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DISCRIMINANT ANALYSIS BETWEEN SICK AND HEALTHY UNITS

By

C.D. Bhattacharya

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SICK AND HEALTHY UNITS

The problem of sickness of industrial units is of late assuming great importance and it is widely considered that a system of forewarning is very much needed in order to get a feel of the impending crisis. Such a system is all the more advantageous to the development banks as part of their follow up activities.

The present study is concerned with the application of Multiple Discriminant Analysis (MDA) in order to identify the different symptoms which explain the sickness phenomenon, their relative contribution in determining the propensity of sickness, as also to suggest a possible cut-off point which may separate the units belonging to the sickness class from those belonging to the healthy ones.

MDA is a statistical tool by means of which the criterion for acceptance or rejection of prospective units can be developed. Thus, on the basis of certain relevant variables good units can be discriminated from the bad ones, successes can be discriminated from failures, healthy units can be discriminated from sick units.

Though primarily it is meant for purposes of analysis, it can also be used for prediction purposes.

For purposes of the present study, out of a total of 91 industrial units listed as sick by the IDBI in its portfolio, a sample of 28 units has been drawn on the basis of the availability of the relevant data. These units belong to six different industry classes, viz. Mini Steel, Transport, Electrical Machinery, Basic Chemicals, Engineering and Miscellaneous. Likewise, a list of 26 healthy industrial units belonging to the same set of industry classes has been drawn so as to develop a discriminant function separating sick units from the healthy ones. Moreover, it has been felt that for purposes of performance appraisal of a particular unit, its functioning for at least four years should be examined. As such, the data relate to the four years ending 1975, 1976, 1977 and 1978 respectively.

Again, for purposes of comparison of the percentage of group cases correctly classified, two different models have been tested. The first of these two models makes use of the following five ratios in percentage terms :

1. $\dfrac{\text{Working Capital}}{\text{Total Assets}}$

2. $\dfrac{\text{Profit/Loss retained}}{\text{Total Assets}}$

3. $\dfrac{\text{Gross Profit/Loss}}{\text{Total Assets}}$

4. $\dfrac{\text{Net Worth}}{\text{Total Liabilities}}$

5. $\dfrac{\text{Sales (net of excise)}}{\text{Total Assets}}$

It may be noted that the model involving the above five ratios resembles the one which Prof. Altman developed in his study entitled, 'Financial ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy'*, the only difference is that it makes use of the figures of Net Worth in place of Market Value of Equity in the numerator of the fourth ratio.

The second model makes use of the following set of four ratios in percentage terms :

1. $\dfrac{\text{Gross Profit/Loss + Depreciation}}{\text{Sales (net of excise)}}$

2. $\dfrac{\text{Operating Profit/Loss + Depreciation}}{\text{Sales (net of excise)}}$

3. $\dfrac{\text{Gross Profit/Loss + Depreciation}}{\text{Total Assets + Accumulated Depreciation}}$

4. $\dfrac{\text{Operating Profit/Loss + Depreciation}}{\text{Total Assets + Accumulated Depreciation}}$

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* E.I. Altman, "Financial ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy," Journal of Finance (September, 1968)

The four ratios given above resemble the four profitability ratios with the highest predictive power as per the ICICI publication entitled, 'Financial ratios as Forewarning Indicators of Corporate Sickness'.

Four purposes of MDA, the DEC-10 computer at the National Centre for Software Development and Computing Techniques at the Tata Institute of Fundamental Research, Bombay has been used. The MDA technique is a part of a Statistical Package for Social Sciences (SPSS) developed by a team of professionals at the University of Pittsburgh, USA and has been made operational on different computer systems. It has been widely used by the research community all over the world.

The Means and Standard Deviations of the nine variables are given in Exhibit 1. The raw input data relating to different variables are required to be transformed to their standardised forms by subtracting the means from the respective variables and dividing the net values by their respective standard deviations. Standardisation of the variables becomes necessary because the discriminant functions developed through the present study are available in their standardised forms.

Discriminant Functions

, The two standardised discriminant functions developed
are :

1) $Z_1 = -0.05561 \quad X_1 - 0.15365 \quad X_2 \quad -0.58455 \quad X_3$
$-0.37462 \quad X_4 - 0.04519 \quad X_5 \quad$ (Model 1)

2) $Z_2 = 0.16533 \quad X_6 - 0.22333 \quad X_7 \quad -1.00189 \quad X_8 +$
$0.04165 \quad X_9 \quad$ (Model 2)

The percentage of group cases correctly classified
is 79.91 in Model 1 and 78.04 in Model 2.

It may be noted from the Discriminant Function
(Model 1) that the coefficients of all the five variables
are negatives. While classifying the units, therefore,
the units with low negative scores should be ranked healthy
and the units with high positive scores should be ranked
sick. Moreover, a comparison of the magnitudes of the
five coefficients reveals that the contributions of the
first and fifth variables in developing the discriminant
function are by no means significant. Obviously, it is
not advisable to discriminate sick units from healthy
ones on the basis of the position of their working
capital and/or sales. The significant contributors to
the discriminant function are the third, fourth and second
variables. The ratios

$\underline{\text{Gross Profit/Loss}}$, $\underline{\hspace{1cm}\text{Net Worth}\hspace{1cm}}$, and $\underline{\text{Profit/Loss retained}}$
$\hspace{0.3cm}\text{Total Assets}\hspace{1.5cm}\text{Total Liabilities}\hspace{2.5cm}\text{Total Assets}$

can, therefore, be effectively used in order to discriminate

sick units from the healthy ones, The major contributor to

the discriminant function is the ratio $\dfrac{\text{Gross Profit/Loss}}{\text{Total Assets}}$,

followed by $\dfrac{\text{Net Worth}}{\text{Total Liabilities}}$ and $\dfrac{\text{Profit/Loss retained}}{\text{Total Assets}}$,

respectively.

