CHAPTER – V

DATA ANALYSIS AND MODEL CONSTRUCTION

5. DATA ANALYSIS AND MODEL CONSTRUCTION

The study comprises of two objectives focusing on wilful default; to apply existing Bankruptcy Prediction Models and construction of new Bankruptcy Models. After computing the data the further discussion is elaborated on two distinct objectives.

5.1. Application of Altman Z-Score Model and Ohlson O-Score Model

The study on Wilful Default companies listed from year 2000 is 106, with the use of Ohlson O-Score Model and Altman Z-Score Model on these companies following results are found. It discusses the efficiency of the model in terms of correct predictability.

According to Altman's Z-score,

1. a number less than 1.81 indicates very high chance of bankruptcy,
2. a score between 1.81 and 2.99 implies moderate chance of bankruptcy, and
3. a score exceeding 3 indicates very low chance of bankruptcy.

As presented in Table 5-1 Altman Results, total 75 companies scored less than 1.81 for at least 5 years, which means that the Z-score was alarming for at least 5 years consecutively. There are only 7 companies in the safe zone for more than 5 years.

Table 5-1 Altman Results

	No. of Companies
<1.8	75
1.81-2.99	24
>3	6

Company Year wise, there are 21 instances where Ohlson's model predicted bankruptcy but not the Altman model. A total of 77 companies are correctly predicted by Altman Model but not by Ohlson Model at different point of time. For all the years, 9 predictions for both the models were at par for all the years.

A total 100 out of 106 companies were correctly predicted as plunging towards bankruptcy by using the Z-score for at least 1 year of entire period. However, 6 companies eluded the prediction, classification of prediction is present in the Table 5-2 Altman's Z-score classification of Prediction Results.

Table 5-2 Altman's Z-score classification of Prediction Results

	Correct Prediction	Default yet not Predicted
Total Companies	100	6*

*Type Error II (Not Predicted but went bankrupt)

The list of these 6 companies not predicted by using Altman Z-Score model is in the Table 5-3 List of companies not predicted by Altman Z-score below.

Table 5-3 List of companies not predicted by Altman Z-score

1	Amar Remedies Ltd.
2	Ameya Laboratories Ltd.
3	Coral Hub Ltd.
4	Lumax Auto Technologies Ltd.
5	Midfield Industries Ltd.
6	Taksheel Solutions Ltd.

As present in Table 5-1, Altman results in three categories. For better understanding and analysis these three categories are labelled as Green, Amber and Red as suggested the categories in the model.

- Green is for the score more than 3
- Amber between 1.81 and 2.99
- Red less than 1.8.

It also shows the companies' Cash flow position from Loan Funds. Number of companies with Net Inflow and Outflow from Loan funds is provided in the Table 5-4 Altman's Z-score year wise under various zones and Increase/Decrease in Cash Flow from Loan Funds of number of companies. It shows in 2007, 2008 and 2009 maximum companies were in either Amber or Red zone or maximum Inflow of Cash from Loan Fund as found through their Cash flow statement. By the year 2017, barely 56 companies were left out of the total population of 106 companies. Analysis of the results from Altman Z-Score year wise based on Green, Amber and Red is provided in the Table 5-4 Altman's Z-score year wise under various zones and Increase/Decrease in Cash Flow from Loan Funds of number of companies. It also shows the companies' Cash flow position from Loan Funds. Number of companies with Net Inflow and Outflow from Loan funds is provided in the table below.

Table 5-4 Altman's Z-score year wise under various zones and Increase/Decrease in Cash Flow from Loan Funds of number of companies

	Altman's Z-score					Inc/Dec Cash Flow from loan fund of No. of Companies	
Year	**Green >3**	**Amber 1.81-2.99**	**Red <1.8**	**Total**	**Amber+Red**	**Outflow**	**Inflow**
2000	0	1	0	1	1	2	3
2001	1	3	15	19	18	3	6
2002	2	14	14	30	28	3	9
2003	4	10	28	42	38	9	13
2004	11	35	39	85	74	15	38
2005	12	31	53	96	84	19	31
2006	18	48	34	100	82	17	39
2007	13	55	34	102	89	11	45
2008	19	51	35	105	86	9	49
2009	4	44	56	104	100	16	51
2010	7	50	46	103	96	24	49
2011	5	24	75	104	99	19	37
2012	2	23	75	100	98	18	28
2013	0	7	86	93	93	19	22
2014	0	11	73	84	84	17	20
2015	1	3	76	80	79	18	14
2016	2	6	66	74	72	15	12
2017	2	1	53	56	54	14	7

Correlation between number of companies having combined Amber and Red ratings and Increase in Loan Funds is 0.76. This indicates that when number of companies' creditworthiness was unsound, banks were still sanctioning loans. From the year 2000 to 2009, the increase in the loan fund peaked at Rs. 8026.21 Cr. and then declined sharply. By the end of 2017, only 56 companies were left and the rest 51 ceased to exist as per the data on Ace Equity.

Ohlson's O-score is divided into 2 parts; probability is more than and less than 50%. When the probability is less than 50% then the chances of company going bankrupt is very high and otherwise for more than 50%. The results from O-score are fairly near to the Z-score; 101 companies were predicted to go bankrupt at some point of time and only 5 companies were missed out. This shows excellent accuracy at around 95%.

Table 5-5 Ohlson's O-score classification of Prediction Results

	Correct Prediction	Default yet not Predicted
Total Companies	101	5*

*Type Error II (Not Predicted but went bankrupt)

The list of these 5 companies which were not predicted by using Ohlson O-Score model is in Table 5-6 List of companies not predicted by Ohlson's O-score below.

Table 5-6 List of companies not predicted by Ohlson's O-score

1	Jaypee Infratech Ltd.
2	Plethico Pharmaceuticals Ltd.
3	Varun Industries Ltd.
4	Innoventive Industries Ltd.
5	Prithvi Information Solutions Ltd.

Interestingly, the lists of companies missed by either model are totally distinct. This indicates that if both the models are used then chances of missing out a company would decrease. Analysis of the results from Ohlson O-Score model year wise based is provided in the

Table 5-7 O-score from 2000 to 2017 and Increase/Decrease of Cash flow from Loan Funds of number of companies. It also shows the companies' Cash flow position from Loan Funds. Number of companies with Net Inflow and Outflow from Loan funds is provided. Major concentration of companies is found between 2007 and 2011 which is around 100 in the give period. During the same period Increase in Cash flow from Loan funds from the companies is also maximum. In 2009, 51 companies were having Net Cash Inflow from loan funds and 70 companies were showing clear sign of approaching towards bankruptcy.

Table 5-7 O-score from 2000 to 2017 and Increase/Decrease of Cash flow from Loan Funds of number of companies

Ohlson's O-score of number of companies				Inc/Dec Cash flow from Loan Funds of number of companies	
Year	**<0.5**	**>0.5**	**Total**	**Outflow**	**Inflow**
2000	6	7	13	2	3
2001	11	8	19	3	6
2002	19	11	30	3	9
2003	29	12	41	9	13
2004	69	16	85	15	38
2005	62	33	95	19	31
2006	37	61	98	17	39
2007	24	78	102	11	45
2008	18	85	103	9	49
2009	31	70	101	16	51
2010	25	76	101	24	49
2011	18	81	99	19	37
2012	22	68	90	18	28
2013	15	66	81	19	22
2014	17	61	78	17	20
2015	17	54	71	18	14
2016	14	43	57	15	12
2017	56	0	56	14	7

Further, interesting facts have surfaced on understanding the pattern of increase and decrease of loan funds. The instances where loan funds increased indicate that there has been cash inflow through loans; additional or new loans have been provided by the banks. If loan fund increases amidst a weakening condition of borrowers, then it would be alarming for the banks. The correlation between less than 0.5 score and increase in loan fund is 0.25. There are 5 companies whose bankruptcy could not be predicted using the model.

The data in Table 5-8 Sector wise data on instances of increase in loan funds and the number of times a high probability of bankruptcy was predictable according to the Z-score is a sector wise bifurcation of the increase in loan funds despite red and amber signals of the companies. In addition, data in Table 5-9 are regarding the subsequent disbursements for 2 to 4 years in sequence, reinforcing the point about disbursements notwithstanding deteriorating creditworthiness which could have been discerned.

Table 5-8 Sector wise data on instances of *increase in loan funds* and *the number of times a high probability of bankruptcy was predictable* according to the Z-score

	High Risk Bankruptcy Frequency of Companies														
Sector	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Agriculture				3		5									
Automobile & Ancillaries			4			5									
Aviation										9					
Capital Goods				6		10					10				
Chemicals							6								
Construction Materials		1			4	5	6		8						
Consumer Durables		1													
Crude Oil	0														
Diamond &Jewellery			2										12		
Electricals		1													
FMCG		1			4	5	6	7	8						
Healthcare					4	5	6		8						
Hospitality				3											
Inds. Gases & Fuels								7							
Infrastructure	**0**		**2**		**12**	**5**	**6**	**14**	**8**					**13**	**14**
Iron & Steel								7		9					
IT	**0**	**2**		**12**		**10**			**8**	**18**		**11**			
Media & Entertainment		1		3	4		6	7	8						
Mining					4										
Miscellaneous					4										
Non - Ferrous Metals		1		3					8						
Paper							**6**				**10**	**11**	**12**		
Plastic Products				3						9					
Power							12								
Realty		1		3	4		12								
Ship Building												11			
Telecom				3											
Textile		**1**		**3**	**8**	**5**	**12**	**21**	**8**	**27**		**11**	**12**		**14**
Trading		1					6			9					

The most instances of disbursement were for Textiles, Infrastructure and IT sectors. Almost every year the companies from these sectors showed the signs of weak financial. Interestingly, studying the pattern of disbursements even after amber and red signals for 2, 3 and 4 times provided an insight into the anomaly of loan disbursements as presented in Table 5-9

Disbursement and Risk Anomaly at various consecutive instances. A total 68 companies were disbursed loans even after strong bankruptcy signals; further, 50 borrowers received disbursement of loan funds consecutively 3 times while with 36 companies it was consecutively 4 times despite strong bankruptcy signals.

Table 5-9 Disbursement and Risk Anomaly at various consecutive instances

Total anomaly in disbursement and Strong Bankruptcy Signals			
the number of times a high probability of bankruptcy was predictable according to the Z-score	**2 Consecutive Years of Loan disbursement**	**3 Consecutive Years of Loan disbursement**	**4 Consecutive Years of Loan disbursement**
0	0	0	0
1	0	0	0
2	0	0	0
3	5	0	0
4	7	3	0
5	7	5	4
6	11	8	5
7	9	8	6
8	8	5	5
9	9	9	5
10	2	2	2
11	4	4	4
12	3	3	2
13	1	1	1
14	2	2	2
Grand Total	68	50	36

This reflects if prominent bankruptcy prediction models would have been used by the bankers, then further disbursement of loan could have been controlled. Out of 107, 36 companies were consecutively provided loan for 4 years. This could also indicate gross negligence or worse, some kind of collusion with the bankers in a few cases.

5.2. Bankruptcy Prediction Models

In line with the objective to build and compare bankruptcy prediction models for wilful default public limited companies listed from the year 2000 by using Logistic Regression, Multivariate Discriminant Analysis and Artificial Neural Network one of the conversions quoted in the famous book by Sir Arthur Conan Doyle in the memoirs of Sherlock Holmes-Adventure I-Silver Blaze is found to be relevant in the context to prediction of bankruptcy.

