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Original Article

Asset Concentration and Z Score in Indian Banks

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Abstract

The paper endeavors to verify the linear and non-linear relationship between z score and asset concentration in Indian banks during 2000-2021 through Auto Regressive Distributed Lag (ARDL) and Non-Linear Auto Regressive Distributed Lag (NARDL) approaches, with special emphasis on the asymmetric impact of asset concentration. It also indicated their trends towards 2050 through Auto Regressive Integrated Moving Average (ARIMA) models. The paper found that both the trends are nonlinear and convergent towards 2050. In NARDL model, positive changes of asset concentration are negatively related with z score while negative changes are positively associated, but all are insignificant, while in ARDL, z score is both related positively and negatively in different lags, but it is positively related with asset concentration at lag four significantly. The asymmetry line and positive response of the cumulative dynamic multiplier of asset concentration on z score are moving upward above the equilibrium line towards positive long-run limit, while the negative response of cumulative dynamic multiplier of asset concentration on z score converged to the negative long run limit successfully. There is no signal of bankruptcy.

Keywords*: Asset Concentration; Asymmetry; Banking Crisis; Cumulative Dynamic Multiplier; Negative Response; Positive Response; Z Score*

JEL classification codes-C22, C32, D40, D82, G33, G34

Introduction

The z score is a well-established indicator of bank's insolvency risk among academicians. A high value of z score represents a low risk. A Z score can give clear signal for financial distress/financial crisis. It can help policy regulations in controlling financial crises and bankruptcy. It is also applicable to medical evaluation, testing scores, investment and trading, and quality control, respectively. Forward-looking z score is an improvement on the method that is widely used in non-financial corporations in returns and pricing.

The z score can be defined as the following equational form:

Z-Score=[(Return on Assets) + (Equity/Total Assets)]/ Standard Deviation (Return on Assets)

This formula allows stakeholders to gauge a bank's financial strength relative to its risk exposure.

Altman z score used profitability, leverage, liquidity, solvency, and activity to forcast whether a company has a high probability of becoming insolvent.

Altman Z-score is as follows:

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Altman Z-Score = 1.2(working capital / total assets) + 1.4(retained earnings / total assets) + 3.3(earnings before interest and tax / total assets) + 0.6(market value of equity / total liabilities) + 1.0(sales / total assets)

The policy of M&A of banks to enable high asset concentration to sustain high z score for forthcoming business improvement will not be favorable to all countries, including India; rather, it may harm bank profitability and financial health. The following empirical evidence teaches us clearly.

The merger of banks did not improve bank profitability and even affected it negatively in SSA during 2003-2019, which was found in the dynamic panel GMM approach. The credit risk and the z score impacted bank profit inversely (Ayagre *et al*., 2024).

In India bank mergers were done to reduce NPA and to hike market share and financial stability but z score of 5 largest banks during 2019-2020-2023-24 showed that SBI is in grey zone, and merged banks are in distress zone (Preethi *et al*., 2024).

Mergers and acquisitions of banks as a deregulation policy may foster financial crises by sharing the insolvency risk of the bank's activity. It contributes to changes in bank assets, and it sometimes involves risk-taking and creates geographical diversification, which causes higher systematic risk. The GMM approach showed that M&A is detrimental to bank's financial health. A 1% increase in assets in merged banks will lead to a reduction in the bank's insolvency level by 0.8% which was examined in US Bank Holding Companies during 1994-2007 (Wang, 2024).

After acquisition of cooperative banks in Drama (Greece), its z score had declined during 2014-2020 (Kyriazopoulos *et al*., 2023).

Therefore, the paper relates nonlinear relationship between z score and asset concentration of 5 big banks and finds out asymmetric impact of asset concentration on z score by which it can be inferred some impacts of the banks' M&A on asset concentration in India.

Important Research

Z score represents financial stability of banks and plays a significant role in risk management because a higher z-score typically interpreted a safer investment. Moreover, credit risk assessment, credit rating agencies, and financial institutions apply the z-score to their evaluation processes.

In USA, z score predicted US financial crisis successfully. In Australia z score performed so brilliantly during economic fluctuations and better financial performances. In South Africa, z score showed good results in return on equity and return on asset performance. In ASEAN, z score predicted better financial health and performance. But in Nigeria and Ethiopia, it failed to predict financial stability of the banking sector, while in Kenya, it succeeded. In franchise value hypothesis, panel data of z score showed good results using a random effect Generalized Least Squares (GLS) regression model in 144 observations across 6 groups with the help of H statistic in 35 commercial banks from 1999 to 2023 (Lelissa & Fava, 2024). In New Zealand, the risk-adjusted z-score was proved as appropriate to predict bank risk (Li *et al.*, 2017).

If z score is greater than 2.99, which indicates financial health of bank is safe; if it lies between 1.80 and 2.99, then the bank is in gray; while if the z score is less than 1.80, then the bank is in distress (Altman, 1968). From a signaling theory perspective, the Z-Score is more reliable for credible market signals in observability and financial performance costs.

Boyd and Graham (1986) examined a study where he considered the z-score as a risk indicator, which showed that a bank may fail or go bankrupt. Subsequently, Boyd and Graham (1988) and Boyd *et al*. (1993) also applied z-score as an indicator of the probability of bankruptcy and investigated the risk effects of bank holding companies' mergers with nonbank financial firms. Moreover, z-score is used in the model of De Young and Torna (2013) as an indicator of financially sick banks, which have the lowest z-scores.

A high z-score requires sustained profitability and financial performance. It is a tool for managing financial risk, improving market transparency, and dwindling information asymmetry between firms and stakeholders (Dumitrescu *et al*., 2025).

