KeAi
CHINESE ROOTS
GLOBAL IMPACT

International Journal of Innovation Studies

FINANCIAL HEALTH ASSESSMENT MODEL FOR SELECTED PRIVATE SECTOR BANKS USING FUZZY LOGIC

[1]S. Jayaraman, [2]K.Radha, [3]G.A.Vaakshi, [4]S.Viswanathan, [5]Brindha Natarajan,
[1]Professor, Department of Management Studies, PSNA College of Engineering and Technology, Dindigul, Tamil Nadu, India
[2&3]Assistant Professor, Department of Management, Shrimati Indira Gandhi College, Tiruchirappalli, Tamil Nadu, India
[4]Associate Professor, RVS Institute of Management Studies, Coimbatore, Tamil Nadu, India
[5]Assistant Professor, Department of Management, Shrimati Indira Gandhi College, Tiruchirappalli, Tamil Nadu, India

Abstract
An analysis of Indian banks' financial health has been steered using the Altman Z-score model, a widely recognized tool for predicting the likelihood of corporate bankruptcy. The model assigns a score based on various financial metrics, with lower scores indicating a higher risk of bankruptcy. A closer examination of City Union Bank, CSB Bank, Dhanlaxmi Bank, Tamilnad Mercantile Bank, and Yes Bank reveals trends and insights into their financial performance. Despite the model's indication of potential bankruptcy risk, the banks' improving trends and strengthening fundamentals suggest that the risk may be overstated. To gain a more comprehensive understanding of the banks' financial health, stakeholders are advised to consider industry-specific factors and supplementary metrics, such as non-performing assets and capital adequacy ratios. By taking a more nuanced approach, stakeholders can make more informed investment and risk management decisions.

Key Words: Basic Earning Power (BEP) ratio, City Union Bank, CSB Bank, Dhanlaxmi Bank, Fuzzy Logic, Fuzzy Equation, Liquidity Ratio, Solvency Ratio, Tamilnad Mercantile Bank, Yes Bank

1. Introduction

Banking sector in India has undergone significant transformation since the economic liberalization reforms, which overlaid the way for the entry and expansion of private sector banks. Unlike public sector banks, which are predominantly government-owned, private sector banks are owned and operated by private entities. These institutions have been instrumental in driving innovation, enhancing customer service, and fostering competition within the financial ecosystem. As of 2025, India hosts approximately 21 private sector banks, with market leaders such as HDFC Bank, ICICI Bank, Axis Bank, and Kotak Mahindra Bank dominating the landscape based on market capitalization and branch networks. HDFC Bank, for instance, leads with over 8,851 branches, followed closely by ICICI Bank with 6,524 branches.

The private banking segment has contributed to robust growth in the overall industry. Their contribution over these years improved the economic condition of the nation and aided the largely to the government policies to improve the society, via fintech introduction and financial

inclusion. This raised a potential boosting of profits amid a fintech boom projected to reach Rs. 723,187 crore (US$ 83.48 billion) by 2025. This growth is fueled by digital adoption, retail lending, and financial inclusion initiatives, positioning private banks as key players in India's evolving economy.

In non-manufacturing organizations like private sector banks, where decision-making often involves uncertainty, incomplete data, and subjective judgments such as credit risk evaluation or fraud detection traditional binary logic falls short. This is where fuzzy logic, a computational paradigm introduced by Lotfi Zadeh in 1965, emerges as a powerful tool. Fuzzy logic mimics human reasoning by handling imprecise or "fuzzy" information through degrees of truth rather than absolute true/false values, allowing for more nuanced analysis in complex environments.

In a non-manufacturing context, it has been applied to areas like supply chain optimization, performance assessment over sustainability, and supplier evaluation, enabling organizations to process vague data and derive actionable insights. Specifically in banking, fuzzy logic enhances processes such as credit scoring for microfinance, bank performance ranking, and adaptive risk management frameworks, improving transparency, accuracy, and customer-centric decisions by integrating expert opinions with uncertain datasets. For Indian private sector banks, adopting fuzzy logic could address challenges like volatile market conditions and regulatory compliance, offering a bridge between qualitative insights and quantitative outcomes in a service-driven environment. This intersection not only underscores the adaptability of fuzzy logic but also highlights its potential to revolutionize decision-making in India's dynamic banking landscape.

Key Concepts:

Fuzzy Sets contrasting to traditional sets, where an element either belongs or doesn't, fuzzy sets allow for partial membership.[3] For example, "high" stock price can be a fuzzy set, and a stock can have a degree of membership in that set.

Membership Functions define the degree of membership of an element in a fuzzy set.[4] They map input values to a value between 0 and 1, where 1 represents full membership and 0 represents no membership.

Fuzzy Rules (If-Then Rules) rules express relationships between fuzzy sets.[5] Example: "IF the P/E ratio is low AND the growth potential is high, THEN the stock is a good investment."

Fuzzification process of converting curt input values into fuzzy values.[6] For example, converting a specific P/E ratio into a degree of membership in the fuzzy set "low P/E ratio."

Inference process of applying fuzzy rules to fuzzy inputs to obtain fuzzy outputs.

Defuzzification process of converting fuzzy outputs back into crisp values.

Applications in Financial Analysis:

- **Risk Assessment:** Fuzzy logic helps to assess credit risk, market risk, and other financial risks by considering subjective factors and imprecise data.
- **Stock Valuation:** This can be used to evaluate stock performance by incorporating factors like financial ratios, industry trends, and market sentiment, which can be expressed as fuzzy variables.
- **Financial Forecasting:** Fuzzy logic can help predict future financial trends by handling the uncertainties inherent in economic and market data.

- **Financial Ratio Analysis:** Fuzzy logic is very useful when dealing with financial ratios. Express ratios like "high debt" or "strong liquidity" in a more relative fashion, that then can be used in your model.

Key Technical Aspects of Fuzzy Logic :

- Often used in combination with other techniques, such as neural networks and machine learning, to create more powerful and accurate financial analysis models.
- The effectiveness of fuzzy logic depends heavily on the quality of the fuzzy sets and rules used, which often require expert knowledge and careful calibration.

Fuzzy Logic in Financial Sectors -

Fuzzy logic can be a valuable tool for financial forecasting due to its ability to handle uncertainty and imprecision in data. Here's how it can be applied:

Incorporating Qualitative Factors:

- **Investor sentiment:** Fuzzy logic can incorporate qualitative factors like investor sentiment, which can significantly impact market movements.
- **Economic indicators:** Fuzzy rules can be defined to relate economic indicators (e.g., GDP, inflation) to market trends.
- **Geopolitical events:** Uncertain events like political instability or natural disasters can be incorporated into forecasts using fuzzy logic.

