

Application of BPNN in the analysis of SBI's Credit Capacity

Roli Pradhan, KK Pathak, VP Singh

Abstract— During the existing business scenario much need exists for a system that can predict the failure of any firm with accuracy much before the bankruptcy actually occurs. Credit decisions by commercial banks are based to a large extent on the financial statements provided by corporate borrowers as monitored using financial ratios suggesting their financial position. This paper uses the tailored back-propagation neural network endeavors to predict the financial ratios expressing the position of a firm to regulate the bankruptcy and assess the credit risks. It first estimates the financial ratio for a firm from 2001-2008 to the train the BPNN and uses the estimates of the year 2009 and 2010 values for the validation process. Finally it dwells to draw predictions for the period 2011-2015 and emphasizes the growing role of BPNN application based prediction models for banking sector with a case study of State Bank of India. We conclude with practical suggestions on how best to integrate models and research into policy making decisions. Along with establishing the ratios, analysis regarding the bankruptcy status of the firm is also analysed. The basic Z Score value of the firm from 2001-2008 has been used to predict the Z Score values upto 2015.

Index Terms—Neural Networks, Credit lending, Credit Capacity, BPNN

I. INTRODUCTION

Credit analysis is a key component of modern finance. Throughout the years many techniques have been developed to assess credit risks. These include credit scoring models often built around the 5Cs of credit (character, capacity, collateral, conditions and capital) and quantitative models pioneered by Beaver and Altman that focus on a borrower's probability of default (or inability to meet credit obligations). Economists see two aspects in the economic crisis, once creditors panic and begin to pull out their holdings; the underlying health of banks — or entire countries — no longer matters a great deal. In a global financial system, national borders are porous. Moving further the year 2008, one of the worst years in the world's economic history, experienced a major global meltdown. This global meltdown led to job lay-offs all across the world. These recent global economic crisis have been devastative due to the absence of effective early warning systems. The need of an effective failure prediction model to act as an alarm for the corporate is the basic need of any economic system. The model has to be robust over time. The prediction

of the financial ratios would convey the position of the firm to regulate the bankruptcy. The stability of the banking sector is of major importance for economic outcomes. Banks form the backbone of modern economies and instability in the banking sector can pose problems to the economic system as a whole. Credit losses, or more generally, asset quality problems, have repeatedly been identified as a key trigger of bank failures, e.g. Graham and Horner (1988), Caprio and Klingebiel (1996). Accordingly, much research effort has gone into developing methods for assessing credit risk both at a systemic and bank-specific level. Two major components determine the extent of a credit loss suffered: first, the probability of a default (PD) and, second, the loss given default (LGD), which equals one minus the recovery rate in the event of default. Most credit risk literature has focussed on estimating PD.

The paper studies the application of neural network in forecasting financial ratios. The financial ratios have been divided into pillars. The paper is an attempt to forecast the ratios so as to communicate the financial position of the firm by forecasting the financial ratios upto 2015. Thus the aspects of lending can be evaluated and re-established. Neural network has been used for the forecasting of financial ratios. The financial position of the banks when they go out to obtain credit can be computed. The forecasted position can also benefit in planning the repayment period and also assists to plan the terms of credit. The bankruptcy analysis using Z Score method has been analysed in this paper.

As portrayed by Altman and Narayan 1998 several flaws existed in this traditional system of credit analysis. It is non-suitable for reasons like it is very expensive to maintain and has significant redundancies. These lead to incorporation of experts for maintenance of assets and liabilities of any bank. At all times any bank must have enough experts to handle its business Volume and should resort to techniques to train more people to render as experts in the long run. Furthermore classic credit analysis has often forced banks into a false sense of security. Failing to protect them against many of the systematic risks embedded in their area of business. Times have suggested that the traditional credit management schemes have led to disappointing results since banks have done a relatively poor job of pricing and managing credit risk. Today the environment of credit has altered and so have the terms of lending too. Credit lending has undergone a transformation over the past two decades due to introduction of credit scoring models. However, the process of granting commercial credit has also changed but the rate is much slower.

II. BRIEF LITERATURE REVIEW

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Credit risk is probability that a borrower will fail to make required payments of principle and interest over the life of the loan. Risk plays an important role in the lending arena. At loan inception, the lender estimates the expected credit risk that the borrower presents over the life of the loan. Absent provisions to control the increase in credit risk, the lender prices the expected outcome in the interest rate of the loan. Both lender and borrower suffer when the expected credit risk of borrower is high, the lender with increased risk over the life of the loan and the borrower with a high interest rate. These suggest that both the parties involved in credit lending benefit when provisions are included in contrast to control increase in credit risk. Bankruptcy is the condition in which a business cannot meet its debt obligations petitions a federal district court for either. This paper examines an alternative approach using neural network to forecast financial ratios so as to relate to prediction of bankruptcy before it actually occurs.