In India, by examining z score model in 12 banks during 2014-2018, it was found that the banks are suffering from sickness with very high NPA and low market share (Joseph *et al*., 2018). The results of z score of 77 banks, in which 21 are public sector, 19 are private, and 37 are foreign banks in India during 2016-2020, implied that commercial banks are safe and private banks are more solvent than public sector banks, although their z scores are less (Rani, 2022). Altman's z score in Indian public sector banks during 2017-18 and 2021-22 revealed that the banks were not in a safe zone (Kumar & Murthy Chodisetty, 2024). The traditional or standard z score consists of many shortcomings. If the forward-looking z-score method is applied, then many shortcomings can be eliminated, and it can provide an early warning system for bank crises. In US banks on the S&P 1500 during 2012-2020, it predicted much better than the z score (Hafeez *et al*., 2022). Tobin regression model revealed that efficiency of public sector banks is higher than private sector banks, while the z-score showed the stability risk of both types of banks during 2004-2020 in India (Patra *et al*., 2022). Applying principal component analysis and dynamic panel method instead of z score in the banks of India, Nepal, Bangladesh, and Pakistan from 2004 to 2018, based on composite index of stability, it was found that the validity of the 'too big to fail' hypothesis in Bangladesh and Pakistan and it assured the 'diversification stability hypothesis' in Nepal and the stability of Indian banks (Gulati *et al*., 2023).

In examining banking sector concentration and individual bank risk in India during 1998-2022 through the application of two steps GMM estimator for accounting reverse causality and risk, it was found that a 1% increase in top 5 banks' asset share had dwindled the z score by 5.85% and distance-to-default by 1.77%. The result is highly significant and identified higher lending to cyclical sectors, enlarged earning volatility, and declined in asset quality (Zeeshan & Singh, 2025).

The values of z score in the study on 10 public and private sector banks in India with highest NPA during 2017-2021 showed that private sector banks performed better than public sector banks with regard to financial stability, although the banks are in safe zone (Rani, 2024).

Objectives of the Study

The paper tries to examine the possible linear and nonlinear impacts of determinants of asset concentration of largest five banks in India on z score of Indian banks during 2000-2021 through ARDL and NARDL models, with special emphasis on the asymmetric impact of asset concentration on z score. The paper also tried to show the behavioral patterns of both the variables. The paper tried to explain how the merger and acquisition of banks enhanced asset concentration, which might negatively impact the banks' financial health.

Methodology

The regression equations of linear and non-linear trends have been calculated in the following fashions:

$$\log(y_i) = a + bt + u_i$$

$$\log(y_i) = a + bt + ct^2 + dt^3 + et^4 + u_i$$

Where y is dependent variable and t is independent variable(time), a,b,c,d and e are constants and u_i indicate the random errors. For all values of i=1,2,3,…….n.

The ARIMA model was estimated by using Box and Jenkins (1976) model. Unit root test was done through Dicky and Fuller (1979) model. The ARDL model was estimated by using the Pesaran and Shin (1999) and Pesaran *et al*. (2001) models. The NARDL estimation and asymmetry were calculated through applying Shin *et al*. (2014) model. The serial correlation and heteroscedasticity tests were done by applying Breusch-Pagan model (1979). The Cumulative sum (CUSUM) test was done through Page (1954) model.

The data on z score for all Indian banks (assumed y) and asset concentration for 5 largest banks in India as a share of total commercial banking assets (annual percentage) (assumed x) from 2000 to 2021 have been collected from Federal Reserve Bank of St. Louis.

Results

Trend Behavior

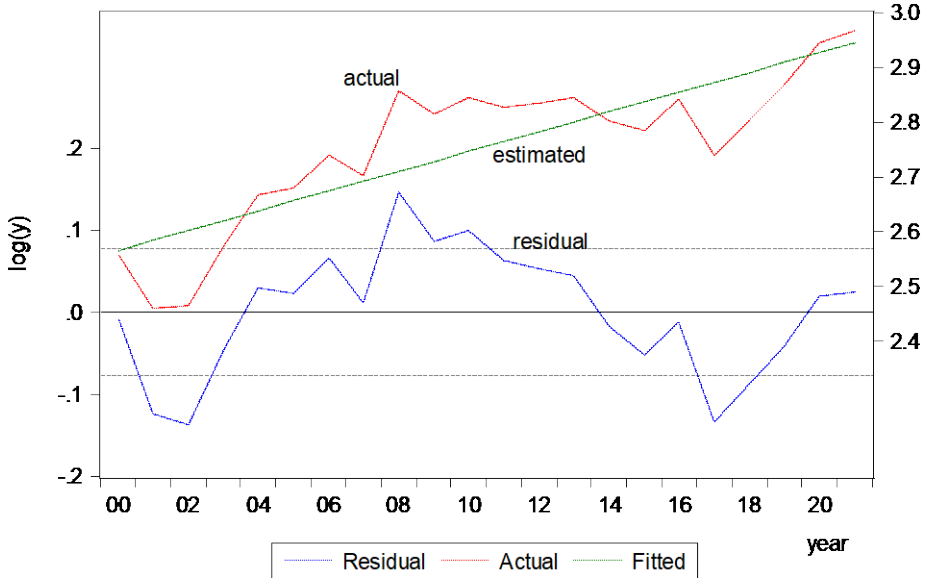
In India, z score of all banks have been catapulting at the rate of 1.804% per year significantly during 2000-2021.The linear regression equation is estimated below.