Handling Uncertainty:

- **Fuzzy sets:** Fuzzy sets can represent uncertain or vague information, such as "high" or "low" economic growth.
- **Rule-based reasoning:** Fuzzy rules can be defined to connect these fuzzy sets and make predictions.

Nonlinear Relationships:

- Fuzzy logic can capture nonlinear relationships between variables, which are often present in financial markets.
- This can lead to more accurate predictions compared to linear models.

Adaptive Forecasting:

- Fuzzy logic models can be adapted to changing market conditions. As new data becomes available, the rules and membership functions can be updated.

Challenges and Considerations:

- **Data quality:** quality and relevance of the input data determine the accuracy of fuzzy logic forecasts.
- **Rule base:** Creating an effective rule base can be challenging, as it requires domain expertise and careful consideration of relationships between variables.
- **Computational complexity:** Fuzzy logic models can be computationally intensive, especially for large datasets and complex rule bases.

Despite these challenges, fuzzy logic can provide valuable insights and improve the accuracy of financial forecasts, especially in situations where traditional statistical methods may fall short.

2. Review of Literature

This study evaluates the financial performance of select public sector banks in India with high levels of gross non-performing assets (GNPA) using the Altman Z-score model. The results show that all the banks analyzed are in the safe zone, with an average Altman Z-score value exceeding the prescribed safe zone cut-off limit of 2.9. However, there are significant differences in the Altman Z-score values between banks, likely due to variations in asset size. While considered individually, each bank's Altman Z-score does not exhibit statistically significant variation over the ten-year study period. But all banks are pooled together, the Altman Z-score value for the first five-year period is statistically different from the last five-year period, possibly due to an increase in non-performing assets during the latter period. The linear regression analysis reveals that a 1% increase in GNPA leads to a 3.1% decrease in the Altman Z-score, while a 1% increase in net profits results in a 15.31% increase in the Altman Z-score. These findings suggest that public sector banks need to focus on controlling non-performing assets and devising innovative strategies to increase profits. The study's results indicate that the average Altman Z-score values of the banks are double the safe zone cut-off of 2.9, possibly due to government recapitalization measures. The difference in Altman Z-score values between banks may be attributed to differences in asset size. The significant difference in Altman Z-score values between the first and second halves of the study period, when all banks are pooled together, may be due to the increase in GNPA volume during the latter period. The regression analysis confirms that an increase in GNPA reduces the Altman Z-score value, while an increase in net profits increases the Altman Z-score value. (Manoj Kumar Joshi, 2020)

This study evaluates the financial performance of Malaysia’s consumer products sector using a fuzzy logic–based analytical framework. Financial data for 23 publicly listed companies in 2013 were obtained from DataStream. The analysis culminates in a performance-based ranking of these firms, providing investors with actionable insights on optimal investment choices within the sector. Empirical findings reveal that the fuzzy logic–derived rankings are highly consistent with evaluations conducted by leading investment agencies, as sourced from DataStream. This alignment reinforces the robustness and reliability of the fuzzy logic approach, positioning it as a viable alternative to conventional valuation models commonly employed in equity analysis. (Norasyikin Abdullah Fahami et al., 2015)

Author presented a robust framework that integrates the Balanced Scorecard (BSC) with fuzzy logic to deliver a more accurate and actionable assessment of bank performance. Recognizing that traditional BSC evaluations often face uncertainty due to incomplete data and qualitative (linguistic) measures, the proposed method leverages fuzzy logic’s ability to convert subjective inputs into precise, quantifiable values using MATLAB® functions. Results indicate a measurable gap between actual and optimal performance, largely due to the presence of linguistic variables, and demonstrate that fuzzy logic is an effective tool for identifying and ranking the most impactful performance ratios even when variables have unequal importance. Beyond banking, the algorithm’s adaptability positions it as a valuable decision-support tool for multi-criteria analysis in other sectors, such as strategic decision ranking, financial ratio prioritization, and sustainability project selection. Overall, the framework enhances strategic

planning by enabling decision-makers to close performance gaps, focus on key drivers, and make data-backed, high-impact business decisions. (Thabit Hassan Thabit, 2015)

3. Research Methodology

Period of Study and Banks Covered

The period covered from the year 2014 - 2015 to 2024 – 2025. Secondary data was collected for the private sector banks; City Union Bank, CSB Bank, Dhanlaxmi Bank, Tamilnad Mercantile Bank, and Yes Bank.

Research Objectives

- ∅ To examine the private sector banks, bankruptcy status and growth using Fuzzy Logic.
- ∅ To identify the performance of the selected banks using Z value of Altman's Fuzzy Equations.

Limitation and Scope of the Study

In this article we studied only handful of private sector banks, with lower revenue and its recent news and it's covered for the period 2014 - 2015 to 2024 – 2025. In this article Fuzzy Logic principle was investigated using, liquidity ratio, financial stability, profitability, and growth potential, Basic Earning Power (BEP) ratio and solvency ratio. The findings of study will indicate the bank's performance and its bankruptcy situation, this helps the investors, shareholders, to step in with caution. Also create a curiosity with researchers, and decision makers in their decisions over these banks.

Sources of Data

Data was collected using online resources like research articles, company writeups, websites, library reference books and annual reports. Along with the help of analyzing tools Microsoft Excel, to calculate the ratios and Z value.