The entire model may, however, be used for the

purposes of discriminating sick units from the healthy

ones, as well as measuring the propensity of sickness

of sick units, for the percentage of group cases correctly

classified is near about 80.

An examination of the second model reveals that

while two of the coefficients are negative, the other two

are positive. However, in terms of magnitude, the contri-

butions of the negative coefficients is much more pronounced

than those made by the positive coefficients. Therefore,

while classifying the units and assigning them with ranks,

the same contention is to be followed, i.e. units with

low negative scores are to be ranked healthy and units

with high positive scores are to be ranked sick. The

major contributor to the discriminant function is the

ratio $\dfrac{\text{Gross Profit/Loss + Depreciation}}{\text{Total Assets + Accumulated Depreciation}}$

followed by the ratio $\dfrac{\text{Operating Profit/Loss + Depreciation}}{\text{Sales}}$.

The contributions of the other two ratios are by no means significant. The model in its entirety may, however, be used for the purpose of discriminating sick units from the healthy ones as well as measuring the propensity of sickness of sick units, for the percentage of group cases correctly classified is about 78.

Ranking according to Discriminant Scores

Having identified the two discriminant functions, let us examine the individual discriminant scores obtained by the sample total of 54 units, composed of 28 sick and 26 healthy units. Exhibit II gives these scores for the four years 1975, 1976, 1977 and 1978 respectively. The last column gives the average scores obtained by the individual units. These scores relate to the discriminant function (Model 1). On the basis of their average discriminant scores, the respective units have been **ranked**, starting from the lowest negative score to the highest positive score (Exhibit III). The average scores of different units along with the state of their health (whether sick or healthy) are shown against the units respectively. On the basis of their average discriminant scores, one may ascertain the propensity of sickness of sick units. It may be noted that amongst the sick units, the sickest unit is Plastic Resins and Chemicals (1.695), followed

by Bombay Malleable Iron Castings (1.622), and India Firebricks and Insulators (1.515). Further, amongst the sick units, the best performers are Kamani Engineering Corporation (-0.606), followed by Somaya Organics Ltd. (-0.214), and Indo Nippan Precision Bearing (0.012).

Coming to the healthy units we find that the healthiest unit is Herdilla Chemicals Limited (-2.332) followed by Associated Bearings Ltd. (-2.122), and Polyolin Industries Limited (-2.064). The worst performers amongst the healthy units are Seven Seas Transportation Ltd. (0.464) followed by Indian Tubes Company Ltd. (0.258) and Anglo American Manne Co. Ltd. (0.232).

Determination of the Cut-off Point

The cut-off point may now be determined. The inherent idea behind this is to refuse credit to those units which have discriminant scores below the cut·off point and extend credit to those with discriminant scores above the cut-off point. In other words, we want to determine the discriminant function value. Using this value for cut-off purposes will minimise the prediction of healthy units when they are sick and the prediction of sick units when they are healthy. In order to determine the cut-off point in practice, it may be noted that there is an area of overlap between the units with ranks

12 and 36 (Exhibit III). From this we may conclude that the cut-off point must be between -0.606 and 0.464. For simplicity, we may want to use the mid point i.e. -0.071 as our cut-off point. Given the cut-off point, we may draw the discriminant boundary line in Exhibit IV. This line discriminates best between healthy and sick units. Healthy units have been shown to the left of the boundary line and sick units have been shown to the right; whereas the circles represent the sick·units, the squares represent the healthy units. For identification purposes, the rank numbers are also given within the circle and the squares. It is interesting to note that there are as many as seven units which have been misclassified, given the cut-off point. Units like Kamani Engineering Corporation (rank 12) and Somaya Organics Limited (rank 19) are classified as healthy units when in fact these are sick. On the other hand, units like A.C.C. Vickers Ltd. (24), Modella Alloys and Steels Ltd. (28), Anglo American Manne Co. Ltd. (29) Indian Tubes Co. Ltd. (31), and Seven Seas Transportation Ltd. (36) have been classified as sick units when in fact these are healthy. Instead of assigning a strict cut-off point, it may be better to allow for misclassifications and designate the area between the score of -0.606 and 0.464 as uncertain, requiring further analysis. Theoretically, this would correspond to the area of overlap in Exhibit V.

In this Exhibit discriminant function value is shown along

the horizontal axis and the probability of occurrence along

the vertical. In the figure the universe of sick units

appear to the right, the healthy ones to the left. The

average discriminant score of sick units $(\bar{Z}s)$ is 0.619

which is much different from the average score for healthy

units $(\bar{Z}_H)$, i.e. -0.618. There is also an area of overlap

between the two universes, sick and healthy units.

Generally, the smaller the area of overlap, the better

is the ability of discriminant analysis to predict the

state of health of a particular unit.

Model 2

Discriminant scores for the same 54 units obtained

through the application of Model 2 are given in Exhibit VI.

As in Exhibit II, the last column gives the average scores

obtained by the individual units. Exhibit VII arranges

these units, starting from the lowest negative discriminant

score to the highest positive score, as it was done in

Exhibit III. It may be noted that as per Model 2, the

healthiest unit is Siporex India Ltd. (-1.752), followed

by Herdilla Chemicals Ltd. (-1.326) and Associated Bearings

Ltd. (-1.112). It may be recalled that Herdilla Chemicals

Ltd. and Associated Bearings Ltd. were the top two healthy

units as per Model 1. Siporex India Ltd. which obtained

the first rank in Model 2 was placed in the fourth rank in

Model 1. The results are, therefore, fairly close to

each other. Amongst the healthy units, the worst

performers are Indian Tubes Company Ltd. (0.764), followed

by The Premier Automobiles (0.309), and A.C.C. Vickers

Ltd. (0.053). It is worth noting that Indian Tubes Company

Ltd. was a poor performer from amongst the healthy units

as per Model 1 as well. The score of A.C.C. Vickers Ltd.

was also below the cut-off point in Model 1. However, the

score of The Premier Automobiles was not as poor in Model

1 as was revealed in Model 2.

