This study examined Chinese companies, revealing that a combined model provides an early warning sign of financial distress, enabling managers, investors, regulators, and the government to make timely decisions and reduce potential losses (Wu et al., 2022).

Objectives:

1. CAMEL predicts the financial distress of selected banks
2. Z-score predicts the financial viability of selected banks

Hypothesis:

1. There is no statistically significant relationship between CAMEL ratings and financial distress among selected banks.
2. There is no statistically significant association between z-scores and the financial performance of the selected banks.

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Methodology:

The study employs a quantitative research strategy that combines descriptive and explanatory techniques to analyze the financial strength of selected banks in the Indian private sector. The quantitative methods are selected because they facilitate the practical testing of the relationship among measurable variables during this period. The population of this study comprises ten selected private sector banks over the period (2016-2024). The sample is selected based on market capitalization, representative of the whole population—large-cap banks, such as HDFC, ICICI, AXIS, and KMB. Mid-cap banks include RBL, FB, KB, and SIB, while banks with small capitalisation are IDBI and Yes Bank. To ensure the accuracy and trustworthiness of the information, the study relies on secondary sources, particularly the Money Control website and the annual reports of selected banks. Although there is no single accounting standard for calculating financial ratios, these are derived from banks' and companies' financial statements, which are prepared in accordance with GAAP/ IFRS. The Altman Z-score is a measured variable, whereas CAMEL variables are manipulated within this study. If there are any changes in predictor variables- CAR, NPA, ROA, BOPO, and FDR- the effect will appear on the targeted variable, which is financial distress. The study uses panel data regression associated with time-series and cross-sectional data. The detailed description is as follows:

$$\text{Altman Z-score (FD)}_{it} = \beta_{0+} \beta_1 \text{CAR}_{it} + \beta_2 \text{ NPA}_{it} + \beta_3 \text{ BOPO}_{it+} \beta_4 \text{ROA}_{it} + \beta_5 \text{FD} + \text{R}_{it+\varepsilon it}$$

To ascertain the association between CAMEL ratios and the Altman Z-score, a linear regression model with lagged variables is implemented. With the help of this method, a change in one variable can help to anticipate the future effect on another. For instance, if NPA is found to be in financial distress, it implies that changes in asset quality can serve as an early warning sign for the distress zone. A series of diagnostic tests, including assessments of normality, the Shapiro-Wilk test, the multicollinearity test, the scatter plot, and the Glejser test, is performed to validate the model. All tests are performed using IBM SPSS software. To ensure comparability and consistency, all variables are standardized. Ethical research standards are maintained by using publicly available data on the Money control website.

Result and discussion

Table 1. Shows the descriptive Statistics

variables	N	Mean	Median	Max.	Min.	SD
Z-SCORE	100	4.7849	3.29	7.26	3.98	.58947
CAR	100	15.9989	14.50	23.00	8.50	2.78538
NPA	100	1.1762	8.10	8.20	.10	1.29883
BOPO	100	45.7551	52.13	73.13	21.00	10.26901
ROA	100	.7396	8.70	2.30	-6.40	1.29893
FDR	100	74.9829	48.53	89.40	40.87	9.19750

Table 1 shows that the average Z-score of 4.7849 reveals that selected banks of the private sector in India were financially stable during the period 2015-2024. Although most banks remained in a safe zone, a few were close to financial distress due to mild financial pressure in these years. These differences among banks may be attributed to variations in management efficiency, operational performance, and risk-taking activities (Altman et al., 2017). The CAR, with a mean value of 15.99%, is considered a very strong capital base, which exceeds the minimum regulatory requirement of 8%. This suggests that the relevant banks adopted a conservative approach by prioritizing financial stability. However, maintaining risk-weighted capital may reduce leverage, and it may also reduce profitability (Muneeza & Hassan, 2020). The NPA average value is 1.18%, which is below the range of 2%-9 % as per RBI guidelines. The lower the NPA value, the higher the quality of Assets, and the more effective the handling of default risk in the banking industry. However, the peak score of 8.2% discloses that certain banks faced increased credit risk, potentially in sectors such as construction and microfinance.

