Optimization
Iranian Journal of Optimization
Volume 8, Issue 1, 2016, 37-45
Research Paper
Online version is available on: www.ijo.iaurasht.ac.ir

Islamic Azad University
Rasht Branch
E-ISSN:2008-5427

A DEA-Topsis Approach to Analyse the Financial Efficiency of Indian Pulic Sector Bank

Tata Hari Krishna[1*] and Nimmagadda Vijaya Sai[1]

[1]Department of Mechanical Engg, V.R. Siddhartha Engineering College,Vijayawada, India

Received: 16 February 2016
Acceptede: 29 May 2016

Keywords:
Data Envelopment Analysis
hybrid analysis
indian banking sector
financial efficiency
topsis

Abstract

In This paper a hybrid DEA method consisting of four phases for assigning the financial efficiency of commercial banks in India is used. This paper is based on panel data of banks for the period from 2011 to 2015. The DEA analysis based on hybrid method of DEA AND TOPSIS is used for ranking efficient Decision Making Units(DMUs) in Data Envelopment Analysis (DEA). However, since each of these methods considers a certain theory for ranking, there may exist different ranks. In practice, choosing a ranking method, the results of which the Decision Maker (DM) would be able to trust is an important issue.

***Correspondence E-mail**: thkvrsec@gmail.com

INTRODUCTION

Generally, efficiency means the maximum output that can be produced from any given total of inputs. This refers to the efficiency of a firm which allocates resources in such a way as to produce the maximum quantity of output. Recent approaches to measure bank efficiency include the parametric and non-parametric approaches. Data Envelopment Analysis (DEA) is a non – parametric approach used to estimate the relative efficiency of organizations. DEA models can handle any number of inputs and outputs. Other approaches, including regression analysis and SFA, can handle only multiple inputs or multiple outputs, but not both. In the present paper a four phased DEA model is proposed to know the efficiency of twenty Public sector banks in India. In this model two hypothetical banks called the ideal and negative-ideal or nadir bank are constructed and used as reference points to evaluate a set of ratios which are taken under CAMEL model. The best relative efficiency of the ideal bank and the worst relative efficiency of the nadir bank are determined. Further, best and worst relative efficiency is determined to determine the each bank's relative closeness coefficient which is the basis for ranking of banks.The structure of the paper is follow. Next section describes empirical literature about banking efficiency in theIndian banking. Third section presents the methodology of DEA Topsis and section 4 describe data and selection of variables. Next part of paper reveals the estimated results and last section concluded the paper.

Literature review

Most empirical studies evaluated banking efficiency in the 1990s and the authors investigated whether private banks were more efficient than state-owned banks. Taci and Zampieri (1998) found that private banks have a higher mean efficiency score, supporting rapid privatization. Bisht et al. (2002) studied the impact of liberalization on the Indian banking sector. They established the fact that the present banking structure is the outcome of a process of expansion, re-organization and consolidation Bonin et al. (2005) found that foreign-owned banks were most efficient and government-owned banks were least efficient. The results of Matoušek and Taci (2005) indicated that foreign banks were on average more efficient than other banks, although their efficiency was comparable with the efficiency of 'good' small banks in the early years of their operation. Weill (2003) found a positive influence of foreign ownership on the cost efficiency of banks in the Czech Republic and Poland. Ram Mohan and Ray (2004), in their article titled, "Comparing Performance of Public and Private Sector Banks: A Revenue Maximization Efficiency Approach" made a comparison of performance among three categories of banks - public, private and foreign banks. In this study, a comparison of public, private and foreign banks in India has been made using data envelopment analysis (DEA). In DEA, physical quantities of inputs and outputs are used. Fries and Taci (2005) found that banking systems in which foreign-owned banks have a larger share of total assets have lower costs and that the association between a country's progress in banking reform and cost efficiency is non-linear. Gopal and Dev (2006), in their research paper, empirically analyzed the productivity and profitability of selected public and private sector banks in India. They evaluated the effect of globalization and liberalization on the productivity and profitability of Indian banks during the period 1996-97 to 2003-04. Ramudu and Rao (2006), while making a fundamental analysis of Indian banking industry, revealed that ever since the Indian economy opened its doors to MNCs, the Indian banking sector has been witnessing bizarre changes in terms of new products and services and shift competition as well. Arora and Kaur (2006) made a comparative appraisal of banks on the basis of seven key performance measures such as returns on assets (ROA), capital asset, risk weighted ratio, NPA to net advances, business per employee, net profitability ratio, NPA level and off-balance-sheet operations of commercial banks for a time period of 9 years, i.e., 1996-2005.Brinda and Dubey (2007) made an econometric analysis on the performance of public sector banks in India vis-à-vis other bank groups, i.e., private sector banks and foreign banks present in India. They applied the statistical techniques like ordinary least square method and bounded influence to analyze the data (return on assets (ROA) and operating profit ratio (OPR),