Coming to the sick units, it is interesting to

note, that Plastics Resins and Chemicals once again occupies

the bottom place with the score of 1.723, followed by

Industrial Plants Ltd. (1.434) and Bengal Arc Steels Ltd.

(1.364). The best performers from amongst the sick units

are Somaya Organics Ltd. (-0.306), Kamani Engineering

Corporation (-0.206) and Indo Nippan Precision Bearing

(-0.204). Incidentally, the same three sick units were

instrumental in performing the best from amongst the sick

units in Model 1 as well; the order was, however, different.

In Model 1, Kamani Engineering Corporation was followed

by Somaya Organics Ltd., and Indo Nippan Precision Bearing

respectively.

In order to determine the cut-off point in Model 2,

the same procedure is to be followed. It may be noted from

Exhibit VII that misclassification starts from Somaya

Organics Ltd. with the score of -0.386 and continues

upto Indian Tubes Co. Ltd. with the score of 0.764. For

the sake of simplicity, the mid value of these two points

may again be taken as the cut-off point. It comes to 0.189.

Given the cut-off point, there are only two healthy units

which have been classified as sick. These are Indian

Tubes Company Ltd. (0.764) and The Premier Automobiles

Ltd. (0.309). On the other hand, there are as many as five

sick units which have been classified as healthy. These

are Canara Steels Ltd. (0.031), Mysore Acetate and Chemicals

Ltd. (-0.041), Indo Nippan Precision Bearing (-0.204), Kamani

Engineering Corporation (-0.206) and Somaya Organics Ltd.

(-0.386). The total number of units misclassified therefore

remains seven, exactly the same number which was found in

Model 1. The discriminant boundary line as per Model 2

is drawn in Exhibit VIII. The universes of healthy and

sick units are shown in Exhibit IX. It may be seen that

the average discriminant score of sick units, i.e. $\overline{Z}_s$ is 0.552

which is much different from the average discriminant

score for the healthy units $(\overline{Z}_H)$, i.e. -0.586. There is

as usual an area of misclassification. Obviously, smaller

this area, better is the ability of the discriminant

analysis to predict the state of health of a particular

unit.

Conclusion

The present study makes use of multiple discriminant analysis for the purpose of identifying the discriminating power of two different models which have been used for separating sick units from the healthy ones. The two different discriminant functions developed are :

$$Z_1 = -0.05561 \ X_1 - 0.15365 \ X_2 - 0.58455 \ X_3$$
$$-0.37462 \ X_4 - 0.04519 \ X_5 \quad \text{and}$$

$$Z_2 = 0.16533 \ X_6 - 0.22333 \ X_7 - 1.00189 \ X_8 +$$
$$0.04165 \ X_9$$

where

$$X_1 = \frac{\text{Working Capital}}{\text{Total Assets}}$$

$$X_2 = \frac{\text{Retained Profit/Loss}}{\text{Total Assets}}$$

$$X_3 = \frac{\text{Gross Profit/Loss}}{\text{Total Assets}}$$

$$X_4 = \frac{\text{Net Worth}}{\text{Total Liabilities}}$$

$$X_5 = \frac{\text{Sales (Net of excise)}}{\text{Total Assets}}$$

$$X_6 = \frac{\text{Gross Profit/Loss + Depreciation}}{\text{Sales (Net of excise)}}$$

$$X_7 = \frac{\text{Operating Profit/Loss + Depreciation}}{\text{Sales (net of excise)}}$$

$$X_8 = \frac{\text{Gross Profit/Loss + Depreciation}}{\text{Total Assets + Accumulated Depreciation}}$$

$$X_9 = \frac{\text{Operating Profit/Loss + Depreciation}}{\text{Total Assets + Accumulated Depreciation}}$$

Whereas Model 1 makes use of the first five variables, Model 2 uses the next set of four variables. Average discriminant scores have been developed for a total of 54 units composed of 28 sick and 26 healthy units for the years 1975, 1976, 1977 and 1978. These units were then arranged in the ascending order of their average discriminant scores. The results are given below :

1.   Out of the nine ratios given above X_3, X_4, and X_2 in Model 1 and X_8 and X_7 in Model 2 have been found to possess the highest discriminating power. Moreover, the coefficients of all the ratios excepting X_6 and X_9 have been found to be negative. Consequently, the unit with the highest positive score is the sickest unit and the unit with the lowest negative score is the healthiest unit.

2.   In terms of their discriminant scores, Herdilla Chemicals Ltd. is the healthiest unit with the score of -2.332 as per Model 1 and Siporex India Ltd. with the score of -1.752 is the healthiest as per Model 2. Whereas the first three positions in Model 1 go to Herdilla Chemicals Ltd., Associated Bearing Ltd and Polyolin Industries Ltd.; in Model 2 these are occupied by Siporex India Ltd., Herdilla Chemicals Ltd. and Associated Bearings Ltd. Siporex India Ltd., the unit which topped in Model 2 was ranked fourth in Model 1.

3. Amongst the healthy units the worst performers are Seven Seas Transportation Ltd., Indian Tubes Company Ltd., and Anglo American Manne Co. Ltd. as per Model 1, whereas these are Indian Tube Company Ltd., The Premier Automobiles and A.C.C. Vickers Ltd. as per Model 2.

4. Plastic Resin and Chemicals Ltd. has been found to be the sickest of the sick units both in Model 1 and 2. The units which followed Plastic Resin and Chemicals Ltd. were Bombay Malleable Iron Castings and India Firebricks and Insulators in Model 1; these were Industrial Plants Ltd. and Bengal Arc Steels Ltd. in Model 2.

