

" BUSINESS FAILURE PREDICTION USING
DISCRIMINANT ANALYSIS "

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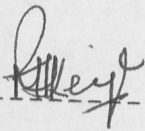
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DECLARATION

This management project is my original work and has not been presented for a degree in any other University

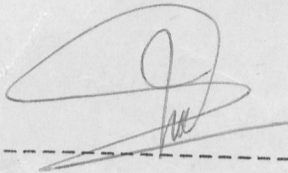
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This management project has been submitted for examination with my approval as University Supervisor.

Signed -----



MR. J.K. NJIRAINI

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ABSTRACT

Business firms are formed to operate into the foreseeable future. However there are cases where a business firm fails to fulfil the objectives for which it was formed or even to survive in the environment in which it was formed. In such cases, the stakeholders in the firm lose substantially, both in monetary and non - monetary terms. But if the failure of a business could be predicted with reasonable accuracy, then the stakeholders can act in good time to avoid or minimize the possible losses.

In this paper, the aim was to formulate a model to predict business failure. Data on some Kenyan companies that failed within the period 1980- 1990, was collected. These companies were matched with comparable successful firms; and ratios from their financial statements subjected to discriminant analysis.

The results showed that it is possible to predict failure with upto 90% accuracy two years before the event. In this case, current ratio, fixed charge coverage, retained earnings to total assets, return on total assets, return on net worth, average collection period and sales to total assets; were identified as the critical ratios that discriminate failed from non - failed firms in Kenya.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND:

The prediction of Business failure has for a long time attracted the attention of both Business managers and scholars. The failure of a business results in losses to various stakeholders, e.g. money by lenders, tax revenue by the government, investment by shareholders, jobs by employees, products by society and general economic slowdown. Therefore failure is costly to society, and its avoidance would eliminate the losses therein associated. Alternatively, if failure can be predicted precisely well in advance, there would be a reduction of the costs associated with it. Failure is in various forms as outlined herebelow:

1.1.1 Forms of Business Failure:

Generally business failure has been described as the inability of a firm to meet its obligations¹. Two major categories of failure can be distinguished:

1. WESTON AND COPELAND: Managerial Finance; Dryden Press, Eighth Edition pg. 952

Economic failure:

This situation occurs when the firm cannot operate "economically". This implies the firm is unable to realize revenues sufficient to cover costs, thus making operating losses continually. Economic failure would also occur in cases where the firm's returns on investment are less than the firm's cost of capital. In such a situation, the owners may want to divest from the business because their investment is not earning sufficient returns. Partial liquidation resulting from large scale cutbacks in operations also falls under economic failure.

Financial failure:

This is in two perspectives; technical insolvency and bankruptcy.

A firm which cannot meet its current obligations as they fall due is suffering from Technical insolvency. This is the case when current liabilities exceed current assets. While bankruptcy is a situation where total liabilities exceed the "fair" value of assets, i.e. a negative net worth.

However not all failure results in liquidation and winding up. Normally liquidation and winding up is as a result of a court order.

1.1.2 Causes of Business Failure:

The causes of corporate failure could be internal or external²

Internal causes are mainly the result of bad management

Bad management may engage in malfeasance and fraud, thereby dissipating the organization's resources and causing failure. Lack of adequate or relevant experience means management cannot be able to cope and respond to the demands of the industry. For example lack of responsiveness to technological advancements due to application of obsolete technology thus leading to inability to match competition.

Poor communication may lead to a communication breakdown and loss of coordination. This will further compound the problem of management for responses to environmental threats will be uncoordinated, leading to eventual failure of the firm. Also Inability to control costs will lead to financial distress and failure. For example trade unions may demand wages, the payment of which leads the firm to financial distress.

External factors include Government action and restrictions, e.g. foreign exchange controls and import restrictions may deny a firm essential raw materials and cause its collapse.

Others may be natural catastrophes e.g. fires, and demographic changes.

2. Dambolena I.G and Khoury S.J. : Ratio Stability and Corporate Failure; Journal of Finance, vol.XXXV, No. 4 Sept. 1980 pg. 1017.

1.1.3 Dealing with Business Failure:

A business that has failed has number of options, which result in either cessation of the firm or its continuation.³

These are as follows:

Out of court procedures:

In these, the firm may continue to exist by getting an extension from its creditors i.e. postponement of payment of debts, or by being granted a composition, where creditors agree to take less than the full amount due in full settlement.

Merger:

Generally a merger forms one economic unit from two or more previous units. The failing firm joins another firm, either as an independent subsidiary or it is absorbed into the operations of the other firm.

Formal legal procedures:

These include liquidation or reorganization.

3. Weston and Copeland: Managerial Finance; Dryden Press, Eighth Edition, pg.954

Reorganization is undertaken if its thought the business is still feasible and can recover from financial distress, and when liquidation will result in extreme loss as compared to reorganization. It involves a restructuring of the business or scaling down of its operations.

Liquidation involves closing down the business and disposing off its assets and using the proceeds to settle outstanding obligations.

CHAPTER 2

LITERATURE REVIEW:

FAILURE PREDICTION MODELS:

The prediction of failure has interested both Academic researchers and Business managers for a long time. Various methods of prediction have been developed over the last decades. These methods can broadly be classified as ratio based and non-ratio based methods. These methods will be reviewed with the accompanying literature below:

2.1 Ratio Based Failure Prediction Models:

Introduction:

In practice financial ratios are used in many areas e.g. by bank loan officers and credit rating agencies to assess the performance of business firms and pinpoint candidates for failure or loan default.

The use of ratios is based on the realization that failing firms' ratios are significantly different from non-failing firms ratios⁴

4. E.I. Altman: Financial ratios, Discriminant analysis and the prediction of corporate bankruptcy; Journal of Finance, Vol.XXIII, No. 4, Sept. 1968.

Generally ratio based models are in two categories:

i) Univariate models

ii) Multivariate models

In this section, both of these models will be surveyed, and their strengths and weaknesses highlighted.

2.1.1 Univariate Models:

The key characteristic which distinguishes these models from other ratio based models is that analysis is based on individual ratios. Thus overall assessment is a product of the individual ratio assessments.