net interest margin (NIM) and operating expense Ratio (OER)). Rao (2007), in his article titled, "Reforms in Indian Banking Sector: Evaluation Study of the Performance of Commercial Banks" found that the nationalization process achieved the widening of the banking industry in India. Sekhar (2007) in his article, "Trends in Growth and Development: Nationalized Banks in India", explained that Indian banking registered tremendous growth in post-nationalization era. Chandra and Srivastava (2008), in their paper titled, "Scenario 2009: Are Indian Banks Ready?" stated that the Indian banking industry has now entered a new phase wherein challenges both within the banking sector and from the economy have to be catered.

MATERIALS AND METHODS

In this paper, a DEA-TOPSIS hybrid method is implemented to evaluate efficiency of banks. A case study of twenty Indian public sector banks are considered and evaluated using deposits, borrowings, interest earned operating expenses as inputs and investments, advances total income as outputs.

DEA-TOPSIS methodology

DEA measures relative performance of a set of producers or decision making units where the presence of multiple inputs and outputs makes comparisons difficult. DEA arises from situations where the goal is to determine the productive efficiency of a system by comparing how well the system converts inputs into outputs. TOPSIS simultaneously considers the distances to the ideal solution and negative ideal solution regarding each alternative and selects the most relative closeness to the ideal solution as the best alternative. That it is, the best alternative in the nearest one to the ideal solution and the farthest one from the negative ideal solution. A relative advantage of TOPSIS is the ability to identify the best alternative quickly. A hybrid approach of integrating DEA into TOPSIS is designed to capitalize on the unique features from both methods for improving multi-criteria decision analysis. A case study is presented to demonstrate the proposed method. The results illustrate the consistency of ranking results, implying potential applicability of the proposed approach. DEA-TOPSIS Integrated methodology for evaluation and ranking of banks is discussed in the following steps.

Step 1: Specification of Bank inputs and outputs

Step 2: Collection of data on inputs and outputs

Step 3: Determine degree of correlation between inputs and outputs

Step 4: Data Normalization

Step 5: Determination of the best relative efficiency (θ^{*}_{l}) of Ideal bank.

LP model proposed by LP model using the Charnes-Cooper's method:

$$\theta^{*}_{l} = \max \sum_{r=1}^{s} u_r * y_r^{\max}$$

$$s.t$$

$$\sum_{i=1}^{m} v_i * x_i^{\min} = 1$$

$$\sum_{r=1}^{s} u_r * y_{rj} - \sum_{i=1}^{m} v_i * x_{ij} \le 0 \qquad \forall j$$

$$u_r, v_i \ge \in, \qquad \forall r, i$$

Where ur (r = 1, . . ., s) and vi (i = 1, . . ., m) are the weights of the r^{th} output and the i^{th} Input, respectively, and '∈' is a small non Archimedean value, with each bank 'j' (j = 1, . . ., n).

Step 6: Determination of the worst relative efficiency (φ^{*}_{N}) of nadir bank.