5. The sick units which have done best as per Model 1 are Kamani Engineering Corporation, Somaya Organics Ltd. and Indo Nippan Precision Bearing. The same three units have done the best as per Model 2 as well.

6. Whereas the cut-off point is -0.071 as per Model 1, the same is found to be 0.189 as per Model 2.

7. Given the cut-off point there are as many as seven units which have been misclassified under both the models. Whereas there are five healthy units classified as sick and two sick units classified as healthy as per Model 1, there are two healthy units classified as sick and five sick units classified as healthy as per Model 2.

8. The percentage of group cases correctly classified is 79.91 as per Model 1 and 78.04 as per Model 2.

9. The average discriminant score of sick units, i.e. 0.619 is much different from the average discriminant score of healthy units, i.e. -0.618 in Model 1. In Model 2 the same is 0.552 for sick units and -0.586 for healthy units.

10. The results given by the two different models are more or less identical. There is not much difference in their overall discriminating power. Either of these two models may, therefore, be used for the purpose of discriminating sick units from the healthy ones, as also determining the propensity of sickness of sick units. If at all a choice is needed, Model 1 is to be preferred for the simple reason that the number of sick units classified as healthy is only two as per Model 1 as compared to five as per Model 2.

* * *

EXHIBIT I

Means and Standard Deviations of the Nine Variables

		Mean	Standard Deviations
VAR	1	3.7616	31.2369
VAR	2	-1.6040	25.8452
VAR	3	5.3868	11.5385
VAR	4	36.7435	61.1695
VAR	5	80.7106	121.3656
VAR	6	-20.1879	237.8865
VAR	7	-120.2547	206.6015
VAR	8	7.2367	8.3518
VAR	9	6.4155	57.8286

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EXHIBIT II

Sick Units with Discriminant Scores (Model 1)

Sl No.	Name of the Unit	Discriminant Scores				
		1975	1976	1977	1978	Average
1.	Shree Engineering Products	0.522	0.488	—	0.004	0.339
2.	Rathi Alloys & Steels Ltd.	0.405	0.477	0.314	0.134	0.333
3.	Saroj Alloys & Steels Ltd.	0.761	0.397	0.574	0.851	0.646
4.	Canara Steels Ltd.	0.867	0.089	0.020	-0.183	0.198
5.	Bombay Malleable Iron Casting and Allied Industries	1.831	—	0.966	2.070	1.622
6.	Bengal Arc Steels Ltd.	0.637	1.016	0.888	0.849	0.848
7.	Indo Nippan Precision Bearing	-0.478	-0.184	0.139	0.476	0.012
8.	Ramon And Demn Limited	-0.033	0.122	0.050	0.155	0.074
9.	Scooters India Ltd.	0.961	1.084	0.954	1.053	1.011
10.	Andhra Pradesh Scooters Ltd	0.786	0.607	0.892	0.375	0.665
11.	Kamani Engineering Corpn.	0.559	-0.761	-0.909	-1.311	-0.606
12.	Lamps, Caps & Filaments Ltd.	0.843	1.900	1.286	0.679	1.177
13.	Tata Merlin and Gerin	0.532	0.291	0.791	0.403	0.504
14.	Toshiba Anand Lamps Ltd.	0.158	0.298	0.579	1.238	0.568
15.	Sylvania and Laxman Ltd.	0.116	0.648	1.294	0.599	0.664
16.	Somaya Organics Ltd.	-0.377	-0.435	-0.102	0.057	0.214
17.	Plastic Resin and Chemicals	1.330	1.576	1.804	2.071	1.695
18.	The Travancore Cochin & Chemicals Ltd.	0.529	0.450	0.777	1.472	0.807
19.	Mysore Acetate & Chemicals Ltd.	0.304	0.347	0.256	0.307	0.304
20.	Jessop and Company Ltd.	0.476	0.133	0.034	0.323	0.242
21.	Industrial Plants Ltd.	0.592	0.846	0.898	0.618	0.739
22.	Steel and Allied Prods. Ltd.	-0.243	0.552	1.427	0.919	0.664
23.	Indian Firebricks & Insulators Ltd.	1.466	2.103	1.220	1.273	1.515
24.	Keltron Counters Ltd.	-0.128	-0.186	1.061	0.618	0.341
25.	Punjab Breweries Ltd.	0.788	0.736	0.429	0.818	0.693
26.	Nagpal Petro Chemicals Ltd	0.287	1.608	2.180	0.865	1.235
27.	Kanona Haycock	0.015	0.167	0.867	0.813	0.466
28	Bolani Ores Ltd.	0.522	0.589	0.801	1.199	0.778

EXHIBIT II (Contd)
Healthy Units with Discriminant Scores (Model 1)