TAMARI (1966) Studied the balance sheets of sixteen industrial companies in Israel which had been declared bankrupt and Twelve companies which were on the verge of bankruptcy in the five year period 1956 - 1960. He found that the financial ratios of these companies were lower than for the industry as a whole for the five years prior to bankruptcy; and that indeed these ratios had fallen during the period.

Debt ratio, Net profit margin and quick ratio, were found to have dropped markedly during the five years prior to bankruptcy. Specifically he found that 70% of the bankrupt companies had a current ratio less than 1:1, while only 30% of all industrial firms in Israel had a similar ratio between 1958 and 1960. Long term financing was insufficient to cover long term investments, while the relative share of equity was lower for

bankrupt firms in the year prior to bankruptcy than among all industries in the five year period reviewed. Majority of bankrupt companies made losses in four out of the five years prior to bankruptcy while the industry profits actually rose by 80%

Tamari constructed an index of risk whereby ratios considered as indicators of financial soundness were weighted, according to their importance to the financial analyst. When the index was tested, it was found that firms with below 30 points had a higher probability of going bankrupt than other firms, say those with 60 points or more.

An example of such an index follows:

Ratio	Points
Equity capital/Total liabilities	25
Profit trend	25
Current ratio	20
Value of production/inventory	10
Sales/receivables	10
Value of production/working capital	<u>10</u>
	100

Adapted from Meir Tamari: Financial ratios as a means of

forecasting bankruptcy;

management international

review, Vol.4, 1966pg19.

BEAVER (1968) in a survey of 79 failed and 79 non - failed firms drawn from Moody's industrial manuals during the period 1954 to 1964, found that non-liquid asset ratios were better predictors of failure both in the short and long term.

2.1.2 Multivariate Models:

ALTMAN (1968), used financial ratios and the technique of discriminant analysis to develop a model to predict corporate bankruptcy. Discriminant analysis is a way of classifying an observation into one of several a priori groupings or make predictions where the dependent variable appears in quantitative form .⁵

* Altman's model computes a score which "discriminates" bankrupt from non-bankrupt firms, while univariate models evaluated each ratio at a time to assess potential failure.

The model took the following form:

$$Z = V_1X_1 + V_2X_2 + V_3X_3 + \dots V_nX_n$$

5. Edward I. Altman: Financial ratios, discriminant analysis and the prediction of corporate bankruptcy; Journal of Finance, Vol XXIII No. 4, Sept 1968.

It was used to transform individual values to a single discriminant score or Z value which would be used to classify firms. $V_1, V_2, V_3, \dots, V_n$ are the discriminant coefficients, while $X_1, X_2, X_3, \dots, X_n$ are independent variables.

A sample of 66 corporations drawn from the U.S.A was used, 33 being firms which filed for bankruptcy during 1946 - 1965; and with an asset range from \$ 0.7 million to \$25.9 million. These firms were carefully matched with equal sized firms which were not bankrupt, thus making 66. He used Test data for one reporting period prior to bankruptcy.

Using the Balance sheets and income statements of the firms, he calculated twenty two ratios. These were in five broad categories i.e. profitability, leverage, solvency, liquidity, and activity ratios.

Using statistical significance tests, evaluation of inter-correlations among ratios, observation of predictive accuracy of various profiles and personal judgement; a ratio profile was established and the discriminant function was as follows: ().

$$Z = 0.012X_1 + 0.014X_2 + 0.033X_3 + 0.006X_4 + 0.999X_5$$

where X_1 = working capital/total assets

X_2 = retained earnings/total assets

X_3 = earnings before interest and taxes/total assets

X_4 = market value equity/book value of total debt

X_5 = sales/total assets

Z = overall index

Firms with Z scores greater than 2.99 were found to be in the non - bankrupt sector while those with a score below 1.81 all went bankrupt. This left a gray area between 1.81 and 2.99. A firm falling in this area was difficult to classify.

An "F" test was performed to test the discriminating ability of the variables, and at 0.001 level, X1 to X4 were significant. X5 did not show a significant difference between groups.

Using data from the initial sample, the model achieved 95% accuracy in classifying firms correctly, for data one year to bankruptcy. For data two years to bankruptcy, the model achieved 72% accuracy in classification.

Using secondary samples, one of bankrupt firms and another of non-bankrupt firms, the model achieved 96% accuracy in classifying bankrupt firms, and 79% accuracy in classifying non-bankrupt firms.

When testing was done for more than two years, the model proved unreliable, which implied that it could only be accurate upto two years prior to bankruptcy. }

Potential weaknesses:

Gray area:

A Z-score between 1.81 to 2.99 was difficult to classify, resulting in a zone of ignorance. This can present difficulties in practical application of the model.

Difficulties in interpretation:

In practice its difficult to give meaning to the Z score. One cannot be able to say what a given measurement means in any terms.

Altman's model was reliable for upto two years prior to bankruptcy. However this is too short a time for third parties, especially long term lenders to extricate themselves from the failing institutions without incurring considerable losses.

ALTMAN and McGOUGH (1974) Sought to develop a criterion to aid the auditor in identifying situations ^{where} ~~were~~ the status of a company as a going concern is in doubt.

They tested Altman's model with data from 34 companies that went bankrupt since 1970. They examined the annual reports of these companies prior to bankruptcy to determine the relevant Z-Score and the corresponding auditors' opinions. Their conclusion was that the model had shown superiority in signaling going concern problems for companies that actually entered bankruptcy, and could be an effective aid to the auditor in forming his judgement.

DAMBOLENA and KHOURY (1980) sought to improve on the Altman model by introducing ratio stability in the discriminant model. They held that it was the stability of every ratio that is relevant and not just the earnings. Therefore they used a ratio stability measure and stepwise discriminant analysis.

A sample of 46 firms from the United States, paired into failed and non-failed categories was used. They extracted data on 12 financial statement items for 8 years prior to failure, for firms that failed during the 1969-75 period.

From this data they calculated 19 ratios as well as four different measures of stability namely standard deviation of each ratio for three and four years periods, standard error of estimate around a 4 year linear trend and coefficient of variation over four years. The ratios were grouped into four major groups i.e. Profitability, activity, turnover and indebttness measures.