> *Colonel Ross: Is there any other point to which you wish to draw my attention?*
>
> *Holmes: To the curious incident of the dog in the night-time.*
>
> *Colonel Ross: The dog did nothing in the night-time.*
>
> *Holmes: That was the curious incident.*
>
> *The circumstance noted by Holmes was to Colonel Ross not a circumstance at all, yet this non-fact was the key to the solution: the crime was committed by someone known to the dog.*

(Source: (Doyle, 1894)*)*

5.2.1. Background of the Model

The objective to build and compare the prediction models for Wilful Default Listed Public Limited Companies in India has been presented in this chapter. The period of study is from 2000 to 2018; total number of wilful default companies listed after the year 2000 declared by the Bank or Financial Institution total up to 106. The model construction is based on these 106 Wilful Default companies and 106 Non-Default Companies. A sample set of Non-Default companies have been selected based on the highest market capitalization of BSE 200 companies. It excludes Banking and Financial Services as the loan provided is part of asset in on the balance sheet of the banks and study focuses on default of those loans provided or an asset to the bank hence in order get true picture of assets BFSI sectors have been excluded. It includes all the wilful default listed companies irrespective of its state, geographical location or sector. The total number of records in terms of data availability of all the companies through the period comes to 1377 and 1942 of wilful default and non-default companies respectively. Hence the total observations throughout the period are 3319 that is company years. The data

has been extracted from EBSCO recognized Ace Equity Database Software for the purpose of analysis and the data has been analysed by using SPSS software powered by IBM. The approximate period taken by the Bank/Financial Institution to declare the entity as Wilful Default may range from a year to two years. Data includes the default status before two years of declaring as Wilful default and published by Credit Information Companies (CIC). The dataset is further analysed with the use of Logistic Regression, Multivariate Discriminant Analysis and Artificial Neural Network method. The reason underlying to consider two years lies in the fact that the actual event of non-repayment would have started at least a year before the entity was declared default by the bank. The data is labelled as 'Yes' coded as '1' and 'No' coded as '0' in the years declared as wilful default and two years prior of default is present in Table 5-10. The total number company years of 'Yes' is 315 while 'No' is 3004.

Table 5-10 Company years of Wilful Default and Non-Default companies

Default	Yes	No	Total
Company year	315	3004	3119

5.2.2. Variable Selection

Since 1928, bankruptcy models have been evolving, in most cases secondary data especially the financial ratios have been used to construct the model. Financial Ratios are better input for bankruptcy prediction as the difference due to magnitude or scale of operations can be eliminated. All the variables short listed are in Ratio form.

Financial ratios reflect broadly the performance of the companies. Variables selected are broadly divided into various categories; Liquidity, Profitability, Solvency and Valuation, Cash flow and Miscellaneous Ratios. Following Table 5-11 is the list of ratios worked out to construct the prediction model.

Table 5-11 List of Ratios

No.	**Types**
1	**Liquidity Ratios**
1.1	Current Ratio
1.2	Net Working Capital/ Total Assets
2	**Profitability Ratios**
2.1	Net Profit Margin
2.2	Operating Profit Margin
2.3	PBIT Margin
2.4	Return on Assets

2.5	Return on Shareholders' Fund
2.6	ROCE
3	**Solvency and Valuation Ratios**
3.1	Interest Service Coverage Ratio
3.2	Total Debt/Total Assets
3.3	Retained Earnings/Total Assets
3.4	PBIT/Total Assets
3.5	Sales/ Total Assets
3.6	Total Debt/EV
3.7	Profit After Tax/ EV
3.8	EV / Total Assets
4	**Cashflow Ratios**
4.1	Increase (Decrease) Loan Funds/Cashflow from Loan
4.2	Cashflow Financing/Cashflow Investing
5	**Miscellaneous**
5.1	Market Capitalization/Outstanding Total Debt
5.2	Sales/Capital Employed
5.3	Minority Interest/PAT

Based on the survey of literature, it was apparent that most of the bankruptcy prediction models since 1928 till date use financial ratios in most of the cases. The nature and the rationale behind selection of financial ratios have been discussed further.

5.2.2.1. Liquidity Ratio

Liquidity Ratios reflects the ability of a company to pay its short-term dues, as they mature. Liquidity is the primal base of survival for any business house. In case of liquidity crunch, company may not be able to pay off its instalment, interest, employee salary, payment to suppliers, etc. Current Ratio signifies the ability to pay short-term liabilities from a firm's cash, bank, inventory, bills receivables and debtors. The study covers the Current Ratio and Net Working Capital to Asset ratio to understand the pattern of liquidity of wilful default and non-default companies in India. It has been used by many previous researchers (Smith & Winakor, 1935)(Merwin, 1942), (Altman, 1968), (Libby, 1975). Current Ratio is an expression ratio between Current Assets and Current Liabilities. Short term liquidity problems can become the reason for major failures. Net Working Capital to Total Assets offer insights on composition of working capital against Total Assets. A company with continuous decline in the ratio signals financial instability.

5.2.2.2. Profitability

The ultimate performance of the firm is reflected through its profits. Profits decide the future of the company. Profit is the result of efficient utilization of assets. It has always been an

important yardstick for analysis. A plethora of researches have used profitability related ratios for bankruptcy models.(Jardin, 2009), (Ahmadi, Soleimani, Vaghfi, & Salimi, 2012),(Aliakbari, 2016),(Nouri & Soltani, 2016). Primarily, Net Profit Margin, Operating Profit Margin, Return on Assets, ROCE, Return on Net-worth and PBIT Margin has been used for building up the models.

5.2.2.3. Solvency and Valuation Ratios

The most critical of all is the long-term solvency ratios; it indicates whether the borrower has maintained good repayment provisions and the trend provides a clear idea of the direction. Categories include Interest Service Coverage Ratio, Total Debt/Total Assets, Retained Earnings/Total Assets, PBIT/Total Assets, Sales/ Total Assets, Total Debt/EV, Profit After Tax/ EV and EV / Total Assets.

Interest service coverage ratio signifies the capacity to cover the interest component against Earnings before Interest and Taxes. Total Debt to Total Assets signifies the amount of debt used to finance Total Assets. Ratios on Retained Earnings to Total Assets show the proportion of Reserves and Surplus to finance assets. Sales to Total Assets and PBIT to Total Assets show how efficiently the company is using its assets for sales and earn PBIT. Rest of the ratios related to the valuation, which are helpful in knowing the worth of the company. The entire ratio helps the evaluator or the prospective lender to decide whether to provide loan; if yes, how much should be the leverage and probability of payback. The ratio related to the Debt, PAT and Total Assets are compared with EV. It provides significant insight on where the company stands and helps bankers to evaluate and approve loans.

5.2.2.4. Cash-flow Ratios

Cash flow is the lifeblood of business. Hence, the evaluation should be done considering the liquidity situation in the business. Increase or Decrease in Loan Funds to Net In/Out) Cash flow signifies whether the company is repaying the loan in normal course or further borrowing to pay off existing debt. Ratio of Cash flow Financing Activities to Cash flow Investing Activities shows a clear situation as well as trend of loan taken against investment. This also indicates whether the long-term borrowings are used for investments in assets or for operating activities.

5.2.2.5. Miscellaneous

Other ratios include Market Capitalization/Outstanding Debt, Sales to Capital Employed and Minority Profit to PAT; the first one is applicable to a listed company only and since the study is based on listed companies the ratio is of relevant and important. It relates the market value of the company to total debt. Market capitalization is the perceived value by all the investors

in the market. It has been used by Altman for Z-Score. Another ratio, Total Sales to Capital Employed show the volume of sales generated in relation to the owners' fund and borrowed fund. It is through the trend one can gauge efficiency of fund usage. Lastly, Minority Interest which is the profit from related companies of the parent company against PAT is used.

5.3. Correlation of variables

Correlation of all the variables is based on Spearman's Correlation Technique. Following are the observations relating to the strong positive or negative relationship between the variables is r >0.5 and r > -0.5. From the following Table 5-12 Correlation Matrix details regarding correlation amongst 21 variables are presented. The highlighted cells indicate strong correlation that is more than 0.5 both positive and negative between two variables.

Table 5-12 Correlation Matrix

PAT /EV	TOTAL	MINORI	CF Fina	Total	sales /Cap	Inc Dec	=Sales/T	=Market	=PBIT/T	=Retaine	=NET	Interest	Return	Return	Return	PBIT	Operatin	Net Prof	Current	
.304	-.044	-.129	-.163	-.090	-.061	.095	.046	-.065	.227	.422	.917	-.028	.056	.005	.226	.210	.204	.272	1.000	Current Ratio
.507	-.573	.232	.107	-.532	.032	-.107	.016	.493	.744	.561	.238	.568	.707	.451	.809	.950	.810	1.000	.272	Net Profit Margin
.287	-.377	.170	.092	-.312	-.286	-.093	-.305	.312	.501	.427	.117	.429	.412	.198	.506	.860	1.000	.810	.204	Operating Profit Margin
.433	-.558	.264	.125	-.488	-.016	-.145	-.047	.489	.703	.497	.174	.586	.658	.395	.732	1.000	.860	.950	.210	PBIT Margin
.569	-.679	.197	.198	-.660	.488	-.106	.493	.593	.960	.565	.253	.659	.920	.660	1.000	.732	.506	.809	.226	Return On Assets
.404	-.299	.078	.090	-.242	.453	-.024	.433	.255	.681	.027	.078	.308	.667	1.000	.660	.395	.198	.451	.005	Return On Shareholders'
.483	-.708	.250	.235	-.693	.543	-.137	.519	.633	.891	.442	.123	.715	1.000	.667	.920	.658	.412	.707	.056	Return On Capital
.201	-.712	.387	.330	-.650	.381	-.222	.322	.710	.637	.440	-.003	1.000	.715	.308	.659	.586	.429	.568	-.028	Interest Service Coverage
.324	-.068	-.155	-.179	-.169	.086	.074	.155	-.049	.264	.362	1.000	-.003	.123	.078	.253	.174	.117	.238	.917	Net Working Capital/Total
.292	-.624	.104	.095	-.736	.048	-.081	.112	.508	.499	1.000	.362	.440	.442	.027	.565	.497	.427	.561	.422	Retained Earning/Total
.551	-.617	.162	.200	-.595	.513	-.094	.524	.537	1.000	.499	.264	.637	.891	.681	.960	.703	.501	.744	.227	PBIT/Total Assets
.082	-.858	.307	.267	-.701	.322	-.195	.270	1.000	.537	.508	-.049	.710	.633	.255	.593	.489	.312	.493	-.065	Market Cap/Bv Of Totaldebt
.334	-.321	.073	.157	-.344	.952	-.030	1.000	.270	.524	.112	.155	.322	.519	.433	.493	-.047	-.305	.016	.046	Sales/Total Assets
-.002	.181	-.147	-.128	.144	-.053	1.000	-.030	-.195	-.094	-.081	.074	-.222	-.137	-.024	-.106	-.145	-.093	-.107	.095	Inc Dec Loan Funds/Cf_Loan
.328	-.360	.112	.189	-.410	1.000	-.053	.952	.322	.513	.048	.086	.381	.543	.453	.488	-.016	-.286	.032	-.061	Sales/Capital Employed
-.290	.820	-.188	-.206	1.000	-.410	.144	-.344	-.701	-.595	-.736	-.169	-.650	-.693	-.242	-.660	-.488	-.312	-.532	-.090	Total Debt/Total Assets
.017	-.231	.138	1.000	-.206	.189	-.128	.157	.267	.200	.095	-.179	.330	.235	.090	.198	.125	.092	.107	-.163	Cf Financing/Cf Investing
.091	-.255	1.000	.138	-.188	.112	-.147	.073	.307	.162	.104	-.155	.387	.250	.078	.197	.264	.170	.232	-.129	Minority Interest/Pat
-.077	1.000	-.255	-.231	.820	-.360	.181	-.321	-.858	-.617	-.624	-.068	-.712	-.708	-.299	-.679	-.558	-.377	-.573	-.044	Total Debt/Ev
1.000	-.077	.091	.017	-.290	.328	-.002	.334	.082	.551	.292	.324	.201	.483	.404	.569	.433	.287	.507	.304	Pat/Ev
-.149	-.633	.236	.208	-.306	.184	-.133	.179	.749	.440	.215	-.175	.536	.500	.346	.465	.381	.261	.372	-.147	Ev/Total Assets

EV/ TOT	-.147	.372	.261	.381	.465	.346	.500	.536	-.175	.215	.440	.749	.179	-.133	.184	-.306	.208	.236	-.633	-.149	1.000

- Net profit Margin and PBIT margin is positively correlated with Operating Profit Margin (does not include Depreciation, Interest and Taxes), Return on Asset, ROCE and PBIT to Total Assets.