Academic studies seeking to predict corporate bankruptcies have a long history. An early study was based on a univariate analysis approach (Beaver 1966). Multivariate analysis techniques used in subsequent studies include discriminant analysis (Altman 1968), logit and probit regressions (Ohlson 1980, Zmijewski 1984) and hazard analysis (Shumway 2001). The exact variables used in these studies vary and include both accounting-based and market-based variables, but all of these studies have proposed reduced form models which are able to predict corporate bankruptcies with a fair degree of accuracy. Shumway (2001) compares the forecasting accuracy of a hazard model using a set of five variables, comprising two accounting-based and three market-based variables, to Altman's (1968) and Zmijewski's (1984) specifications which used mainly accounting-based variables, and concludes that the hazard model with accounting and market-based variables is the most accurate. In an examination of secular changes in the ability of accounting variables to predict bankruptcy, Beaver et al. (2005) find a slight decline in the predictive ability of financial ratios based on accounting variables over the period 1962 to 2002, with a corresponding improvement in the incremental predictive ability of market-based variables. Structural models of default, based on Merton (1974) and commercialized by firms like Moody's KMV (Crosbie and Bohn 2001), have also been studied (e.g., Vassalou and Xing 2004; Hillegeist et al. 2004). Although Hillegeist et al. (2004) find that these structural models outperform purely accounting-based, reduced form models, Campbell et al. (2008) find that information from structural models does not add any additional explanatory power to reduced form models utilizing both accounting and market information. Bharath and Shumway (2008) show that the functional form suggested by the Merton model is useful for predicting defaults, though it does not serve as a sufficient statistic for the probability of default.

III. MODEL DESIGN AND METHODOLOGY

In this paper, a two step methodology has been adopted. The step 1 provides the steps formulated for the prediction of financial ratio pillars, followed by step 2 enlists the steps followed for the Z Score for bankruptcy predictions.

The basic ratios are formulated from details mentioned in published statements like balance sheet, cash flow statements, yearly details of banks, profit and loss statements obtained

from CMIE database, Reserve Bank of India. Data is also taken from the official websites of the banks and financial institutions and the internet. Prior researchers have identified financial ratio for bankruptcy prediction and the usefulness of these financial ratios for bankruptcy prediction can be known from the literature survey. Consequently this research work uses financial data i.e. published time series data for the last 11 years from 2000 to 2009. In the step 1 this research tries to present a holistic view by incorporating all various ratios and then relating them to examine the explanatory capabilities of the financial ratios to suggest the position of the bank. Construction of the basic ratios into ratio pillars is a vital ingredient of the basic work done prior to deployment of neural network.

Step 1: Estimating the input ratios

Part A: Eight ratio pillars have been constructed for the needful.

1. Investment Valuation Ratio Pillar.
2. Profitability Ratio Pillar.
3. Management Efficiency Ratio Pillar.
4. Profit & Loss Ratio Pillar.
5. Debt Coverage Ratio Pillar.
6. Cash Flow Indicator Ratio Pillar.
7. Leverage Ratio. Ratio Pillar.
8. Overall Performance Ratio Pillar.

Part B: Prediction of Financial Ratios using ANN Model

1. Catering to Neural Network inputs
2. Tolerance level Minimization
3. Data convergence using Neural Networks
4. Formulation of Absolute error
5. Prediction of ratios in each Ratios pillar
6. Data Validation

Step 2: Z Score for bankruptcy prediction.

Part A: Formulation of Internal Parameters of Z Score

The basic ratios are formulated from details mentioned in published statements like balance sheet, cash flow statements, yearly details of banks, profit and loss statements obtained from CMIE database, Reserve Bank of India. Data is also taken from the official websites of the banks and financial institutions and the internet. Consequently this research work uses financial data i.e. published time series data for the last 11 years from 2000 to 2009.

1. (Current Assets-Current Liabilities)/Total Assets
2. Retained Earnings/ Total Assets.
3. EBIT/ Total Assets
4. Equity/Total Liabilities

Part B: Prediction of Z Score Internal Parameters using BPNN

1. Catering to Neural Network inputs
2. Tolerance level Minimization
3. Data convergence using Neural Networks
4. Formulation of Absolute error
5. Prediction of ratios in each Ratios pillar
6. Data Validation

IV. BPNN MODEL APPLICATION – CASE OF SBI

Step 1: Formulation of Basic Ratio Pillars: The basic input sheets for all the eight pillars are formulated for SBI. The process of ratio pillar formulation uses the book formulae for computation of the ratios in each pillar, which will further be used as input parameters for Artificial Neural Network. The details of the ratios and the values are enlisted in the table 1.

Step 2: Computation of internal parameters of Z Score:

The basic input sheets for all the internal parameters are formulated for State bank of India. The process of input ratio formulation uses the book formulae for computation of the ratios, which will further be used as input parameters for Artificial Neural Network. The Altman Z-Score prediction uses the Neural Network (1, 5, 4). The number of input rows are 1. The hidden layers are 5 and the outcomes are 4 internal parameters. The input point is time and output has been the required ratios. The period for input has been from 2000-2006 which has been normalized from 1 to 8. The details of the ratios and the values are enlisted in the table 2.