Predictive accuracy of a model without stability measures was tested and compared with the accuracy of one with stability measures. It was noted that the model with stability measures was superior in predictive accuracy.

Limitations of Ratio Based Models:

Ratio based models are subject to some of the limitations of financial ratios, the main being that they use accounting data. Accounting data is subject to different interpretations and even manipulation. Use of different accounting methods as in inventory valuation and depreciation. For example, two firms with similar performance and financial position may report different profit figures and asset values due to differences in accounting methods. Subsequent ratios will reflect these differences, and any model analyzing these two firms may classify them as different, whereas there is no actual difference in performance or financial situation; but merely accounting manipulation.

In the absence of financial accounting data, ratio analysis is impossible to carry out, thus ratio based models cannot be used. This is a problem in a country like Kenya where many small businesses do not maintain any accounting records at all, or keep them in incomplete form. Its difficult to calculate financial ratios for such firms, hence impossible to use ratio based models to predict their failure or otherwise.

2.2 NON RATIO BASED MODELS:

In business failure prediction, there are models which use other basis than financial ratios to predict failure. Though such models are not as common as ratio based models, nor as easy to understand and apply, they can be very useful in cases where there is suspected or known falsification of financial statements, or where such statements are not available.

CATASTROPHE MODEL:

This model is very useful in situations where the path towards failure is not smooth and continuous, but is explosive, sudden or catastrophic. Catastrophe theory maintains that changes in a systems parameter can cause catastrophe behaviour in a dependent variable or state.⁶

Catastrophe models have three important properties:⁷

Divergence:

Small continuous changes in parameters or initial conditions can lead to large discontinuous changes (catastrophes) in a state or variable.

6. Thomas Ho and Anthony saunders, A catastrophe model of bank behaviour; Journal of finance, vol. XXXV.NO.3, December 1980.

7. Ibid pg.1190

Asymmetry:

Implies that as parameters increase or decrease, there will be a discontinuous jump in the dependent variable as a parameter increases which will be different from its behaviour when the parameter is decreasing.

Stability:

Catastrophe condition is robust to marginal changes in the underlying relationships. i.e. some relationships may change marginally but catastrophe will still occur.

Using two conflicting variables, e.g. rage and fear, a simple model of catastrophe has been demonstrated by Ho and Saunders. The dependent variable in this case is aggression. As fear increases slowly relative to rage, catastrophe changes in behaviour will occur e.g. sudden changes from attack to defense as fear begins to gradually dominate rage. (see diagram 1)

At point 1, there is a high level of rage relative to fear, causing a high level of aggression. But as fear is increased, keeping rage constant; aggression will gradually fall until that point where any marginal increase in fear will lead to a large discontinuous fall in aggression. (point 3). This is catastrophic behaviour. Such a situation on an equilibrium surface is folded and represents the cusp catastrophe.

Figure 1 The Cusp Catastrophe

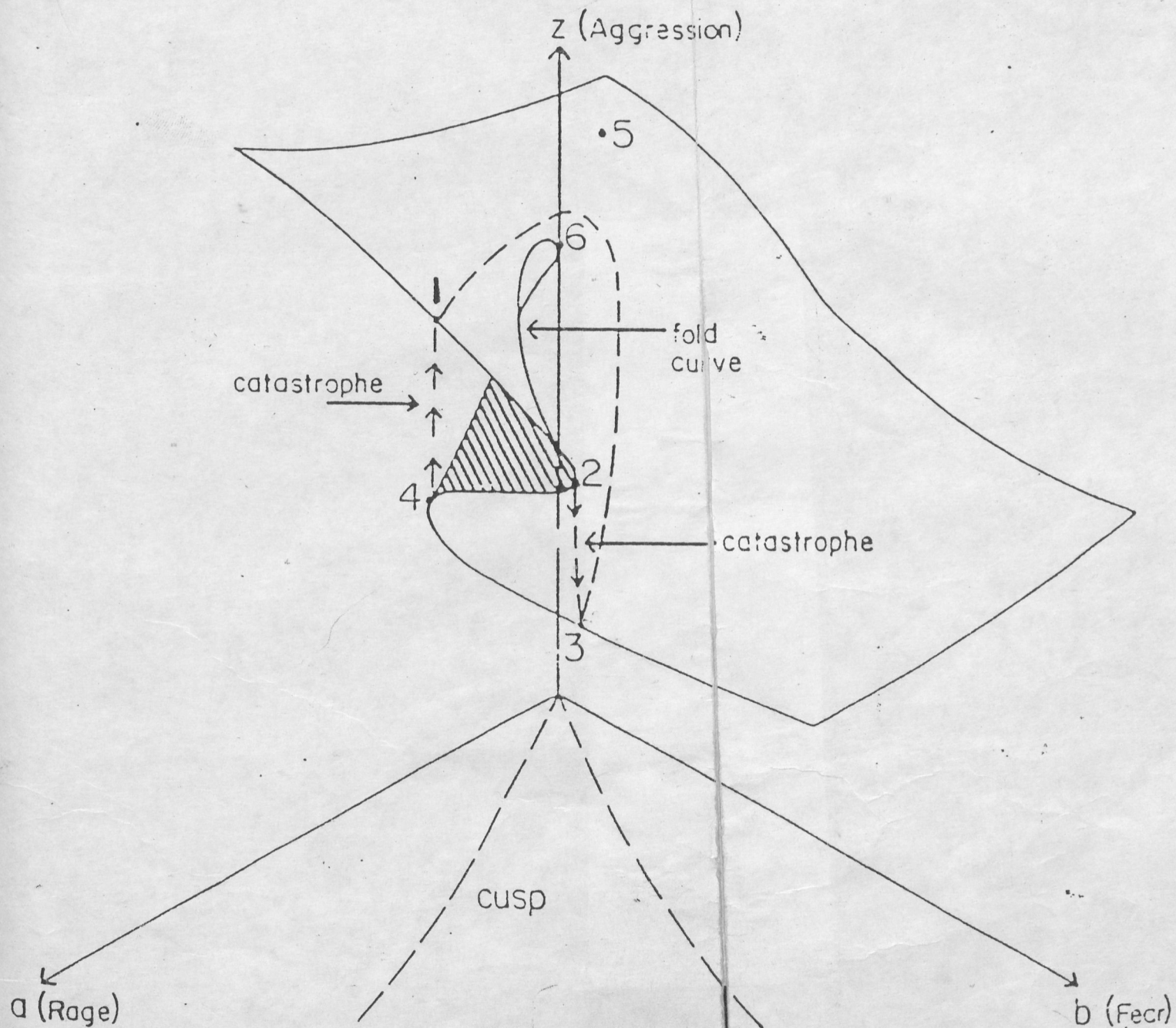


Figure 1 The cusp catastrophe

Using the above logic Ho and Saunders (1980) developed a catastrophe model for bank failure. Using probability of failure as the dependent variable and the riskiness of the bank and activities of regulatory bodies as parameters, they were able to show that even if regulatory bodies were to act as lenders of the last resort infinitely, a catastrophic jump in the probability of failure of a bank could occur. (see diagram 2)