Sl No.	Name of the Unit	1975	1976	1977	1978	Average
1.	Indian Tubes Co. Ltd.	0.416	0.986	-0.413	0.041	0.258
2.	Hindustan Malleable & Forgings Limited	-0.340	-0.448	-0.788	-0.764	-0.585
3.	India Forge and Drop Stamplings Ltd.	-1.704	-0.977	0.171	-0.971	-0.870
4.	Madras Forging and Allied Industries	1.307	-0.777	-0.449	-0.059	-0.619
5.	Usha Alloys and Steels Ltd.	0.188	0.138	-0.167	-0.690	-0.133
6.	Modella Steels & Alloys Ltd.	0.056	0.376	0.366	0.061	0.215
7.	Punjab Concast Steels Ltd.	-0.049	-0.385	-0.526	-2.326	-0.822
8.	The Premier Automobiles Ltd.	-3.889	0.035	-0.166	0.274	-0.937
9.	Bharat Gears Ltd.	-0.034	0.278	-0.213	-0.552	-0.130
10.	Anglo American Manne Co Ltd.	-0.811	0.272	0.222	1.245	0.232
11.	Associated Bearing Co Ltd.	1.937	-2.028	-2.461	-2.062	-2.122
12.	Aluminirm Industries Ltd.	-0.418	-0.567	-0.205	0.315	-0.219
13.	Asian Cable Corporation Ltd.	-1.837	-1.375	-1.031	-0.904	-1.287
14.	Graphite India Ltd.	-0.908	-0.967	-1.065	-0.929	-0.967
15.	Punjab Anand Batteries Ltd.	0.121	0.175	0.094	-1.140	-0.193
16.	Shesasayee Industries Ltd.	0.022	-0.259	-0.473	-0.752	-0.365
17.	Polyolin Industries Ltd.	-1.876	-1.985	-1.927	-2.468	-2.064
18.	Sudarshan Chemical Inds.	-0.478	-0.388	-0.389	-0.296	-0.388
19.	Chemicals & Plastics Ltd.	-0.816	-0.617	-0.991	-1.539	-0.991
20.	Herdilla Chemicals Ltd.	-1.296	-2.105	-2.473	-3.452	-2.332
21.	Shriram Peston & Rings Ltd	-0.856	-0.373	0.096	-0.017	-0.288
22.	Star Textile Engineering Ltd	-0.117	-0.150	-0.252	0.201	-0.080
23.	ACC Vickers Ltd.	0.080	0.032	0.063	-0.367	-0.048
24.	Seven Seas Transportation Ltd	-0.031	0.077	0.866	0.943	0.464
25.	Indo French Time Inds. Ltd.	-0.286	-0.282	-0.716	-0.585	-0.467
26.	Siporex India Ltd.	0.417	-1.654	-1.694	-2.377	-1.327

EXHIBIT III

Sick and Healthy Units arranged in ascending order of discriminant scores (Model 1)

S.No.	Name of the Unit	Score	S/H
1.	Herdilla Chemicals Limited	-2.332	H
2.	Associated Bearings Ltd.	-2.122	H
3.	Polyolin Industries Ltd.	-2.064	H
4.	Siporex India Ltd.	-1.327	H
5.	Asian Cable Corporation Ltd.	-1.287	H
6.	Chemicals and Plastics India	-0.991	H
7.	Graphite India Ltd.	-0.967	H
8.	The Premier Automobiles Ltd.	-0.937	H
9.	India Forge and Drop Stamplings Ltd.	-0.870	H
10.	Punjab Concast Steels Ltd.	-0.822	H
11.	Madras Forging and Allied Industries	-0.619	H
12.	Kamani Engineering Corporation	-0.606	S
13.	Hindustan Malleable and Forgings Ltd.	-0.585	H
14.	Indo French Time Industries Ltd.	-0.467	H
15.	Sudarshan Chemical Industries Ltd.	-0.388	H
16.	Shesasayee Industries Ltd.	-0.365	H
17.	Shriram Peston and Rings	-0.288	H
18.	Aluminium Industries Ltd.	-0.219	H
19.	Somaya Organics Ltd.	-0.214	S
20.	Punjab Anand Batteries Ltd.	-0.193	H
21.	Usha Alloys and Steels Ltd.	-0.133	H
22.	Bharat Gears Ltd.	-0.130	H
23.	Star Textile Engineering Ltd.	-0.080	H

Cut-off point

S.No.	Name of the Unit	Score	S/H
24.	ACC Vickers Ltd.	-0.048	H
25.	Indo Nippan Precision Bearing	0.012	S
26.	Remon and Demn Ltd.	0.074	S
27.	Canara Steels Ltd.	0.198	S

Exhibit III (Contd)

Sick and Healthy Units arranged in ascending order of discriminant scores (Model 1)

S.No.	Name of the Unit	Score	S/H
28.	Modella Steels and Alloys Ltd.	0.215	H
29.	Anglo American Manne Co. Ltd.	0.232	H
30.	Jesson and Company Ltd.	0.242	S
31.	Indian Tubes Company Ltd.	0.258	H
32.	Mysore Acetate and Chemicals	0.304	S
33.	Rathi Alloys and Steels Ltd.	0.333	S
34.	Shri Engineering Products	0.339	S
35.	Keltron Counters Ltd.	0.341	S
36.	Seven Seas Transportation Ltd.	0.464	H
37.	Kanona Haycock	0.466	S
38.	Tata Merlin and Gerin	0.504	S
39.	Toshiba Anand Lamps Ltd.	0.568	S
40.	Saroj Alloys and Steels Ltd.	0.646	S
41.	Steel and Allied Products	0.664	S
42.	Sylvania and Laxman Ltd.	0.664	S
43.	Andhra Pradesh Scooters	0.665	S
44.	Punjab Breweries Ltd.	0.693	S
45.	Industrial Plants Ltd.	0.739	S
46.	Bolani Ores Ltd.	0.778	S
47.	The Travancore Cochin & Chemicals Ltd.	0.807	S
48.	Bengal Arc Steels Ltd.	0.848	S
49.	The Scooters India Ltd.	1.011	S
50.	Lamps, Caps and Filaments	1.177	S
51.	Nagpal Petro Chemicals	1.235	S
52.	India Firebricks and Insulators	1.515	S
53.	Bombay Malleable Iron Castings	1.622	S
54.	Plastic Resin and Chemicals	1.695	S

EXHIBIT IV

Discriminant Analysis between Healthy and Sick Units   (Model 1)