V. BPNN MODELING ANALYSIS, RESULTS AND OUTCOMES

After the computation of the basic ratio pillars, as suggested by Table 1, this section uses the ratios in each pillar as inputs to train the network. The network after training computes the values of the ratios from 2009 upto the year 2015 at different tolerance level. The validation is done by the values obtained for the year 2009 and 2010. The tolerance level that provides the closest values is considered for prediction. The Table 2 provides details of the convergence study done for all the pillars for the bank in the study. Table 3 provides details of the percentage error at the adopted level of tolerance.

After the computation of the basic ratio pillars, as suggested by Table 2, this section uses the ratios as inputs to train the network. The network after training computes the values of the ratios from 2008 upto the year 2015 at different tolerance level. The validation is done by the values obtained for the year 2008 to 2010. The tolerance level that provides the closest values is considered for prediction. A 1-6-5 size backpropagation neural network is used for prediction of the Z-Score internal parameters. The internal parameters are then used in the formula to find the Z-Score value for the banks upto the year 2015. Table 4 provides details of the percentage error at the adopted level of tolerance.

VI. ANALYSIS & FINDINGS

The Investment Valuation Ratio Pillar it has been observed that the Dividend per Share moves in the range from 5% to 34% and the similar swing of 2% to 33% has been predicted by the neural network. The ratio Operating Profit Per Share (Rs) shows a movement of 1% to 33% as suggested by the network also being 0.4% to 25%. The ratio Net Operating Profit Per Share (Rs), shows a movement of 0.1% to 26% as suggested by the network also being 0.4% to 20%. For Earnings Per Share shows a movement from 0.5% to 23% is observed and the network shows a similar fashion being approximately 0.4% to 16%. For Book Value shows a movement from 2% to 23% is observed and the network shows a similar fashion being approximately 0.2% to 20%.

For Net Operating income per share shows a movement from 0.2% to 30% is observed and the network shows a similar fashion being approximately 0.3% to 22%.

In the Profitability ratio pillar the Adjusted Cash Margin (%), moves in the range from 7% to 32% and the similar swing of 5% to 18% has been predicted by the neural network. The ratio Net Profit Margin shows a movement of 5% to 16% as suggested by the network also being 0.5% to 15%.

In the Profit and Loss Ratio pillar it has been observed that the Interest Expended / Interest Earned moves in the range from 5% to 7% and the similar swing of 1% to 9% has been predicted by the neural network. The ratio Operating Expense / Total Income shows a movement of 0.3% to 10% as suggested by the network also being 3% to 7%. For Selling Distribution Cost Composition shows a movement from 3.7% to 10% is observed and the network shows a similar fashion being approximately 2% to 14%. For Quick Ratio shows a movement from 5% to 17% is observed and the network shows a similar fashion being approximately 0.5% to 14%.

In the leverage ratio pillar it has been observed that the Net Financial Leverage moves in the range from 2% to 20% and the same movement of ratios has been predicted by the neural network of 0.5% to 17%. For the Interest Coverage the ratios oscillate in the range from 0.8% to 5% and the network suggests a similar trend. For the Long term debt to assets ratio shows a movement from 3% to 22% is observed and the network moved a similar pattern of 1% to 22%. For Debt –Equity Ratio shows a movement from 7% to 31% is observed and the network moved a similar pattern from 1% to 33%. For Owner's fund as % of Total Source shows a movement from 4% to 30% is observed and the network moved a similar pattern. For Total debt to assets ratio shows a movement from 0.1% to 0.1% is observed and the network moved a same pattern. For Long term debt to assets ratio shows a movement from 0% to 2% is observed and the network moved a similar pattern.

In the Debt Leverage Ratio it has been observed that Credit Deposit Ratio shows a movement of 3% to 5% as suggested by the network also being 1% to 5%. For Investment Deposit Ratio shows a movement from 4% to 15% is observed and the network shows a similar fashion being approximately 2% to 12%. For Cash Deposit Ratio shows a movement from 2% to 45% is observed and the network shows a similar fashion being approximately 4% to 40%. For Total Debt to Owners Fund shows a movement from 1.2% to 21% is observed and the network shows a similar fashion being approximately 0.8% to 16%.

In the Cashflow ratio pillar it has been observed that the Dividend Payout Ratio Net Profit show a range of 1% to 11% a similar kind of error in the range of 1% to 19% is predicted by the network. The Dividend Payout Ratio cash Profit moves in the range from 2% to 17% and the similar swing of 2% to 12% has been predicted by the neural network. The ratio Earning Retention Ratio shows a movement of 0.1% to 8% as suggested by the network also being 1% to 7%. The ratio cash Earning Retention Ratio shows a movement of 0.62% to 5% a similar trend of 1% to 9% is projected by the network. For Adjusted Cash Flow Times shows a movement from 0.14% to 12% is observed and the network shows a similar fashion being approximately 0.1% to 14%.