Log(y)=2.5469+0.01804t +u_i

(74.17)* (6.90)*

R^2=0.704, F=47.63*, Durbin Watson (DW)=0.708, n=22, y=z score of banks, t= year, *= significant at 5% level. u_i=random error. *t* values are given in first brackets.

In Figure 1, the fitted line of z score is moving upward significantly (green line) while the actual line is showing upswings and downswings (red line) during the specified period.



Source: Author's own

Figure 1: The Fitted Line of z Score

So that, the actual path of the z score is non-linear which has been estimated as trend with four phases which is given below.

$\log(y)_t$=2.527-0.0434t+0.0190t^2-0.00154t^3+3.71$e^{-05}t^4$

(41.47)* (-1.24) (3.17)* (-3.99)* (4.43)*

Where R^2=0.925, F=52.64*, DW=2.367, n=22, *= significant at 5% level, t values are shown in first brackets.

In the first phase, z score has been decreasing at the rate of 4.3% per year; in the second phase, it is rising at the rate of 1.90% per year; in the third phase, it is decreasing at the rate of 0.15% per year; and in the fourth phase, it is increasing exponentially at the significant rate of 0.000371% per year.

In Figure 2, the estimated nonlinear trend of z score during 2000-2021 is depicted, which is finally increasing, but it proceeded through cycles, which implies that the stability and financial crisis protection ability of banks have both been increasing and decreasing during the last two decades.

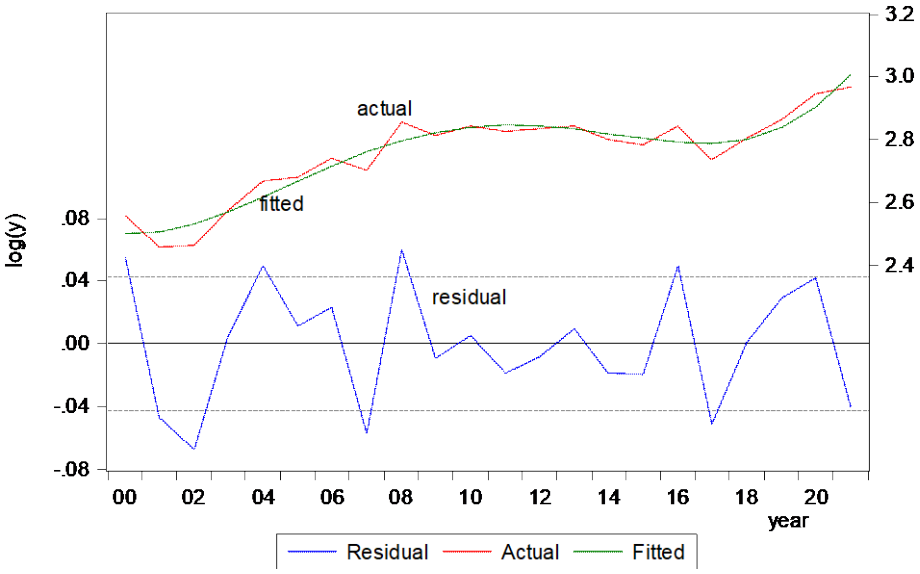


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Figure 2: Non-linear Trend of z Score

ARIMA (1,0,1) model of z score of India during 2000-2021 is estimated for forecast model for 2050 which is given below.

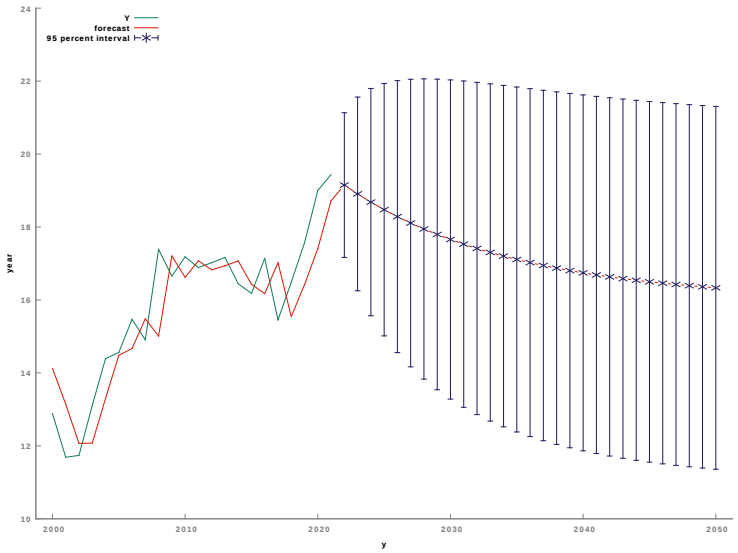
$Y=16.00025+0.9228$ AR (1)-0.0319 MA (1) $+1.0233\sigma^2$

(8.10)* (6.43)* (-0.104) (2.84)*

Where R^2=0.757, F=18.72*, n=22, Akaike Information Criteria (AIC) =3.30, SC=3.50, DW=1.867*, *=significant at 5% level. Inverted AR root=0.92, Inverted MA root=0.03.

In this estimated ARIMA (1,0,1) model of z score stated that both of its Auto Regression (AR) and Moving Average (MA) processes are converging because its coefficients are less than one, and volatility is minimum because the coefficient of σ2 is significant. Both the inverted AR and MA roots are less than one, which implies that the model is stable and stationary.

Thus, the model has been approaching towards equilibrium within 2050, which signifies that its autoregressive and moving average processes have been converging, which is shown in Figure 3.