Healthy Units ← Discriminant Boundary Line
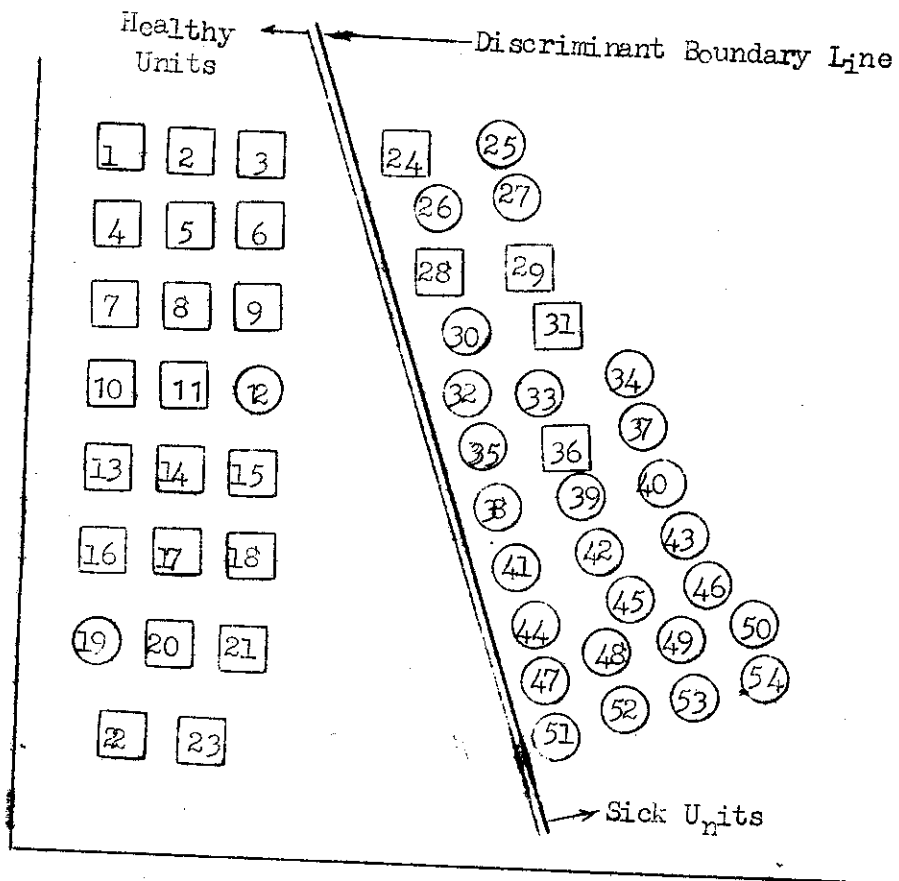
Sick Units

EXHIBIT V

Universes of Healthy and Sick Units

(Model 1)

Healthy Units   Sick Units

$\overline{Z}_H$ $\overline{Z}_S$

(-0.618)   (0.619)

Discriminant Function Value

Probability of Occurrence
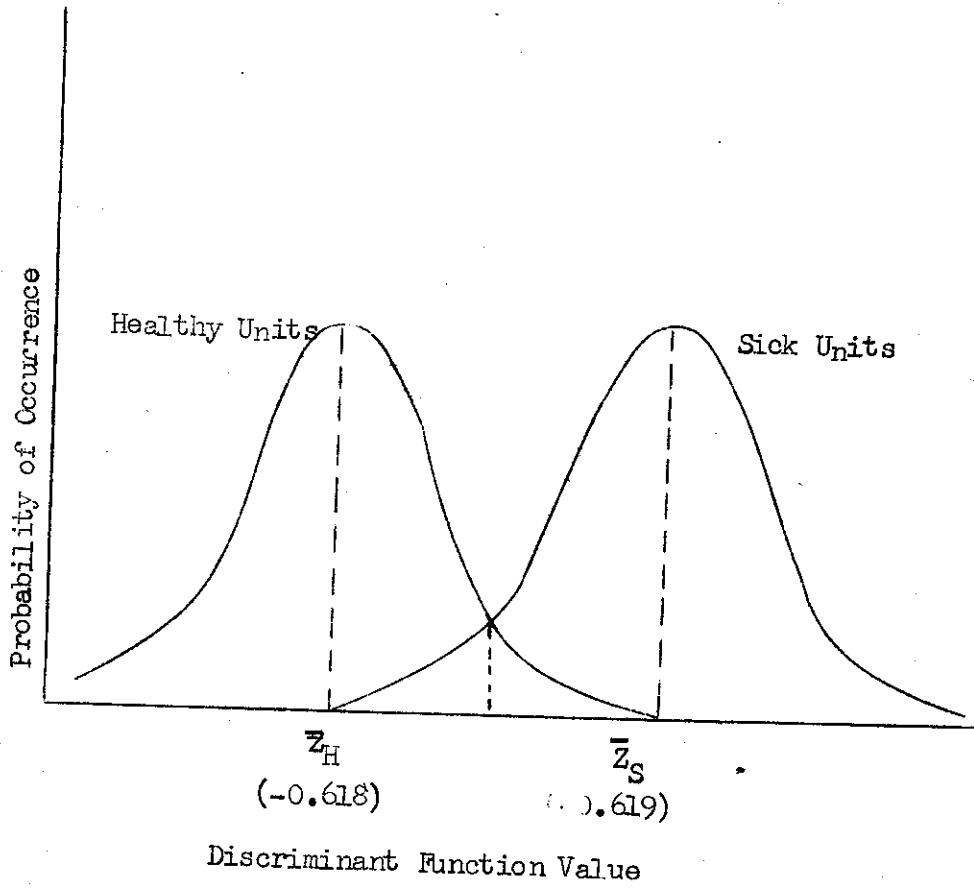
EXHIBIT VI
Sick Units with Discriminant Scores (Model 2)