In the Managerial Efficiency ratio pillar it has been observed that the Interest Income / Total Funds show a range of 0.6% to 6%, similar kind of error in the range of

0.2% to 10% is predicted by the network. The Interest Expended / Total Funds moves in the range from 0.6% to 12% and the similar swing of 12% to 20% has been predicted by the neural network. The ratio Operating Expense / Total Funds shows a movement of 0.04% to 9% as suggested by the network also being 0.001% to 0.8%. The ratio Profit before Provisions / Total Funds shows a movement of 0.5% to 12% a similar trend of 0.1% to 13% is projected by the network. For Net Profit / Total Funds, shows a movement from 1% to 20% are observed and the network shows a similar fashion being approximately 0.3% to 26%. The Loans turnover ratio being shows a movement from 0.6% to 6% is observed and the network shows a similar fashion being approximately 0.2% to 6.6%. The ratio being Total Income / Capital Employed (%) shows a movement from 0.3% to 5% is observed and the network shows a similar fashion being approximately 0.1% to 5%. The Interest Expended / Capital Employed (%), shows a movement from 0.6% to 12% is observed and the network shows a similar fashion being approximately 0.2% to 12%. The Asset Turnover Ratio shows a movement from 5% to 18% is observed and the network shows a similar fashion being approximately 0.7% to 17%.

The study suggests that SBI has been continuously improving its operating efficiency with the cost-to-average assets ratio declining from 2.46% in FY06 to 2.23% in FY07. It is also raising its thrust on non-interest income, which formed nearly 30% of total income in FY07. Currently, India's loan-to-GDP ratio is still low at 41% compared to other emerging economies. This provides enormous scope for the Indian financial services sector. SBI has finally begun

A 1-6-5 size backpropagation neural network is used for prediction of the Z-Score internal parameters. The internal parameters are then used in the formula to find the Z-Score value for the banks upto the year 2015. Table 6 provides details of the percentage error at the adopted level of tolerance.

The values have then been substitutes in the Z-Score formula for market credits to compute the Z-Score values from 2008 to 2015. The market has witnessed several ups and downs during the period 2005 and 2010 and the modeled BPNN has been able to closely predict the Z-Score values from 2005 to 2010. The trained BPNN has been able to forecast the Z-Score values in approximation to the actual values suggesting that the BPNN has the ability to forecast the Z-Score parameters financial ratios. The predicted values of Z Score are depicted in Table 7.

The Z Score values reveal that it is safe to lend to SBI as the values lie in the safe zone. The bank can get credit at relaxed norms. Even the period of repayment can be long. For SBI bank the movement of Z-Score has been from 0.4% to 5.1%. The trend exhibited by the predicted value is from 0.1% to 3%. (Figure No: 1)

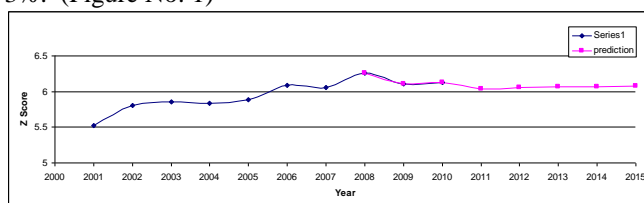


Figure No: 1: Z-Score SBI Bank

VII. CONCLUSION

In times of economic distress the model would provide assistance to finding the financial viability of the firm. As the ratio pillars incorporate all the terms to be included while assessment of the firm's financial position there are less chances of being misguided in the terms of credit lending. This model would act as an early warning system for the corporate as has long been desired. The tailored back-propagation neural network endeavors to predict the financial ratios expressing the position of a firm to regulate the bankruptcy and assess the credit viability when a bank requires credit and can also be utilized to plan the periods of recovery of the lent amount. The analysis also suggested the forecast of the financial position of the firm in case of loan value enhancement as well as the extension of the repayment period. This also renders to be effective in the designing of policies related to credit viability thus proves to be a vital tool to regulate the occurrence of credit defaults. This paper provides an alternative method for gaining insights into the dynamics of recovery rates for distressed bank lending over longer periods of time, i.e. through economic cycles. Since the late 1980s, banks of most developed countries have reported on the level of loans and other assets considered impaired from a credit risk perspective. Moreover, banks not only report the gross book value of these assets but typically also their expected realizable value thus providing a point in time estimate of overall recovery rates of their total distressed asset portfolio. These values can be interpreted as a proxy for expected recoveries by bank management just as the distressed price based methods represent market expected recovery values of corporate bonds. The main benefit of the method is that recovery estimates are for a representative composition of bank distressed credit exposures rather than the specific bond portfolios of the traditional bond LGD literature. It also enables analysis over longer periods and mirrors outcomes for the whole system, not just a single bank.

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Table1: Ratios used as Inputs for the Neural Network.