- Return on Asset is highly correlated with Net Profit Margin, Operating Profit Margin and PBIT margin, Return on Shareholders' Fund, ROCE, PBIT to Total Assets and PAT to Enterprise Value; negatively related to Total Debt to Total Assets and Total Debt to Enterprise Value.

- ROCE is strongly related to Net Profit Margin, Return on Shareholders' Fund, Return on Assets and ROCE, PBIT to Total Assets, Market Capitalization to Total Debt and Sales to Capital employed while negatively correlated with Total Debt to Total Assets.

- Interest Service coverage ratio is strongly related with ROCE and Return on Assets, also with Net Profit and Operating Profit Margin, PBIT to Total Assets and negatively with Total Debt to Enterprise Value.

- PBIT to Total Assets is strongly related to 11 other variables including Net Profit, Operating and PBIT margin, Return on Total Assets, on Capital Employed, and on Shareholders' fund, PAT to EV, Market Capitalization to Total Debt and negatively with Total Debt to assets.

- Market Capitalization to Total Debt is strongly related to 8 variables including Return on Total Assets and Return on Capital Employed, Retained Earnings to Total Assets and negatively with Total Debt to Enterprise Value and Total Debt to Total Assets.

- Total Debt to Enterprise Value is related negatively to Return on Assets, ROCE and Interest Service Coverage Ratio

- Cash flow from Financing to Cash flow from Investing Activities and Minority Interest to PAT does not have strong correlation with another single variable.

5.4. Logistic Regression

Logistic Regression is a statistical technique which uses logistic function for dichotomous dependent variables. It is mainly used where the outcome is binary; 0 or 1, default or not, buy or not, etc. The Logistic Regression computes the probability that the binary response is as a function of a set of predictor variables and regression coefficients presented as:

$X=[X_{0,}, , ...X_n]^T$-Independent Variables

$B=[\beta_0+ \beta_1+ \beta_2+..... \beta_n]^T$ – Regression co-efficient

P=probability

β_0=Constant

The outcome of Logistic Regression function provides the probability and to ensurethat the probability is between 0 to1 the function is divided by 1 and the function in the numerator.

$$\ln\left(\frac{p}{1+p}\right) = \beta 0 + \beta_1 + \beta_{2.....} X_n \beta n$$

With the use of SPSS statistical software the database selected are computed and the details of the results are as follows:

The method selected was enter to display each step of optimal model with Classification plots, Hosmer-Lemeshow goodness of-fit, Correlation of variables, Iteration History and Constant in the model. By default, Classification cut off is 0.5 and Maximum iteration are 20 while Probability stepwise has Entry of 0.05 and Removal of 0.10. The results are computed using Forward method; forward method starts model construction with 1 variable and keeps adding significant variables and eliminates insignificant variables.

As presented in Table 5-13 Case Processing Summary Total observations or company years are 3319 out of which 94.1% data was considered for computing, the software generally exclude incomplete or non-numeric observations which is 196 in total and 5.9 % out of the total observations.

Table 5-13 Case Processing Summary

Unweighted Cases		N	Percent
Selected Cases	Included in Analysis	3123	94.1
	Missing Cases	196	5.9
	Total	3319	100.0
Unselected Cases		0	.0
Total		3319	100.0

As mentioned the Logistic Regression model is constructed through various iterations, the details are all the steps are presented in Table 5-14 Classification Table-Step 0 , Table 5-15 Iteration History-Log Likelihood-Fitness for Constant Coefficients, Table 5-16 Step 0-Variables in the Equation, Table 5-17 Forward Stepwise (Likelihood Ratio), Similarly, the variables in the equation step forward for Logistic Regression for this case is presented in Table 5-18 Variables in the Equation-Step Forward Logistic Regression. It ultimately shortlists 9 variables as discussed above.

Table 5-18 Variables in the Equation-Step Forward Logistic Regression and In furtherance to model building process the forward likelihood of variables is computed in Table 5-19 Variables not in the Equation-Step Wise-Forward Likelihood. It considers all the variables in the first step and keeps removing step by step. At the end 12 variables are left that means 9 are significant and discussed in Table 5-18 Variables in the Equation-Step Forward Logistic Regression.

Table 5-19 Variables not in the Equation-Step Wise-Forward Likelihoodin this study total 9 steps or iterations were worked to come up with the most efficient Logistic Regression Model. The following Table 5-14 Classification Table-Step 0that is the baseline model starts with 90.5% accuracy where none of the prediction of default was made correctly. This means all observations were predicted as Non-Default.

Table 5-14 Classification Table-Step 0

			Predicted		
			DEFAULT		Percentage
	Observed		NO	YES	Correct
Step 0	DEFAULT	NO	2827	0	100.0
		YES	296	0	.0
	Overall Percentage				90.5
a. Constant is included in the model.					
b. The cut value is .500					

The Log likelihood goodness fit is found to be 1957.878 after step 5 for the constant of Logistic Regression as presented in Table 5-15 Iteration History-Log Likelihood-Fitness for Constant

Coefficients where constant co-efficient iteration stands at -2.257. The result of constant variable is derived in 5 steps; the system stops iteration when the change in the result is less than 0.01.

Table 5-15 Iteration History-Log Likelihood-Fitness for Constant Coefficients

Iteration History[a,b,c]			
			Coefficients
Iteration		-2 Log likelihood	Constant
Step 0	1	2086.488	-1.621
	2	1962.256	-2.131
	3	1957.888	-2.251
	4	1957.878	-2.257
	5	1957.878	-2.257

a. Constant is included in the model.

b. Initial -2 Log Likelihood: 1957.878

c. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001

The constant of the equation is statistically significant with Wald at 1364.455. The constant in the equation is -2.257. The baseline variable or the constant in the equation is significant variable.

Table 5-16 Step 0- Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-2.257	.061	1364.455	1	.000	.105

The next step is to the Forward Stepwise where significant co-efficient variables are included step wise. From the Table 5-17 Forward Stepwise (Likelihood Ratio) it is observed that a total 9 steps are observation in the entire history of iteration. Shortlisted variables in the iterations are Total Debt to Total Assets, Sales to Total Assets, Enterprise Value to Total Asset, Sales to Capital employed, Net Working Capital to Total Assets, ROCE, PBIT Margin, Net Profit Margin and Operating Profit Margin out of 21 variables included.

Table 5-17 Forward Stepwise (Likelihood Ratio)

Iteration History[a,b,c,d,e,f]											
		Coefficients									
Itera-tion	-2 Log likely-hood	Con-stant	Total Debt/	Sales/ TOTAL	EV/TOTAL	Sales/ Capi-talEm	NWC/ TOTAL	Return onCapi-tal	PBIT Mar-gin	NetProfitMar-gin	Opera-tingPr

				Total Assets	ASSETS	ASSETS	plo-yed	ASSETS	Employed			ofitMar-gin
Step 1	1	1812.55	-2.031	1.183								
	2	1525.374	-3.116	2.509								
	3	1473.315	-3.812	3.559								
	4	1470.299	-4.032	3.891								
	5	1470.285	-4.048	3.916								
	6	1470.285	-4.048	3.916								
Step 2	1	1780.719	-1.778	1.091	-0.238							
	2	1452.818	-2.427	2.164	-0.667							
	3	1364.086	-2.58	2.873	-1.301							
	4	1348.707	-2.502	3.077	-1.804							
	5	1347.992	-2.474	3.112	-1.945							
	6	1347.99	-2.473	3.114	-1.952							
	7	1347.99	-2.473	3.114	-1.952							
Step 3	1	1779.878	-1.768	1.088	-0.232	-0.008						
	2	1447.685	-2.376	2.141	-0.637	-0.043						
	3	1339.312	-2.374	2.803	-1.183	-0.201						
	4	1291.23	-2.06	3.121	-1.548	-0.58						
	5	1269.041	-1.87	3.571	-1.606	-1.108						
	6	1263.39	-1.781	3.955	-1.611	-1.524						
	7	1263.038	-1.76	4.084	-1.616	-1.656						
	8	1263.037	-1.759	4.093	-1.616	-1.665						
	9	1263.037	-1.759	4.093	-1.616	-1.665						
Step 4	1	1778.062	-1.769	1.083	-0.222	-0.008	-0.005					
	2	1445.373	-2.369	2.126	-0.629	-0.044	-0.007					
	3	1335.662	-2.358	2.782	-1.178	-0.204	-0.009					
	4	1285.956	-2.035	3.101	-1.546	-0.593	-0.011					
	5	1262.176	-1.835	3.568	-1.605	-1.145	-0.013					
	6	1255.698	-1.734	3.982	-1.611	-1.6	-0.015					
	7	1255.25	-1.711	4.132	-1.617	-1.753	-0.015					
	8	1255.248	-1.709	4.143	-1.617	-1.765	-0.015					
	9	1255.248	-1.709	4.143	-1.617	-1.765	-0.015					
Step 5	1	1753.25	-1.578	0.781	-0.222	-0.019	-0.005	-0.461				
	2	1411.952	-2.039	1.613	-0.586	-0.077	-0.005	-0.885				
	3	1304.417	-1.997	2.189	-1.037	-0.261	-0.006	-1.118				
	4	1253.707	-1.667	2.503	-1.321	-0.689	-0.008	-1.155				
	5	1227.757	-1.436	2.978	-1.348	-1.297	-0.01	-1.218				
	6	1221.209	-1.348	3.416	-1.334	-1.761	-0.012	-1.277				
	7	1220.802	-1.326	3.559	-1.337	-1.908	-0.012	-1.286				
	8	1220.8	-1.325	3.569	-1.338	-1.918	-0.012	-1.286				
	9	1220.8	-1.325	3.569	-1.338	-1.918	-0.012	-1.286				

