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Research Paper

Modeling the Efficiency of Top Nationalised Indian Banks : A DEA-Neural Network Approach

Statistics

KEYWORDS : Data Envelopment Analysis, Probabilistic Neural Networks, Nationalised Indian Banks.

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ABSTRACT

In this paper, we investigate the efficiency of Nationalised Indian banks using two quantitative techniques: Data Envelopment Analysis and networks. The study uses a probabilistic neural network (PNN) and a traditional statistical classification method to model and classify the relative efficiency of top nationalized Indian banks. DEA has proven itself to be both theoretically sound framework for performance measurement and an acceptable method by those being measured. This paper assesses bank branches efficiency using DEA technique and neural network techniques. From a policy perspective, this study highlights the economic importance of encouraging increased efficiency throughout the nationalized Indian banks.

1. Introduction

The performance of any economy to a large extent is dependent on the performance of the banking sector as it being the predominant component of the financial service industry. The Indian banking sector went through structural changes since its independence keeping in view its financial linkages with the rest of the economy and to meet the social and economic objectives of development (Kumbhakar and Sarkar, 2005). Facing major economic crisis, the Reserve bank of India (RBI) launched major banking sector reforms in 1991 aimed at creating a more profitable, efficient and sound banking system, based on the recommendations of the first Narasimham committee on financial sector reforms. The purpose of this paper is to propose a methodology based on Data Envelopment Analysis (DEA) and Neural network that addresses to this issue of efficiency using data from Nationalised Indian banks (source RBI Website).

The application of quantitative techniques in the area of finance became very popular and especially, assessing Bank performance with the use of advances in Operational Research and Neural Networking. Using a recognized and valid measure of efficiency is critical for managers seeking to increase the effectiveness of their organizations. Over the past two decades, data envelopment analysis (DEA) has become a popular methodology for evaluating the relative efficiencies of decision making units (DMUs) within a relatively homogenous set (e.g. Sun & Lu, 2005). DEA is an approach to estimate the production function of organizations and organizational units and enables the assessment of their efficiency.

2. Literature review

Literature related to efficiency studies can be traced back to Farrell (1957), who treated the production frontier as the basis for efficiency assessment. In 1978, Charnes, Cooper and Rhodes (CCR) described a mathematical programming formulation for the empirical evaluation of relative efficiency of a Decision Making Unit (DMU) on the basis of the observed quantities of inputs and outputs for a group of similar referent DMUs. Banker (1980) and Banker, Charnes and Cooper (1984) (BCC) provided a formal link between DEA and estimation of efficient production frontiers via constructs employed in production economics. Sathye (2003) used DEA to study the relative efficiency of Indian banks in the late 1990's with that of banks operating in other countries. He found that the public sector banks have a higher mean efficiency score as compared to the private sector banks in India, but found mixed results when comparing public sector banks and foreign commercial banks in India.

Kumbhakar and Sarkar (2004) estimated the cost efficiency of public and private sector banks in India by using the stochastic cost frontier model with specification of translog cost function. Seiford and Zhu (1999) examined the performance of the top 55 US banks using a two-stage DEA approach. Results indicated that relatively large banks exhibit better performance on profitability, whereas smaller banks tend to perform better with respect to marketability. Drake and Howcroft (2002) assessed the relative efficiency of UK clearing bank branches using DEA method. This paper utilized the basic efficiency indices and extended the analysis by examining the relationship between size and efficiency. Das et al, (2004) examined the efficiency of Indian banks by using DEA model. Four input measures: deposits and other borrowings, number of employees, fixed assets and equity, and three output measures: investments, performing loan assets and other non-interest fee based incomes were used in the analysis. He found that Indian banks did not exhibit much of a difference in terms of input or output oriented technical and cost efficiency. However, in terms of revenue and profit efficiencies prominent differences were seen. He also found that size of the bank, ownership of the bank, and listing on the stock exchange had a positive impact on the average profit and revenue efficiency scores.