Ratio Pillar	Tolerance	Ratios	2000	2001	2002	2003	2004	2005	2006	2007	2008
Investment Valuation	0.1	Dividend Per Share	1	1	1	1	2	3	6	10	10
		Operating Profit Per Share (Rs)	2.564	3.654	4.879	5.576	27.289	69.32	57	74.53	109.81
		Net Operating Profit Per Share (Rs)	30.23	39.62	45.56	53.232	150.04	308.0	310.5	383.89	505.09
		Free Reserves Per Share (Rs)	68.82	68.296	67.764	67.232	66.7	63.79	69.61	64.29	63.79
		Earnings Per Share	17.06	19.484	20.234	15.29	17.65	18.14	22.67	31.808	44.85
		Book Value	10.40	18.053	26.5	31.74	41.79	44.72	45.65	48.84	64.98
		Net Operating Income per share	88.85	109.45	135.6	139.59	176.81	248.9	287.7	321.65	341.98
Profit & Loss	0.1	Interest Expended / Interest Earned	33.89	37.084	40.269	43.454	46.639	52.64	51.31	52.2	61.2
		Other Income / Total Income	5.226	4.804	4.382	3.96	3.538	4.62	1.33	1.52	1.43
		Operating Expense / Total Income	44.89	42.368	39.846	37.324	34.802	30.19	31	30.36	23.1
		Selling Distribution Cost Composition	0.274	0.258	0.242	0.226	0.21	0.19	0.2	0.14	0.14
		Current Ratio	0.047	0.044	0.041	0.038	0.035	0.03	0.03	0.03	0.02
		Quick Ratio	5.009	5.634	6.259	6.884	7.509	5.98	10.69	11.1	9.4
Profitability	0.1	Interest Spread	3.192	3.318	3.444	3.57	3.696	3.67	3.94	4.4	4.18
		Adjusted Cash Margin (%)	18.17	17.708	17.237	16.76	16.29	15.64	16.35	14.1	13.72
		Net Profit Margin	14.84	14.65	14.452	14.25	14.05	13.84	14.5	12.53	12.68
		Return on Long Term Fund (%)	1.309	14.77	28.231	41.692	55.153	81	74.57	80.76	111.52
		Return on Net Worth (%)	16.77	17.18	17.585	17.99	18.39	22.49	17.01	16.03	19
		Adjusted Return on Net Worth (%)	8.306	9.732	11.158	12.584	14.01	17.95	15.83	15.17	18.99
		Gross Profit Ratio	0.75	0.769	0.741	0.762	0.752	0.725	0.71	10.796	10.60
Leverage	0.1	Financial Leverage	7.658	6.723	4.685	3.348	3.337	3.417	3.777	3.649	3.57
		Net financial leverage	107.4	109.17	97.247	82.47	70.78	49.20	45.26	46.859	54.63
		Operating Leverage	0.000	0.0001	0.0001	0.0001	0.0001	0.000	0.000	0.0000	0.0000
			17	5	3			1	09	7	5
		Interest Coverage	1.15	1.175	1.271	1.426	1.428	1.414	1.36	1.378	1.388
		Long Term Debt / Equity	971.0	1194.6	1318.7	1151	1251	1224	1302	1507.2	1868.4
		Debt-Equity ratio	255.0	299.21	343.54	324.9	385.7	400.3	460.7	515.13	631.21
		Owner's fund as % of Total Source	0.844	0.87	0.851	0.918	0.936	0.962	0.968	0.972	0.875
		Total debt to assets ratio	0.889	0.894	0.885	0.887	0.872	0.839	0.87	0.873	0.864
		Long term debt to assets ratio	0.889	0.894	0.885	0.887	0.872	0.839	0.87	0.873	0.864
Debt Coverage	0.1	Credit Deposit Ratio	35.13	39.436	43.741	48.04	52.35	56.33	60.6	65.97	70.55
		Investment Deposit Ratio	67.75	63.406	59.056	54.70	50.35	48.56	41.16	33.23	32.38
		Cash Deposit Ratio	14.77	14.222	13.672	13.12	12.57	8.48	14.74	13.78	9.02
		Total Debt to Owners Fund	8.781	9.57	10.359	11.14	11.93	13.14	13.19	13.79	15.44
		Financial Charges Coverage Ratio	1.669	1.638	1.607	1.576	1.545	1.6	1.39	1.42	1.42
		Financial Charges Coverage Ratio Post Tax	1.482	1.456	1.43	1.404	1.378	1.36	1.33	1.29	1.25
Cash-flow	0.1	Dividend Payout Ratio Net Profit	1.708	4.52	7.332	10.144	12.956	14.01	14.98	30.71	23.4
		Dividend Payout Ratio Cash Profit	0.543	2.306	5.155	8.004	10.853	12.4	13.26	27.26	21.61
		Earning Retention Ratio	98.27	95.464	92.652	89.84	87.02	85.98	84.99	69.28	76.59