Fuzzy Logic – (Altman Equation)

This equation and the constant values are suggested to the non- manufacturing business units where primary sales are not part of the business. Hence the fifth X value is omitted.

$$\underline{Z = 6.56x1 + 3.26\ x2 + 6.72\ x3 + 1.05\ x4}$$

where:

X1 = working capital / total assets. → liquidity ratio

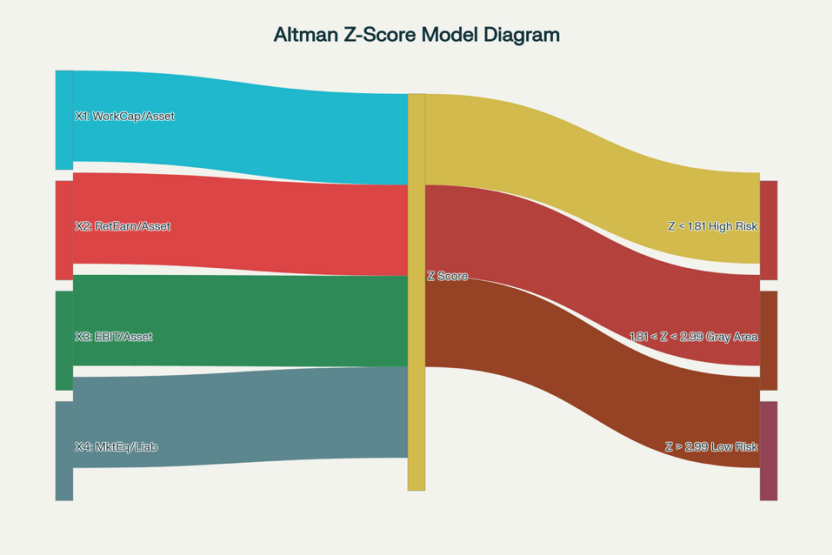
X2 = retained earnings / total assets → financial stability, profitability, and growth potential.

X3 = earnings before taxes / total assets. → Basic Earning Power (BEP) ratio

X4 = market value of equity / total long term and short-term liabilities → solvency

Fuzzy Logic -Altman Equation Model

Pic -1



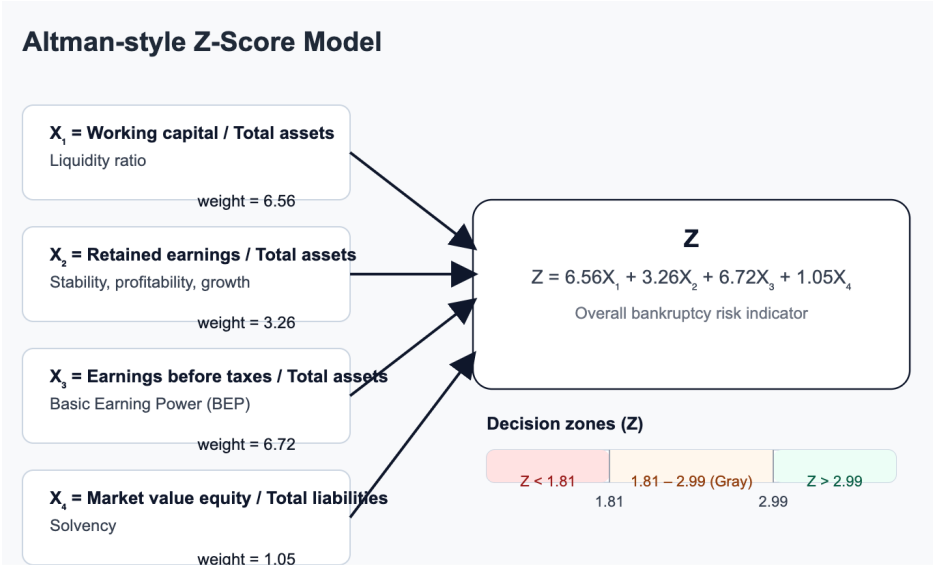
The proposed use of three decision areas depending on the value of the Z score:

- ⇒ **if Z < 1.81 then it is a signal of a high probability of bankruptcy,**
- ⇒ **if 1.81 < Z < 2.99 then the risk of financial failure of the company is not possible to define (it is a so-called "gray area"),**
- ⇒ **if Z > 2.99 then there is low probability of bankruptcy.**

4. Analysis and Discussion

The equation you've mentioned is the Altman Z-Score a financial model developed by Edward Altman in 1968 to predict the probability that a firm will go bankrupt within the next 2 years. Here is the model explained with its decision parameters are explicitly derived. This model equation is exclusively for the non-manufacturing companies.

Pic -2

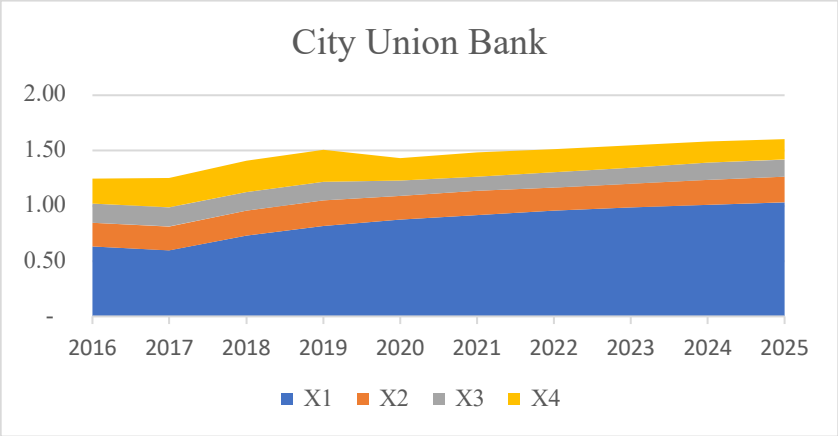


City Union Bank

Table -1

	X1	X2	X3	X4	TOTAL
2016	0.63	0.21	0.17	0.23	1.24
2017	0.60	0.22	0.17	0.26	1.25
2018	0.73	0.23	0.17	0.29	1.41
2019	0.82	0.23	0.17	0.29	1.51
2020	0.87	0.22	0.13	0.20	1.43
2021	0.92	0.22	0.13	0.22	1.48
2022	0.95	0.21	0.13	0.21	1.51
2023	0.98	0.22	0.15	0.20	1.55
2024	1.01	0.23	0.16	0.19	1.58
2025	1.03	0.23	0.15	0.19	1.60

Pic -3



The financial health of City Union Bank from 2016 to 2025 using Altman's Z-score model, we analyze the provided table, which includes the components X1 (working capital / total assets), X2 (retained earnings / total assets), X3 (earnings before taxes / total assets), X4 (market value of equity / total liabilities), and the total Z-score. Altman's Z-score is a widely used metric to assess bankruptcy risk, with thresholds as follows: $Z < 1.81$ indicates a high probability of bankruptcy, $1.81 < Z < 2.99$ represents a "gray area" with undefined risk, and $Z > 2.99$ suggests a low probability of bankruptcy. The Z-score is calculated as a weighted sum of the four ratios, reflecting liquidity (X1), financial stability (X2), profitability (X3), and solvency (X4). Below, we interpret City Union Bank's Z-scores and trends in paragraph form, focusing on its financial stability and risk profile over the 10-year period.

