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Discriminant Analysis: An Applied Mathematical Tool to Navarathna Company's Financial Performance

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Abstract: The role played by the Navratna companies (PSUs) towards the GDP of Indian economy is 26%, it can never be ignored. In this study, linear discriminant analysis is used to analyze the financial performance of Navratna PSUs (Public Sector Units). The discriminating factors have been identified for effective prediction of their categories according to their financial performance as poor and high. This study uses linear discriminant analysis, the most popular analytical tools to discriminate the financial performance of companies as high and poor. Through this study, the discriminating variables that discriminate the best performing Navratna companies are identified. Furthermore, a discriminating score that classifies the companies as high and poorly performing PSUs is identified. The real world dataset from the year 2012-13 to 2015-16 and relevant statistical measures have been used for performance evaluation of these companies. This study can be used for identification, monitoring, evaluation, analysis, measure and ranking of the company and categorizing them in terms of financial performance. Using the Z score any company can identify their position and concentrate on the identified variables. Considering their role in the development of Indian economy and also their service to Indian citizens in ways such as manufacturing and producing products, raw materials and offering numerous other services, it is necessary frequently monitor their financial health for better sustenance. This study has developed a discriminant model for evaluating financial performance of Navratna companies.

Key words: Navratna, discriminant analysis, financial performance, developing model, net profit, total tax

INTRODUCTION

Linear Discriminant Analysis (LDA) originally developed by Fischer (1936) is commonly used to obtain a linear combination of features to characterize or separate two or more classes of objects or events. It is an algorithm that separates two or more categories by generating features with linear combinations. The separator between object groups would be a line for two features. The separator for three features would be a plane and for more than three features, the separator would be a hyper plane. The class of a new observation is determined by the distance of mean vector of each group using Mahalanobis distance.

A variable that has two or more categories is called categorical variable (or a nominal variable) and represents the types of data that may be divided into groups. Categorical variables have no intrinsic ordering and there is no numerical meaning. Gender, the field of study, hair color, college attended, the status of disease infection and political affiliation are categoric variables and there is no intrinsic ordering to the categories (i.e., highest to lowest). Dichotomous variables are variables with two categories whereas polytomous variables contain more two categories (Agresti, 2002).

In data analysis, it is difficult to deal with data that represent multiple independent variables and categorical dependent variable and to understand the use of independent variables that contribute to the discovery of differences in the categories. A problem of major practical and research interest is the assignment of observations or objects into predefined homogenous groups. For example, to determine who will or will not graduate from college, quantitative information can be used. When only two distinct values are assumed by the categorical dependent variables, it becomes a simple binary classification problem. When a person is ill, he wants a doctor to diagnose his disease from the symptoms. This is an example of multiple classes or categories of the categorical dependent variables. And under classification problems,

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the attempt to predict values of a categorical dependent variable is done from one or more continuous and/or categorical predictor variables.

Statistics is the process of placing an observation p in one of the predefined categories or groups and defining an ideal classification method that distinguishes the classes from each other.

The primary objective is to build a discriminant function of Navratna companies. To obtain the optimal discrimination between the classes, the p variables on an indicator is summarized by obtaining information. To obtain optimal discrimination between the classes and to determine the rule applicable to new cases, the decision rule is derived by the assumption of availability of data sample of pre-classified cases. An approach that is model-based is used to derive the decision rule.

Navratna: After independence, public sector enterprises played important roles in the development of the Indian economy and in overcoming socio-economic problems. The Ministry of Heavy Industries and Public Enterprises administers the CPSE companies in which there is 51% or more direct holding of the central government or other CPSEs. The 1956 industrial policy included the expansion of public sectors that supported the idea to promote economic development by the state actually managing industrial concerns.

At the time of independence, the country had a low level of savings and investment, heavy unemployment, weak industrial base and poor infrastructural facilities and thus India needed a big push for highly performing companies.