Source: Author's own

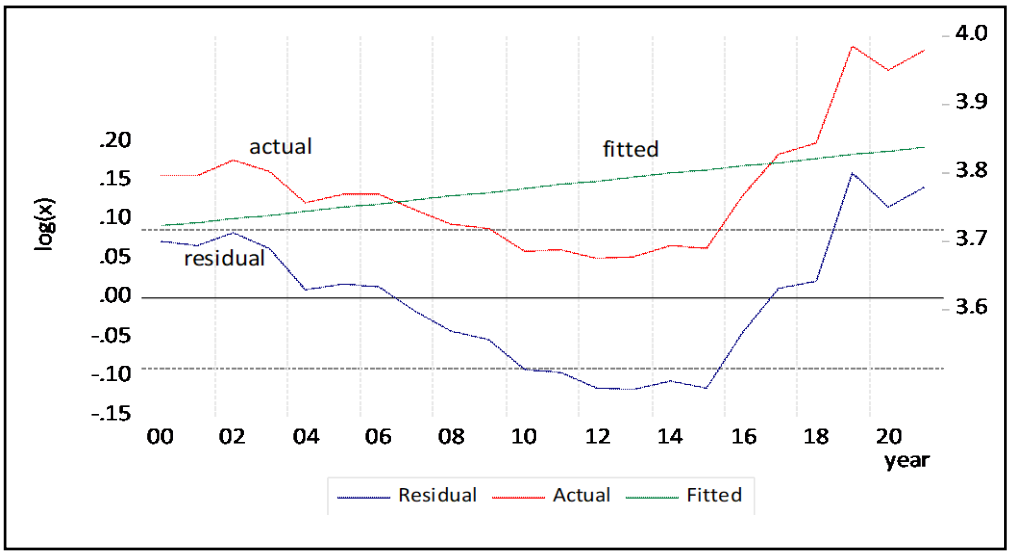
Figure 3: Forecast for z Score

Asset concentration of 5 big banks in India during 2000-2021 has been rising at the rate of 0.549% per year significantly which is shown below.

Log(x)=3.7155+0.00549t+u_i

(95.01)* (1.84)**

Where R^2=0.145, F=3.405**, DW=0.235, n=22, *=significant at 5% level, **=significant at 10% level.



Source: Plotted by author

Figure 4: Fitted Asset Concentration

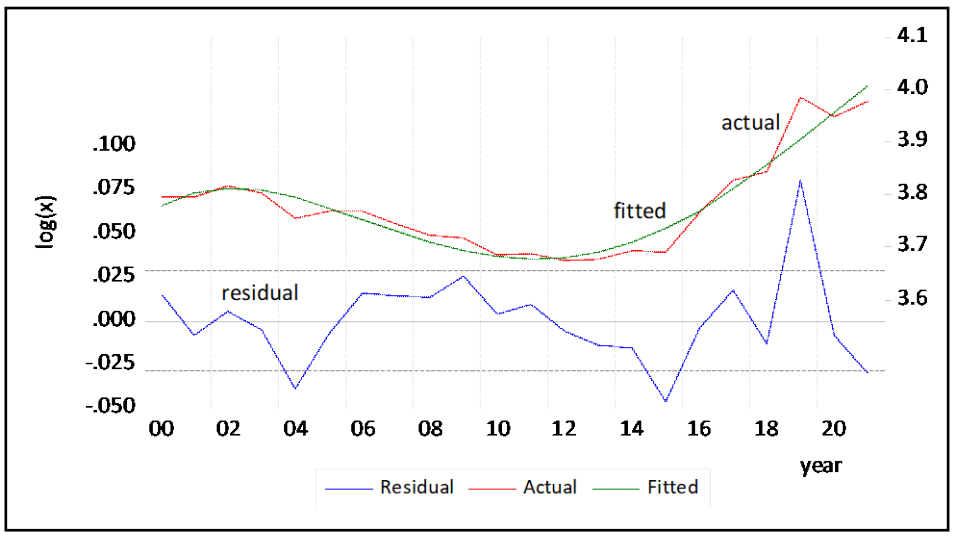
The trend line of asset concentration of banks has four phases in which it is increasing in the first and third phases while it is decreasing in second and fourth phases respectively at 5% significant level.

$$\log(x) = 3.733 + 0.0574t - 0.0127t^2 + 0.00080t^3 - 1.43e^{-05}t^4$$

(91.14)* (2.44)* (-3.15)* (3.07)* (-2.54)*

Where R^2=0.92, F=52.29*, n=22, DW=1.85, *=significant at 5% level.

In Figure 5, the non-linear trend of asset concentration of banks in India is plotted below where it is partially U shaped.



Source: Author's own

Figure 5: Non-linear Trend of Bank Assets

The ARIMA (1,1,1) is estimated for forecasting for the year 2050 which is shown below,

dlog(x)=0.00868-0.4699AR (1) +0.4106MA (1) +0.00173σ^2

(0.64) (-0.043) (0.0379) (2.911)*

R^2=0.0045, F=0.025*, n=21, DW=1.83, AR root=-0.47, MA root=-0.41, AIC=-3.13, Schwartz Criteria (SC)=-2.93.

The increment of bank assets for the long-run process has been converging towards equilibrium because its AR and MA processes are converging since the coefficients of AR and MA are less than one, which implies that the model is stable and stationary since their values of roots are less than unity. Since the t-values of coefficients are not significant, then it did not merge to the equilibrium towards 2050, which is seen in the forecasting model, but with declining volatility, it moves towards zero in a stable way.