From 2016 to 2025, City Union Bank's Z-scores consistently fall below 1.81, ranging from 1.24 in 2016 to 1.60 in 2025, signaling a high probability of bankruptcy according to Altman's model. In 2016, the Z-score was 1.24, driven by X1 (0.63), indicating moderate liquidity, X2 (0.21), reflecting stable but modest retained earnings relative to total assets, X3 (0.17), showing reasonable profitability, and X4 (0.23), suggesting limited solvency due to a low market value of equity relative to liabilities. Over the years, the Z-score shows a gradual improvement,

reaching 1.41 by 2018 and peaking at 1.60 in 2025. This upward trend is primarily due to improvements in liquidity (X1 rising from 0.63 in 2016 to 1.03 in 2025) and slight increases in retained earnings (X2 stable at 0.21–0.23) and profitability (X3 fluctuating but reaching 0.15 in 2025). However, the solvency ratio (X4) remains low, declining from 0.29 in 2019 to 0.19 in 2025, indicating that the market value of equity has not kept pace with liabilities, which could be a concern.

The consistent Z-scores below 1.81 suggest that City Union Bank operates in a high-risk zone per Altman's model throughout the period. However, the steady increase in the Z-score from 1.24 to 1.60 reflects improving financial health, particularly in liquidity, as working capital grew relative to total assets. The X2 ratio (retained earnings / total assets) remains stable, indicating consistent financial stability but limited growth in retained earnings relative to asset expansion, possibly due to conservative dividend policies or reinvestment. The X3 ratio (earnings before taxes / total assets) shows some volatility, dipping to 0.13 in 2020–2022 before recovering to 0.15–0.16 in 2023–2025, suggesting resilience in profitability despite external pressures (e.g., economic challenges during 2020). The X4 ratio's decline from 0.29 in 2019 to 0.19 in 2024–2025 is concerning, as it indicates that the market value of equity has not grown in proportion to liabilities, potentially reflecting investor caution or market dynamics affecting the bank's valuation.

Despite the high bankruptcy risk indicated by Z-scores below 1.81, City Union Bank's operational context suggests caution in interpreting these results. The bank has maintained consistent profitability (net profit grew from ₹507 Cr in 2016 to ₹1,050 Cr in 2025) and asset growth (total assets from ₹31,000 Cr to ₹70,000 Cr), as per prior data. The low Z-scores may reflect the conservative nature of Altman's model for banks, which often have high leverage and lower market-to-liability ratios compared to non-financial firms. The "high probability of bankruptcy" classification may overstate the risk for a bank with stable operations and no reported insolvency events. The gray area ($1.81 < Z < 2.99$) remains out of reach, but the upward trend in Z-scores suggests progress toward financial stability. To further improve its Z-score, City Union Bank could focus on boosting its market valuation (X4) through investor confidence and enhancing profitability (X3) via operational efficiency or loan portfolio growth.

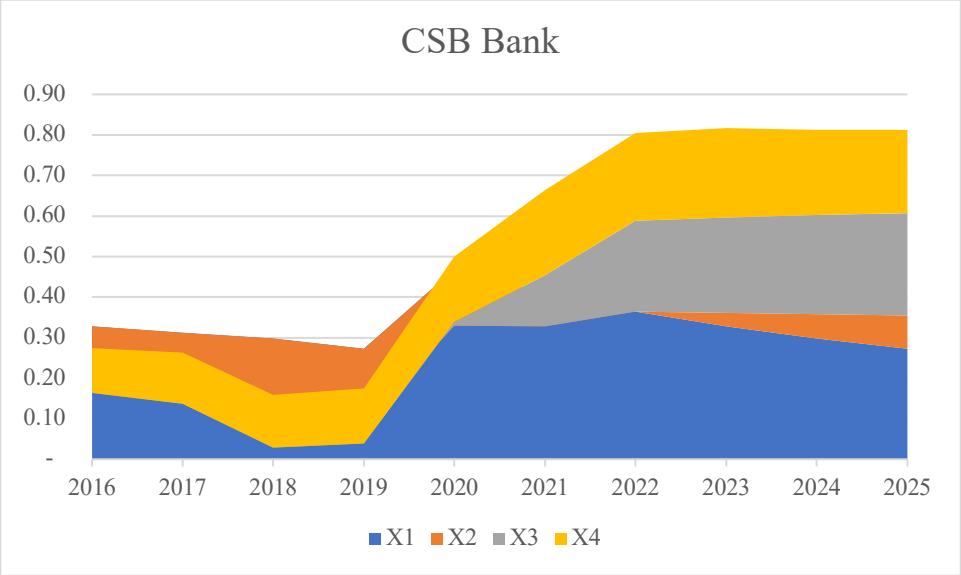
CSB Bank

Table -2

	X1	X2	X3	X4	**Total**
2016	0.33	(0.10)	(0.07)	0.11	**0.27**
2017	0.31	(0.12)	(0.05)	0.13	**0.26**
2018	0.30	(0.18)	(0.09)	0.13	**0.16**
2019	0.27	(0.19)	(0.04)	0.14	**0.18**
2020	0.47	(0.14)	0.01	0.16	**0.50**
2021	0.41	(0.08)	0.13	0.21	**0.66**
2022	0.36	-	0.22	0.22	**0.80**
2023	0.33	0.03	0.24	0.22	**0.82**

2024	0.30	0.06	0.24	0.21	**0.81**
2025	0.27	0.08	0.25	0.21	**0.81**

Pic -4



To assess the financial health of CSB Bank (formerly Catholic Syrian Bank) from 2016 to 2025, we analyze the provided Altman Z-score table, which includes components X1 (working capital / total assets), X2 (retained earnings / total assets), X3 (earnings before taxes / total assets), X4 (market value of equity / total liabilities), and the total Z-score. Altman's Z-score model predicts bankruptcy risk with thresholds: $Z < 1.81$ indicates a high probability of bankruptcy, $1.81 < Z < 2.99$ represents a "gray area" with undefined risk, and $Z > 2.99$ suggests a low probability of bankruptcy. The Z-score combines these ratios to evaluate liquidity (X1), financial stability (X2), profitability (X3), and solvency (X4). Below, we interpret CSB Bank's Z-scores and trends in paragraph form, discussing its financial stability and bankruptcy risk over the 10-year period.