The following mathematical model is adopted to determine the worst relative efficiency of nadir bank

$$\varphi^{*}_{N} = \min \sum_{r=1}^{s} u_r * y_r^{\min}$$

$$s.t$$

$$\sum_{i=1}^{m} v_i * x_i^{\max} = 1$$

$$\sum_{r=1}^{s} u_r * y_r^{\max} - \sum_{i=1}^{m} v_i * x_i^{\min} * \theta^{*}_{l} \ge 0 \qquad \forall j$$

$$\sum_{r=1}^{s} u_r * y_{rj} - \sum_{i=1}^{m} v_i * x_{ij} \le 1 \qquad \forall j$$

$$u_r, v_i \ge \in, \qquad \forall r, i$$

Step 7: Determination of the best relative efficiency (θ^{*}_{l}) of i^{th} bank.

The following mathematical model is adopted to determine the best relative efficiency of i^{th} bank.

$$\theta^*_i = \max \sum_{r=1}^{s} u_r * y_{rp}$$

$$s.t$$

$$\sum_{i=1}^{m} v_i * x_{ip} = 1$$

$$\sum_{r=1}^{s} u_r * y_r^{\max} - \sum_{i=1}^{m} v_i * x_i^{\min} * \theta^*_l = 0$$

$$\sum_{r=1}^{s} u_r * y_{rj} - \sum_{i=1}^{m} v_i * x_{ij} \le 1 \quad \forall j$$

$$u_r, v_i \ge \in, \qquad \forall r, i$$

Step 8: Determination of the worst relative efficiency (θ^*_l) of i^{th} bank.

The following mathematical model is adopted to determine the worst relative efficiency of i^{th} bank.

$$\varphi^*_i = \min \sum_{r=1}^{s} u_r * y_{rp}$$

$$s.t$$

$$\sum_{i=1}^{m} v_i * x_{ip} = 1$$

$$\sum_{r=1}^{s} u_r * y_r^{\min} - \sum_{i=1}^{m} v_i * x_i^{\max} * \varphi^*_N = 0$$

$$\sum_{r=1}^{s} u_r * y_{rj} - \sum_{i=1}^{m} v_i * x_{ij} \le 0 \quad \forall j$$

$$u_r, v_i \ge \in, \qquad \forall r, i$$

The above mathematical models may be solved to determine the efficiency of the banks using LINGO 8.0 solver of LINDO systems.

Step 9: Calculation of the relative closeness of banks The RC index is calculated for each bank 'i' using the following equation.

$$RC_i = \frac{(\varphi^*_i - \varphi^*_N)}{(\varphi^*_i - \varphi^*_N) + (\theta^*_l - \theta^*_i)}$$

Step 10: Ranking of the banks Determine the ranking order of all banks according to their RC index.

Case study

In the present paper, the performance of the twenty public sector banks in India are evaluated and ranked using proposed integrated method.

Input and output dimensions

Berger and Humphrey (1997) and Favero and Papi (1995) pointed out that the intermediation approach is most appropriate for banks as a whole because most activities consist of converting huge deposits and funds into loans and financial investments. Following the intermediation approach, this paper considered four inputs and three outputs. Deposits (D), Borrowings (B), Interest Expenses (IE) and Operating Expenses (OE) are considered as in-

Table 1: Average data on the inputs and outputs of the banks

S.No	Bank	DEPOSITS	BORROWINGS	INTEREST EARND	OPERATING EXPENCES	INVESTMENTS	ADVANCES	TOTAL INCOME
1	Allahabad Bank	1708977397	105113874	164872921	30317209	552550858	1244286107	181488450
2	Andhra Bank	1237320898	110983897	126411233	21191396	366642698	973261127	137685225
3	Bank of Baroda	4701295674	289074874	337319121	37453756	1028592273	3338620738	374772878
4	Bank of India	4015644224	355975667	326962664	36507053	1002367841	3048112212	363469717
5	Bank of Maha	953264699	84704002	94025169	7967391	307834264	731861614	101992559
6	Canara Bank	3742890587	205945231	342580448	34533289	1158129237	2636473211	377113737
7	Central Bank of India	2194418081	184333993	214134090	16288969	735921211	1629933609	230423059
8	Corporation Bank of India	1623267958	133097348	150004258	20678812	557390711	1176376811	165114473
9	IDBI	1343016859	585670866	243573118	30805530	949964369	1880079363	272376564
10	Indian Bank	1400176456	34891519	133174281	25013206	414546625	1038577167	146048332
11	IOB	1246118509	54065382	118218383	21174671	402654866	924962954	212968667
12	Oriental Bank	1736830720	65972426	169172669	25537050	429766873	1242364225	185016068
13	PNB	4073645309	404359683	389789114	82723618	1285658823	3148820320	434786214
14	SBI	8430795645	1125283063	824647911	209432853	2515038720	7178975238	940249102
15	SBI_B	561500081	52628394	69881554	15139230	181263107	551352394	79055447
16	SBI_T	789330173	65391257	80069793	15105121	244358630	613998036	70715415
17	Syndicate Bank	1893242961	125004231	168152642	30928686	2214526836	1509206681	181350479
18	UBI	2607274722	239398662	248078248	48151737	778818617	2043458685	274845362
19	UCO	1773164786	99224200	130534506	22846391	554509600	1279657535	173021969
20	United Bank	975879827	42542795	88667619	15408385	360521200	635969880	99448230