This fluctuation highlights the importance of portfolio diversification in maintaining consistent financing quality (Anwar & Saad, 2021). The value of SD 1.3 indicates moderate fluctuation in asset quality across banks. The mean value of BOPO is 45.76%, revealing that operational efficiency in selected banks is not only satisfactory but also indicates strong performance, as their operating costs are less than half of their operational income. The ROA mean value is 0.74%, indicating that the profitability of the sampled banks is moderate. This level correlates with the global Indian private sector banking performance, which generally reflects lower but steady returns due to profit-sharing structures rather than interest-based lending (Beck, Demirgüç-Kunt, & Merrouche, 2013). The SD 1.3 value indicates that while several banks sustained consistent profitability, others experienced losses, either due to weak financial portfolios or financial pressures. The average FDR of 74.98% suggests that banks maintained an acceptable regulatory range of management, converting deposits into loans or financing activities, and minimal liquidity risk. The median figure, 48.53%, signifies a good quality of liquidity efficiency in transforming deposits into financing while maintaining sufficient reserves. The SD of 9.2 signifies significant variation in the liquidity management technique used by sampled banks.

In summary, these descriptive findings indicate that the selected private banks maintained stable capitalization, consistent liquidity, and good asset quality. The ROA and cost efficiency showed significant variability among banks. These findings verify that ROA and BOPO are crucial in assessing financial health using the CAMLE framework and the Altman Z-score.

Table 2. Shows the fixed effect model

Variables	Significance level	Sig. value	t-Statistic
CAR	0.05	0.027	2.249
NPA	0.05	0.198	1.297
BOPO	0.05	0.680	-0.414
ROA	0.05	0.659	-0.443
FDR	0.05	0.200	1.291

The CAR variable has a t-statistic of 2.249 with a probability value of 0.027<0.05, which states that it has a noticeable impact on financial distress. The NPA variable has a t-score of 1.297 with a probability value of 0.198 >0.05, so it is assumed that NPA variables do not have a significant effect on financial distress. The BOPO variable has a t-statistic of -0.414 with a probability value of 0.680> 0.05, which shows that it is insignificant to financial distress. The ROA t-statistic is -0.443 with a probability value of 0.659>0.05 standard value, which suggests that ROA has an insignificant influence on financial distress. Lastly, liquidity variable FDR has a t-score of 1.291 with a probability value of 0.2>0.05, showing an insignificant effect on financial distress.

Table 3 shows the common effect regression model

Variables	Sig. value	Coefficients
Z-score	0.000	5.021
CAR	0.002	0.073
NPA	0.853	0.010
BOPO	0.317	-0.005
ROA	0.035	0.126
FDR	0.004	-0.017

The common effect regression model (pooled OLS) examines how CAMEL variables influence the financial distress of selected banks of the private sector in India. The coefficients indicate the direction and magnitude of the effect of each variable on the outcome. A statistically significant intercept indicates that when the value of all covariates is zero, the score of Z is 5.021.

The CAR has a Probability value is 0.002 (<0.05), which means substantial and positively correlated with financial distress. The value of CAR is 0.073, which means that if CAR increases, the variable Z-

score value increases by 0.073 as well. The NPA's significant value is 0.853> 0.05, which means insignificant but has positively correlated with financial distress. The value of NPA increased by 0.010, and the variable Z-score value also increased by 0.010. The BOPO's significant value is 0.317> 0.05, which means insignificant, but it has a negative correlation with financial distress. The value of BOPO decreased by -0.005, and the variable Z-score value also decreased by -0.005. The ROA's significant value is 0.035> 0.05, which means insignificant, but it has positively correlated with financial distress. The value of ROA increased by 0.126, and the variable Z-score value also increased by 0.126. The FDR's probability value is 0.004< 0.05, which means it is important, but it has a negative correlation with financial distress. The value of FDR decreased by -0.017, and the variable Z-score value also decreased by -0.017.

Implications of CAR on Z-score

There is a statistically significant relationship between CAR and Z-score, as demonstrated by the t-statistic of 2.249 and the probability value of 0.027 (<0.05). Capital adequacy is positively correlated with the financial stability of banks, as per findings of 0.073. The higher the CAR, the better the financial stability, and it is less likely that the company will experience financial distress. The takeaway here is that selected Indian private sector banks maintain high capital ratios, indicating that more capital is allocated to generate income. It allows banks to absorb unanticipated losses, protect depositors, and reduce systemic risk. The high capital adequacy ratio acts as a substantial buffer against economic crisis (Muneeza & Hassan, 2020).

Implications of NPA on Z-score

Despite having a positive coefficient of 0.010, the NPA variable does not significantly affect the z-score; this is supported by a t-value of 1.297 and a probability value of 0.198 (p> 0.05). The positive sign indicates that there is a negligible effect on financial stability from a slight increase in non-performing assets over the period. This may happen because selected Indian private sector banks mitigate the effects of financial defaults by keeping sufficient provisioning and loss reserves (Anwar & Saad, 2021).