Sl No.	Name of the Unit	1975	1976	1977	1978	Average
1.	Shri Engineering Products	0.488	0.463	–	-0.319	0.211
2.	Rathi Alloys & Steels Ltd.	0.717	0.576	0.161	-0.218	0.309
33.	Saroj Alloys & Steels Ltd.	1.235	0.368	0.589	1.093	0.821
4.	Canara Steels Ltd.	1.385	-0.015	-0.367	-0.880	0.031
5.	Bombay Malleable Iron Casting and Allied Industries	1.461	–	0.412	1.458	1.110
6.	Bengal Arc Steels Ltd.	0.996	1.434	1.564	1.463	1.364
7.	Indo Nippan Precision Bearing	-0.840	-0.401	0.049	0.377	-0.204
8.	Ramon D& Demn Ltd.	0.446	0.384	0.310	0.448	0.397
9.	Scooters India Ltd.	1.604	1.324	0.364	0.867	1.040
10.	Andhra Pradesh Scooters Ltd.	0.000	1.168	1.514	0.623	0.826
11.	Kamani Engineering Corporation	0.581	-1.814	-1.973	-1.618	-1.206
12.	Lamps, Caps & Filaments	0.852	2.112	2.113	-0.033	1.261
13.	Tata Merlin & Geri■	0.588	0.045	0.800	-0.015	0.355
14.	Toshiba Anand Lamps	0.027	0.217	0.712	1.110	0.517
15.	Sylvania & Laxman Ltd.	0.228	1.006	1.796	0.210	0.810
16.	Somaya Organics Ltd.	0.000	-1.098	-0.369	-0.078	-0.386
17.	Plastics Resins & Chemicals	2.672	1.581	1.330	1.307	1.723
18.	The Travancore Cochin & Chemicals Ltd.	0.547	0.554	0.635	0.647	0.596
19.	Mysore Acetate & Chemicals	0.093	-0.025	-0.184	-0.056	-0.041
20.	Jessop & Company Ltd.	0.350	0.017	-0.136	0.685	0.229
21.	Industrial Plants Ltd.	0.907	1.135	2.912	1.501	1.434
22.	Steel & Allied Products Ltd	-0.272	0.754	1.930	1.524	0.984
23.	India Fire Bricks & Insulators Ltd.	0.000	1.100	0.827	1.125	0.763
24.	Keltron Counters Ltd.	-0.616	-0.502	1.467	0.515	0.216
25.	Punjab Breweries Ltd.	1.111	0.491	-0.025	0.290	0.467
26.	Nagpal Petrochemicals Ltd.	0.033	1.631	0.953	0.000	0.654
27.	Manone Hay Cock	-0.227	0.223	0.940	0.969	0.476
28.	Bolani Ores Ltd.	0.960	0.594	0.629	0.601	0.696

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EXHIBIT VI (Contd)
Healthy Units with Discriminant Scores (Model 2)

Sl. No.	Name of the Unit	1975	1976	1977	1978	Average
1.	Indian Tubes Company Ltd.	0.692	2.356	-0.318	0.327	0.764
2.	Hindustan Malleable & Forgings Ltd.	-0.738	-0.628	-0.939	-0.945	-0.813
3.	India Forge & Drop Stampings Ltd.	-1.616	-0.541	-0.568	-0.568	-0.539
4.	Madras Forging & Allied Industries Ltd.	-1.953	-0.520	-0.504	0.499	-0.620
5.	Usha Alloys & Steels Ltd.	0.059	-0.042	-0.615	-1.349	-0.487
6.	Modella Steels & Alloys Ltd.	-0.139	0.475	-0.142	-0.425	-0.058
7.	Punjab Concast Steels Ltd.	-0.479	-0.360	-0.546	-1.714	-0.775
8.	The Premier Automobiles Ltd.	-0.352	0.450	0.143	0.996	0.309
9.	Bharat Gears Ltd.	-0.351	-0.078	-0.857	-1.552	-0.710
10.	Anglo American Manne Co Ltd	-0.878	0.502	0.509	1.435	0.392
11.	Associated Bearing Co Ltd.	-1.303	-1.091	-1.264	-0.788	-1.112
12.	Aluminium Industries Ltd.	-0.457	-0.601	-0.155	0.618	-0.149
13.	Asian Cable Corpn. Ltd.	-1.276	-0.692	-0.623	-1.293	-0.971
14.	Graphite India Ltd.	-1.555	-1.134	-0.901	-0.564	-1.039
15.	Punjab Anand Batteries Ltd.	0.024	0.054	-0.065	-2.139	-0.532
16.	Shesasayee Industries Ltd.	-0.180	-0.684	-1.011	-1.224	-0.775
17.	Polyolin Industries Ltd.	-1.439	-0.982	-0.802	-1.387	-1.153
18.	Sudarshan Chemical Industries	-0.746	-0.781	-0.787	-0.466	-0.695
19.	Chemicals & Plastics India Ltd.	-0.759	-0.294	-0.749	-1.442	-0.811
20.	Herdilla Chemicals Ltd.	-0.669	-1.616	-1.408	-1.611	-1.326
21.	Shriram Piston & Rings Ltd.	-2.027	-1.361	-0.520	-0.728	-1.159
22.	Star Textile Engineering Ltd	-0.224	-0.277	-0.603	0.222	-0.221
23.	ACC Vickers Ltd.	0.184	0.258	0.269	-0.498	0.053
24.	Seven Seas Transportation Ltd.	-0.710	-0.450	0.656	0.596	0.023
25.	Indo French Time Industries Ltd.	-1.188	-0.784	-1.312	-0.988	-1.068
26.	Siporex India Limited	0.068	-3.428	-2.106	-1.540	-1.752

EXHIBIT VII

Sick and Healthy Units arranged in ascending order of Discriminant Scores (Model 2)