Application of BPNN in the analysis of SBI's Credit Capacity

		Cash Earning Retention Ratio	100.5	97.7	94.848	91.996	89.144	87.6	86.72	72.73	78.38
		Adjusted Cash Flow Times	71.85	71.822	71.79	71.75	71.72	64.77	73.73	80.65	75.05
Managerial Efficiency	0.1	Interest Income / Total Funds	5.417	5.854	6.291	6.728	7.165	8.52	7.23	7.88	8.86
		Interest Expended / Total Funds	1.217	1.668	2.119	2.57	3.021	3.91	3.63	3.92	4.86
		Operating Expense / Total Funds	3.193	3.07	2.947	2.824	2.701	2.7	2.27	2.43	2.08
		Profit Before Provisions / Total Funds	1.175	1.272	1.369	1.466	1.563	2.17	1.29	1.53	1.96
		Net Profit / Total Funds	0.888	0.928	0.968	1.008	1.048	1.24	1.06	1	1.14
		Loans Turnover	0.184	0.18	0.176	0.172	0.168	0.18	0.15	0.14	0.15
		Total Income / Capital Employed (%)	5.838	6.244	6.65	7.056	7.462	8.94	7.33	8	8.99
		Interest Expended / Capital Employed (%)	1.217	1.668	2.119	2.57	3.021	3.91	3.63	3.92	4.86
		Asset Turnover Ratio	4.876	4.908	4.94	4.972	5.004	5.28	4.75	5.48	4.35
Overall	0.1	Capital Adequacy Ratio	9.122	9.615	10.108	10.60	11.09	11.58	11.88	12.34	13.47
		Advances / Loans Funds (%)	59.09	61.028	62.958	64.88	66.81	68.74	65.66	76.16	78.31
		Return on invested capital (ROIC)	0.062	0.059	0.051	0.049	0.065	0.057	0.055	0.044	0.031
		Return on Equity (ROE)	0.208	0.242	0.242	0.293	0.299	0.301	0.183	0.17	0.202
		Fixed Assets Ratio	1.366	1.593	1.851	2.062	2.4	3.642	3.386	3.599	3.872
		Capital Turnover Ratio	3.298	3.058	2.862	2.601	2.1	1.804	1.221	1.271	1.407
		Sales /net fixed Assets	7.97	8.616	9.183	9.869	8.793	9.401	9.929	11.199	14.12

Table 2: Training Pattern for SBI Internal Parameters of Z-Score

Input Parameters				
Time	(CA-CL)/Total Assets	Retained Earnings/ Total Assets	EBIT/ Total Assets	Equity/Total Liabilities
2000	0.73659	0.049465	0.077749	0.002013
2001	0.781807	0.046565	0.077392	0.001667
2002	0.791241	0.047891	0.075746	0.001511
2003	0.796349	0.052424	0.064382	0.0014
2004	0.805242	0.057737	0.061314	0.001291
2005	0.837653	0.058967	0.058853	0.001144
2006	0.827194	0.061765	0.062825	0.001066

Table 3: The percentage error and Tolerance Level for the Eight Ratio Pillars:

Ratio Pillar	Tolerance	Ratios	2009			2010		
			Actual	Predicted	%Error	Actual	Predicted	%Error
Investment Valuation	0.10	Dividend Per Share	29.00	27.43	5.40	25.89	25.18	2.74
		Operating Profit Per Share (Rs)	230.04	227.36	1.17	229.51	225.43	1.78
		Net Operating Profit Per Share (Rs)	1179.4	1120.76	4.98	1181.31	1166.64	1.24
		Free Reserves Per Share	373.99	331.75	11.29	362.43	348.60	3.82
		Earnings Per Share	72.90	70.42	3.40	72.51	71.24	1.75
		Book Value	106.56	108.88	-2.18	115.75	116.44	-0.59
		Net Operating Income per share	776.48	768.09	1.08	778.25	764.20	1.81
Profit & Loss	0.10	Interest Expended / Interest Earned	67.28	1.18	22.91	0.33	0.04	5.74
		Other Income / Total Income	69.16	1.56	24.58	0.31	0.06	6.08
		Operating Expense / Total Income	-2.80	-32.22	-7.30	5.17	-42.93	-5.93
		Selling Distribution Cost Composition	69.64	0.59	23.61	0.31	0.05	7.31
		Current Ratio	70.12	1.25	25.38	0.30	0.06	6.97
		Quick Ratio	-0.70	-110.18	-7.49	1.39	-22.44	4.67
Profitability	0.10	Interest Spread	4.34	6.42	-47.84	4.13	7.40	-79.18
		Adjusted Cash Margin (%)	13.04	12.74	2.30	12.38	10.72	13.42
		Net Profit Margin	12.03	10.84	9.88	11.54	10.84	6.11
		Return on Long Term Fund (%)	100.35	96.33	4.01	94.90	96.20	-1.37
		Return on Net Worth (%)	15.74	15.24	3.21	14.32	13.14	8.28
		Adjusted Return on Net Worth (%)	15.74	15.23	3.21	14.33	15.15	-5.70
Leverage	0.10	Gross Profit Ratio	12.85	11.26	12.38	12.91	11.46	11.24
		Interest Income / Total Funds	4.08	3.53	13.65	2.58	3.45	-33.56
		Interest Expended / Total Funds	13.73	14.01	-1.99	12.62	12.53	0.69
		Operating Expense / Total Funds	-0.12	0.00	102.99	0.26	0.00	98.64
		Profit Before Provisions / Total Funds	1.33	1.34	-1.10	1.47	1.42	2.85