In the diagram, as the bank increases its risky loans portfolio, hence its riskiness, depositors react by withdrawing deposits (d). Initially the bank can cover the withdrawals by drawing on its capital and reserves, but at some point it will not be able to cover the withdrawals by capital hence regulatory authorities come as lenders of the last resort (g).

But as risky loans increase withdrawals increase and regulatory bodies lend more, and the rate of intervention eventually overtakes the rate of withdrawals, (point x). Beyond this there will come a point where the probability of failure (f) will suddenly rise in a discrete fashion thereby producing a catastrophe.

In Kenya, market based models cannot be easily applied, for the stock market is small and only 56 firms are quoted in the stock exchange. Therefore a ratio based method is chosen, for it makes it possible to incorporate all firms, whether publicly quoted or not.

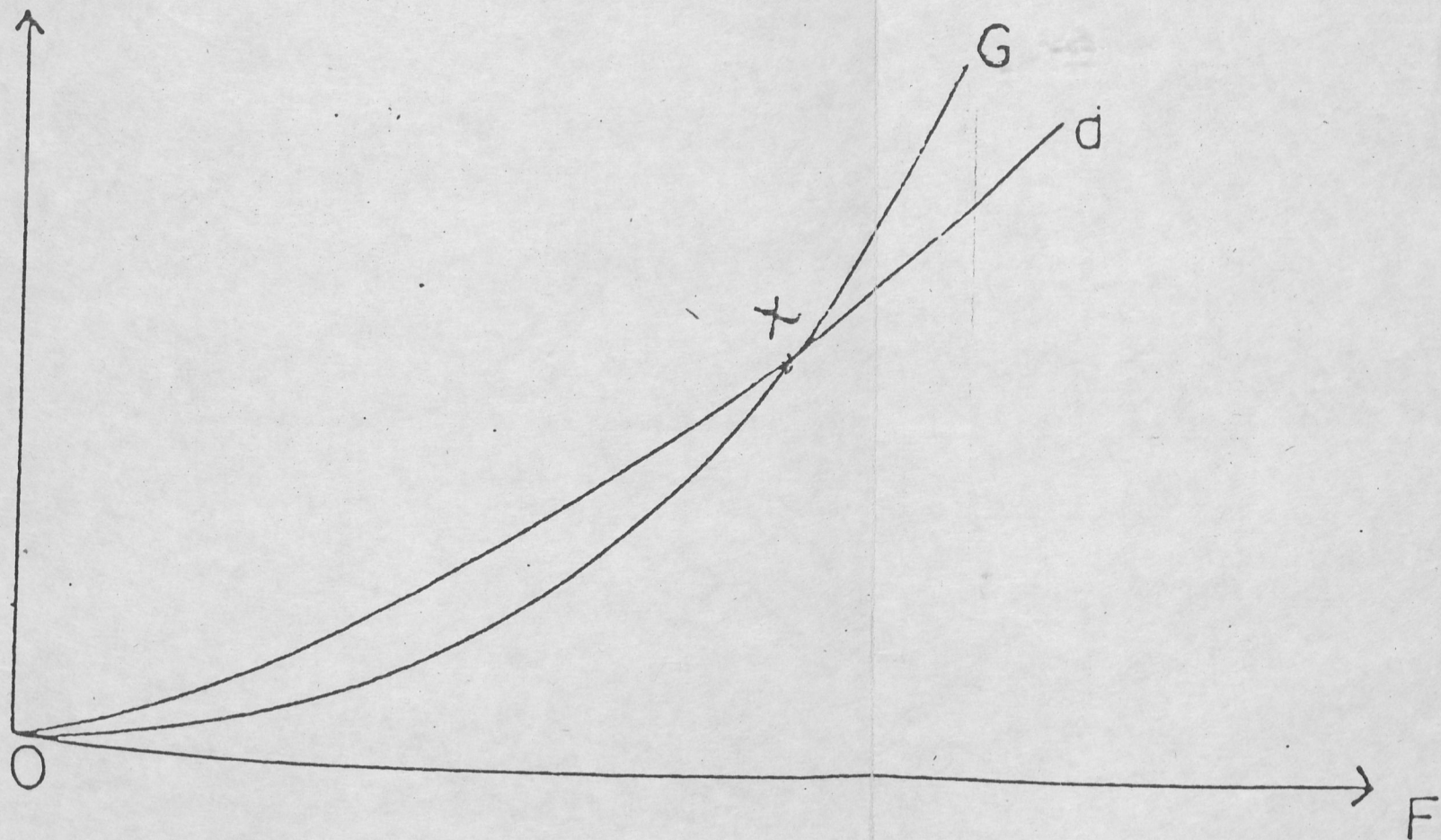


Figure 2 G and d Functions

CHAPTER 3:

3.1 STATEMENT OF THE PROBLEM

Business enterprises are usually formed to operate into the foreseeable future. This is the basis of the going concern assumption. But when failure occurs, the going concern assumption is violated and the various stakeholders incur substantial losses. Such losses could be avoided or reduced if there was an early warning system to predict impending doom. The problem therefore is one of developing a discriminant function to predict such failure before it actually occurs.

3.2 OBJECTIVES OF THE STUDY:

This study aims at developing a discriminant function for use in predicting failure in Kenya. Further, the function so developed will be tested.