Public sector enterprises have been titled "Navratna companies" by the government of India in 1997 which allowed them greater autonomy to compete in the global market. A score of 60 is the qualifying criteria for being a Navratna Company. The parameters for the score include total manpower cost to total cost of production or cost of services, net profit to net worth Interest and Taxes (PBDIT) to capital employed, profit before depreciation, Earning Per Share (EPS), PBIT to turnover and interest sector performance. Additionally, before being a Navratna, a company must first be a Miniratna and have four independent directors on its board.

Literature review: There are many research studies that have focused on classifier performance, specifically, Linear Discriminant Analysis (LDA), its methodology and algorithm. In this study, we present studies that have been carried out on linear discriminant analysis.

Efron (1975) discussed the performance of the relative efficiency of logistic regression and normal discrimination analysis. He showed that when the data are multivariate normal, LR is less efficient than LDA. He also found that LR is between one-half and two-third as effective as normal discrimination.

Montgomery *et al.* (1987) compared the method of stepwise LDA and LR in the veterinary first data set. They also compared the selected variable, selection order, the sign and magnitude of the estimated coefficients of the discriminating models in the second data set. They concluded that LR is preferable to LDA when the assumptions of the equal variance and normality are not met.

Antonogeorgos *et al.* (2009) also studied both methods, i.e., LDA and LR in their clinical study to predict the probability of specific categorical outcomes amongst several explanatory variables. The objective of their research was to estimate the convergence of these two methods in health sciences data set.

Pohar *et al.* (2004) used several simulated datasets to analyze the LDA and Multinomial Logistic Regression (MLR) methods. The researcher concluded that LDA is more appropriate when the variables are normally distributed and MLR only overcomes when the number of categories is small.

Maroco *et al.* (2011) compared seven data mining nonparametric classifiers to the traditional classifiers (LDA, Quadratic Discrimination Analysis (QDA), LR) in terms of sensitivity, specificity and classification accuracy. They showed that among all these LDA ranks first in the prediction of dementia using several neuropsychological tests.

Singh and Paliwal (2010) estimated the impact of disinvestment during 1985-86 to 2004-05 on the performance of specific monopoly units and competitive firms in the Indian public sector enterprises. They posited that the selected monopoly units proved its efficiency in generating profit as we as controlling costs in the same period while the selected competitive firms declined significantly during the post-disinvestment period in terms of profitability.

Seema *et al.* (2011) assessed 38 selected CPSEs in India (of 44 disinvested enterprises till March 2008) for the period 1986-87 to 2009-10 using performance metrics such as profitability, efficiency, liquidity, leverage and productivity ratios. He showed that small amounts of disinvestment did not yield the desired results in most dimensions.

Sur and Panja (2014) conducted a comparative analysis of the profitability of NTPC Ltd., the only Maharatna CPSE in the power sector, during pre- and post-liberalization periods. During this study, the profitability performance of the company was assessed on the basis of average, consistency, trend, etc., of some selected profitability ratios using statistical tools and

techniques. NTPC Ltd., proved to be a better performer in terms of profitability in the post-liberalization period than during the pre-liberalization time frame.

Vijayakumar and Jayachitra (2014) investigated the profitability performance of 12 CPSEs in the manufacturing sector such as fertilizer, heavy engineering, medium and light engineering, petroleum (refinery and marketing) and transportation equipment in both the pre and post-disinvestment periods. Using suitable statistical tools and techniques, the study showed that 58% of the companies were able to enhance their profitability during the post-disinvestment period.

Vijayakumar and Jayachitra (2015) performed comparative analysis of the pre and post-disinvestment financial and operating performance of 12 CPSEs in India, of the cognate groups belonging to the manufacturing sector such as fertilizer, heavy engineering, medium and light engineering, petroleum (refinery and marketing) and transportation equipment. Using relevant statistical tools and techniques, it showed that companies belonging to the heavy engineering sector experienced more significant improvements in the post-disinvestment period while performance unsatisfactory for companies dealing with transportation equipment.