Rank	Name of the Unit	Score	S/H
1.	Siporex India Ltd.	-1.752	H
2.	Herdilla Chemicals Ltd.	-1.326	H
3.	Associated Bearings Ltd.	-1.112	H
4.	Indo French Time Industries	-1.608	H
5.	Graphite India Ltd.	-1.039	H
6.	Asian Cable Corporation Ltd.	-0.971	H
7.	Hindustan Malleable and Forgings Ltd.	-0.813	H
8.	Chemicals & Plastics India Ltd.	-0.811	H
9.	Shesasayee Industries Ltd.	-0.775	H
10.	Punjab Concast Steels Ltd.	-0.775	H
11.	Bharat Gears Ltd.	-0.710	H
12.	Sudarshan Chemical Industries	-0.695	H
13.	Madras Forging & Allied Industries Ltd	-0.620	H
14.	India Forge & Drop Stamplings Ltd.	-0.539	H
15.	Punjab Anand Batteries	-0.532	H
16.	Usha Alloys and Steels Ltd.	-0.487	H
17.	Somaya Organics Ltd.	-0.386	H
18.	Star Textile Engineering Ltd.	-0.221	H
19.	Kamani Engineering Corporation	-0.206	S
20.	Indo Nippan Precision Bearing	-0.204	S
21.	Shriram Peston & Rings Ltd.	-1.159	H
22.	Polyolin Industries Ltd.	-1.153	H
23.	Aluminium Industries Ltd.	-0.149	H
24.	Modella Steel and Alloys Ltd.	-0.058	H
25.	Mysore Acetate and Chemicals Ltd.	-0.041	S
26.	Seven Seas Transportation Ltd.	-0.023	H
27.	Canara Steels Ltd.	0.034	S

EXHIBIT VII (Contd)

Sick and Healthy Units arranged in ascending order of Discriminant Scores (Model 2)

Rank	Name of the Unit	Score	S/H
28.	ACC Vickers Ltd.	0.053	H
		Cut-off point	
29.	Shri Engineering Products	0.211	S
30.	Keltron Counters Ltd.	0.216	S
31.	Jessop and Company Ltd.	0.229	S
32.	The Premier Automobiles	0.309	H
33.	Rathi Alloys and Steels	0.309	S
34.	Tata Merlin and Gerin	0.355	S
35.	Anglo American Manne Co Ltd.	0.392	S
36.	Ramon and Demn Ltd.	0.397	S
37.	Punjab Breweries Ltd.	0.467	S
38.	Kanone Haycock	0.476	S
39.	Toshiba Anand Lamps	0.517	S
40.	The Travancore Cochin & Chemicals Ltd.	0.596	S
41.	Nagpal Petrochemicals Ltd.	0.654	S
42.	Bolani Ores Ltd.	0.696	S
43.	India Firebricks and Insulators Ltd	0.763	S
44.	India Tubes Company Ltd.	0.764	H
45.	Sylvania and ALaxman Ltd.	0.810	S
46.	Saroj Alloys and Steels	0.821	S
47.	Andhra Pradesh Scooters	0.826	S
48.	Steel and Allied Products	0.984	S
49.	Scooters India Ltd.	1.040	S
50.	Bombay Malleable Iron Castings	1.110	S
51.	Lamps, Caps, and Filaments	1.261	S
52.	Bengal Arc Steels Ltd.	1.364	S
53.	Industrial Plans Ltd.	1.434	S
54.	Plastic Resin and Chemicals	1.723	S

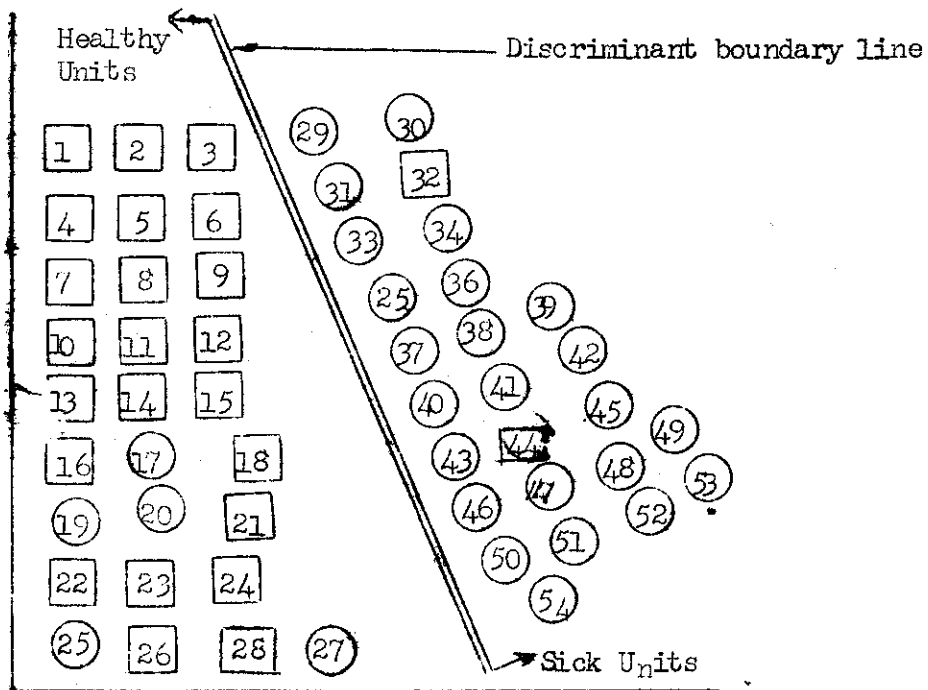## EXHIBIT VIII

Discriminant Analysis Between Healthy and Sick Units (Model 2)

EXHIBIT IX

Universes of Healthy and Sick Units

(Model 2)

$\overline{Z}_H$ (-0.586)　　$\overline{Z}_S$ (0.552)

Discriminant Function Value

Probability of Occurrence

Healthy Units　　　Sick units