3.3 SIGNIFICANCE OF THE STUDY:

The study would be of interest to stakeholders in business firms, for it can be useful as an early warning system to predict impending failure. It would also be useful to scholars and academics, for it would add to the body of knowledge and provide a basis for further research in business failure.

3.4 RESEARCH DESIGN

The population of interest is those companies, registered with the Registrar of Companies; that went into receivership from 1980 to 1990. Data has been extracted from the annual accounts of these companies, for four years prior to year of receivership or liquidation. Each of these companies has been matched with a similar non-failed company, on the basis of industry and absolute net assets size, and ratios calculated from these accounts, following the method used by Altman. These ratios are the following:

Current ratio
Quick ratio
Working capital to total debt
Equity to total liabilities
Total debt to total assets
Times interest earned
Fixed charge coverage
Cash flow coverage
Retained earnings to total assets
Profit margin on sales
Return on total assets
Return on net worth
Inventory turnover
Average collection period
Fixed assets turnover

sales to total assets

3.5 TECHNIQUE OF ANALYSIS

Discriminant analysis has been used. Specifically, a discriminant function was formulated from the ratios. The function is in the form:

$$Z = a_1x_1 + a_2x_2 + a_3x_3 + \dots + a_nx_n.$$

where:

Z = discriminant score

$a_1, a_2, \dots, a_n$ = discriminant coefficients

$x_1, x_2, \dots, x_n$ = independent variables

CHAPTER 4:

4.1. DATA ANALYSIS

Discriminant analysis is a multivariate technique that seeks to determine whether a set of variables significantly differentiate among two or more sets of data, as well as determine the specific combination of variables that most efficiently differentiate among groups.⁸

In this case, the aim was to determine that set of ratios that maximizes the differences between failed and successful firms. An initial sample of fifteen ratios were calculated from the financial statements of 20 companies in Kenya that failed between 1980 and 1990 (SEE APPENDIX 1). These ratios were initially all subjected to discriminant analysis, the results of which are shown in APPENDIX 2. To eliminate the ratios with a weak predictive power, a correlation test using a statgraphics package was carried out and ratios with a correlation of more than 0.8 were identified and in each case one of them eliminated from the sample. The elimination procedure was based on the relative magnitude of the coefficient of the ratio in an initial discriminant function that contained all the variables. (see appendix 2) This was done mainly because of the data capacity limitations of the

8. Nderitu M.M. Unpublished M.B.A. project, 1989 pg 28-29.

statgraphics package. Ratios remaining after the elimination were subjected to further discriminant analysis, resulting in the following discriminant function: (FULL STATISTICS:APPENDIX 3)

$$Z = -0.36716x_1 + 0.16603x_7 + 13.258x_8 + 2.82167x_{10} - 0.65541x_{11} + 0.01818x_{13} + 1.02299x_{15} - 2.72963$$

where;

x_1 = current ratio

x_7 = Fixed charge coverage

x_8 = Retained earnings to total assets ✓

x_{10} = Return on total assets

x_{11} = Return on net worth

x_{13} = Average collection period

x_{15} = sales to total assets

The above ratios are discussed herebelow:

current ratio:

This ratio is calculated as current assets divided by current liabilities. It indicates the extent to which claims of a short term nature are covered by current assets, these being assets that are expected to be converted into cash within the maturity period of the claims. Though no standard exists as to

the level of this ratio, it should at least be 1:1; implying that claims of a short term nature should be covered by assets of a short term nature.

Fixed charge coverage:

Fixed charges include interest payments, lease obligations, and other amounts that the firm is obligated by contractual arrangements to pay regularly. It indicates the firm's ability to cover fixed obligations from the income generated from its obligations. The ratio is calculated as follows;

$$\frac{\text{Income before tax} + \text{Interest charges} + \text{Lease obligations}}{\text{Interest charges} + \text{Lease obligations}}$$

Retained earnings to total assets:

This ratio, calculated by dividing retained profits by the total assets, shows how much of the income of the firm is ploughed back into the business. This is important because retained earnings comprise one of the principal sources of internal financing.

Return on total assets:

Return on total assets indicates how effectively the firm has employed its total resources. This is important because for survival, the firm should be able to employ its resources to gen-

erate sufficient returns to justify their investment. The ratio is calculated by dividing Net income plus after tax interest expense by total assets.

Return on Net worth:

This indicates how much return the shareholders investment is earning from the firm's operations. If the return does not conform to the expectations of shareholders, they may divest from the company thus threatening its survival. It is calculated by dividing Net income by Net worth.

Average collection period:(A.C.P)

A.C.P. indicates the average period the firm has to wait from the time it makes a sale to the point when the payment is received. It indicates how well management is able to collect cash from sales, for a heavy burden in receivables indicates tied up capital which could be otherwise invested elsewhere to produce some returns. The ratio is calculated by dividing receivables by sales per day.

Sales to total assets:

This ratio indicates how much a given investment in assets is able to generate in sales revenue. Generally the more sales a given level of assets earns the better the performance of the firm.

CHAPTER 5:

5.1 CONCLUSION

In general ratios can be used to predict company failure. However the types of ratios that will best discriminate between failing companies and successful companies appear to differ from place to place. From the analysis presented, it would appear that in Kenya; current ratio, fixed charge coverage, retained earnings to total assets, return on total assets, return on net worth, average collection period and sales to total assets can be used successfully in predicting failure for a period upto two years before it occurs.

This suggests that stakeholders in a business enterprise should pay attention to liquidity, leverage and activity ratios. However the model attained an overall correct classification of 95% in the first one year, which is similar to results obtained by Altman (1968). This should however not be construed to imply that these are the only ratios that can predict failure successfully. It is possible that other ratios can do equally well, and thus the results herein should not be taken like holy writ.

5.2 RECOMMENDATIONS OF THE STUDY:

The results of the study suggest that stakeholders in a business firm can predict failure before it occurs by paying attention to current ratios, gearing ratios and performance ratios. The fact that such can help predict failure for upto two years before it occurs implies that stakeholders in a business enterprise can avoid the losses associated with failure by taking appropriate action well in advance. It is also an early warning system to other interested parties. Therefore it is suggested that financial ratios be adopted as useful tools in failure prediction and especially using multivariate approaches.