From the above discussion, it can be seen that studies have been performed to compare different types of analytical methods, i.e., linear discriminant analysis, quadratic discriminant analysis, regression analysis and other analytical methods and some tried to identify the benefit of one method over another. One of the studies considered fewer factors than others and was not able to yield the desired result in all the dimensions. One of the studies showed that only 58% of companies were able to improve their financial performance. One other study tried to target all the CPFEs but was able to benefit only an area specific industry instead of satisfying all the CPFEs.

This study is conducted to bridge the above gaps in knowledge. Discriminant analysis is performed for Navratna companies to analyze and compare their financial performance.

Objectives of the study: To study and understand the financial performance of the selected 8 Navratna companies (PSU) for a period of 4 years from 2012-13 to 2015-16. Of the above 8 Navratna companies, 4 PSU are the 'high performing' Navratna companies and another 4 PSU are poorly performing Navratna companies. To study and understand important financial performance variables of these 2 groups of Navratna companies.

To study the discriminating factors that discriminate the good Navratna companies from the poorly performing Navratna companies.

The scope of the study:

- The main focus of this study is finding the discriminating variables and discriminating score
- Further detailed study is aimed at ranking the high performance Navratna companies

Limitations of the study: The study is limited to the period of April 2012-13 to 2015-16 for ranking analysis.

MATERIALS AND METHODS

Types of research: Analytical research design is followed in a large part of the study while descriptive research design is used less.

Sampling

Population: The 15 Navratna companies are selected for the study.

Samples: Based on the net profit as a percentage of total assets, 4 good-performing Navratna companies are selected.

Statistical tools for analysis: Discriminant analysis is used to find the discriminating factors influencing the performance of Navratna companies. The performance of the Navratna companies ranking and scoring techniques are used for ranking. Mean values are used in calculating the grand discriminating score.

Analytical tools: The study is used to analyze the performance of 4 Navratna companies. The ranking is based on financial variables such as gross profit, net profit deposits interest income interest expenditure, the cost of fund, etc. Based on net profit as a percentage of total assets, 4 good-performing Navratna companies and 4 poorly performing Navratna companies are selected. The ranking analysis is used to rank the high performance Navratna companies.

Source of data: The main source of data is a secondary source. The following source is used for collecting the data 4 years balance sheet items and profit and loss account details for 4 years are collected from their respective official website.

Analysis and interpretation

Net profit:

- NMDC secured 1st rank in terms of net profit. It secured 4th, 1st, 1st and 1st in the year 2013-2016, respectively (Table 1)
- PGCIL secured 4th rank in terms of net profit

Table 1: Net profit rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	4505.00	9768.00	9761.00	9462.00	1
PFCL	9060.00	8378.00	7558.00	5967.00	2
PGCIL	7618.78	6289.38	6263.75	5644.86	4
RECL	8045.21	7427.04	6531.12	5163.95	3

Table 2: Net operating cash flow rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	3374.63	4007.22	3720.80	3087.07	4
PFCL	13297.70	21445.27	19471.44	15481.13	1
PGCIL	16900.00	15800.08	14786.90	12689.48	3
RECL	13278.01	23898.23	17243.78	20058.88	2

Table 3: Sales/revenue rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	8231.79	14623.33	14147.31	12,943.12	4
PFCL	27474.00	24862.00	22955.00	19090.00	1
PGCIL	21780.76	17898.58	16782.25	14686.26	2
RECL	23756.28	20388.05	17228.94	13638.70	3

Table 4: Growth in net profit rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	-52.8400	0.03115	1.2290	-12.7000	4
PFCL	2.9199	9.98500	22.5790	45.7780	3
PGCIL	21.0380	10.71169	6.2089	30.0941	2
RECL	6.9923	12.30000	22.6800	17.5800	1

Net operating cash flow:

- PFCL secured 1st rank in terms of net operating cash flow. It secured 2nd, 2nd, 1st and 2nd in the year 2013-2016, respectively
- NMDC secured 4th rank in terms of net operating cash flow (Table 2)

Sales/revenue:

- PFCL secured 1st rank in terms of rales/revenue. It secured 1st rank in the year 2013-2016
- NMDC secured 4th rank in terms of sales/revenue (Table 3)

Growth in net profit:

- RECL secured 1st rank in terms of growth in net profit. It secured 2nd, 1st, 1st and 3rd in the year 2016, 2015, 2014 and 2013, respectively
- NMDC secured rank 4th in terms of growth in net profit (Table 4)

Gross profit/gross income:

- PGCIL secured 1st rank in terms of gross profit/gross income. It secured 1st rank in the year 2013-2016
- PFCL secured 4th rank in terms of gross profit/gross income (Table 5)

Table 5: Gross profit/gross income rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	4690.79	9881.52	9865.98	9616.84	3
PFCL	9060.66	8378.23	7558.31	5967.04	4
PGCIL	18824.05	15354.11	13426.95	11532.00	1
RECL	11906.22	9526.58	7505.16	5474.94	3

Table 6: Growth in gross profit rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	-0.525200	0.001575	0.025900	-0.117000	4
PFCL	0.081450	0.108479	0.266670	0.106870	3
PGCIL	0.226024	0.143529	0.164321	0.265389	2.
RECL	0.249700	0.269300	0.307800	0.276100	1

Table 7: Interest income rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	1669.73	2185.84	1996.86	2200.95	3
PFCL	11168.00	9883.18	20978.71	16922.91	1
PGCIL	2704.89	2374.69	2135.48	1875.56	2
RECL	366.30	378.85	96.38	56.13	4

Table 8: Profit per share/earnings (Rs.) rankings

Company Name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	7.64	16.200	16.19	16.00	3
PFCL	46.31	44.961	41.04	39.48	2
PGCIL	11.50	9.640	10.68	8.91	4
RECL	56.99	53.270	47.30	38.66	1

Table 9: Gross interest expense rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	105.03	77.69	94.55	36.14	4
PFCL	1638.31	1514.59	1398.51	1256.93	3
PGCIL	2241.50	2405.80	2154.56	1975.09	2
RECL	13407.10	11371.62	9593.39	7849.54	1

Growth in gross profit:

- RECL secured 1st rank in terms of growth in gross profit. It secured 1st rank in the year 2013-2016
- NMDC secured 4th rank in terms of growth in gross profit (Table 6)

Interest income:

- PFCL secured 1st rank in terms of interest income. It secured 1st rank in the year 2013-2016 (Table 7)
- RECL secured 4th rank in terms of interest income

Profit per share/earnings (Rs.):

- RECL secured 1st rank in terms of rofit/share/earning. It secured 1st, 1st, 1st and 2nd rank in the year 2013-2016, respectively
- PGCIL secured 4th rank in terms of profit/ share/earning (Table 8)

Gross interest expense:

- RECL secured 1st rank in terms of gross interest expense. It secured 1st rank in the year 2013-2016
- NMDC secured 4th rank in terms of Gross interest expense (Table 9)

Table 10: Profit per employee rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	0.812539	1.799910	1.74187	1.66467	4
PFCL	19.40180	18.61820	16.4100	13.1800	1
PGCIL	2.187300	1.699778	1.76997	1.44921	3
RECL	19.84000	15.85000	12.5290	9.2000	2

Table 11: Income tax rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	1477.01	3346.03	3339.12	3122.75	1
PFCL	3092.64	2475.24	2086.13	1415.08	3
PGCIL	2904.80	3267.90	2935.89	2363.68	2
RECL	3749.55	3134.24	1667.44	1384.09	4

Table 12: Total current assets rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	19276.08	23889.76	23861.19	25592.18	2
PFCL	43954.91	30183.71	24743.34	26096.55	1
PGCIL	7930.10	9069.00	8210.05	7390.34	4
RECL	46504.57	17878.56	15179.35	15041.76	3