3. Objective of the study

The main objective of this paper assesses efficiency of Indian banks using DEA technique and neural network techniques. The study uses a probabilistic neural network (PNN) and a traditional statistical classification method to model and classify the relative efficiency of top nationalized Indian banks. To evaluate the overall performance measure and put forward the non-performing of Banking system using DEA

4. Methodology

4.1 Data Envelopment Analysis

Data Envelopment Analysis is a linear programming procedure for a frontier analysis of inputs and outputs. The basic DEA model for 'n' DMUs with 'm' inputs and 's' outputs proposed by CCR, the relative efficiency score of pth DMUs is given by

$$Max Z_r = \frac{\sum_{k=1}^{s} V_k Y_{kr}}{\sum_{j=1}^{m} U_j X_{jr}}$$

$$s.t. \frac{\sum_{k=1}^{s} V_k Y_{ki}}{\sum_{j=1}^{m} U_j X_{ji}} \le 1 \forall i \qquad (1)$$

$$V_k, U_j \ge 0 \forall k, j$$

where k = 1 to s (no. of outputs); j = 1 to m (no. of inputs); i = 1 to n (no.of DMUs);
Y_{ki} = amount of output k produced by DMU i; X_{ji} = amount of input j utilized by DMU i; V_k = weight given to output k and U_j = weight given to input j.

The fractional programme shown in Equation (1) can be reduced to LPP as follows:

$$Max Z_r = \sum_{k=1}^{s} V_k Y_{kr}$$

$$s.t. \sum_{j=1}^{m} U_j X_{jr} = 1$$

$$\sum_{k=1}^{s} V_k Y_{ki} - \sum_{j=1}^{m} U_j X_{ji} \le 0 \forall i \qquad (2)$$

$$V_k, U_j \ge 0 \forall k, j$$

This model is called CCR output oriented maximization DEA model. The efficiency score of 'n' DMUs is obtained by running the above LPP 'n' times.

4.2 Probabilistic Neural Network

Applications of neural network to pattern classification have been extensively studied in the past many years. Various kinds of neural-network architecture including multilayer perceptron (MLP) neural network, radial basis function (RBF) neural network, self-organizing map (SOM) neural network, and probabilistic neural network (PNN) have been proposed. Because of ease of training and a sound statistical foundation in Bayesian estimation theory, PNN has become an effective tool for solving many classification problems.

The architecture of a typical PNN is as shown in Fig. 1. The PNN architecture is composed of many interconnected processing units or neurons organized in successive layers. The input layer unit does not perform any computation and simply distributes the input to the neurons in the pattern layer.

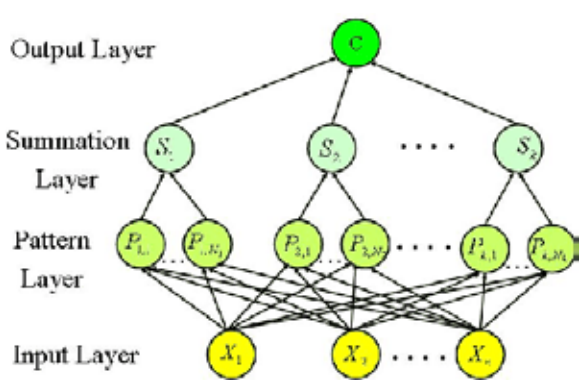

Fig.1. PNN Diagram

5. Problem formulation & Data source

There is a mathematical approach to DEA that can be adopted which is illustrated using Linear Programming technique. In this paper, we have taking 15 Nationalised Indian Banks using pure technical efficiency (TE) approach to DEA. In this study we use the VRS output-orientation model with the default weights suggested by the software. We have used two input measure such as interest expended, operating expenses and two output measures, namely Investments and Interest income. Data has been collected from RBI website for evaluation.