Step 6	1	1751.597	-1.579	0.778	-0.218	-0.018	-0.005	-0.454	-0.014			
	2	1406.653	-2.061	1.642	-0.569	-0.074	-0.008	-0.864	-0.036			
	3	1297.419	-2.06	2.272	-0.996	-0.251	-0.014	-1.1	-0.058			
	4	1246.51	-1.75	2.6	-1.249	-0.671	-0.035	-1.134	-0.072			
	5	1220.68	-1.526	3.076	-1.256	-1.272	-0.051	-1.193	-0.077			
	6	1214.085	-1.437	3.514	-1.236	-1.739	-0.055	-1.25	-0.079			
	7	1213.66	-1.414	3.661	-1.237	-1.891	-0.057	-1.258	-0.08			
	8	1213.658	-1.413	3.671	-1.238	-1.902	-0.057	-1.258	-0.08			
	9	1213.658	-1.413	3.671	-1.238	-1.902	-0.057	-1.258	-0.08			
Step 7	1	1744.73	-1.594	0.78	-0.214	-0.018	-0.006	-0.415	-0.015	-0.002		
	2	1391.62	-2.097	1.638	-0.549	-0.072	-0.008	-0.807	-0.036	-0.007		
	3	1276.068	-2.149	2.286	-0.932	-0.245	-0.014	-1.041	-0.057	-0.016		
	4	1225.182	-1.888	2.618	-1.133	-0.651	-0.035	-1.08	-0.071	-0.024		
	5	1200.667	-1.67	3.066	-1.127	-1.232	-0.05	-1.138	-0.076	-0.029		
	6	1194.666	-1.584	3.48	-1.107	-1.675	-0.054	-1.196	-0.077	-0.029		
	7	1194.299	-1.563	3.616	-1.108	-1.814	-0.055	-1.205	-0.078	-0.029		
	8	1194.298	-1.562	3.625	-1.108	-1.824	-0.056	-1.205	-0.078	-0.029		
	9	1194.298	-1.562	3.625	-1.108	-1.824	-0.056	-1.205	-0.078	-0.029		
Step 8	1	1744.628	-1.595	0.782	-0.213	-0.018	-0.006	-0.416	-0.015	0.002	-0.004	
	2	1391.698	-2.097	1.637	-0.549	-0.073	-0.008	-0.806	-0.036	-0.005	-0.002	
	3	1271.295	-2.106	2.229	-0.942	-0.247	-0.014	-1.046	-0.055	-0.242	0.225	
	4	1216.613	-1.829	2.534	-1.146	-0.648	-0.034	-1.076	-0.067	-0.465	0.433	
	5	1191.046	-1.595	2.935	-1.149	-1.204	-0.048	-1.122	-0.071	-0.73	0.683	
	6	1185.205	-1.502	3.294	-1.131	-1.615	-0.051	-1.167	-0.071	-0.884	0.827	
	7	1184.886	-1.481	3.412	-1.131	-1.74	-0.053	-1.173	-0.072	-0.907	0.849	
	8	1184.885	-1.48	3.42	-1.131	-1.748	-0.053	-1.173	-0.072	-0.907	0.849	
	9	1184.885	-1.48	3.42	-1.131	-1.748	-0.053	-1.173	-0.072	-0.907	0.849	
Step 9	1	1742.479	-1.601	0.785	-0.212	-0.018	-0.006	-0.408	-0.015	0.001	-0.008	0.008
	2	1387.456	-2.129	1.667	-0.538	-0.071	-0.008	-0.791	-0.036	-0.003	-0.018	0.026
	3	1265.739	-2.151	2.269	-0.928	-0.242	-0.014	-1.009	-0.055	-0.311	0.271	0.043
	4	1207.529	-1.85	2.557	-1.154	-0.635	-0.033	-1.039	-0.064	-0.85	0.778	0.075
	5	1178.293	-1.613	2.915	-1.166	-1.165	-0.045	-1.061	-0.064	-1.607	1.476	0.139
	6	1172.307	-1.526	3.244	-1.144	-1.549	-0.047	-1.105	-0.064	-2.008	1.845	0.172
	7	1172.008	-1.508	3.354	-1.14	-1.667	-0.048	-1.113	-0.064	-2.049	1.883	0.175
	8	1172.006	-1.507	3.361	-1.14	-1.675	-0.048	-1.113	-0.064	-2.049	1.884	0.174
	9	1172.006	-1.507	3.361	-1.14	-1.675	-0.048	-1.113	-0.064	-2.049	1.884	c

a. Method: Forward Stepwise (Likelihood Ratio)

b. Constant is included in the model.

c. Initial -2 Log Likelihood: 1957.878

d. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

e. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

f. Estimation terminated at iteration number 9 because parameter estimates changed by less than .001.

Total of 9 significant variables in the equations are pROCEssed further step by step starting from Constant variable and Total Debt to Total asset. The variables in the equations are built up as listed below. The variables follow the method step by step of adding variables to build up the Logistic Regression formula as presented in Similarly, the variables in the equation step forward for Logistic Regression for this case is presented in Table 5-18 Variables in the Equation-Step Forward Logistic Regression. It ultimately shortlists 9 variables as discussed above.
Table 5-18 Variables in the Equation-Step Forward Logistic Regression.

a. Variable(s) entered on step 1: Total Debt/Total Assets.
b. Variable(s) entered on step 2: Sales to Total Asset.
c. Variable(s) entered on step 3: Enterprise Value/Total Assets.
d. Variable(s) entered on step 4: Sales/Capital Employed.
e. Variable(s) entered on step 5: NWC/Total Assets.
f. Variable(s) entered on step 6: ROCE.
g. Variable(s) entered on step 7: PBIT Margin.
h. Variable(s) entered on step 8: Net Profit Margin.
i. Variable(s) entered on step 9: Operating Profit Margin.

Similarly, the variables in the equation step forward for Logistic Regression for this case is presented in Table 5-18 Variables in the Equation-Step Forward Logistic Regression. It ultimately shortlists 9 variables as discussed above.

Table 5-18 Variables in the Equation-Step Forward Logistic Regression

Steps and Variables		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
1	Total Debt/Total Assets	3.916	.235	278.51	1	.000	50.191	31.688	79.497
	Constant	-4.048	.140	839.59	1	.000	.017		
2	Sales/Total Assets	-1.952	.205	90.39	1	.000	.142	.095	.212
	Total Debt/Total Assets	3.114	.229	184.59	1	.000	22.513	14.366	35.281
	Constant	-2.473	.183	182.75	1	.000	.084		
3	Sales/Total Assets	-1.616	.196	68.18	1	.000	.199	.135	.291
	Total Debt/Total Assets	4.093	.314	169.72	1	.000	59.916	32.368	110.909
	EV/Total Assets	-1.665	.253	43.48	1	.000	.189	.115	.310
	Constant	-1.759	.196	80.73	1	.000	.172		
4	Sales/Total Assets	-1.617	.197	67.04	1	.000	.198	.135	.292
	Sales/Capital Employed	-.015	.008	3.51	1	.061	.985	.969	1.001
	Total Debt/Total Assets	4.143	.322	165.59	1	.000	63.003	33.520	118.420
	EV/Total Assets	-1.765	.262	45.33	1	.000	.171	.102	.286
	Constant	-1.709	.198	74.56	1	.000	.181		
5	NWC/Total Assets	-1.286	.236	29.69	1	.000	.276	.174	.439

	Sales/Total Assets	-1.338	.196	46.70	1	.000	.262	.179	.385
	Sales Capital/Em-ployed	-.012	.008	2.49	1	.114	.988	.973	1.003
	Total Debt/Total Assets	3.569	.338	111.48	1	.000	35.477	18.291	68.810
	EV/Total Assets	-1.918	.264	52.82	1	.000	.147	.088	.246
	Constant	-1.325	.208	40.40	1	.000	.266		
6	Return on Capital Employed	-.080	.034	5.49	1	.019	.923	.863	.987
	NWC/Total Assets	-1.258	.237	28.16	1	.000	.284	.179	.452
	Sales/Total Assets	-1.238	.199	38.66	1	.000	.290	.196	.428
	Sales/Capital Employed	-.057	.028	4.09	1	.043	.945	.894	.998
	Total Debt/Total Assets	3.671	.343	114.7	1	.000	39.310	20.082	76.948
	EV/Total Assets	-1.902	.266	50.97	1	.000	.149	.089	.252
	Constant	-1.413	.212	44.47	1	.000	.243		
7	PBIT Margin	-.029	.012	6.34	1	.012	.971	.949	.994
	ROCE	-.078	.033	5.63	1	.018	.925	.867	.986
	NWC/Total Assets	-1.205	.241	24.95	1	.000	.300	.187	.481
	Sales/Total Assets	-1.108	.197	31.70	1	.000	.330	.225	.486
	Sales/Capital Employed	-.056	.028	3.97	1	.046	.946	.896	.999
	Total Debt/Total Assets	3.625	.345	110.55	1	.000	37.529	19.095	73.757
	EV/Total Assets	-1.824	.263	48.15	1	.000	.161	.096	.270
	Constant	-1.562	.216	52.08	1	.000	.210		
8	Net Profit Margin	.849	.339	6.28	1	.012	2.336	1.203	4.537
	PBIT Margin	-.907	.357	6.45	1	.011	.404	.201	.813
	Return on Capital Employed	-.072	.033	4.89	1	.027	.930	.873	.992
	NWC/Total Assets	-1.173	.246	22.64	1	.000	.309	.191	.502
	Sales/Total Assets	-1.131	.199	32.45	1	.000	.323	.219	.476
	Sales/Capital Employed	-.053	.028	3.53	1	.060	.949	.898	1.002
	Total Debt/Total Assets	3.420	.354	93.45	1	.000	30.584	15.287	61.187
	EV/Total Assets	-1.748	.261	44.78	1	.000	.174	.104	.290
	Constant	-1.480	.221	44.64	1	.000	.228		
9	Net Profit Margin	1.884	.493	14.61	1	.000	6.577	2.504	17.276
	Operating Profit Margin	.174	.050	12.32	1	.000	1.191	1.080	1.312
	PBIT Margin	-2.049	.529	15.00	1	.000	.129	.046	.363
	ROCE	-.064	.032	3.94	1	.047	.938	.880	.999
	NWC/Total Assets	-1.113	.251	19.58	1	.000	.329	.201	.538
	Sales/Total Assets	-1.140	.201	32.29	1	.000	.320	.216	.474
	Sales/Capital Employed	-.048	.029	2.85	1	.091	.953	.901	1.008
	Total Debt/Total Assets	3.361	.349	92.72	1	.000	28.832	14.546	57.149
	EV/Total Assets	-1.675	.259	41.76	1	.000	.187	.113	.311
	Constant	-1.507	.223	45.84	1	.000	.222		

In furtherance to model building process the forward likelihood of variables is computed in Table 5-19 Variables not in the Equation-Step Wise-Forward Likelihood. It considers all the variables in the first step and keeps removing step by step. At the end 12 variables are left that means 9 are significant and discussed in Table 5-18 Variables in the Equation-Step Forward Logistic Regression.

Table 5-19 Variables not in the Equation-Step Wise-Forward Likelihood

			Score	df	Sig.
Step 1	Variables	Current Ratio	.926	1	.336
		Net Profit Margin	15.068	1	.000
		Operating Profit Margin	7.187	1	.007
		PBIT Margin	15.128	1	.000
		Return On Assets	36.498	1	.000
		Return On Shareholders Fund	2.487	1	.115
		ROCE	34.158	1	.000
		Interest Service Coverage Ratio	.877	1	.349
		NWC/Total Assets	36.940	1	.000
		Retained Earnings/Total Assets	.028	1	.868
		PBIT/Total Assets	42.756	1	.000
		Market Cap/BV Of Debt	.116	1	.733
		Sales/TA	78.091	1	.000
		Inc dec Loan Funds/CF From Loan	.004	1	.951
		Sales/Capital Employed	2.824	1	.093
		Cf Financing/Cf Investing Activities	2.498	1	.114
		Minority Interest/Pat	.148	1	.700
		Debt/EV	.231	1	.630
		Pat/EV	.042	1	.837
		EV/Total Assets	27.046	1	.000
Step 2	Variables	Current Ratio	.397	1	.529
		Net Profit Margin	9.006	1	.003
		Operating Profit Margin	4.137	1	.042
		PBIT Margin	9.130	1	.003
		Return On Assets	14.429	1	.000
		Return On Shareholders Fund	1.409	1	.235
		ROCE	11.474	1	.001
		Interest Service Coverage Ratio	.745	1	.388
		NWC/Total Assets	19.903	1	.000
		Retained Earning/Total Assets	3.029	1	.082
		PBIT/Total Assets	16.715	1	.000
		Market Cap Of Debt	.129	1	.720
		Inc Or Dec Loan Funds/CF From Loan	.076	1	.783
		Sales/Capital Employed	5.409	1	.020

		Cf Financing/Cf Investing	1.024	1	.311
		Minority Interest/Pat	.131	1	.717
		Total Debt/Ev	.194	1	.659
		Pat/EV	.020	1	.887
		EV/Assets	33.550	1	.000
Step 3	Variables	Current Ratio	1.032	1	.310
		Net Profit Margin	7.607	1	.006
		Operating Profit Margin	3.849	1	.050
		PBIT Margin	7.691	1	.006
		Return On Total Assets	6.213	1	.013
		Return On Shareholders Fund	1.304	1	.253
		Return On Capital Employed	3.399	1	.065
		Interest Service Coverage Ratio	.412	1	.521
		NWC/Total Assets	33.007	1	.000
		Retained Earning/Total Assets	3.483	1	.062
		PBIT/Total Assets	7.985	1	.005
		Market Cap TO BV Of Debt	.007	1	.933
		Inc Or Dec Loan Funds/CF From Loan	.121	1	.728
		Sales/Capital Employed	42.323	1	.000
		Cf Financing/Cf Investing	.929	1	.335
		Minority Interest/PAT	.113	1	.737
		Total Debt/EV	.145	1	.703
		PAT/EV	.022	1	.883
Step 4	Variables	Current Ratio	1.004	1	.316
		Net Profit Margin	7.520	1	.006
		Operating Profit Margin	3.834	1	.050
		PBIT Margin	7.602	1	.006
		Return On Assets	5.965	1	.015
		Return On Shareholders Fund	1.297	1	.255
		Return On Capital Employed	10.251	1	.001
		Interest Service Coverage Ratio	.417	1	.518
		NWC/Total Assets	30.844	1	.000
		Retained Earning/Total Assets	2.475	1	.116
		PBIT/Total Assets	7.647	1	.006
		Market Cap TO BV Of Debt	.006	1	.937
		Inc Or Dec Loan Funds/CF From Loan	.126	1	.722
		Cf Financing/Cf Investing	.926	1	.336
		Minority Interest/PAT	.113	1	.737
		Total Debt/EV	.151	1	.698
		PAT/EV	.026	1	.873
Step 5	Variables	Current Ratio	1.003	1	.317
		Net Profit Margin	6.630	1	.010
		Operating Profit Margin	2.899	1	.089
		PBIT Margin	6.763	1	.009
		Return On Assets	1.103	1	.294
		Return On Shareholders Fund	1.137	1	.286