		Net Profit / Total Funds	1253.4	1159.42	7.50	1171.12	1174.23	-0.27
		Loans Turnover	1519.0	1513.05	0.40	1407.96	1450.86	-3.05
		Total Income / Capital Employed (%)	91.27	89.26	2.21	87.46	88.22	-0.87
		Interest Expended / Capital Employed (%)	1.00	1.00	0.00	1.00	1.00	0.00
		Asset Turnover Ratio	0.83	0.82	0.40	0.84	0.84	-0.21
Debt Coverage	0.10	Credit Deposit Ratio	74.97	36.38	8.37	12.81	1.36	1.23
		Investment Deposit Ratio	69.87	41.50	7.91	13.63	1.42	1.25
		Cash Deposit Ratio	6.81	-14.06	5.52	-6.38	-4.34	-1.88
		Total Debt to Owners Fund	79.90	32.45	8.96	11.74	1.34	1.22
		Financial Charges Coverage Ratio	73.81	36.16	8.24	12.51	1.42	1.25
		Financial Charges Coverage Ratio Post Tax	7.62	-11.43	8.06	-6.61	-5.92	-3.04
Cash-flow	0.10	Dividend Payout Ratio Net Profit	22.90	22.96	5.74	24.14	21.59	4.91
		Dividend Payout Ratio Cash Profit	21.13	21.89	-1.40	22.39	21.43	2.24
		Earning Retention Ratio	77.11	76.09	0.12	75.87	77.02	-0.29
		Cash Earning Retention Ratio	78.88	78.93	-1.23	77.61	79.85	-1.70
		Adjusted Cash Flow Times	75.05	77.67	-3.30	76.50	77.53	-1.53
Managerial Efficiency	0.10	Interest Income / Total Funds	9.82	10.41	-5.96	8.82	10.54	-19.45
		Interest Expended / Total Funds	5.83	6.18	-5.96	4.74	6.27	-22.29
		Operating Expense / Total Funds	2.60	2.77	-6.36	2.59	2.78	-7.47
		Profit Before Provisions / Total Funds	1.30	1.33	-2.00	1.41	1.30	7.51
		Net Profit / Total Funds	0.96	1.09	-13.76	1.08	1.10	-1.74
		Loans Turnover	0.18	0.16	11.69	0.17	0.16	6.47
		Total Income / Capital Employed (%)	9.90	10.43	-5.30	8.90	10.55	-18.57
		Interest Expended / Capital Employed (%)	5.83	6.18	-5.96	4.74	6.27	-22.29
		Asset Turnover Ratio	5.14	5.50	-7.09	4.60	5.59	-21.50
Overall	0.10	Capital Adequacy Ratio	14.25	13.43	5.75	14.40	13.70	4.90
		Advances / Loans Funds (%)	78.34	77.06	1.63	80.60	78.13	3.07
		Return on invested capital (ROIC)	0.01	0.02	-7.75	0.35	0.01	96.29
		Return on Equity (ROE)	0.16	0.20	-24.36	0.15	0.19	-27.08
		Fixed Assets Ratio	41.52	38.97	6.15	47.00	43.33	7.81
		Capital Turnover Ratio	0.09	0.10	-12.03	0.03	0.10	-262.76
		Sales /net fixed Assets	19.86	20.06	-0.99	21.07	20.53	2.52

Table 4: Z-Score Convergence Study for SBI

Tolerance	Ratios	2008			2009			2010		
		Actual	Predicted	% Error	Actual	Predicted	% Error	Actual	Predicted	% Error
0.01	(CA-CL)/Total Assets	0.8352	0.8205	1.7491	0.8104	0.8218	-1.4020	0.8353	0.8228	1.4948
	Retained Earnings/Total Assets	0.0854	0.0650	23.9487	0.0794	0.0676	14.8341	0.0677	0.0700	-3.3350
	EBIT/Total Assets	0.0748	0.0594	20.5561	0.0791	0.0589	25.5990	0.0635	0.0586	7.7366
	Equity/Total Liability	0.0011	0.0010	6.0949	0.0009	0.0010	-15.6433	0.0007	0.0010	-51.2262
	Z Value	6.2630	6.0365	3.6177	6.1298	6.0484	1.3269	6.2630	6.0583	3.2683

Table 5: Details in brief of the predicted ratios in all eight pillars:

Ratio Pillar	Tolerance	Ratios	2009.00	2010.00	2011.00	2012.00	2013.00	2014.00	2015.00
Investment Valuation	0.1	Dividend Per Share	16.45	20.58	27.43	25.18	26.22	26.83	27.21
		Operating Profit Per Share (Rs)	154.42	180.50	227.36	225.43	213.35	216.90	219.10
		Net Operating Profit Per Share (Rs)	829.11	945.25	1120.7	1166.64	1094.1	1110.90	1121.4
		Earnings Per Share	60.11	69.75	70.42	71.24	65.45	66.23	66.74
		Book Value	86.09	90.23	108.88	116.44	102.87	103.70	104.20
		Net Operating Income per share	539.67	628.50	768.09	764.20	731.80	742.05	748.27
Profit & Loss	0.20	Adjusted Cash Margin (%)	12.74	10.72	10.70	9.68	8.66	7.64	6.63
		Net Profit Margin	10.84	10.84	9.84	10.83	10.83	11.98	10.83
		Return on Net Worth (%)	15.23	13.14	12.04	12.95	12.86	14.77	14.68
		Adjusted Return on Net Worth (%)	15.23	15.15	15.06	14.97	14.89	14.81	14.74