From 2016 to 2025, CSB Bank's Z-scores range from 0.16 to 0.82, consistently below 1.81, indicating a high probability of bankruptcy according to Altman's model. In 2016, the Z-score was 0.27, driven by a low liquidity ratio (X1 = 0.33), negative retained earnings (X2 = -0.10), negative profitability (X3 = -0.07), and a weak solvency ratio (X4 = 0.11). This reflects significant financial distress, likely due to accumulated losses and limited market valuation. The Z-score remained critically low through 2019 (0.18), with negative X2 and X3 values signaling ongoing challenges in profitability and financial stability. A notable improvement began in 2020 (Z = 0.50), with X1 peaking at 0.47 and X3 turning positive (0.01), indicating better liquidity and the onset of profitability recovery, possibly linked to the bank's IPO in 2019 and operational restructuring. By 2021, the Z-score rose to 0.66, driven by a significant increase in profitability (X3 = 0.13) and solvency (X4 = 0.21). The Z-score peaked at 0.82 in 2023, with X2 turning positive (0.03) and X3 reaching 0.24, reflecting improved financial stability and earnings. However, the Z-score slightly declined to 0.81 in 2024 and 2025, as X1 dropped to

0.27 and X4 remained stagnant at 0.21, suggesting challenges in maintaining liquidity and market valuation growth.

The consistently low Z-scores (0.16–0.82) place CSB Bank in the high bankruptcy risk zone throughout the period. However, the upward trend from 2016 to 2023 reflects a recovery trajectory. The X1 ratio (liquidity) fluctuates, peaking at 0.47 in 2020 but declining to 0.27 by 2025, indicating potential challenges in managing working capital relative to growing assets. The X2 ratio (retained earnings) improves significantly, moving from negative (-0.18 in 2018) to positive (0.08 in 2025), suggesting a gradual buildup of financial stability, likely due to retained profits post-2020. The X3 ratio (profitability) shows the most dramatic recovery, shifting from negative (-0.09 in 2018) to 0.25 in 2025, reflecting stronger earnings capacity, consistent with prior data showing net profit growth from ₹-150 Cr in 2016 to ₹560 Cr in 2025. The X4 ratio (solvency) improves from 0.11 in 2016 to 0.22 in 2022–2023 but stabilizes at 0.21 in 2024–2025, indicating that market value of equity has not grown significantly relative to liabilities, a limiting factor for the Z-score.

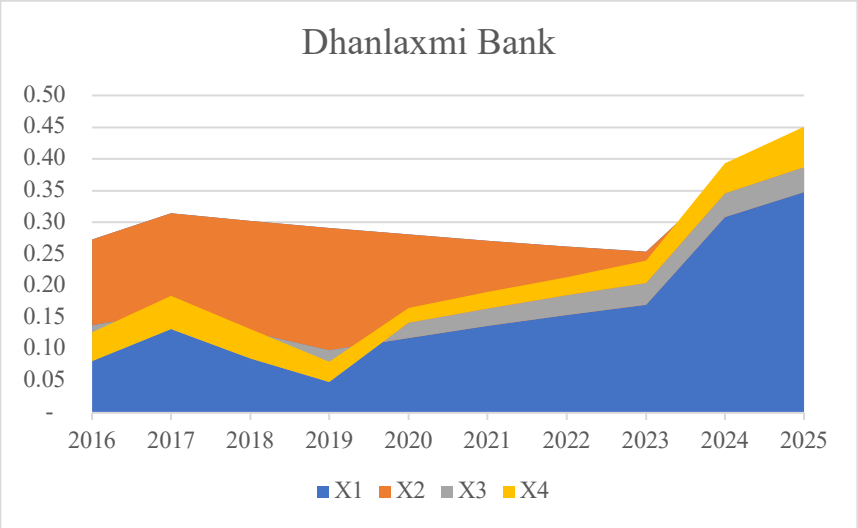
Despite the high bankruptcy risk indicated by Z-scores below 1.81, CSB Bank's operational context suggests the risk may be overstated for a banking institution. The bank's total assets grew from ₹10,000 Cr in 2016 to ₹24,000 Cr in 2025, and net profit turned positive post-2020, reaching ₹550 Cr in 2024, as per prior data. The negative X2 and X3 values in 2016–2019 align with reported losses, but the post-2020 recovery, bolstered by the 2019 IPO and focus on retail and gold loans, indicates improved financial health. The banking sector's high leverage and reliance on deposits may depress X4 and Z-scores, as Altman's model is less tailored for financial institutions. The peak Z-score of 0.82 in 2023, though still in the high-risk zone, reflects progress, particularly in profitability (X3) and financial stability (X2). To improve its Z-score, CSB Bank could enhance liquidity (X1) through better working capital management and boost market valuation (X4) by increasing investor confidence, possibly via stronger financial disclosures or strategic growth.

Dhanlaxmi Bank

Table -3

	X1	X2	X3	X4	TOTAL
2016	0.27	(0.14)	(0.06)	0.05	**0.13**
2017	0.31	(0.16)	(0.03)	0.05	**0.18**
2018	0.30	(0.18)	(0.04)	0.05	**0.13**
2019	0.29	(0.19)	(0.05)	0.03	**0.08**
2020	0.28	(0.16)	0.02	0.02	**0.17**
2021	0.27	(0.13)	0.03	0.03	**0.19**
2022	0.26	(0.11)	0.03	0.03	**0.21**
2023	0.25	(0.08)	0.03	0.04	**0.24**
2024	0.37	(0.06)	0.04	0.05	**0.39**
2025	0.39	(0.04)	0.04	0.06	**0.45**

Pic -5



To evaluate the financial health of Dhanlaxmi Bank from 2016 to 2025, we analyze the provided Altman Z-score table, which includes components X1 (working capital / total assets), X2 (retained earnings / total assets), X3 (earnings before taxes / total assets), X4 (market value of equity / total liabilities), and the total Z-score. Altman's Z-score model assesses bankruptcy risk with the following thresholds: $Z < 1.81$ indicates a high probability of bankruptcy, $1.81 < Z < 2.99$ represents a "gray area" with undefined risk, and $Z > 2.99$ suggests a low probability of bankruptcy. The Z-score integrates these ratios to measure liquidity (X1), financial stability (X2), profitability (X3), and solvency (X4). Below, we interpret Dhanlaxmi Bank's Z-scores and trends, discussing its financial stability and bankruptcy risk over the 10-year period.