		Return On Capital Employed	7.644	1	.006
		Interest Service Coverage Ratio	.454	1	.501
		Retained Earning/Total Assets	4.875	1	.027
		PBIT/Total Assets	2.948	1	.086
		Market Cap TO BV Of Debt	.007	1	.935
		Inc Or Dec Loan Funds/CF From Loan	.195	1	.659
		Cf Financing/Cf Investing	.179	1	.672
		Minority Interest/PAT	.074	1	.786
		Total Debt/EV	.133	1	.716
		PAT/EV	.029	1	.866
Step 6	Variables	Current Ratio	1.044	1	.307
		Net Profit Margin	6.747	1	.009
		Operating Profit Margin	2.891	1	.089
		PBIT Margin	6.878	1	.009
		Return On Assets	2.038	1	.153
		Return On Shareholders Fund	1.206	1	.272
		Interest Service Coverage Ratio	.433	1	.511
		Retained Earning/Total Assets	3.006	1	.083
		PBIT/Total Assets	4.422	1	.035
		Market Cap TO BV Of Debt	.006	1	.939
		Inc Or Dec Loan Funds/CF From Loan	.188	1	.665
		Cf Financing/Cf Investing	.177	1	.674
		Minority Interest/PAT	.071	1	.790
		Total Debt/EV	.129	1	.720
		PAT/EV	.029	1	.864
Step 7	Variables	Current Ratio	1.245	1	.264
		Net Profit Margin	10.354	1	.001
		Operating Profit Margin	2.394	1	.122
		Return On Assets	.361	1	.548
		Return On Shareholders Fund	1.291	1	.256
		Interest Service Coverage Ratio	.394	1	.530
		Retained Earning/Total Assets	4.187	1	.041
		PBIT/Total Assets	1.684	1	.194
		Market Cap TO BV Of Debt	.006	1	.938
		Inc Or Dec Loan Funds/CF From Loan	.163	1	.686
		Cf Financing/Cf Investing	.057	1	.812
		Minority Interest/PAT	.069	1	.793
		Total Debt/EV	.122	1	.727
		PAT/EV	.038	1	.846
Step 8	Variables	Current Ratio	1.010	1	.315
		Operating Profit Margin	24.270	1	.000
		Return On Assets	.028	1	.866
		Return On Shareholders Fund	1.228	1	.268
		Interest Service Coverage Ratio	.399	1	.528
		Retained Earning/Total Assets	3.623	1	.057

		PBIT/Total Assets	.538	1	.463
		Market Cap TO BV Of Debt	.007	1	.935
		Inc Or Dec Loan Funds/CF From Loan	.163	1	.686
		Cf Financing/Cf Investing	.014	1	.906
		Minority Interest/PAT	.061	1	.805
		Total Debt/EV	.125	1	.723
		PAT/EV	.045	1	.833
Step 9	Variables	Current Ratio	.788	1	.375
		Return On Assets	.105	1	.745
		Return On Shareholders Fund	1.157	1	.282
		Interest Service Coverage Ratio	.371	1	.542
		Retained Earning/Total Assets	2.995	1	.084
		PBIT/Total Assets	.626	1	.429
		Market Cap TO BV Of Debt	.007	1	.935
		Inc Or Dec Loan Funds/CF From Loan	.173	1	.677
		Cf Financing/Cf Investing	.027	1	.870
		Minority Interest/PAT	.053	1	.817
		Total Debt/EV	.124	1	.725
		PAT/EV	.045	1	.833

Further, residual Chi-Squares are not computed because of redundancies. The next step is to check the new models with explanatory variables are getting better or improved as compared to baseline model. For assessing, chi-square test is computed and presented in Table 5-20 Omnibus Tests of Model Coefficients. It is to check if there is a significant difference between Log-likelihoods of the baseline model and the new developed model. Chi-Square of the model starts with 487.6 and after 9th step its significantly improves to 785.9.

Table 5-20 Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	487.594	1	.000
	Block	487.594	1	.000
	Model	487.594	1	.000
Step 2	Step	122.295	1	.000
	Block	609.888	2	.000
	Model	609.888	2	.000
Step 3	Step	84.953	1	.000
	Block	694.842	3	.000
	Model	694.842	3	.000
Step 4	Step	7.789	1	.005
	Block	702.630	4	.000
	Model	702.630	4	.000
Step 5	Step	34.448	1	.000

	Block	737.078	5	.000
	Model	737.078	5	.000
Step 6	Step	7.142	1	.008
	Block	744.220	6	.000
	Model	744.220	6	.000
Step 7	Step	19.360	1	.000
	Block	763.581	7	.000
	Model	763.581	7	.000
Step 8	Step	9.412	1	.002
	Block	772.993	8	.000
	Model	772.993	8	.000
Step 9	Step	12.879	1	.000
	Block	785.872	9	.000
	Model	785.872	9	.000

There has been a significant improvement in the models developed as compared to baseline model as presented in Table 5-21 R square- Model Summary. Log Likelihood has decreased from 1470 to 1172 with pseudo R Square; Cox & Snell R square and Nagelkerke R square. Cox and Snell R-Square improved from 0.145 to 0.222 in the new model as compared to baseline model. Similarly, Nagelkerke R square has also improved from 0.31 to 0.478 in new model.

Table 5-21 R square- Model Summary

Step	-2 Log likelihood	Cox & Snell Rsquare	Nagelkerke Rsquare
1	1470.285[a]	.145	.310
2	1347.990[b]	.177	.381
3	1263.037[c]	.199	.428
4	1255.248[c]	.201	.433
5	1220.800[c]	.210	.451
6	1213.658[c]	.212	.455
7	1194.298[c]	.217	.466
8	1184.885[c]	.219	.471
9	1172.006[c]	.222	.478

The significant 9 variables are Net Profit Margin, Operating Profit Margin, PBIT Margin, Return on Capital Employed, Working Capital to Total Assets, Sales to Total Assets, Total Debt to Assets and Enterprise to Total Assets. The statistically significant equation is:

P =(-1.507+1.884 Net Profit Margin+ 0.174 Operating Profit Margin -2.049 PBIT Margin -0.64 ROCE -1.113 Working Capital to Total Assets -1.140 Sales to Total Assets+.361 Total Debt to Total Assets -1.675 EV to Total Assets)/1+(-1.507+1.884 Net Profit Margin+0.174

Operating Profit Margin -2.049 PBIT Margin -0.64 ROCE -1.113 Working Capital to Total Assets -1.140 Sales to Total Assets+3.361 Total Debt to Assets -1.675 EV to Total Assets)

Maximum weight is provided to Total Debt to Total Assets followed by Net Profit Margin, negative relation with PBIT Margin is substantial followed by EV to Total Assets, Working Capital to Total Assets, and Sales to Total Assets.

With the significant model construction and accuracy rate of 93.1% Logistic Regression has been able to provide world class accuracy; it is above 90% as per the literature.

5.5. Multivariate Discriminant Analysis

Discriminant Analysis searches for a set of prediction equations; it helps to classify independent into groups through independent variables. It helps in better understanding of the relationship amongst the variables. It helps to find relationship through mathematical expressions. Discriminant analysis is used to determine the minimum number of dimensions needed to describe these differences. A distinction is sometimes made between descriptive discriminant analysis and predictive discriminant analysis.

Based on the SPSS software, the data has provided the results presented in Table 5-22 Analysis Case Processing Summary. Out of total 3319 company years 196 were not considered for computing as at least one of the discriminating variables was missing it is same as Logistic Regression where 94.1% of the data was considered for computation. The canonical structure represents correlations between observed variables and the unobserved discriminant functions (dimensions).

Table 5-22 Analysis Case Processing Summary

Unweighted Cases		N	Percent
Valid		3123	94.1
Excluded	Missing or out-of-range group codes	0	.0
	At least one missing discriminating variable	196	5.9
	Both missing or out-of-range group codes and at least one missing discriminating variable	0	.0
	Total	196	5.9
Total		3319	100.0

Canonical discriminant analysis is used to determine relationship between various categorical variables and a group of independent variables. It is a multivariate technique used when

relationship is to be found between various types of variables and the ultimate outcome. Like in this case, all the financial ratios are the variables and independent outcome or variable is the result, whether the company is default or not. Canonical Correlation is more than 0.5. Eigen value is the value calculated and used in deciding how many factors to extract in the overall analysis is 0.352 as provided in Table 5-23 Eigenvalues.

Table 5-23 Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.352[a]	100.0	100.0	.510

Wilks' lambda is a measure of how well each function separates cases into groups. It is equal to the proportion of the total variance in the discriminant scores not explained by differences among the groups. In this case it is 0.74 as present in

Table 5-24 Wilks' **Lambda** which is far from 0 means less number of variables contributes to the discriminant function. However, it is statistically significant.

Table 5-24 Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1	.740	938.252	21	.000

As per Table 5-25 Standardized Canonical Discriminant Function Coefficients among 21 variables 13 variables have positive relation while 8 are negative. The variables with positive relation are as mentioned below:

1. Net Profit Margin
2. Return on Shareholders' Fund
3. ROCE
4. Interest Service Coverage Ratio
5. Net Working Capital/Total Asset
6. PBIT/Total Asset
7. Sales/Total Assets
8. Increase or Decrease Loan Funds/CF from Loan
9. Sales/Capital Employed
10. CF Financing/CF Investing
11. Minority Interest/PAT
12. PAT/EV
13. EV /Total Assets

The substantial weights are of Net Profit Margin, PBIT Margin, Return on Assets, PBIT/Total Assets, Total Debt/Total Assets, Total Debt/EV and PAT/EV.

Strongest positive relation is with Net Profit Margin followed by PBIT to Assets, while, strongest negative relation is with PBIT margin followed by Return on Asset. Insignificant relation comes out with Current Ratio, Market Capitalization to Book Value of Total Debt, Increase (Decrease) of Cash flow from Financing Activities to Cash flow from Loan, Interest Service Coverage Ratio and Minority Interest to PAT as present in the following Table 5-25 Standardized Canonical Discriminant Function Coefficients.

Table 5-25 Standardized Canonical Discriminant Function Coefficients

	Function
Variables	**1**
Current Ratio	-.018
Net Profit Margin	1.432
Operating Profit Margin	-.368
PBIT Margin	-.910
Return on Assets	-.859
Return on Shareholders' Funds	.097
ROCE	.101
Interest Service Coverage Ratio	.008
Net Working Capital/Total Assets	.422
Retained Earnings/Total Assets	-.186
PBIT/Total Assets	.921
Market Cap/BV of Total Debt	-.010
Total Sales/Total Assets	.205
Inc or Dec Loan Funds/CF from Loan	.009
Sales/Capital Employed	.095
Total Debt/Total Assets	-.671
CF Financing/CF Investing	.067
Minority Interest/PAT	.020
Total Debt/EV	-1.224
PAT/EV	1.215
EV/Total Assets	.031

The Centroids in Multivariate Discriminate Analysis represents correlation between three continuous discriminating variables and the dimensions created with the unobserved discriminant functions. From the Table 5-26 Functions at Group Centroids, non default that is '0' which is interpreted as the point at which the company is predicted to be safe and lowest chance of bankruptcy is at 0.192. For prediction of wilful default companies the threshold is -1.833. It means the overall score of any company below -1.833 has a very high chance of bankruptcy. This can be summarized as the score above 0.192 is safe for the lender and below -1.833 is highly unsafe. Between 0.192 and -1.833 can be considered as the caution zone where lender has to get cautious.