puts. On the other hand, Investments (I), Loans and Advances (LA) and Total Income (TI) are considered as outputs. Secondary sources of data collection have been used, viz. journals, IBA bulletin, statistics published by Reserve bank of India and annual reports published by the banks. In the present study, the performance of public sector banks in India using an integrated approach for a five year period from 2011-15 is evaluated. Data on the inputs and outputs is shown in appendix E. Average data on the inputs and outputs of the banks is shown in table 1.

RESULTS AND DISCUSSION

Evaluation of efficiency and ranking of banks of 20 Indian public sector banks is carried out by adopting DEA-TOPSIS methodology.

Correlation between inputs and outputs

Data in the above table is considered and the correlation between inputs and outputs is calculated for identifying whether increasing amounts of inputs lead to greater outputs using Minitab-14. The Table 2 provides the pearson correlation matrix.

From the correlation matrix it is observed that the correlations between inputs and outputs are high and positive. The p-values for the individual hypothesis tests of the correlations are being zero as shown in brackets. Since all the p-values are smaller than 0.01, there is sufficient evidence at $\alpha = 0.01$ that there exists significant correlation between inputs and outputs. Hence the requirements for data envelopment analysis are met as positive and statistically significant inter-correlations between inputs and outputs are existed.

DEA-TOPSIS Approach

In the DEA-TOPSIS approach the best relative efficiency of ideal bank, the worst relative efficiency of the nadir bank, best relative efficiency and the worst efficiency of each bank are determined to arrive the final ranking, Model calculations for the year 2015 are shown in table 6.

Table 2: Pearson correlation matrix

Outputs	Inputs			
	Deposits	Borrowings	Interest Expenses	Operating Expenses
Investments	0.826 (p= 0.00)	0.807 (p= 0.00)	0.849 (p= 0.00)	0.821 (p= 0.00)
Loans and advances	0.979 (p= 0.00)	0.929 (p= 0.00)	0.991 (p= 0.00)	0.941 (p= 0.00)
Total Income	0.962 (p= 0.00)	0.929 (p= 0.00)	0.986 (p= 0.00)	0.974 (p= 0.00)