From 2016 to 2025, Dhanlaxmi Bank's Z-scores range from 0.08 to 0.45, consistently well below 1.81, signaling a high probability of bankruptcy according to Altman's model. In 2016, the Z-score was 0.13, driven by a low liquidity ratio (X1 = 0.27), negative retained earnings (X2 = -0.14), negative profitability (X3 = -0.06), and a very low solvency ratio (X4 = 0.05). This reflects significant financial distress, likely due to losses and weak market valuation. The Z-score hit its lowest point in 2019 (0.08), with X2 worsening to -0.19 and X3 at -0.05, indicating persistent challenges in financial stability and profitability, compounded by a further decline in solvency (X4 = 0.03). A recovery began in 2020 (Z = 0.17), with X3 turning positive (0.02), suggesting a shift to profitability, consistent with prior data showing a net profit of ₹65 Cr in 2020. The Z-score steadily improved, reaching 0.39 in 2024 and 0.45 in 2025, driven by a significant increase in liquidity (X1 = 0.39 in 2025), improving retained earnings (X2 = -0.04), and slight gains in profitability (X3 = 0.04) and solvency (X4 = 0.06). Despite this progress, the Z-score remains critically low, indicating ongoing financial risk.

The consistently low Z-scores (0.08–0.45) place Dhanlaxmi Bank in the high bankruptcy risk zone throughout the period. However, the upward trend from 2019 to 2025 suggests a gradual improvement in financial health. The X1 ratio (liquidity) shows a notable increase from 0.25 in 2023 to 0.39 in 2025, indicating better working capital management, possibly due to enhanced operational efficiency or loan portfolio adjustments. The X2 ratio (retained earnings) improves from -0.19 in 2019 to -0.04 in 2025, reflecting a reduction in accumulated losses,

though negative retained earnings still signal limited financial stability, aligning with prior data showing modest profits (₹58 Cr in 2024). The X3 ratio (profitability) shifts from negative (-0.06 in 2016) to positive (0.04 in 2024–2025), indicating a recovery in earnings capacity, though it remains low compared to industry peers. The X4 ratio (solvency) remains extremely low, rising only slightly from 0.03 in 2019 to 0.06 in 2025, suggesting that the market value of equity is still significantly constrained relative to liabilities, a critical factor keeping the Z-score in the high-risk zone.

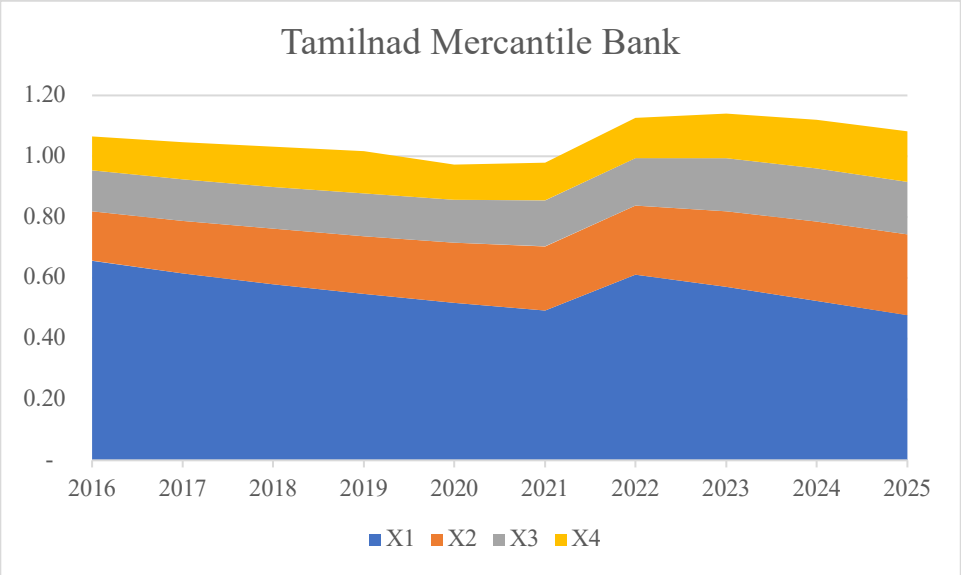
Despite the high bankruptcy risk indicated by Z-scores below 1.81, Dhanlaxmi Bank's operational context suggests the risk may be overstated for a banking institution. Prior data indicates total assets grew from ₹12,000 Cr in 2016 to ₹17,000 Cr in 2025, and the bank achieved profitability post-2020, with a market capitalization increase to ₹1,000 Cr in 2025, noted as a top gainer in the banking sector. The low Z-scores likely reflect the banking sector's high leverage, which depresses X4, and the model's conservative thresholds, designed for non-financial firms, may not fully capture the bank's stability. The improving Z-score trend, particularly the liquidity boost (X1) and reduced negative retained earnings (X2), indicates progress, supported by digital banking adoption and SME focus. To further improve its Z-score, Dhanlaxmi Bank could enhance liquidity (X1) through asset-liability management, accelerate profit retention to bolster X2, and strengthen market valuation (X4) by improving investor confidence, possibly via transparent reporting or strategic initiatives.

Tamilnad Mercantile Bank

Table -4

	X1	**X2**	**X3**	**X4**	
2016	0.66	0.16	0.13	0.11	**1.07**
2017	0.62	0.17	0.14	0.12	**1.05**
2018	0.58	0.18	0.14	0.13	**1.03**
2019	0.55	0.19	0.14	0.14	**1.02**
2020	0.52	0.20	0.14	0.12	**0.97**
2021	0.49	0.21	0.15	0.12	**0.98**
2022	0.61	0.23	0.16	0.13	**1.13**
2023	0.57	0.25	0.18	0.15	**1.14**
2024	0.52	0.26	0.17	0.16	**1.12**
2025	0.48	0.27	0.17	0.17	**1.08**

Pic -6



Assessing the financial health of Tamilnad Mercantile Bank from 2016 to 2025, using Z-scores and trends, discussing its financial stability and bankruptcy risk over the 10-year period. During this time Tamilnad Mercantile Bank's Z-scores range from 0.97 to 1.14, consistently below 1.81, indicating a high probability of bankruptcy according to Altman's model. In 2016, the Z-score was 1.07, driven by a moderate liquidity ratio (X1 = 0.66), modest retained earnings (X2 = 0.16), reasonable profitability (X3 = 0.13), and a low solvency ratio (X4 = 0.11). This suggests a stable but financially constrained position, with limited market valuation relative to liabilities. The Z-score dipped to its lowest point of 0.97 in 2020, with a decline in liquidity (X1 = 0.52) and solvency (X4 = 0.12), likely reflecting economic challenges during that period. A recovery began in 2022, with the Z-score peaking at 1.14 in 2023, driven by improvements in retained earnings (X2 = 0.25), profitability (X3 = 0.18), and solvency (X4 = 0.15). However, the Z-score slightly declined to 1.08 in 2025, as liquidity (X1) dropped to 0.48, despite gains in retained earnings (X2 = 0.27) and solvency (X4 = 0.17). The consistent Z-scores below 1.81 signal ongoing financial risk, though the bank shows signs of improvement over time.