Table 5-26 Functions at Group Centroids

DEFAULT	Function 1
0	.192
1	-1.833

The ultimate results on prediction accuracy are presented in Table 5-27 Classification Results. It shows overall 91.2% of the cases or the observations are predicted correctly. 2666 observation of Non Default were correctly predicted as Non Default while 115 were not predicted accurately. In case of default 161 were incorrectly predicted while 181 were correctly prediction. Prediction rate of Non default correctly is 94.3% and Default is 61.1%.

Table 5-27 Classification Results

			Predicted Group Membership		
		DEFAULT-1/2	0	1	Total
Original	Count	0	2666	161	2827
		1	115	181	296
	%	0	94.3	5.7	100.0
		1	38.9	61.1	100.0
91.2% of original grouped cases correctly classified.					

The overall predictability of MDA in this case is 91.2% with 21 variables. Out of 21 variables 14 variables are have correlation less than 0.5 on either side, 7 variables have strong correlations which includes Net Profit Margin, PAT to EV, PBIT to Total Assets, Total Debt to Total Assets, Return on Assets, PBIT Margin Total Debt to Enterprise Value. The Centroid of the variable correlations is 0.1922 for Non Default and for default it is -1.833.

5.6. Artificial Neural Network (ANN)

Artificial Neural Network is an attempt to replicate the brain's neural network. It has been used extensively for programming of Artificial Intelligence Software. As per the literature review, this method has the highest accuracy rate. With reference to the study conducted, results from SPSS software is discussed below. It takes several steps to come up with the results. It starts with Case PROCEssing of eligible data followed by input layer variables, hidden layer and Output layer. It also provides the summary of model predictions and shows normalized data of variables in descending order of importance.

By default, ANN case processing is divided into training and testing data in the proportion of 70:30. Training data of 70% is the selected randomly by the system to build up the model and the same model is tested on 30 % of the data. Out of total 3319 observations of company years 196 are excluded as discussed above in Logistic Regression and MDA. Approximate training data is 2161 and testing is 962 as presented in Table 5-28 Case Processing Summary.

Table 5-28 Case Processing Summary

		N	Percent
Sample	Training	2161	69.2%
	Testing	962	30.8%
Valid		3123	100.0%
Excluded		196	
Total		3319	

Further, as presented in Table 5-29 Network Information, the ANN works with the model where there are at least 3 layers; input, hidden and outer layers. In the study, input layer consists of 21 variables and it has 1 hidden layer with 6 units. For the hidden layer Activation function is Hyperbolic Tangent function. Output layers are 2 with activation function Softmax.

Table 5-29 Network Information

Input Layer	Covariates	1	Current Ratio
		2	Net Profit Margin
		3	Operating Profit Margin
		4	PBIT Margin
		5	Return on Assets
		6	Return on Shareholders' Fund
		7	ROCE
		8	Interest Service Coverage Ratio
		9	Net Working Capital/Total Assets
		10	Retained Earning/Total Assets
		11	PBIT/Total Assets

		12	Market Cap/BV Of Total Debt
		13	Sales/TOTAL ASSETS
		14	Inc Dec Loan Funds/CF From Loan
		15	Sales/Capital Employed
		16	Total Debt/Total Assets
		17	CF Financing/CF Investing
		18	Minority Interest/PAT
		19	Debt/EV
		20	PAT/EV
		21	EV/Total Assets
	Number of Units[a]		21
	Rescaling Method for Covariates		Standardized
Hidden Layer(s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1[a]		6
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables	1	DEFAULT
	Number of Units		2
	Activation Function		Softmax
	Error Function		Cross-entropy

Excluding the bias unit

As the function takes Softmax Activation function, the error function is the cross entropy error. It shows training data incorrectly predicted was 6.2% and testing data predicted incorrectly was 7.8%, the same is presented in the Table 5-30 Model Summary.

Table 5-30 Model Summary

Training	Cross Entropy Error	372.757
	Percent Incorrect Predictions	6.2%
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	0:00:00.78
Testing	Cross Entropy Error	181.972
	Percent Incorrect Predictions	7.8%

The results are generated in two categories; Training and Testing as discussed in Table 5-28 Case Processing Summary. The details of the incorrect prediction which is the cross entropy error in Table 5-30 Model Summary are further displayed with details in Table 5-31 Classification. The model constructed using ANN provides 92.2% correct predictions. In training section, the overall correct prediction rate is 93.8% and testing data prediction accuracy is 92.2%. As the final outcome testing data accuracy is to be considered for the model. Non-Default predictions were 97.4% accurate in Training data and 96.5% in Testing data while Default predictions were 58.1% in Training and 51.6% in Testing data.

Table 5-31 Classification

Sample	Observed	Predicted		
		NO	YES	Percent Correct
Training	NO	1908	50	97.4%
	YES	85	118	58.1%
	Overall Percent	92.2%	7.8%	93.8%
Testing	NO	839	30	96.5%
	YES	45	48	51.6%
	Overall Percent	91.9%	8.1%	92.2%

Dependent Variable: DEFAULT

The function provides independent variable importance in Table 5-32 Independent Variable Importance; highest is PBIT/Total Assets followed by EV/Total Assets, Operating Profit Margin, Cash Flow Financing/Cash Flow Investing, Total Debt/Total Asset, Sales/Capital Employed, Retained Earnings/Total Assets, Return on Shareholders' Funds, PBIT/Sales, and others.

Table 5-32 Independent Variable Importance

	Importance	Normalized Importance
Current Ratio	.027	28.5%
Net Profit Margin	.040	41.9%
Operating Profit Margin	.065	67.7%
PBIT Margin	.049	51.4%
Return on Assets	.043	45.0%
Return on Shareholders' Fund	.051	52.9%
ROCE	.031	32.0%
Interest Service Coverage Ratio	.025	26.2%
Net Working Capital/Total Assets	.045	46.4%
Retained Earning/Total Assets	.058	60.0%
PBIT/Total Assets	.096	100.0%
Market Cap/BV Of Total Debt	.025	26.2%
Sales/TOTAL ASSETS	.035	36.7%
Inc Dec Loan Funds/CF From Loan	.044	46.3%
Sales/Capital Employed	.058	60.1%
Total Debt/Total Assets	.060	62.3%
CF Financing/CF Investing	.063	65.5%
Minority Interest/PAT	.037	38.9%
Debt/EV	.032	33.7%
PAT/EV	.029	30.1%
EV/Total Assets	.086	89.2%

The details of normalized importance of variable in descending order is presenting in below Figure 5-1 Normalized Importance-Artificial Neural Network.

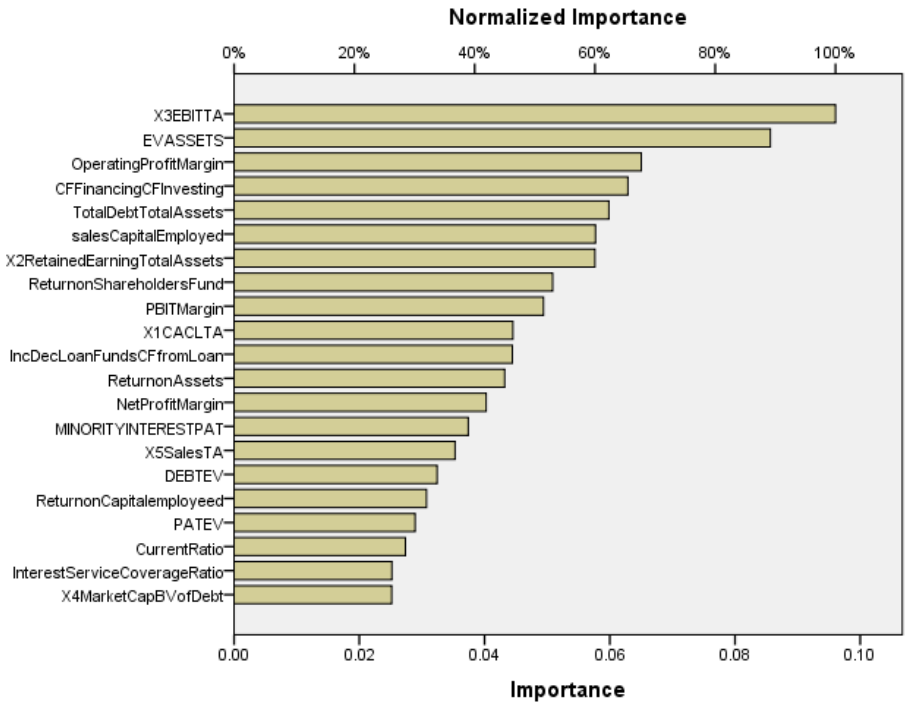

Figure 5-1 Normalized Importance-Artificial Neural Network

Further, the pictorial representation of Artificial Neural Network with 3 layers; Input, Hidden and Output layers are presented in Figure 5-2 Artificial Neural Network 1 layer structure. It shows various nodes connected from Input layer that is 21 variables from 3319 company years are computed and presented in Hidden layers of 6 nodes providing the ultimate outcome of Yes or No in terms of default.