Table 13: Total assets rankings

Company name	2015-16	2014-15	2013-14	2012-13	Final score
NMDC	33346.0	34470.0	31477.0	30894.0	4
PFCL	246636.8	228664.4	194164.1	169228.8	1
PGCIL	158300.9	139589.1	128892.0	119847.0	3
RECL	206944.9	183455.9	152852.9	130507.3	2

Profit per employee:

- PFCL secured 1st rank in terms of profit per employee. It secured 2nd, 1st, 1st and 1st rank I the year 2013-2016, respectively
- NMDC secured 4th rank in terms of profit per employee (Table 10)

Income tax:

- NMDC secured 1st rank in terms of income tax. It secured 4th, 1st, 1st and 1st rank in the year 2013-2016, respectively
- RECL secured 4th rank in terms of income tax (Table 11)

Total current assets:

- PFCL secured 1st rank in the terms of total current assets. It secured 2nd, 1st, 1st and 1st rank in the year 2013-2016, respectively
- PGCIL secured 4th rank in the terms of total current assets (Table 12)

Total assets:

- PFCL secured 1st rank in terms of total assets. It secured 1st rank in the year 2013-2016
- NMDC secured 4th rank in terms of total assets (Table 13)

Table 14: Overall final rank

Name of the Navratna company	Rank
NMDC	1
PFCL	2
PGCIL	3
RECL	4

RESULTS AND DISCUSSION

Finding from ranking analysis

Overall final rank: From the individual ranking analysis and overall ranking analysis, NMDC Navratna company was ranked top among the high performing Navratna companies. This Navratna company's performance is far better than the other 3 Navratna companies. It ranked firstin the analysis of the following financial variables (Table 14).

- Net operating cash flow
- Sales/revenue
- Growth in net profit
- Gross profit/gross income
- Growth in gross profit
- Interest income
- Profit per share/earning
- Gross interest expense
- Interest expended as percentage of total asset
- Net profit before interest
- Profit per employee
- Business per employee
- Income tax
- Total current assets
- Total assets

Result from discriminating analysis: Z score that discriminate the bad Navratna companies from good Navratna companies is given. The results of the discriminating function indicate that there is 100% correct classification. The 5 important variables that discriminate the good Navratna company from the bad Navratna company are:

- Net operating cash flow = -2.733
- Growth in net profit = 4.059
- Interest income = -0.309
- Income tax = -0.830
- Total assets = 1.198
- Z-score for high performing Navratna company = 5, 17, 191.206
- Z-score for poor performing Navratna company = 38, 761.21
- Z-score for discriminating function = 2, 77, 976.215

Table 15: Classification results

		Predicted group membership	
Original/score	Poor	High	Total
Count			
Poor	4	0	4
High	0	4	4
Percentage			
Poor	100	0	100
High	0	100	100

100% of original grouped cases correctly classified

Table 16: Functions at group centroids*

Score	Function (1)
0.00	-6.722
1.00	6.722

*Significant values

Classification results: The high performing companies and poor performing companies are 100% classified. This study is validated through this classification. The high performing companies and poor performing companies correctly classified (Table 15).

Group statistics: For 4 high performing Navratna companies:

- Net operating cash flow = 13658.79
- Total assets = 136829.43
- Growth in net profit = 9.037
- Interest income = 4812.15
- Income tax = 2610.1

For 4 poorly performing Navratna companies:

- Net operating cash flow = 844.95
- Total assets = 10094.9
- Growth in net profit = 7.66
- Interest Income = 224.02
- Income tax = 236.70

Functions at group centroids: These are the means of the discriminant function scores by group for each function calculated. Functions at group centroids is 6.722 (Table 16).

Eigen values: Each of a set of values of a parameter for which a differential equation has a non-zero solution (an Eigenfunction) under given conditions. The Eigenvalue is 40.533 (Table 17).