Table 1
Data table for financial year 2011-12-

DMU's	Input		Output	
	interest expended	operating expenses	investments	interest income
Bank of India	201672	49407	867536	284807
Bank of baroda	193567	51587	832094	296737
Canara bank	231613	46737	1020574	308506
Punjab national bank	230136	70028	1226295	364280
Union bank of india	142354	39875	623636	211443
Central bank of india	139809	37490	592433	191495
Indian overseas bank	128809	31631	555659	178971
Oriental bank of commerce	115991	23155	521013	158149
UCO bank	107303	20562	457715	146324
Allahabad bank	103606	26914	542832	155233
Syndicate bank	101833	28141	408151	152684
Corporation bank	98709	17836	474746	130178
Indian bank	78133	21870	379760	122313
Andhra bank	75794	18042	296289	113387
United bank of india	54819	13833	290588	79611

Note-Amount in Million

Table 2
VRS output-orientation result with improvement-

DMU's	DEA Efficiency	Interest expended	Operating expenses	Investments	Interest income
Bank of India	97%	201672 to 201672	49407 to 49407	867536 to 897717	284807 to 294725
Bank of baroda	100%	193567 to 193567	51587 to 51587	832094 to 832094	296737 to 296737
Canara bank	100%	231613 to 231613	46737 to 46737	1020574 to 1020574	308506 to 308506
Punjab national bank	100%	230136 to 230136	70028 to 70028	1226295 to 1226295	364280 to 364280
Union bank of india	96%	142354 to 142354	39875 to 39875	623636 to 672334	211443 to 221359
Central bank of india	90%	139809 to 139809	37490 to 37490	592433 to 660803	191495 to 213000
Indian overseas bank	94%	128809 to 128809	31631 to 31631	555659 to 591723	178971 to 190489
Oriental bank of commerce	100%	115991 to 115991	23155 to 23155	521013 to 521013	158149 to 158149
UCO bank	100%	107303 to 107303	20562 to 20562	457715 to 457715	146324 to 146324
Allahabad bank	100%	103606 to 103606	26914 to 26914	542832 to 542832	155233 to 155233
Syndicate bank	90%	101833 to 101833	28141 to 28141	408151 to 477340	152684 to 169650
Corporation bank	100%	98709 to 98709	17836 to 17836	474746 to 474746	130178 to 130178
Indian bank	100%	78133 to 78133	21870 to 21870	379760 to 379760	122313 to 122313
Andhra bank	100%	75794 to 75794	18042 to 18042	296289 to 296289	113387 to 113387
United bank of india	100%	54819 to 54819	13833 to 13833	290588 to 290588	79611 to 79611

Bank wise performance Graph-

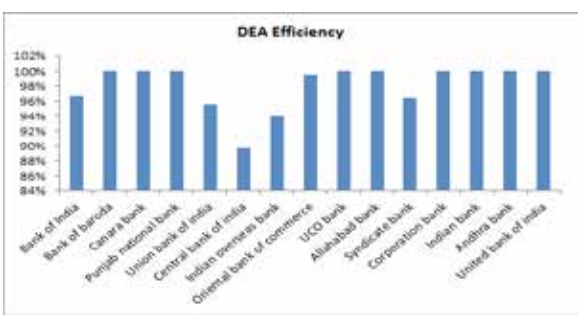

Table 3
Efficient Banks Reference set frequencies-

DMU's	Peer Group	Frequencies
bank of india	canara bank,punjab national bank,bank of baroda,corporation bank	0
bank of baroda	bank of baroda	7
canara bank	canara bank	3
punjab national bank	punjab national bank	5
union bank of india	punjab national bank,bank of baroda,indian bank	0
central bank of india	punjab national bank,bank of baroda,allahabad bank,indian bank	0
indian overseas bank	bank of baroda,uco bank,allahabad bank,andhra bank	0
oriental bank of commerce	canara bank,bank of baroda,uco bank,corporation bank	0
uco bank	uco bank	3
allahabad bank	allahabad bank	3
syndicate bank	punjab national bank,bank of baroda,indian bank	0
corporation bank	corporation bank	3
indian bank	indian bank	4
andhra bank	andhra bank	2
united bank of india	united bank of india	1

Probabilistic Neural Network

NNs have received a great deal of attention over the past few years. They are being used in the areas of prediction and classification, areas where regression models and other related statistical techniques have traditionally been used. To study the effectiveness of the PNN-based classification of relative efficiency, the results of PNN were compared with the Multinomial logistic regression. Multinomial logistic regression is an extremely simple and efficient method of classification. In this BCC method is used to calculate efficiency scores as outlined above. The results

are grouped into three categories based on the efficiency scores. The efficiency score interval of A1 (0.98, 1) is referred to as 'best efficient interval'. The efficiency score interval of A2 (0.95, 0.98) is referred to as 'medium efficient interval'. The efficiency score interval of A3 (0.85, 0.95) is referred to as ' inefficient interval'.