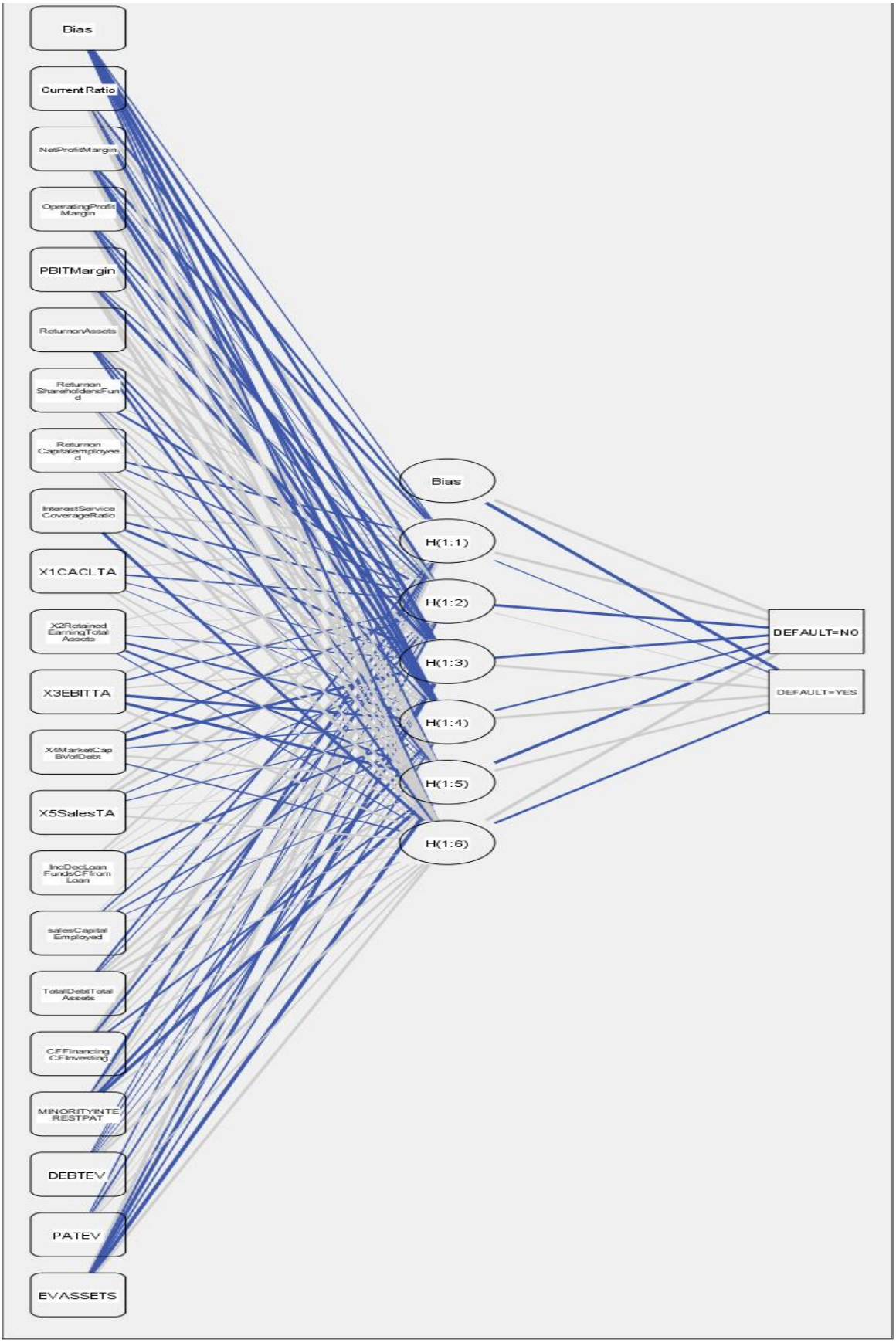

Figure 5-2 Artificial Neural Network 1 layer structure

Artificial Neural Network constructs the models using 70% of the data as Training and remaining 30% as testing to construct and test the model constructed using the method. It takes 21 variables as input, provides 6 nodes from hidden layer and 2 outcomes in output layer. With the use of Softmax activation function, Cross Entropy Error for Training and testing data is 6.2% and 7.8% respectively. Overall prediction accuracy of testing data is 92.2%. The variables of high importance are highest is PBIT/Total Assets followed by EV/Total Assets, Operating Profit Margin, Cash Flow Financing/Cash Flow Investing, Total Debt/Total Asset, Sales/Capital Employed, Retained Earnings/Total Assets, Return on Shareholders' Funds, PBIT/Sales, and others.

5.7. Decision Tree

Decisions Trees creates classification and helps in better identifying groups, discover relationships between groups and predict future events. Visual diagrams enable to present categorical results in an intuitive manner; it can clearly explain the results to non-technical audiences. The trees explore results and visually determine model flows. Visual results can help to find specific subgroups and relationships that might not be uncovered using more traditional statistics. Because classification trees break the data down into branches and nodes which can easily see where a group splits and terminates. The model construction details as the input for Decision Tree is present in Table 5-33 Model Summary. It takes the growing Method as CHAID. CHAID stands for Chi-square Automatic Interaction Detector, it is a tool used to discover the relationship between variables. It enables to construct the model or tree to explain the outcome with given input or dependent variables. Maximum Tree depth allowed in the system is 3 with minimum nodes in parents of 100 and minimum child node of 50. In the study, the outcome shows the decision tree has 24 numbers of node and 16 terminal nodes with a depth of 3.

Table 5-33 Model Summary

Specification	Growing Method	CHAID
	Dependent Variable	DEFAULT

	Independent Variables	Current Ratio, Net Profit Margin, Operating Profit Margin, PBIT Margin, Return on Assets, Return on Shareholders' Funds, ROCE, Interest Service Coverage Ratio, Net Working Capital/Total Assets, Retained Earnings/Total Assets, PBIT/Total Assets, Market Cap/BV of Total Debt, Sales/Total Assets, Inc Dec Loan Funds/CF from Loan, Sales/Capital Employed, Total Debt/Total Assets, CF Financing/CF Investing, Minority Interest/PAT, Debt/EV, PAT/EV, EV/Total Assets
	Validation	None
	Maximum Tree Depth	3
	Minimum Cases in Parent Node	100
	Minimum Cases in Child Node	50
Results	Independent Variables Included	PBIT/TOTAL ASSETS, Sales/TOTAL ASSETS, Market Cap/BV of Total Debt, PBIT Margin, Interest Service Coverage Ratio
	Number of Nodes	24
	Number of Terminal Nodes	16
	Depth	3

The results from the decision tree shows 5 selected independent variables. These variables are PBIT to Total Assets, Sales to Total Assets, Market Capitalization to Book Value of Total Debt, PBIT Margin, and Interest Service Coverage Ratio as mentioned in Table 5-33 Model Summary.

Risk estimate as presented in Table 5-34 Risk presents the estimate as 0.069 and Standard Error is 0.04 by using CHAID growing method.

Table 5-34 Risk

Estimate	Std. Error
.069	.004

Growing Method: CHAID
Dependent Variable: DEFAULT

The pictorial representation of Decision Tree for prediction is present in Figure 5-3- Decision Tree Analysis (Part A) and Figure 5-4 Decision Tree Analysis (Part B) the same is presented in a tabular form in Table 5-35 Tree Table. The process involves 23 nodes where 5 variables PBIT to Total Assets, Sales to Total Assets, Market Capitalization to Book Value of Total Debt, PBIT Margin, and Interest Service Coverage Ratio are used in iteration. All these are significant variables where Chi-square value for PBIT to Assets is 1116.31, Sales to Total Assets 45.23, Market Capitalization to Book Value of Total Debt is 41.42, PBIT Margin is 10.09 and Interest Service Coverage Ratio is 14.328. Parent node number includes 0, 1, 2, 3, 4, 13, 14 and 17.

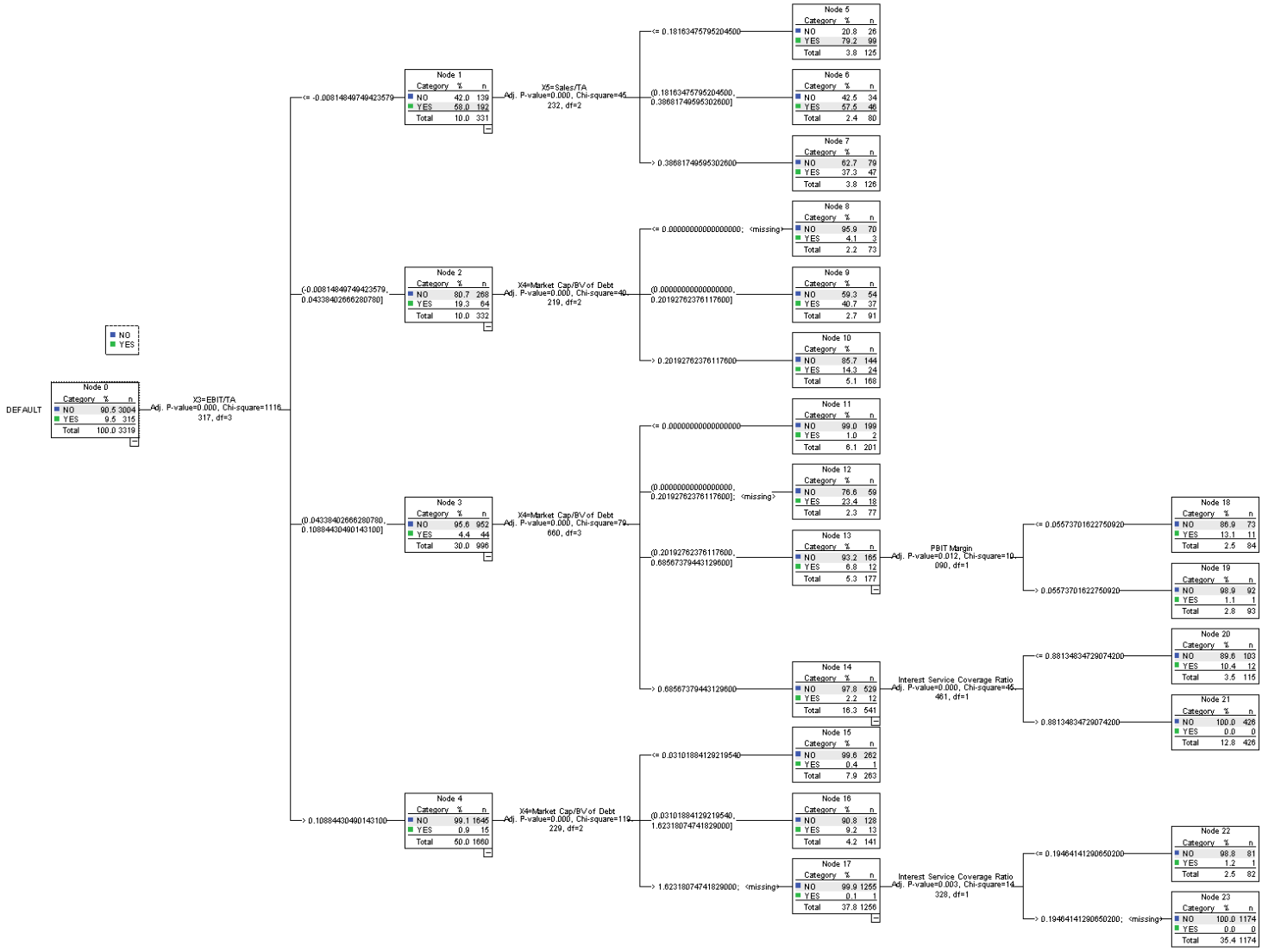

Figure 5-3- Decision Tree Analysis (Part A)

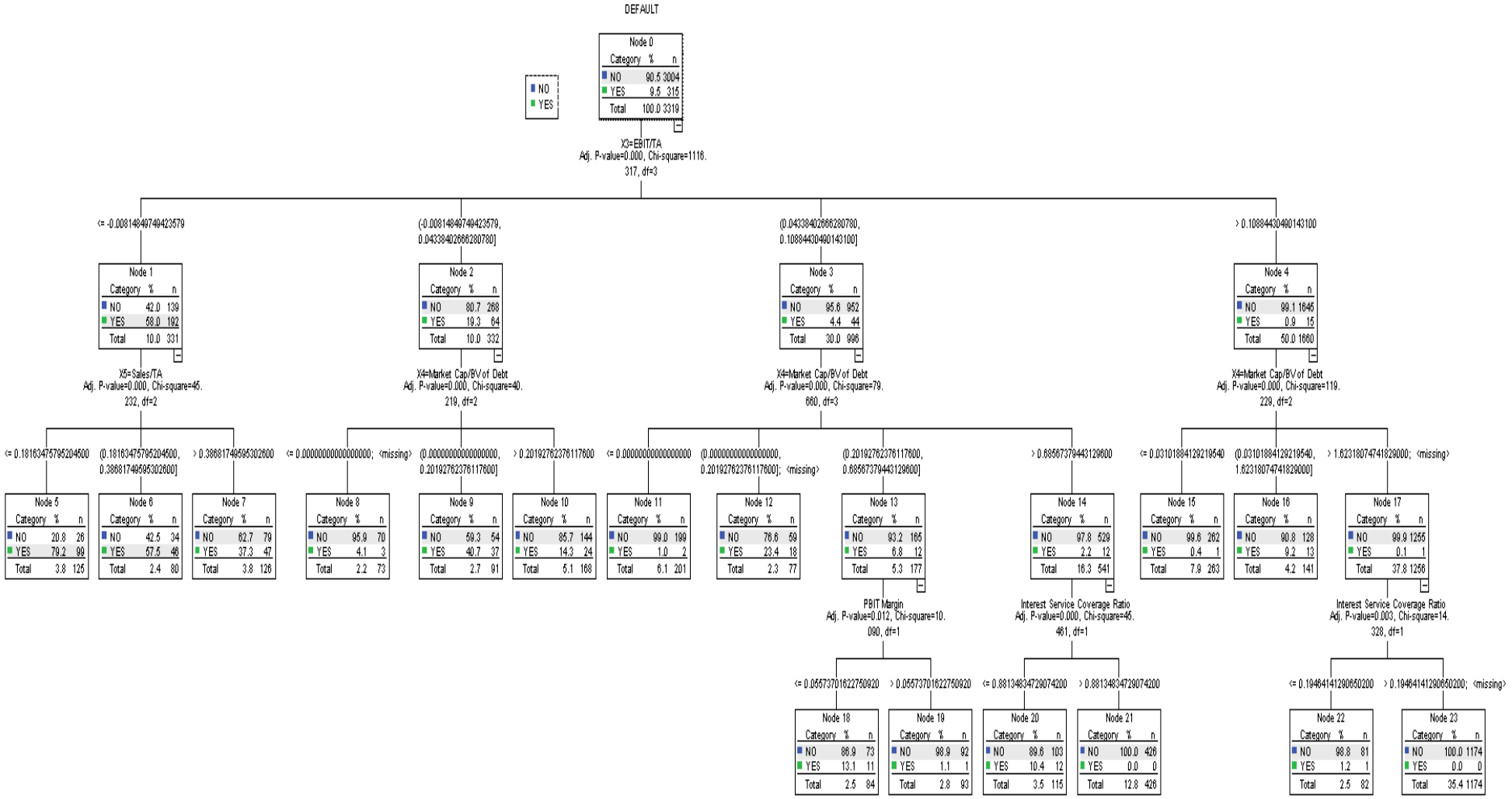

Figure 5-4 Decision Tree Analysis (Part B)