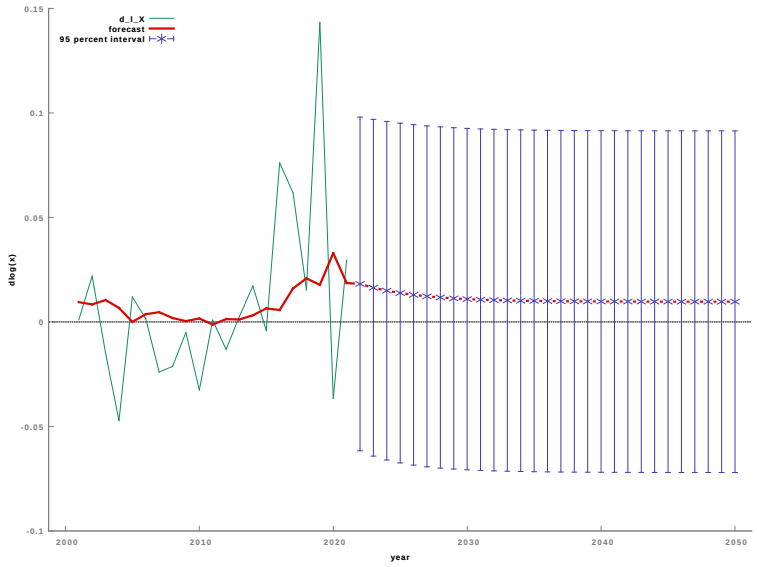


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Figure 6: Bank Assets Forecast for 2050

ARDL Estimate

The level series of z score and asset concentration have unit roots showing ADF values less than the significant level, so that the series are non-stationary. On the other hand, the first difference series of z score and asset concentration have no unit roots and are stationary.

Table 1: Unit Root Test

Variables	ADF(Tabulated) 5% sig. level (-3.69)	Probabilities	Results
x	-1.618	0.7441	Unit root
d(x)	-5.64	0.0010	No unit root
y	-2.010	0.5622	Unit root
d(y)	-5.621	0.0011	No unit root

Source: Calculated by author

The ARDL model is estimated between z score and the asset concentration of 5 big banks of India during 2000-2021 because it is to examine whether there is a correlation between bank mergers, profit motives, and asset concentration both in the short run and in the long run. So that ARDL (4,3) model is chosen from the 50 automatically selected models.

The present value of z score has significant positive and negative relation with its previous periods, while the asset concentration of 5 big banks in the first two years has an insignificant negative relation,

but in the t-4 period, it is positively associated significantly, while in the t-3 period, the positive association is insignificant. If the asset concentration increases by 1% per year, then z score will increase by 1.849% successively 4 years later. The result is highly significant because of high R^2 and significant F and DW. Here Akaike Information Criterion is minimum.

$$\log(y)_t = -5.913 - 0.506\log(y)_{t-1} + 0.425\log(y)_{t-2} + 0.537\log(y)_{t-3} + 0.392\log(y)_{t-4} - 0.1147\log(x)_t$$

(-4.99)* (-2.39)* (2.75)* ((2.54)* (2.85)* (-0.57)

$$-0.233\log(x)_{t-1} + 0.212\log(x)_{t-2} + 1.849\log(x)_{t-3}$$

(-0.81) (0.84) (4.25)*

Where R^2 =0.935, F=16.21, DW=2.75*, AIC=-3.96, n=18, *= 5% significant level, ARDL (4,3), x= asset concentration of 5 big banks, y=z score, t values are in first brackets.

NARDL Estimate

Automatically selected NARDL model [ARDL (3,3,3)] during 2004-2021 (adjusted) among 100 evaluated models in India is estimated below.

$$y_t = 7.989 - 0.5163y_{t-1} + 0.363y_{t-2} + 0.6148y_{t-3} - 0.0158x_t^+$$

(1.21) (-1.61) (1.07) (1.72) (-0.09)

$$-0.1168x_{t-1}^+ - 0.0054x_{t-3}^+ - 0.725x_t^- + 0.0733x_{t-1}^- + 0.0845x_{t-2}^- + 0.635x_{t-3}^-$$

(-0.637) (-0.033) (-1.54) (0.19) (0.19) (1.42)

Where R^2=0.928, F=7.13*, AIC=2.08, SC=2.67, DW=2.16, n=18, Max lag=4, y=z score of banks, x=asset concentration of 5 largest big banks in India, *=significant at 5% level. t values shown in the first brackets, and loglikelihood =-6.72.

The estimated NARDL model states that z score is negatively related to its previous two years and positively related to the previous three years, but all are insignificant. It is negatively related to the positive changes of asset concentration of all four lags insignificantly, while it is positively associated with negative changes of asset concentration of all lags except at the level that is negatively related, but all relations are insignificant, although its R^2 is highly significant with minimum AIC.

The Bounds test revealed that F=4.138, which is greater than the values of I(0) and I(1) at 10% and 5% significant levels except for I(1) at the 5% level. The values are shown in Table 2.

Table 2: Bounds Test (H0=No level relationship)

Test Statistic	Value	Significant	I(0)	I(1)
F	4.138486	10%	2.915	3.695
k	2	5%	3.538	4.428

Source-Calculated by author

Thus, the estimated error correction model is shown below.

$$d(y)_t = -0.537CE - 0.978d(y)_{t-1} - 0.614d(y)_{t-2} - 0.0158d(x)_t^+$$

(-4.98)* (-5.17)* (-2.50)* (-0.17)

$$-0.686d(x)_{t-1}^+ - 0.691d(x)_{t-2}^+ - 0.725d(x)_t^- - 0.719d(x)_{t-1}^- - 0.635d(x)_{t-2}^-$$

(-4.37)* (-3.85)* (-3.68)* (-3.17)* (-2.49)*

Where R^2=0.865, loglikelihood=-6.72, AIC=1.74, SC=2.19, DW=2.16, n=18, *=significant at 5% level.