Wilk's Lambda: Wilk's lambda is a test statistic used in Multivariate Analysis of Variance (MANOVA)to test whether there are differences between the means of identified groups of subjects on a combination of dependent variables. The Wilk's lambda is 0.024 (Table 18).

Table 17: Eigenvalues*

Function	Eigenvalue	Variance (%)	Cumulative (%)	Canonical Correlation
1	40.533[a]	100.0	100.0	0.988

Table 18: Wilk's lambda*

Test of function (s)	Wilk's lambda	χ^2	df	Sig.
1	0.024	13.043	5	0.023

*Significant values

Table 19: Structure matrix

Variables	Function (1)
Income tax	0.714
Sales/revenue[a]	0.370
Interest expended as percentage of total asset[a]	0.362
Gross profit/Gross income	0.327
Net operating cash flow	0.237
Total assets	0.214
Profit per share/earning (Rs.)[a]	-0.208
Growth in gross profit[a]	-0.128
Interest income	0.088
Net profit before interest[a]	0.062
Business per employee[a]	-0.019
Gross interest expense[a]	0.016
Profit per employee[a]	-0.012
Total current assets[a]	-0.008
Growth in net profit	0.007

[a]Significant value

Table 20: Standardized canonical coefficients*

Variables	Function (1)
Net operating cash flow	-2.733
Total assets	4.059
Growth in net profit	-0.309
Interest income	-0.830
Income tax	1.198

*Significant values

Structure matrix: The structure matrix shows that the coefficient of each variables from income tax to growth in profit (Table 19).

Standardized canonical discriminant function coefficients: The standardized coefficients allow you to compare variables measured on different scales. Coefficients with large absolute values correspond to variables with greater discriminating ability (Table 20).

Discriminating score for high performing Navratna companies using canonical discriminant function coefficients = High performing Navratna companies group statistics values for NOCF*discriminate function coefficient for NOCF+High performing Navratna companies group statistics values for total assets *discriminate function coefficient for total assets+High performing Navratna companies group statistics values for growth in net profit*discriminate function coefficient for growth in net profit+High performing Navratna companies group statistics values for interest income *Discriminate function coefficient interest income+High

performing Navratna companies group statistics values for income tax*Discriminate function coefficient*Income tax = 13658.79*(-2.733)+136829.43*4.059+9.037*(-0.309)+4812.15*(-0.830)+2610.1*1.198 = 5, 17,191.206.

Discriminate score for poorly performing Navratna companies = poorly performing Navratna companies group statistics values for NOCF*Discriminate function coefficient for NOCF+Poorly performing Navratna companies group statistics values for total assets*Discriminate function coefficient for total assets. +Poorly performing Navratna companies group statistics values for growth in net profit*Discriminate function coefficient for growth in net profit+Poorly performing Navratna companies group statistics values for interest income*Discriminate function coefficient interest income. +Poorly performing Navratna companies group statistics values for income tax* Discriminate function coefficient*income tax = 844.95* (-2.733)+10094.9*4.059+7.66*(-0.309)+224.02*(-0.830)+236.702*1.198 = 38,761.21.

Discriminate score = Grand mean values for NOCF* discriminate function coefficient for NOCF+Grand mean values for total assets*Discriminate function coefficient for total assets+Grand mean values statistics values for growth in net profit*Discriminate function coefficient for growth in net profit+Grand mean values for interest income*Discriminate function coefficient interest income. +Grand mean values for income tax*Discriminate function coefficient*Income tax = 7251.87*(-2.733)+73462.165*4.059+8.348*(-0.309)+2518.08*(-0.830)+1423.401*1.198 = 2, 77,976.215.

CONCLUSION

Through this study, NMDC Ltd. is the highly performing Navratna companies among all the Navratna companies. The financial performance of Navratna companies depends on the variables, net profit before interest as a percentage of total asset and profit per employee. The proposed model using this discriminate score to differentiate the financial performance of high and poor performing companies.

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