Table 5-35 Tree Table

Node	NO		YES		Total		Predicted Category	Parent Node	Primary Independent Variable				
	N	Percent	N	Percent	N	Percent			Variable	Sig.	Chi-Square	df	Split Values
0	3004	90.50%	315	9.50%	3319	100.00%	NO						
1	139	42.00%	192	58.00%	331	10.00%	YES	0	PBIT/TOTAL ASSETS	0	1116.31	3	<= -.008
2	268	80.70%	64	19.30%	332	10.00%	NO	0	PBIT/TOTAL ASSETS	0	1116.31	3	(-.0081
3	952	95.60%	44	4.40%	996	30.00%	NO	0	PBIT/TOTAL ASSETS	0	1116.31	3	(.0433, .1088]
4	1645	99.10%	15	0.90%	1660	50.00%	NO	0	PBIT/TOTAL ASSETS	0	1116.31	3	> .108
5	26	20.80%	99	79.20%	125	3.80%	YES	1	Sales/TOTAL ASSETS	0	45.232	2	<= .181
6	34	42.50%	46	57.50%	80	2.40%	YES	1	Sales/TOTAL ASSETS	0	45.232	2	(.181
7	79	62.70%	47	37.30%	126	3.80%	NO	1	Sales/TOTAL ASSETS	0	45.232	2	> .386
8	70	95.90%	3	4.10%	73	2.20%	NO	2	Market Cap/BV of Total Debt	0	40.219	2	0
9	54	59.30%	37	40.70%	91	2.70%	NO	2	Market Cap/BV of Total Debt	0	40.219	2	0, .201
10	144	85.70%	24	14.30%	168	5.10%	NO	2	Market Cap/BV of Total Debt	0	40.219	2	> .201
11	199	99.00%	2	1.00%	201	6.10%	NO	3	Market Cap/BV of Total Debt	0	79.66	3	<= .0

12	59	76.60%	18	23.40%	77	2.30%	NO	3	Market Cap/BV of Total Debt	0	79.66	3	(.00, .201],
13	165	93.20%	12	6.80%	177	5.30%	NO	3	Market Cap/BV of Total Debt	0	79.66	3	(.2019, .6850]
14	529	97.80%	12	2.20%	541	16.30%	NO	3	Market Cap/BV of Total Debt	0	79.66	3	> .685
15	262	99.60%	1	0.40%	263	7.90%	NO	4	Market Cap/BV of Total Debt	0	119.229	2	<= .031
16	128	90.80%	13	9.20%	141	4.20%	NO	4	Market Cap/BV of Total Debt	0	119.229	2	(.031, 1.62]
17	1255	99.90%	1	0.10%	1256	37.80%	NO	4	Market Cap/BV of Total Debt	0	119.229	2	> 1.623, <missing>
18	73	86.90%	11	13.10%	84	2.50%	NO	13	PBIT Margin	0.012	10.09	1	<= .0557
19	92	98.90%	1	1.10%	93	2.80%	NO	13	PBIT Margin	0.012	10.09	1	> .055
20	103	89.60%	12	10.40%	115	3.50%	NO	14	Interest Service Coverage Ratio	0	45.461	1	<= .881
21	426	100.00%	0	0.00%	426	12.80%	NO	14	Interest Service Coverage Ratio	0	45.461	1	> .881
22	81	98.80%	1	1.20%	82	2.50%	NO	17	Interest Service Coverage Ratio	0.003	14.328	1	<= .194

23	1174	100.00%	0	0.00%	1174	35.40%	NO	17	Interest Service Coverage Ratio	0.003	14.328	1	> .194

Table 5-36 Prediction and Observed Classification

Observed	Predicted		
	NO	YES	Percent Correct
NO	2944	60	98.0%
YES	170	145	46.0%
Overall Percentage	93.8%	6.2%	93.1%

Growing Method: CHAID Dependent Variable: DEFAULT

As present in Table 5-36 Prediction and Observed Classification overall accuracy predicted is 93.1% which is made of 98% of Non-Default company years and 46% of Default company years. Correctly predicted NO companies years are 2944 and YES companies years are145.

By using Decision Tree technique to predict default, it gist of the analysis lies in the fact that by using 21 variables only 5 variables are significant and can predict correctly at 93.1% accuracy using 23 nodes.

5.8. Comparison of Models-Results and Variables

All the models in the study; Logistic Regression, Multivariate Discriminant Analysis, Artificial Neural Network and Decision tree support each other and overcomes the deficiency of one another as discussed in the survey of literature. All the models are discussed at length, based on the results following is the summary of accuracy. Logistic Regression and Decision Tree are ranked number one with accuracy rate of 93.1% followed by ANN at 92.2% and MDA at 91.2% as present in Table 5-37 Summary-Accuracy wise Ranking. Interestingly, models for bankruptcy prediction require two distinct characteristics for the end user; transparency and accuracy. In the present study Logistic Regression and Decision Tree has both accuracy as well as transparency. Transparency is in terms of weight provided to various variables; in Logistic Regression and decision tree transparency is one of the strength and in this case it fulfils both the needs accuracy and transparency.

Table 5-37 Summary-Accuracy wise Ranking

Rank	**Technique**	**Accuracy (%)**
1	Logistic Regression	93.1
1	Decision Tree	93.1
2	Artificial Neural Network	92.2
3	Multivariate Discriminate Analysis	91.2

On the basis of various variables especially financial performance, the decision maker can keep an eye on the financial performance of the borrower. Following discussion is the significant

variables found across the models as present in Table 5-38 Significant variables from all the techniques.

Table 5-38 Significant variables from all the techniques

All Variables	LR	MDA	ANN	DT
CF Financing/CF Investing			□	
Current Ratio			□	
Total Debt/EV		□		
EV/Total Assets	□			
Inc Dec Loan Funds/CF from Loan			□	
Interest Service Coverage Ratio				□
Minority Interest/PAT				
Net Profit Margin	□	□	□	
Operating Profit Margin	□	□	□	
PAT/EV	□	□		
PBIT Margin	□	□	□	□
Return on Assets	□		□	
ROCE	□			
Return on Shareholders' Fund			□	
Sales/Capital Employed	□		□	
Total Debt/Total Assets	□	□	□	
Net Working Capital/Total Assets	□	□	□	
Retained Earning/Total Assets			□	
PBIT/Total Assets	□	□	□	□
Market Cap/BV of Total Debt				□
Sales/Total Assets	□	□		□

As analysed across all the models in the present study, it is found that Logistic Regression has 12 significant variables, 9 for MDA, 5 for Decision Tree and 13 for ANN. ANN variables are taken as 50 per cent cut off from the Normalized importance data.

Significant variables have been shortlisted based on statistical importance provided through results. PBIT Margin and PBIT/Total Asset has been present in all the models, it indicates Profit before Interest and Taxes is the most important variable. It indicates PBIT as a measure of liquidity would indicate the capacity to pay Total Debt obligations. Efficiency of using Assets and Sales in relation with PBIT is also seen in all the models. Other important ratios present in the models are Net Profit Margin, Operating Profit Margin, Total Debt to Total Assets, Net Working Capital to Current Liabilities and Sales to Total Assets. These ratios are

related to Profitability, Liquidity, Activity and Capital Structure. Distinct 10 ratios present in only ANN model; Cash Flow Financing to Cash flow Investing Activities, Current Ratio, Total Debt to EV, EV to Total Assets, Increase or Decrease Loan Funds to Cash Flow from Loan, Interest Service coverage Ratio, ROCE and Shareholders' Funds, Retained Earnings to Total Assets and Market Capitalization to Book Value of Total Debt. There is only one ratio which was not found significant in any of the models that is Minority Interest to PAT. Summary of significant variable present in all models is presented in Table 5-39 Summary of Significant Variables amongst all Models.

Table 5-39 Summary of Significant Variables amongst all Models

Sr. No.	Variables	Number of Techniques using corresponding variable
1	CF Financing/CF Investing	1
2	Current Ratio	1
3	Total Debt/EV	1
4	EV/Total Assets	1
5	Inc Dec Loan Funds/CF from Loan	1
6	Interest Service Coverage Ratio	1
7	Minority Interest/PAT	0
8	Net Profit Margin	3
9	Operating Profit Margin	3
10	PAT/EV	2
11	PBIT Margin	4
12	Return on Assets	2
13	ROCE	1
14	Return on Shareholders' Fund	1
15	Sales/Capital Employed	2
16	Total Debt/Total Assets	3
17	Net Working Capital/Total Assets	3
18	Retained Earnings/Total Assets	1
19	PBIT/Total Assets	4
20	Market Cap/BV of Debt	1
21	Sales/Total Assets	3

5.9. Conclusion

The research conforms to the bankruptcy prediction models accuracy; bankruptcy can be predicted with a high degree of reliability by using Altman's Z-score and Ohlson's O-score models. However, only 11 distinct companies, 6 by Altman's and 5 by Ohlson's scores eluded the prediction during the period. Since the sets of companies are different, it indicates that if more than one model is used by the banks, then the chances of bankruptcy prediction increases. The accuracy of the Altman and Ohlson models has been 94% and 95% respectively; the accuracy rate is high and attests to their reliability.

In the current study the companies listed from 2000 to 2011 has been constantly increasing, however, after the year 2011 has been a constant decline in listed companies. Currently only 56 out of 106 are in existence. A strong positive correlation of 0.76 between the increases in loans fund and high to moderate chances of bankruptcy according to Altman's model is found while with O-score it is only positive 0.26. The continual funding by the banks is an indication of taking warning signals lightly in many cases.

The continuous disbursement of loans after discernible high risk signals by the banks is not desirable. This is an indication of lapse on the part of the banks; 36, 50 and 68 companies were provided with loans for 4, 3 and 2 times consecutively even after weakening financial condition. The methodology adopted by the banks for monitoring the performance of the companies by using bankruptcy prediction models warrants a close look.

The study concludes that Logistic Regression and Decision Tree are the best amongst the shortlisted models to predict wilful default public limited companies in India. Both the models balance the requirement for the end user that is Transparency and Accuracy of the model. Surprisingly, Artificial Neural Network resulted in 92.2% accuracy, however, it is known for its better accuracy as per the literature review followed by Multiple Discriminant Analysis with 91.2%. Profit before Interest and Taxes has been one of the most important since it was present in all the models. Also, ANN gives the highest weight to PBIT to Total Assets. This indicates PBIT is the critical factor for predicting wilful default.

Net profit Margin, Operating Profit Margin, Total Debt to Total Assets, Net Working Capital to Current Liabilities and Sales to Total Assets variables are found to very important ratios since they were present in all models except Decision Tree. Logistic Regression considers important 12 variables, ANN with 9, MDA with 7 and Decision Tree with only 5 variables. Interest Service Coverage Ratio and Market Capitalization to Book Value of Total Debt were the variables included in Decision Tree but not in any other model and other common variables found in Logistic Regression are; Sales/Total Assets, PBIT/Total Assets and PBIT Margin.