The estimated error correction signifies that the positive and negative responses of asset concentration on the increment of bank's z score are negative in all the lags which are significant at 5% level (except

for $d(x)_t^+$). Even, increment of z score is negatively associated with its previous two years significantly. The t value of the coefficient of y_{t-1} in cointegrating equation is negative and significant which implies that it is convergent.

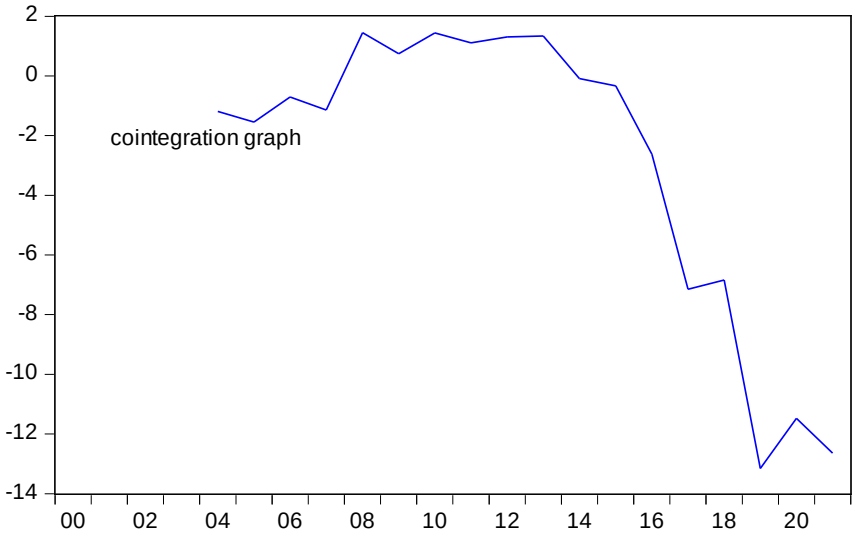
The cointegrating equation is given below.

$$CE = -0.537y_{t-1} - (1.0293x_t^+ + 0.1251x_t^- + 14.8587)$$

(-4.98)* (1.02) (0.127) (4.16)*

The cointegrating equation has been converging towards equilibrium at the speed of adjustment of 53.7% per annum significantly. The relation between z score and asset concentration is positive during both positive and negative changes, which are insignificant at 5% level, for which the cointegrating equation tends to the equilibrium, and finally it departed away. It is prepared in Figure 7.

Figure 7: Cointegrating Equation



Source: Plotted by author

The model did not face any serial correlation problem since F statistic and nR^2 statistic are greater than 5% level of probabilities of Chi-square (2) which is given in Table 3.

Table 3: Serial Correlation Test

Statistic	**Value**		**Probability**
F-statistic	0.664456	Prob. F (2,4)	0.5634
nR^2	4.488798	Prob. Chi-Square (2)	0.1060

Source-Author's calculation

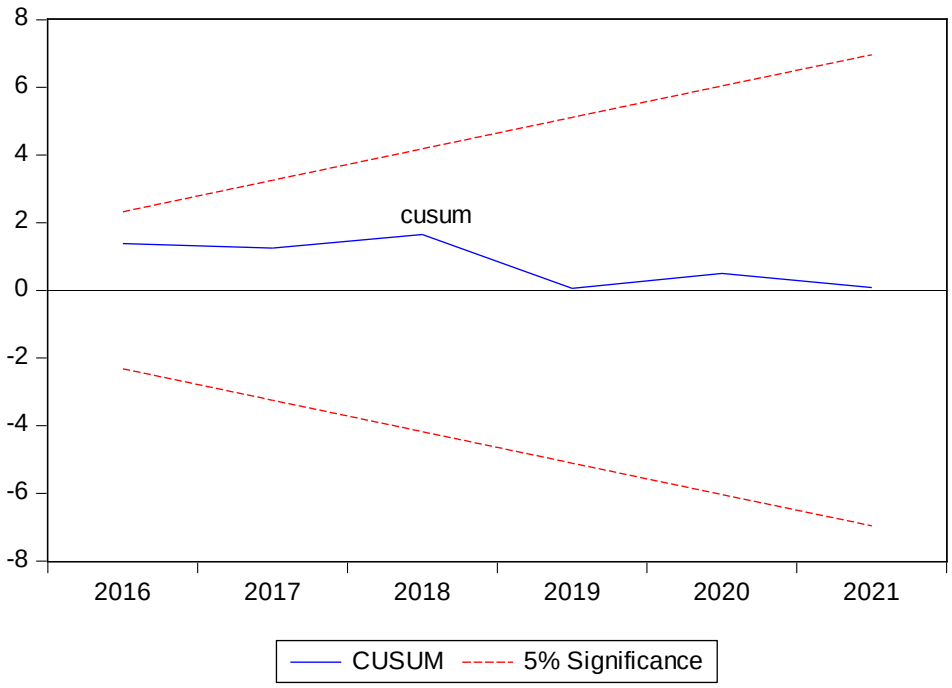
The model has no heteroscedasticity problem since F statistic, nR^2 statistic and scaled explained SS statistic are greater than 5% probabilities of Chi-square statistic. It is given in the Table 4.

Table 4: Breusch-Pagan-Godfrey Heteroskedasticity Test

F-statistic	1.039792	Prob. F(11,6)	0.5075
nR^2	11.80653	Prob. Chi-Square (11)	0.3784
Scaled explained SS	0.774008	Prob. Chi-Square (11)	1.0000

Source-Calculated by author

The model is stable since the Cumulative Sum line passes through ±5% significant levels which is diagrammed in Figure 8 below.