Application of BPNN in the analysis of SBI's Credit Capacity

Profitability	0.10	Interest Expended / Interest Earned	69.16	70.12	72.89	73.51	74.01	74.42	74.76
		Operating Expense / Total Income	24.58	25.38	25.20	26.03	26.89	26.77	26.66
		Selling Distribution Cost Composition	0.31	0.30	0.27	0.27	0.27	0.27	0.28
		Quick Ratio	6.08	6.97	7.79	6.88	6.95	7.00	7.04
Leverage	0.10	Net financial leverage	14.01	12.53	12.53	12.53	12.55	13.58	13.64
		Interest Coverage	1.34	1.42	1.43	1.42	1.35	1.36	1.36
		Long Term Debt / Equity	1159.42	1174.2	1187.7	1200.33	1212.4	1024.67	837.80
		Debt-Equity ratio	1513.0	1450.8	1508.	1518.4	1519.0	1519.08	1519.0
		Owner's fund as % of Total Source	89.25	88.22	90.96	91.26	91.27	91.27	91.27
		Total debt to assets ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Long term debt to assets ratio	0.82	0.84	0.83	0.82	0.84	0.82	0.82
Debt Coverage	0.20	Credit Deposit Ratio	69.87	73.81	74.63	75.34	70.96	71.50	71.97
		Investment Deposit Ratio	41.50	36.16	35.87	36.64	36.49	35.42	34.43
		Cash Deposit Ratio	7.91	8.23	8.50	8.72	8.89	8.94	8.15
		Total Debt to Owners Fund	13.63	12.51	12.40	12.29	12.20	13.10	13.02
Cash-flow	0.20	Dividend Payout Ratio Net Profit	21.59	22.95	23.29	23.60	21.89	24.14	24.00
		Dividend Payout Ratio Cash Profit	21.42	21.89	20.32	21.71	21.06	21.38	18.66
		Earning Retention Ratio	77.02	76.09	75.17	74.24	74.30	70.36	75.42
		Cash Earning Retention Ratio	79.85	78.93	76.01	76.08	76.15	76.21	75.27
		Adjusted Cash Flow Times	77.53	77.66	77.79	77.92	78.03	78.14	78.24
Managerial Efficiency	0.10	Interest Income / Total Funds	9.71	8.84	8.93	8.99	9.02	9.04	9.06
		Interest Expended / Total Funds	6.64	6.23	6.49	6.57	6.63	6.66	6.68
		Profit Before Provisions / Total Funds	1.31	1.48	1.15	1.04	0.93	0.85	0.78
		Loans Turnover	0.16	0.15	0.15	0.15	0.15	0.15	0.16
		Total Income / Capital Employed (%)	9.94	9.13	9.25	9.33	9.38	9.42	9.44
		Interest Expended / Capital Employed (%)	6.64	6.16	6.49	6.58	6.63	6.66	6.68
		Asset Turnover Ratio	4.41	5.48	5.95	6.60	6.63	6.66	6.67
Overall	0.40	Capital Adequacy Ratio	13.43	12.45	12.47	12.49	12.50	12.51	12.52
		Advances / Loans Funds (%)	73.96	74.46	74.82	75.07	75.25	75.38	75.47
		Return on invested capital (ROIC)	0.04	0.03	0.02	0.02	0.01	0.01	0.01
		Fixed Assets Ratio	4.05	4.13	4.19	4.23	4.25	4.27	4.28
		Capital Turnover Ratio	0.86	0.66	0.68	0.71	0.73	0.74	0.75

Table 6: Prediction of Internal Parameters of Z-Score using BPNN.

S.No	Tolerance	Years	Output			
			(Current Assets –Current Liability) / Total Assets	Retained earnings/ Total Assets	Earning Before Interest and Tax / Total Assets	Equity/Total Liability
1	0.01	2009	0.82233	0.06815	0.05891	0.00102
2		2010	0.82336	0.07064	0.05875	0.00100
3		2011	0.82422	0.07277	0.05876	0.00099
4		2012	0.82495	0.07457	0.05885	0.00098
5		2013	0.82557	0.07606	0.05899	0.00097
6		2014	0.82611	0.07730	0.05915	0.00096
7		2015	0.82657	0.07831	0.05929	0.00095

Table 7: Prediction of Z-Score using BPNN.

Year	2009	2010	2011	2012	2013	2014	2015
Z Score	6.110547	6.129766	6.041783	6.053048	6.062925	6.071476	6.078811