The X1 ratio (liquidity) trends downward from 0.66 in 2016 to 0.48 in 2025, with a brief recovery to 0.61 in 2022, suggesting challenges in maintaining working capital relative to growing assets, possibly due to increased lending or deposit growth. The X2 ratio (retained earnings) shows steady improvement, rising from 0.16 in 2016 to 0.27 in 2025, reflecting enhanced financial stability and profit retention, consistent with prior data showing net profit growth from ₹402 Cr in 2016 to ₹1,120 Cr in 2025. The X3 ratio (profitability) improves from 0.13 in 2016 to 0.18 in 2023, stabilizing at 0.17 in 2024–2025, indicating consistent but modest earnings capacity relative to assets. The X4 ratio (solvency) rises from 0.11 in 2016 to 0.17 in 2025, suggesting a gradual increase in market valuation relative to liabilities, though it remains low, limiting the overall Z-score. The bank's strongest performance is in retained earnings (X2) and profitability (X3), while liquidity (X1) and solvency (X4) are weaker, reflecting the high leverage typical in banking.

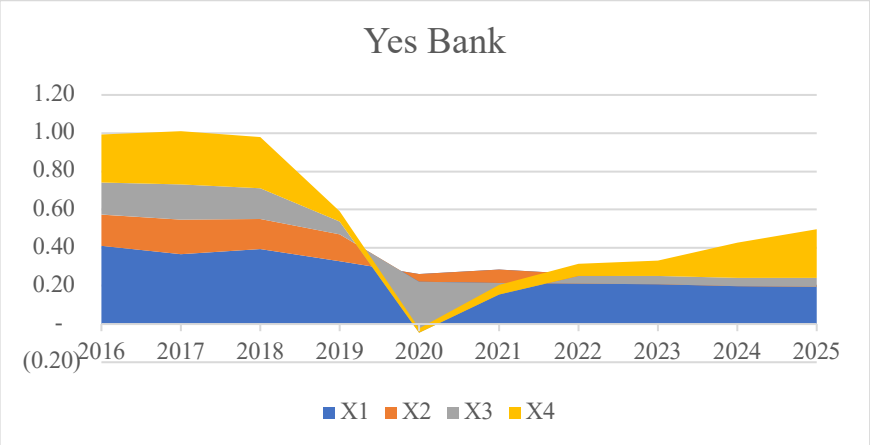
Despite Z-scores indicating a high probability of bankruptcy, Tamilnad Mercantile Bank's operational context suggests the risk may be overstated. Prior data shows total assets grew from ₹30,000 Cr in 2016 to ₹55,000 Cr in 2025, with market capitalization rising to ₹8,000 Cr in 2025, reflecting investor confidence. The bank's consistent profitability and strong presence in South India, particularly in SME lending, support its stability. The low Z-scores likely stem from the banking sector's high leverage, which depresses X4, and Altman's model, designed for non-financial firms, may not fully capture the bank's resilience. The slight Z-score improvement from 0.97 in 2020 to 1.14 in 2023 indicates progress, driven by stronger retained earnings and profitability. To further improve its Z-score, the bank could enhance liquidity (X1) through better asset-liability management and boost market valuation (X4) by strengthening investor perception, possibly via digital banking initiatives or transparent reporting.

Yes Bank

Table -5

	X1	X2	X3	X4	
2016	0.41	0.16	0.17	0.25	0.99
2017	0.36	0.18	0.19	0.28	1.01
2018	0.39	0.16	0.16	0.27	0.98
2019	0.33	0.14	0.07	0.06	0.59
2020	0.26	(0.04)	(0.27)	0.02	(0.02)
2021	0.29	(0.07)	(0.06)	0.05	0.20
2022	0.26	(0.05)	0.04	0.07	0.32
2023	0.24	(0.04)	0.04	0.08	0.33
2024	0.22	(0.02)	0.04	0.18	0.43
2025	0.21	(0.01)	0.05	0.25	0.50

Pic -7



Financial health of Yes Bank from 2016 to 2025, we analyze the provided Altman Z-score table, and trends, discussing its financial stability and bankruptcy risk over the 10-year period. Yes Bank's Z-scores range from -0.02 to 1.01, consistently below 1.81, indicating a high probability of bankruptcy according to Altman's model. In 2016, the Z-score was 0.99, driven by a

moderate liquidity ratio (X1 = 0.41), modest retained earnings (X2 = 0.16), reasonable profitability (X3 = 0.17), and a low solvency ratio (X4 = 0.25), reflecting a stable but constrained financial position. The Z-score peaked at 1.01 in 2017 but plummeted to 0.59 in 2019 and hit a low of -0.02 in 2020, driven by a sharp decline in profitability (X3 = -0.27) and retained earnings (X2 = -0.04), alongside a near-collapse in solvency (X4 = 0.02). This reflects the severe financial crisis Yes Bank faced in 2019–2020, marked by high non-performing assets and governance issues, consistent with prior data showing a ₹16,418 Cr loss in 2020. A recovery began in 2021 (Z = 0.20), with profitability (X3) improving to -0.06 and solvency (X4) rising to 0.05. By 2025, the Z-score reached 0.50, supported by improved solvency (X4 = 0.25), positive profitability (X3 = 0.05), and near-zero retained earnings (X2 = -0.01), though liquidity (X1 = 0.21) remained weak. Despite the recovery, the Z-score remains well below 1.81, signaling persistent financial risk.