Source: Plotted by author

Figure 8: Stability

The distribution of residuals is normal because the Jarque Bera=0.861 whose probability is 0.649 which is accepted.

The impact of cumulative dynamic multiplier of positive response of asset concentration on the z score moves above from the equilibrium line, while impact of cumulative dynamic multiplier of negative response of asset concentration on the z score moves below the equilibrium line, and the asymmetry moves below positive response but above equilibrium line, all of which are passing through ±5% confidence interval limits. It is presented in Figure 9.

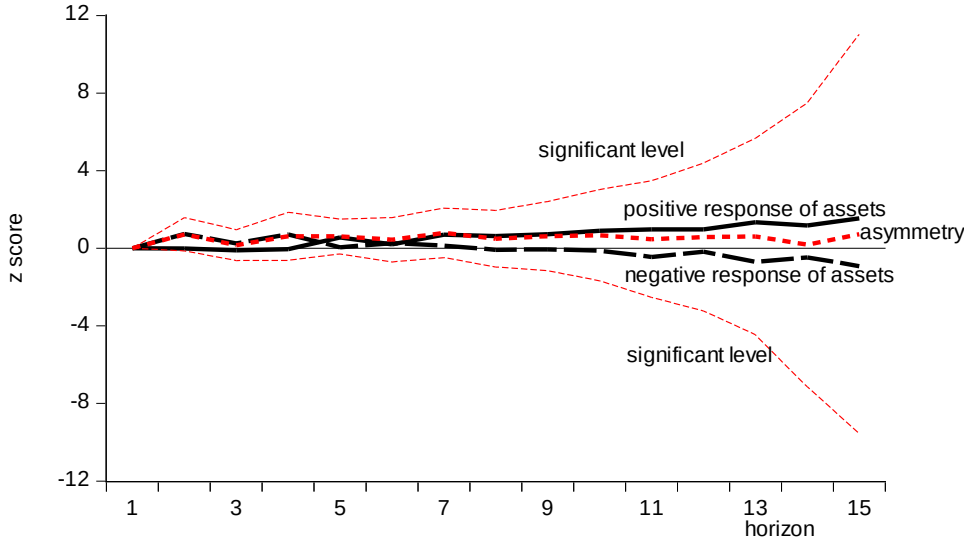


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Figure 9: Cumulative Dynamic Multipliers

Asymmetry Effects

The asymmetric impact of asset concentration on the z score in India during 2000-2021 has been estimated, which is given below. It states that in the long run, the positive and negative changes of

cumulative dynamic multipliers of asset concentration at lag one have positive associations with incremental z score where the former is significant and the latter is insignificant. In the short run, both positive and negative responses of the incremental cumulative dynamic multipliers of asset concentration on the incremental z score are negative, where positive responses in (t-1) and (t-2) are significant and others are insignificant. In the long run, the incremental z-score is insignificantly negatively related to its previous period, while in the long run, it is significantly negatively related to its previous two years. The estimated equation is shown below.

$$dlog(y) = 1.8203 - 0.673\log(y)_{t-1} + 1.386\,\mathrm{cdmlog}(x)^{+}_{t-1} + 0.058cdmlog(x)^{-}_{t-1}$$

(1.85) (-1.73) (2.92)* (0.062)

$$-0.889dlog(y)_{t-1} - 0.567dlog(y)_{t-2} - 0.0427d(cdmlog(x)^{+}_{t} - 1.9007d(cdmlog(x)^{-}_{t}$$

(-2.48)* (-1.937)** (-0.103) (1.719)

$$-1.726d(cdmlog(x)^{+}_{t-1} - 2.015d(cdmlog(x)^{-}_{t-1} - 1.774d(cdmlog(x)^{+}_{t-2}$$

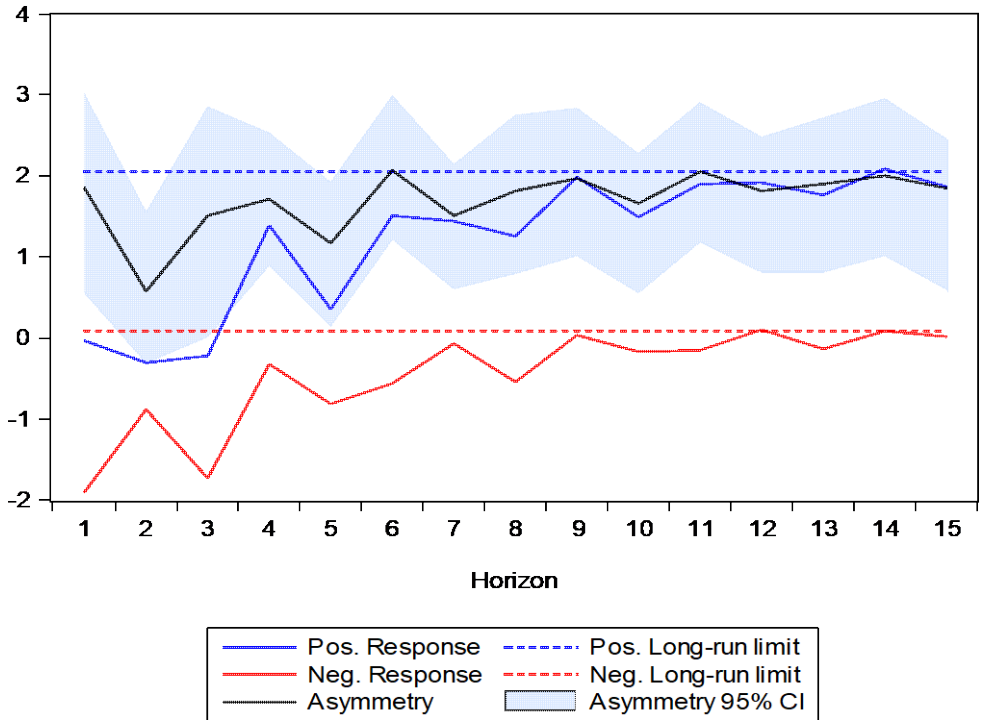
(-2.01)** (-1.78) (-2.00)**

$$-1.685d(cdmlog(x)^{-}_{t-2}$$

(-1.56)