Table 4
PNN classification Summary with Variable impact-

Summary	
Training	
Number of Cases	12
Training Time	0:00:00
Number of Trials	66
Reason Stopped	Auto-Stopped
% Bad Predictions	13.3333%
Root Mean Square Error	0.3233
Mean Absolute Error	0.1478
Std. Deviation of Abs. Error	0.1277
Testing	
Number of Cases	3
% Bad Predictions (30% Tolerance)	16.3333%
Root Mean Square Error	0.3896
Mean Absolute Error	0.2197
Std. Deviation of Abs. Error	0.1426
Data Set	
Name	Data Set #1
Number of Rows	15
Manual Case Tags	NO
Variable Impact Analysis	
operating expenses	81.9246%
interest expended	18.0754%

85.2% of orginal grouped cases correctly classified

Table 5
Multinomial logistic regression summary

Classification

Observed	Predicted			
	1	2	3	Percent Correct
1	10	0	0	100.0%
2	0	3	0	100.0%
3	0	0	2	100.0%
Overall Percentage	66.7%	20.0%	13.3%	100.0%

6. CONCLUSION

This paper presents a unique approach of DEA, PNN & Multinomial logistic regression model for evaluating Indian banks performance. A sample of Nationalised Indian Banks has analyzed for effectiveness using DEA. The analysis provides the precise corrective figure for every output and input in order to improve their efficiency of an inefficient bank. We have investigated the performance of Indian banks by using CCR based DEA model (Table 2). Further we have classified efficiency into three groups to correct classification by using PNN and Multinomial logistic regression. We have got result from PNN as 85.2% of original grouped cases corrected classified and 100% groups classified through Multinomial logistic regression. It is in the hands of mangers to skillfully use these results as a support for decision-making. This study provides scope for further research using larger sample size and panel data with different sets of input and outputs to test the robustness of the results.

REFERENCE

❖ Charnes, A., Cooper, W.W. and Rhodes, E. (1978), "Measuring the efficiency of decision making units", European Journal of Operations Research, 2: 429-444. | ❖ Cooper, W.W., Seiford, L.M. and Tone, K. (2000) Data envelopment Analysis, Boston: Kluwer. | ❖ Banker, R., Charnes, A., & Cooper, W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science, 30, 1078–1092. | ❖ Wang, N. S., Yi, R. H., & Wang, W. (2008). Evaluating the performances of decision making units based on interval efficiencies. Journal of Computational and Applied Mathematics, 216, 328–343. | ❖ Mostafa, M. (2009). Modeling the competitive market efficiency of Egyptian companies: A probabilistic neural network analysis, 36, 39–48. | ❖ Seiford, L., & Zhu, J. (1999). Profitability and marketability of the top 55 US commercial banks. Management Science, 45, 1270–1288. | ❖ Sengupta, J. (1995). Dynamics of data envelopment analysis: Theory of systems efficiency. Boston, MA: Kluwer Academic Publishers. | ❖ Wu, D., Yang, Z., & Liang, L. (2006). Using DEA–neural network approach to evaluate branch efficiency of a large Canadian bank. Expert Systems with Applications, 31, 108–115. | ❖ Satye. M, (2003). Efficiency of Banks in developing Economy. The case of India. European Journal of Operational Research. 148(3). 662-671. | ❖ Kumbhakar. S.C. and Sarkar, S. (2004). Deregulation, Ownership and Efficiency in Indian Banking: An application of Stochastic Frontier Analysis. IGIDD working paper. Available at: www.igidr.ac.in/conf/finwrk/workshop.pdf. | ❖ Drake, L., & Howcroft, B. (2002). An insight into the size efficiency of a UK bank branch network. Managerial Finance, 28, 24–36. | ❖ Sun, S., & Lu, W. (2005). Evaluating the performance of the Taiwanese hotel industry using a weight slacks-based measure. Asia-Pacific Journal of Operational Research, 22, 487–512. | ❖ Annual bank data available : http://www.rbi.org.in