5.3 LIMITATIONS OF THE STUDY:

The results herein presented should be viewed subject to the following limitations:

The ratios used to develop the model are only a few among a large number of possible ratios. Therefore it cannot be claimed that these are the best predictors, but are only a part of a possibly large group of predictors.¹ Research in other countries has shown that some other ratios successfully predicted failure upto five years before it actually occurred. Tamari (1966) identified Debt ratio,, quick ratio, and Net profit margin as good predictors of failure in Israeli companies. In this study not all the possible variables were tested, due to limitations of time.

2

The software package used had limitations as to the amount of data it could take. Thus the initial lotus worksheet on which the ratios were calculated had to be substantially reduced to fit into the data capacity of the statgraphics package in 640 kilobyte DOS microcomputer. A more robust software package could definitely have done a better job.

The matching sample of successful firms could not be strictly matched on stratified random sample basis for financial information on privately owned companies is not publicly available. Also the reporting practices of some of the companies in the sample could not allow some of the ratios to be calculated. For this reason four failed firms were matched with non - failed firms with an absolute net asset size of upto shs. five million more. It is possible that a more strict matching could have obtained different results.

5.4 SUGGESTIONS FOR FURTHER STUDIES:

In Kenya, few if any studies have been undertaken in the past in this area of business failure prediction. But failures do constantly occur. In the mid-eighties for example, there were mass failures of indigneous financial institutions, and yet this did not stimulate research into failure prediction; despite the

heavy losses that were incurred by various stakeholders, which could otherwise have been avoided if such failure could have been predicted well in advance.

Since it can be reasonably expected that there will always be companies failing, research into failure prediction is inevitable. This paper therefore should not be taken as the final word on the matter, but should merely act as the pathbreaker towards further research. However the problem of data availability remains acute, as those managing many firms consider financial statements to be confidential information and do not easily release such information particularly where the firm is a potential candidate for failure.

Therefore a concerted effort is necessary on the part of both academicians and business managers, for research in the area to be comprehensively undertaken. Managers to provide the necessary information, and academicians and researchers to undertake the relevant research.

Of particular interest would be inquiry into whether those companies that decline to disclose information about themselves and are hostile to researchers are failure candidates.

APPENDIX O: KEY TO THE FINANCIAL RATIOS

APPENDIX O: KEY TO RATIOS USED IN THE ANALYSIS

- X1 = CURRENT RATIOS
- X2 = QUICK RATIO
- X3 = WORKING CAPITAL TO TOTAL DEBT^{*}
- X4 = EQUITY TO TOTAL LIABILITIES
- X5 = TOTAL DEBT TO TOTAL ASSETS
- X6 = TIMES INTEREST EARNED^{*}
- X7 = FIXED CHARGE COVERAGE^{*}
- X8 = RETAINED EARNINGS TO TOTAL DEBT^{*}
- X9 = PROFIT MARGIN ON SALES
- X10 = RETURN ON TOTAL ASSETS[✓]
- X11 = RETURN ON NET WORTH
- X12 = INVENTORY TURNOVER
- X13 = AVERAGE COLLECTION PERIOD
- X14 = FIXED ASSETS TURNOVER
- X15 = SALES₁ TOTAL ASSETS

APPENDIX 1: FINANCIAL RATIOS USED FOR THE SAMPLE FIRMS USED TO DEVELOP THE MODEL.

Year	1	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	Z-SCORE	ST
1	1	0.770126	0.646463	-0.22316	0.816371	0.550548	-0.54507	-0.83459	-0.21258	-0.33863	-0.11731	-0.16045	1.938339	194.4746	0.159811	0.113971	-1.0998	F
1	1	0.955033	0.491613	-0.03507	-0.08247	1.089893	-0.54507	-0.83459	-0.20175	-0.02966	-0.14275	1.588032	8.513739	31.26281	25.59285	4.812486	1.54597	S
1	1	0.387497	0.209534	-0.40132	1.377395	0.420628	-0.86234	-0.86234	-0.07463	-0.26308	-0.0822	-0.13501	5.475872	56.32388	0.332874	0.297324	-0.7334	F
1	1	0.409211	0.088958	-0.27247	0.447008	0.691081	1.392896	1.392896	-0.0422	0.043951	0.040417	0.130836	6.082942	14.59249	1.400475	0.620911	-1.3355	F
1	1	0.763796	1.315544	-0.10807	0.206069	0.829139	1.574416	-0.28466	0.073645	0.085768	0.043837	0.256568	2.686026	14.70618	0.693896	0.511112	-5.6659	F
1	1	0.734383	0.381168	0.000009	0.838059	0.437396	-0.60213	-0.60213	-0.05276	0.11802	0.154242	0.420779	6.910636	56.0334	2.153792	1.306919	-0.1175	F
1	1	0.783459	0.460397	-0.20717	0.370483	0.729669	0.082535	-0.33757	-0.10932	-0.24823	-0.159914	-0.58871	2.842672	119.9706	1.415122	0.641124	-0.5827	F
1	1	0.452786	0.858068	-0.37303	0.01762	0.984233	0.248826	-0.33757	-0.30958	-0.20886	-0.08785	-5.57248	1.546926	24.09437	0.6042	0.420645	-4.1035	F
1	1	1.01287	1.01287	0.01287	0.040868	0.960736	0.093004	-0.33757	-0.00238	-0.05322	-0.00276	-0.0704	4.499644	63.4323	1.93085	-0.00276	-1.503	F
1	1	0.394386	0.149594	-0.45954	0.26502	0.869551	-8.45074	-8.45074	-0.0714	-0.28089	-0.36342	-1.73474	4.499644	63.4323	1.694731	1.293813	-0.0313	F
2	2	0.657102	0.561218	-0.99462	0.136949	0.879546	2.808696	2.808696	-0.09314	0.077347	0.147019	0.924049	21.36895	78.26853	2.662955	1.51846	-10.553	F
2	2	1.703165	0.488831	0.762465	0.405276	0.711603	4.183049	3.802771	0.012429	0.029412	1.083776	0.18809	0.976244	98.69868	1.77667	0.656542	7.27416	S
2	2	1.002498	0.940088	0.002345	0.131422	0.987821	6.357903	6.167764	0.025049	1.804284	0.003497	0.030477	21.23961	188.3772	7.335456	1.308245	0.33562	S
2	2	2.917701	2.917701	1.917701	0.649424	0.58416	4.449882	4.259744	0.151018	0.637014	0.142182	0.059125	11.10783	143.5379	4.556063	0.982394	2.7113	S
2	2	13.95702	13.95702	1.49418	10.67123	0.499946	8.532757	8.532757	0.549248	1.016501	0.022644	0.038248	13.67318	82.78135	0.290438	0.095906	6.28069	S
2	2	1.524599	0.621353	0.28202	0.28202	0.635678	1.225169	1.225169	0.094996	0.010338	0.03559	0.026779	0.687288	80.767	1.9702	0.943707	0.42269	S
2	2	7.155123	3.194321	0.452579	0.96974	0.518948	1.595805	5.997052	0.458477	0.374243	0.098533	0.089089	11.50887	25.96505	0.241648	0.114515	4.25705	S
2	2	1.534465	1.534465	0.534465	1.266682	0.550265	4.164752	4.68485	0.199679	0.10903	0.099422	0.220174	4.270897	104.8585	9.917698	0.802824	1.71118	S
2	2	0.430055	0.142267	-0.40613	0.782948	0.552755	-2.03845	-1.60837	0.295581	-0.07679	-0.09557	-0.22083	10.97968	6.295994	1.49844	1.244614	3.06929	S
2	2	0.201021	0.180149	-0.24014	0.529644	0.582829	21.99545	21.99545	0.065794	0.108527	0.07006	0.079768	10.64585	1.594677	6.115698	0.825413	8.18461	S