Table 3: Normalized decision matrix of the year- 2015

Bank	DEPOSITS	BORROWINGS	INTEREST EARND	OPERATING EXPENCES	INVESTMENTS	ADVANCES	TOTAL INCOME
Allahabad Bank	0.0946	0.0613	0.1024	0.0872	0.0912	0.0921	0.0996
Andhra Bank	0.0758	0.0655	0.0850	0.0643	0.0751	0.0774	0.0819
Bank of Baroda	0.3021	0.1510	0.2231	0.1033	0.1976	0.2632	0.2172
Bank of India	0.2602	0.1715	0.2255	0.0993	0.1935	0.2472	0.2186
Bank of Maha	0.0597	0.0476	0.0658	0.0236	0.0593	0.0606	0.0627
Canara Bank	0.2318	0.1099	0.2272	0.1068	0.2347	0.2029	0.2215
Central Bank of India	0.1250	0.1112	0.1372	0.0445	0.1542	0.1159	0.1298
Corporation Bank of India	0.0975	0.0446	0.1016	0.0593	0.1024	0.0892	0.0965
IDBI	0.0146	0.2647	0.1462	0.0959	0.1954	0.1281	0.1475
Indian Bank	0.0828	0.0113	0.0823	0.0660	0.0741	0.0774	0.0790
IOB	0.1204	0.0032	0.1243	0.0986	0.1313	0.1056	0.1196
Oriental Bank	0.0998	0.0280	0.1037	0.0699	0.0011	0.0893	0.1013
PNB	0.2453	0.1955	0.2405	0.2462	0.2443	0.2340	0.2394
SBI	0.7714	0.8783	0.7915	0.9078	0.7995	0.7993	0.8024
SBI_B	0.0412	0.0324	0.0468	0.0414	0.0363	0.0428	0.0455
SBI_T	0.0446	0.0163	0.0497	0.0452	0.0430	0.0423	0.0485
Syndicate Bank	0.1249	0.0760	0.1123	0.0850	0.1120	0.1246	0.1088
UBI	0.1550	0.1514	0.1666	0.1442	0.1520	0.1572	0.1633
UCO	0.1049	0.0044	0.1005	0.0623	0.1112	0.0906	0.0980
United Bank	0.0532	0.0174	0.0529	0.0425	0.0753	0.0410	0.0547

Table 4: Best and worst relative efficiencies of banks

S.No	Bank	BEST	WORS
1	Allahabad Bank	0.8384	0.6294
2	Andhra Bank	0.8116	0.6235
3	Bank of Baroda	0.7888	0.5475
4	Bank of India	0.8088	0.5857
5	Bank of Maha	0.8265	0.6166
6	Canara Bank	0.8123	0.6197
7	Central Bank of India	0.7395	0.6067
8	Corporation Bank of India	0.8546	0.6146
9	IDBI	1.0000	0.5108
10	Indian Bank	1.0000	0.6135
11	IOB	1.0000	0.6101
12	Oriental Bank	0.8665	0.6162
13	PNB	0.7786	0.6328
14	SBI	0.7514	0.6560
15	SBI_B	0.8454	0.6291
16	SBI_T	0.9167	0.6112
17	Syndicate Bank	0.8696	0.5945
18	UBI	0.7751	0.6343
19	UCO	0.9766	0.6142
20	United Bank	0.7790	0.5494

Table 5: Closeness coefficients and ranking of the banks

S.No	Bank	CC	RANK
1	Allahabad Bank	0.0105	4
2	Andhra Bank	0.0104	6
3	Bank of Baroda	0.0091	19
4	Bank of India	0.0098	17
5	Bank of Maha	0.0103	8
6	Canara Bank	0.0104	7
7	Central Bank of India	0.0101	15
8	Corporation Bank of India	0.0103	12
9	IDBI	0.0085	20
10	Indian Bank	0.0103	11
11	IOB	0.0102	14
12	Oriental Bank	0.0103	9
13	PNB	0.0106	3
14	SBI	0.0110	1
15	SBI_B	0.0105	5
16	SBI_T	0.0102	13
17	Syndicate Bank	0.0099	16
18	UBI	0.0106	2
19	UCO	0.0103	10
20	United Bank	0.0091	18

Normalization of the data

Normalized decision matrix of the year- 2015 is obtained and is shown in the table 3.

Interpretations: (SIR PLEASE WRITE BEST AND WORST EEICIENTY)

The best and worst relative efficiencies of banks are determined by solving the LP model discussed in step 6 and Step 7 respectively using LINGO 8.0 solver.

DISCUSSION on table 4

Closeness coefficient: Closeness coefficient of the banks is determined as per the methodology. Ranking of banks is done based on the closeness coefficients. The Table below shows the closeness coefficients and ranking of the banks.