Where R^2=0.879, F=3.99*, AIC=-3.59, DW=2.28*, n=18, loglikelihood=44.363, *= significant at 5% level **= significant at 10% level, maximum 4 lags, ARDL(3,3), 2004-2021(adjusted).

In Figure 10, the positive response from cumulative dynamic multiplier on z score is upward rising with volatility away from equilibrium and converges towards a positive long-run limit. The asymmetry line is identical with it but moving above it. The negative response from the cumulative dynamic multiplier on z score has been converging towards negative long-run limit, which is very close to the equilibrium line. But it is moving outside the confidence interval while positive response and asymmetry converge within the confidence interval.



Source: Plotted by author

Figure 10: Asymmetry

Policy Implications

In ARDL model, negative effect of asset concentration on z score is insignificant, while in NARDL, both positive and negative changes of asset concentration affected z negatively, but they are insignificant. In asymmetry, all positive and negative changes of cumulative dynamic multiplier of asset concentration have negative impacts in which positive changes are only significant. Therefore, M&A of banks produces inverse implications in India on financial health of banks through changes in asset concentration. On the other hand, the policy could not reduce NPA and increase profit of banks significantly.

Discussion

There is no relevant recent research paper that explained the asymmetric impact of z score and asset concentration through the NARDL model on Indian banks. However, there are other studies that analyzed the consequences of z score of Indian banks in different periods. Most of the findings of the papers assured the non-possibility of banking failure or crisis.

Considering CMIE and RBI data for SBI, PNB and Oriental Bank of Commerce from 2008 to 2020, the z scores through Back Propogation Neutral Network prediction model assured that there is no possibility of bankruptcy. The z score of SBI varies from 0.4% to 5.1% and its trend varied from 0.1% to 3% while PNB's score showed 0.2% to 3% with trend from 0.2% to 3% and the score of OBC varied from 0.1% to 4.6% and the trend varied from 0.2% to 3.1% (Pradhan, 2014). The Altman's z score of 21 private banks and top 5 private banks of India during 2018-2022 verified that they are safe from forthcoming bank failure and baking crisis (Azam *et al*., 2023). Asset concentration of top 5 banks has negative relation with their Z score in India during 1998-2022, where 1% increase in asset concentration decreases z score by 5.85% per year significantly (Zeeshan & Singh, 2025). The Z score of Nainital Bank was obtained as 4.82 in 2013, which declined to 4.39 in 2014 and increased to 4.95 in 2015 followed by a decline to 4.61 in 2016 and an increase to 5.04 in 2017. Thus, it is expected that the growth in advances will change the ratings because the investment pattern and profits will change. But there is no chance of bank failure (Chandra *et al*., 2019). The study of Public Sector Banks in India during 2020-2024 in their z score revealed that they are financially stable, safe, and have no sign of banking crisis (Reddy *et al*., 2025). Even, the Altman z score of Bangladesh Development Bank during 2010-2018 fell into grey zone, where the average of six banks showed 1.52 score and z score of the remaining banks was found to be less than 1.10 which is in distress zone. It may cause banking crisis (Debnath *et al*., 2020).

The findings of the present model revealed that the trends of z score Indian banks have no sign of bankruptcy and the relation between asset concentration and z score assured that there is no forthcoming banking crisis in India, however, the relation clearly showed a signal of asymmetric impact.

Limitations

The model requires more long-run data than it had so that good results may emerge. Indian bank's z score is also dependent on profits of banks, credit/deposit ratio, employment of the banks, and share price index of non-performing assets of banks, respectively. Therefore, the inclusion of such variables will produce valuable observations. Moreover, the process of bank privatization can be included as a control variable. There is huge scope for future research in this theme.

Conclusion

The paper concludes that z score of Indian banks is linearly upward, but actually it is non-linear with four phases showing as inverse s shaped during 2000-2021. ARIMA (1,0,1) model of z score for 2050 has been converging significantly. On the other hand, asset concentration of five largest banks in India during 2000-2021 is linearly upward, but it is non-linear with four phases showing nearly U shape. ARIMA (1,1,1) model of asset concentration for 2050 is stationary and convergent. The estimated ARDL model stated that z score is both positively and negatively related in different lags, but it is positively related with asset concentration at lag four significantly. The estimated NARDL model indicated that

positive changes of asset concentration are negatively related with z score while negative changes are positively associated, but all are insignificant. Although, in error correction model, all positive and negative changes of asset concentration are negatively related with z score significantly. The cointegration equation has been approaching towards equilibrium, where positive and negative changes of asset concentration are positively related with the insignificant z-score. The model has no serial correlation and heteroscedasticity problems and is shown to be stable. The asymmetry line and positive response of the cumulative dynamic multiplier of asset concentration on z score are moving upward above the equilibrium line towards positive long-run limit, while the negative response of cumulative dynamic multiplier of asset concentration on z score converged to the negative long-run limit successfully. There is no signal of bankruptcy or banking crisis.

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Conflict of interests

There is no conflict of interests in publication of this paper.

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