**NOTE: Code 1 implies a failed firm, while Code 2 implies a non-failed firm.

APPENDIX 2: RESULTS OF THE INITIAL DISCRIMINANT FUNCTION USING
ALL THE 15 RATIOS
Discriminant Analysis for YEARR1. YEAR1

Discriminant Function 1	Eigenvalue 10.784926	Relative Percentage 100.00	Canonical Correlation .95663	
Functions Derived 0	Wilks Lambda .848542	Chi- Square 25.901624	DF 15	Sig.Level .03907

Discriminant Analysis for YEARR1. YEAR1

Standardized Discriminant Function Coefficients

X1	-2.05812
X2	1.07652
X3	-0.51425
X4	-0.36216
X5	0.22587
X6	-0.83496
X7	2.22305
X8	3.39794
X9	-0.78303
X10	1.11264
X11	-1.41678
X12	0.49565
X13	2.05438
X14	-1.29563
X15	2.74362

Discriminant Analysis for YEARR1. YEAR1

Unstandardized Discriminant Function Coefficients

X1	-0.67440
X2	0.36224
X3	-0.81938
X4	-0.15772
X5	1.12653
X6	-0.16593
X7	0.45730
X8	20.6150
X9	-1.78721
X10	4.35400
X11	-1.02188
X12	0.09244
X13	0.03584
X14	-0.21791
X15	2.61358
CONSTANT	-6.37838

Discriminant Analysis for YEARR1. YEAR1

Group Centroids		1			
1	Discriminant	-3.11552	Relative	Canonical	
2	Function	3.11552	Percentage	Correlation	
			100.00	.91393	
Functions Derived		Wilks' Lambda	Chi-Square	DF	Sig. Level
					.00047
Classification Results for YEARR1.YEAR1					

Classification Results for YEARR1.YEAR1

Predicted Group (count percentage)

Actual Group	1		2		TOTAL	
	10	100.00	0	.00	10	100.00
1						
2	0	.00	10	100.00	10	100.00

APPENDIX 3: RESULTS OF THE FINAL DISCRIMINANT FUNCTION

Discriminant Analysis for YEARR1. YEAR1

Discriminant Function 1	Eigenvalue 5.0708024	Relative Percentage 100.00	Canonical Correlation .91393	
Functions Derived 0	Wilks Lambda .1647229	Chi- Square 26.150616	DF 7	Sig.Level .00047

Discriminant Analysis for YEARR1. YEAR1

Standardized Discriminant Function Coefficients

	1
X1	-1.12049
X7	0.81684
X8	2.18530
X10	0.72106
X11	-0.90870
X13	1.04186
X15	1.07389

Discriminant Analysis for YEARR1. YEAR1

Unstandardized Discriminant Function Coefficients

	1
X1	-0.36716
X7	0.16803
X8	13.2580
X10	2.82167
X11	-0.65541
X13	0.01818
X15	1.02299
CONSTANT	-2.72963

Discriminant Analysis for YEARR1. YEAR1

Group Centroids	1
1	-2.13629
2	2.13629

Classification Results for YEARR1.YEAR1

Predicted Group (count percentage)

Actual Group	1		2		TOTAL	
1	10	100.00	0	.00	10	100.00
2	1	10.00	9	90.00	10	100.00