In this method, it is observed that SBI is ranked as first with relative closeness value of 0.110 followed by UBI with relative closeness

Ranking of the banks through DEA-TOPSIS method for the years 2011-2015

S.No	Bank	2011	2012	2013	2014	2015	Average
1	Allahabad Bank	9	20	10	13	4	12
2	Andhra Bank	7	12	12	7	6	6
3	Bank of Baroda	20	4	17	18	19	19
4	Bank of India	19	3	19	17	17	18
5	Bank of Maha	11	15	3	10	8	7
6	Canara Bank	12	18	11	8	7	11
7	Central Bank of India	8	13	4	15	15	10
8	Corporation Bank of India	10	14	15	9	12	14
9	IDBI	4	5	18	20	20	16
10	Indian Bank	13	16	13	6	11	13
11	IOB	6	6	8	4	14	5
12	Oriental Bank	16	19	9	14	9	15
13	PNB	2	9	7	3	3	3
14	SBI	1	1	16	1	1	2
15	SBI_B	18	8	2	2	5	4
16	SBI_T	3	10	5	16	13	8
17	Syndicate Bank	14	7	20	12	16	17
18	UBI	5	2	6	5	2	1
19	UCO	17	11	1	11	10	9
20	United Bank	15	17	14	19	18	20

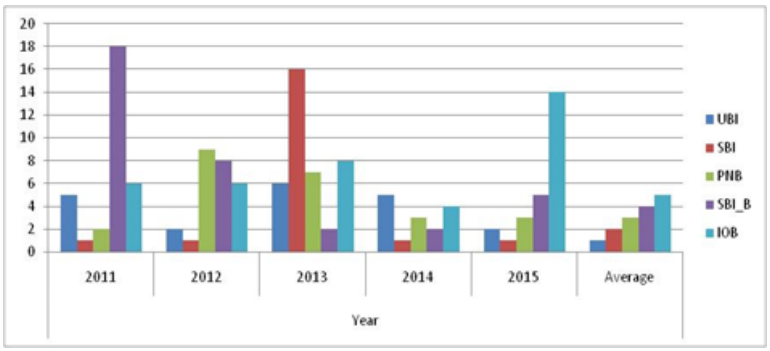

Fig. 1. Average data for the FY 2011-2015

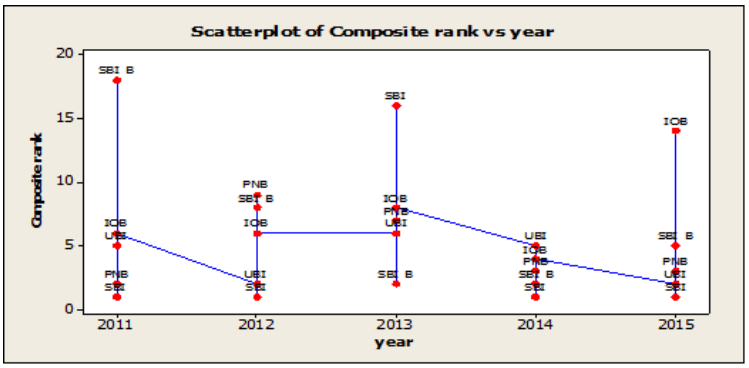

Fig. 2. The scattered plot of composite rank with respect to the ranks of the bank

value of 0.0106. SBI dominated all the banks in all the outputs (Investments, Loans and advance and Total Income). SBI shows minimum guaranteed efficiency. IDBI is ranked least efficient with relative closeness value of 0.0085. It is due to the fact that minimum guaranteed efficiency.

Ranking of the banks through DEA-TOPSIS method for the years 2011-2015 and the average data is shown in table 6.

Thus as per the average data for the FY 2011-2015, it is observed that UBI is ranked first followed by SBI and PNB bank. United bank is ranked as least efficient in mean perspective (Figure 1).

The scattered plot of composite rank with respect to the ranks of the bank is shown in Figure 2.

CONCLUSION

In real problems of Data Envelopment Analysis, it often happens that we would like to rank the Decision Making Units. There exist many different DEA methods. Hence, selecting the best method for ranking DMUs is a main question in DEA. These methods do not often have any theoretical problems dealing with most data. Since each of these methods considers a certain theory for ranking, they may give different ranks. As a result, in practice, choosing a ranking method, the results of which the Decision Maker (DM) would be able to trust, is an important issue. In this article a method has been proposed by which ranking is carried out by using different ranking methods, each of which is important and significant. The method was based on the TOPSIS method. In the proposed method, efficient DMUs and ranking methods play the role of alternatives and criteria respectively. Then by using the TOPSIS method we rank the alternatives. One of the most important points about the proposed method is that it removes the concern of the DM in choosing a particular method for ranking. Since each method decides the ranking score only based upon one viewpoint, it can be concluded that each ranking method shows only a percentage of the reality and therefore, using only one method, in case we would be able to choose it, would be untrustworthy. The proposed method provides the possibility of using the results of all existing ranking methods and therefore its results will be more reliable for the efficiency.