Implications of BOPO on Z-score

The BOPO variable is insignificant to Z-score, as shown in the result that t-(-0.414) and probability 0.680 (>0.05). Although the absence of statistical significance, the negative coefficient of -0.005 suggests that operational inefficiency has an inverse relationship with financial stability. While operational efficiency does not directly impact profitability, this study suggests that it may not immediately affect solvency. However, problems with cost management may be causing earnings to decline over time if the BOPO ratio remains persistently elevated (Iqbal & Molyneux, 2005).

Implications of ROA on Z-score

With a t-value (-0.443) and a probability value (0.659)>0.05, the fixed effect model provides conclusive proof that ROA strongly influences Z-score. However, the positive coefficient of 0.126 suggests that the return on assets is positively correlated with the score of Z, indicating that financially stable banks are indeed more profitable. Since the Z-score defines the capital buffer against losses, a positive ROA indicates better financial health and less risk of insolvency. ROA measures the amount of profit from assets, and higher profitability makes it easier to absorb asset volatility. The score of Z and the degree of stability are both enhanced by higher ROA, as more earnings are available to compensate for losses (Altman et al., 2017)

Implications of FDP on Z-score

There is strong evidence that the FDR variable significantly affects the Z-score; its t-value is 1.291, and the probability value is 0.200(>0.05). Although the consequences are not statistically significant, the negative coefficient of -0.017 suggests that there may be a decrease in financial stability as a result of

increasing financial relative to deposits. This finding contradicts the hypothesis that liquidity management is the sole determinant of stability. A low FDR can indicate an inefficient allocation of funds, whereas a high FDR may increase liquidity risk. Hence, efficient risk management and quality control of financing are necessary for sustaining an ideal FDR (Lubis et al., 2025).

In general, the findings suggest that among selected banks in the Indian private sector, according to the common effect model, CAR, ROA, and FDR have a significant impact on the Z-score, whereas NPA and BOPO are insignificant. This discovery confirms that, according to the CAMEL and the Altman Z-score model, a bank's earning potential is the most important factor in determining its financial health. This study found that the positive relationship between ROA and financial stability is a good sign of profitable growth, indicating a path to preserve financial stability. Therefore, in the long run, banks need to improve their risk management and continue to expand while balancing profitability, liquidity, and NPA.

Conclusion

Based on the findings of the panel data regression and linear regression with lagged variable tests on the CAMEL ratio variables on selected Indian private sector banks during the 2015-2024 periods:

The analysis was conducted using both fixed-effect and common-effect models. The result demonstrates that substantial heterogeneity exists among selected banks in the Indian private sector, which affects the linkage between the CAMAL ratio and the Altman Z-score. The Z-score is significantly influenced by the ROA variable, indicating that profitability is crucial for maintaining financial health and reducing default risk. Efficient utilisation of assets contributes to the solvency position of selected banks, which ultimately improves their financial stability through higher profitability. According to the Glejser test, only CAR has a substantial impact on the Z-score, and the other variables become insignificant in the fixed-effect model. According to the common effect model, CAR, ROA, and FDR have a considerable influence on the Z score, whereas NPA and BOPO are not major determinants of the Z-score. While operational efficiency and financial activities help keep the financial system stable, the extent of their impact is highly dependent on liquidity policies and internal management at individual banks. The Z-score is influenced by most of the CAMEL variables, indicating that changes in these financial indicators may impact the bank's level of financial soundness (Lubis et al., 2025). The ever-changing nature of the financial management of selected Indian private banks is reflected in the fact that the degree of association varies across banks and over time.

In this study, the primary determinant is capital adequacy. Financial stability is elevated with a higher ratio of CAR, and it reduces the risk of a financial crisis. The higher the CAR, the better the financial stability, and the lower the probability of financial distress. The takeaway here is that selected Indian private sector banks maintain high capital ratios, indicating that more capital is allocated to generate income. It allows banks to absorb unanticipated losses, protect depositors, and reduce systemic risk (Kaur, 2019). The high capital adequacy ratio acts as a substantial buffer against economic crisis.

In conclusion, the results indicate that selected Indian private banks can still utilize the CAMEL technique, along with the Altman Z score, to anticipate insolvency. It is essential to consistently manage variables such as capital, assets, management, earnings, and liquidity to reduce financial distress. Among all CAMEL indicators, capital stands out as the most relevant in predicting financial performance and stability (Lubis et al., 2025).

Limitation

This study is limited to the selected ten banks of the private sector in India, and the last ten years of secondary data are utilized to arrive at the final result. The result may be skewed due to data availability, reporting procedures, and the inherent limitations of secondary sources, as the research is based only on available financial information.

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