APPENDIX 4: RESULTS OF TESTING THE MODEL WITH COMPANY DATA TWO YEARS PRIOR TO FAILURE

Year 2	X1	COEFF.	X7	COEFF.	X8	COEFF.	X10	COEFF.	X11	COEFF.	X13	COEFF.	X15	COEFF.	CONST.	Z-SCORE	ST
1	0.90446	-0.0367	-2.2702	0.16603	-0.1588	13.258	-0.1333	2.82167	-0.2343	-0.6554	206.8	0.01818	0.27011	1.02299	-2.7296	-1.0998	F
1	1.09143	-0.0367	0.01524	0.16603	-0.0365	13.258	-0.029	2.82167	-0.8856	-0.6554	34.3579	0.01818	3.59227	1.02299	-2.7296	1.54597	S
1	0.51433	-0.0367	0.30077	0.16603	0.01356	13.258	-0.0176	2.82167	-0.0269	-0.6554	89.3756	0.01818	0.18821	1.02299	-2.7296	-0.7334	F
1	0.52475	-0.0367	1.82198	0.16603	0.01665	13.258	0.02245	2.82167	0.06011	-0.6554	12.068	0.01818	0.63209	1.02299	-2.7296	-1.3355	F
1	1.31554	-0.0367	0.46693	0.16603	-0.3263	13.258	0.00614	2.82167	-0.0334	-0.6554	36.6213	0.01818	0.64092	1.02299	-2.7296	-5.6659	F
1	0.88332	-0.0367	0.14719	0.16603	0.00764	13.258	0.12797	2.82167	0.3484	-0.6554	75.881	0.01818	0.98384	1.02299	-2.7296	-0.1175	F
1	0.46039	-0.0367	0.41364	0.16603	0.00468	13.258	0.00468	2.82167	0.01387	-0.6554	37.5195	0.01818	1.31645	1.02299	-2.7296	-0.5827	F
1	0.46322	-0.0367	0.41364	0.16603	-0.2096	13.258	0.03234	2.82167	0.34066	-0.6554	27.2283	0.01818	0.96908	1.02299	-2.7296	-4.1035	F
1	1.04883	-0.0367	0.47273	0.16603	0.00065	13.258	0.00065	2.82167	0.00909	-0.6554	64.9815	0.01818	0.00065	1.02299	-2.7296	-1.503	F
1	0.74041	-0.0367	-0.684	0.16603	0.00336	13.258	-0.0964	2.82167	-0.2546	-0.6554	64.9815	0.01818	1.67964	1.02299	-2.7296	-0.0313	F
2	0.51789	-0.0367	-3.0661	0.16603	-0.4032	13.258	-0.1643	2.82167	6.21789	-0.6554	69.5318	0.01818	1.29562	1.02299	-2.7296	-10.553	F
2	1.57438	-0.0367	2.66263	0.16603	0.02369	13.258	2.59459	2.82167	0.30514	-0.6554	57.5009	0.01818	1.11328	1.02299	-2.7296	7.27416	S
2	1.01497	-0.0367	-0.3625	0.16603	0.02432	13.258	0.02862	2.82167	0.35875	-0.6554	54.2897	0.01818	1.96244	1.02299	-2.7296	0.33562	S
2	3.65439	-0.0367	-0.2553	0.16603	0.19873	13.258	0.15765	2.82167	0.07871	-0.6554	60.4408	0.01818	1.45711	1.02299	-2.7296	2.7113	S
2	8.82896	-0.0367	9.42748	0.16603	0.44467	13.258	0.03098	2.82167	0.06496	-0.6554	18.604	0.01818	1.45711	1.02299	-2.7296	6.28069	S
2	1.20865	-0.0367	-0.0423	0.16603	0.08205	13.258	-0.0287	2.82167	-0.1481	-0.6554	69.1778	0.01818	0.82322	1.02299	-2.7296	0.42269	S
2	11.3557	-0.0367	1.39395	0.16603	0.46126	13.258	0.16759	2.82167	0.22802	-0.6554	34.1953	0.01818	0.10909	1.02299	-2.7296	4.25705	S
2	2.07359	-0.0367	1.39395	0.16603	0.11879	13.258	0.08772	2.82167	0.24059	-0.6554	78.0942	0.01818	1.17398	1.02299	-2.7296	1.71118	S
2	0.58189	-0.0367	-2.763	0.16603	0.39737	13.258	-0.1297	2.82167	-0.2447	-0.6554	7.10506	0.01818	1.06266	1.02299	-2.7296	3.06929	S
2	0.02573	-0.0367	17.321	0.16603	0.14974	13.258	0.10435	2.82167	0.07894	-0.6554	49.8822	0.01818	4.79424	1.02299	-2.7296	8.18461	S

**NOTE: State implies that class the companies in the sample are classified to be in, i.e failed (F) or successful (S)

APPENDIX 5 : RESULTS OF TESTING THE MODEL WITH A HOLDOUT SAMPLE OF FIRMS.

ACTUAL	X1	COEFF.	X7	COEFF.	X8	COEFF.	X10	COEFF.	X11	COEFF.	X13	COEFF.	X15	COEFF.	CONST.	Z-SCORE
1	0.026251	-0.36716	-0.02388	0.16603	0.014942	13.258	1.606795	2.82167	88.0518	-0.65541	0.296746	0.01818	0.245559	1.02299	-2.72963	-55.4647 F
1	-0.05032	-0.36716	-0.00783	0.16603	-0.02911	13.258	7.57946	2.82167	35.88693	-0.65541	3.606362	0.01818	3.2657	1.02299	-2.72963	-1.82609 F
1	-0.18763	-0.36716	-0.27534	0.16603	-0.18953	13.258	6.136461	2.82167	28.46585	-0.65541	0.522962	0.01818	0.171009	1.02299	-2.72963	-6.37662 F
1	-0.45177	-0.36716	-0.00691	0.16603	0.006241	13.258	2.810897	2.82167	7.428369	-0.65541	0.666198	0.01818	0.574629	1.02299	-2.72963	1.180599 S
1	-0.07547	-0.36716	-0.31327	0.16603	-0.14798	13.258	1.800192	2.82167	49.38253	-0.65541	0.473843	0.01818	0.582655	1.02299	-2.72963	-31.3974 F
2	0.097968	-0.36716	-0.22069	0.16603	-0.10457	13.258	16.19007	2.82167	62.25501	-0.65541	1.337608	0.01818	0.748386	1.02299	-2.72963	1.481731 S
2	0.569674	-0.36716	-0.00126	0.16603	0.001261	13.258	0.983071	2.82167	80.3665	-0.65541	0.875609	0.01818	0.09918	1.02299	-2.72963	-52.7035 F
2	-0.00575	-0.36716	0.012276	0.16603	0.015467	13.258	7.604049	2.82167	16.3008	-0.65541	1.629884	0.01818	1.067262	1.02299	-2.72963	9.373435 S
2	1.338635	-0.36716	0.051131	0.16603	0.09104	13.258	8.259065	2.82167	22.9741	-0.65541	1.281034	0.01818	0.966057	1.02299	-2.72963	7.25283 S
2	0.963464	-0.36716	0.441443	0.16603	0.028969	13.258	8.259065	2.82167	21.43322	-0.65541	0.12049	0.01818	4.358405	1.02299	-2.72963	11.09159 S

NOTE: ACTUAL STATE: 1= FAILED FIRM, while 2= NON-FAILED FIRM

STATE IS THE PREDICTED CLASS OF THE COMPANY i.e F for FAILED and S for NON-FAILED

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