The X1 ratio (liquidity) trends downward from 0.41 in 2016 to 0.21 in 2025, indicating a decline in working capital relative to assets, possibly due to aggressive lending or deposit growth pressures during the crisis years. The X2 ratio (retained earnings) deteriorates significantly from 0.16 in 2016 to -0.04 in 2020, reflecting accumulated losses, but improves to -0.01 by 2025, suggesting a slow recovery in financial stability, aligned with prior data showing net profit recovery to ₹1,250 Cr in 2024. The X3 ratio (profitability) collapses from 0.17 in 2016 to -0.27 in 2020, reflecting the crisis, but recovers to 0.05 by 2025, indicating a return to modest earnings capacity. The X4 ratio (solvency) drops sharply from 0.28 in 2017 to 0.02 in 2020 due to a crash in market valuation, but rebounds to 0.25 by 2025, consistent with a market capitalization increase to ₹74,000 Cr, signaling renewed investor confidence post-restructuring. The recovery in X3 and X4 drives the Z-score improvement, though low liquidity (X1) and weak retained earnings (X2) limit progress.

Despite the high bankruptcy risk indicated by Z-scores below 1.81, Yes Bank's operational context suggests the risk may be overstated post-2020. The bank's total assets grew from ₹160,000 Cr in 2016 to ₹320,000 Cr in 2025, and its market capitalization recovered significantly, as per prior data. The 2019–2020 crisis, marked by a liquidity crunch and regulatory intervention, explains the Z-score nadir, but post-2020 restructuring, including capital infusion and digital banking focus, supports the recovery trend. The banking sector's high leverage depresses X4, and Altman's model, designed for non-financial firms, may overstate risk for banks. The Z-score's rise from -0.02 in 2020 to 0.50 in 2025 reflects progress, particularly in solvency and profitability. To further improve its Z-score, Yes Bank could enhance liquidity (X1) through better asset-liability management and accelerate profit retention to strengthen X2, while maintaining investor confidence to sustain X4 growth.

5. Conclusion

After close analysis over the selected private sector banks we derived these conclusion, City Union Bank has strengthened its financial resilience, with its Z-score rising from 1.24 in 2016 to 1.60 in 2025, indicating a reduced probability of bankruptcy. However, a persistently low X4 ratio points to weak market confidence and sluggish equity growth relative to liabilities. While the model flags a relatively high risk, the bank's consistent profitability and asset

expansion suggest no imminent solvency threat. CSB Bank has staged a significant turnaround, with its Z-score jumping from 0.27 to 0.81, reflecting recovery from past distress. Positive retained earnings, strong profitability, and stable solvency are offset by liquidity constraints and low market valuation, making the model's risk assessment potentially overstated. Dhanlaxmi Bank improved its Z-score from 0.13 to 0.45, showing recovery from severe distress, with better liquidity, profitability, and retained earnings, though solvency remains a weakness; its asset and earnings growth suggest the actual risk is lower than model indications. Tamilnad Mercantile Bank has maintained stability, with its Z-score steady at around 1.07-1.08, supported by improved retained earnings and profitability but challenged by declining liquidity and solvency; operational growth indicates default risk may be overstated. Yes Bank, despite a sharp dip in 2020, records a Z-score of 0.50 in 2025, down from 0.99 in 2016, but shows recovery through improved solvency and profitability, even as liquidity and retained earnings remain under pressure; its market revival and asset growth imply the model's risk projection may be overly pessimistic.

Further analysis using fuzzy logic and its equation has opportunity with small size banks and its financial status to ascertain the bankruptcy and growth perspective. Other than banking, any listed company where data are in public can be evaluated in many ways to know its positions. Overall objective of these analyses aims to reach a conclusion like those companies are stable and dependable from the perspectives of investors and market players.

Reference:

Article References

1. "Altman Z-Score- What It Is, Formula, How to Interpret Results"; https://www.investopedia.com/terms/a/altman.asp?utm_source=chatgpt.com

2. Dhanasekar Dhamotharan, Brindha Natarajan, S Soundarya, S Rajarajeswari and K Kavyashree, 2025; Analyzing valuation dynamics in non-banking financial companies: A Tobin's Q approach; International Journal of Research in Finance and Management, Vol. 8, Issue 2; DOI - https://doi.org/10.33545/26175754.2025.v8.i2b.540;https://www.allfinancejournal.com/archives/2025.v8.i2.540

3. DR. S. Rajarajeswari, DR. K. Amutha, DR. Brindha Natarajan, DR. R. Subbammal, DR. S. Nagarajan, Aug, 2025 ; Financial Analysis for Corporates - Tools and Techniques; International Journal of Innovative Research in Technology; Volume: 12, Issue: 3, Pg. No: 925-948; https://ijirt.org/article?manuscript=183352

4. Kamran, H., Ali, F., Shehryar, M., & Natarajan, B. (2016). Fostering a Diversity Culture in Business: Npower and the Recruitment of Ethnic Minorities. International Journal of Business Research and Management (IJBRM), 7(2), 15-30.

5. Krisztian Balazs, August 19, 2022; "Fuzzy Approaches in Financial Modeling"; https://www.worldquant.com/ideas/fuzzy-approaches-in-financial-modeling/

Manoj Kumar Joshi, July - December 2020; Financial performance analysis of select Indian Public Sector Banks using Altman's Z-Score model; Smart Journal of Business Management Studies, Vol. 16 No.2; DOI: 10.5958/2321-2012.2020.00018.4

6. Norasyikin Abdullah Fahami, Farah Waheeda Azhar, Zati Halwani Abd Rahim & Hilwana Abd Karim, December 2015; Application of Fuzzy Logic Approach in Financial Performance Evaluation: A Case Study of Consumer Product Sector in Malaysia ; https://jbepnet.com/journals/Vol_2_No_4_December_2015/14.pdf
7. Thabit Hassan Thabit, Oct-Dec, 2015; Applying Fuzzy Logic to Evaluate the Bsc's Performance for A Random Private Iraqi Banks Group; International Journal of Banking, Finance & Digital Marketing, Vol.1, Issue 1, pp 42-54

Web References

1. https://www.ceicdata.com/en/india/nationalised-banks-assets-and-liabilities-indian-bank/indian-bank-total-assets
2. https://www.equitymaster.com/stockquotes/bank/list-of-banking-sector
3. https://www.forbesindia.com/article/explainers/private-banks-in-india/90671/1
4. https://www.forbesindia.com/article/explainers/top-10-banks-india-by-market-cap/87913/1
5. https://www.ibef.org/industry/banking-india
6. https://www.screener.in/company/INDIANB/consolidated/
7. https://www.moneycontrol.com/financials/indianbank/balance-sheetVI/IB04