REFERENCES

Adel Hatami-Marbini et al. (2009). "An ideal-seeking fuzzy data envelopment analysis framework". *Elsevier Applied soft computing*, 10 (10), 1062-1070.

Ali Kamil,T ., & Ercan,S. (2006). "The Analytic Hierarchy & The Analytic Network Process in Multicriteria Decision Making : A Comparative Study". *Journal Of Aeronautics And Space Technologies*, 2 (4), 55-65.

Arora, S.; and Kaur, S. (2006). "Financial Performance of Indian Banking Sector in Post-Reform Era". *The Indian Journal of Commerce*, 59(1), 96-105.

Bhattacharyya, A., & Chakraborty, S. (2014). A DEA-TOPSIS-based approach for performance evaluation of Indian technical institutes. *Decision science letters*, 3(3), 397-410.

Bhayani, S. (2006). Performance of the New Indian Private Sector Banks: A Comparative Study. *Journal of Management Research*, 5(11), 53-70.

Bhutia, P. (2012). "Application of AHP & TOPSIS method for supplier selection problem". IOSR *Journal of Engineering*, 2 (10), 43-50.

Bisht, N.S., Mishra, R.C., & Belwal, R. (2002). "Liberalisation and its Effects on Indian Banking". *Finance India*, 16(1),147-152.

Bodla, B.S. & Verma, R. (2006). "Evaluating Performance of Banks through CAMEL Model: A Case Study of SBI and ICICI". *The ICFAI Journal of Bank Management*, 5(3),49-63.

Brinda, J.,& Dubey, A. K. (2007). "Performance of Public Sector Banks: An Econometric Analysis". *The Indian Banker*, 2(12), 26-34.

Chandra, A. S., & Srivastava, M. (2008). "Scenario 2009: Are Indian Banks Ready?" . *The Indian Banker,* 3(1), 34-37.

Chaudhry,S.,& Singh,S. (2012). "IMPACT OF REFORMS ON THE ASSET QUALITY IN INDIAN BANKING". *International Journal of Multidisciplinary Research*, 2(1), 13-31.

Chaudhry,S.,& Singh,S. (2012). "IMPACT OF REFORMS ON THE ASSET QUALITY IN INDIAN BANKING ZENITH. *International Journal of Multidisciplinary Research* , 2 (1), January 2012.

Chen, Y. C., Chiu, Y. H., Huang, C. W., & Tu, C. H. (2013). The analysis of bank business performance and market risk-Applying Fuzzy DEA. *Economic Modelling*, 32, 225-232.

Gopal, M.,& Dev, S. (2006). "Productivity and Profitability of Select Public Sector and Private Sector Banks in India: An Empirical Analysis". *The ICFAI Journal of Bank Management*, 5(4), 59-67.

Gupta, R. (2008). "A CAMEL Model Analysis of Private Sector Banks in India". *Journal of Gyan Management*, 2(1),3-8.

Iman Dabashi et al. (2013). "A Data Envelopment Analysis of Banks Performance in Iran". *International Research Journal of Applied and Basic Sciences*, 4 (9),2422-2426.

Karimzadeh, M. (2012). Efficiency analysis by using Data Envelop Analysis model: evidence from Indian banks. I*nternational Journal of Latest Trends in Finance and Economic Sciences*, 2(3), 228-237.

Kwan, S., & Eisenbeis, RA. (1997). "Bank risk, capitalization, and operating efficiency". *Journal of Financial Services Research*, 12(2/3), 117-31.

Md kabir, A. (2012). "Performance Analysis through CAMEL Rating: A Comparative Study of Selected Private Commercial Banks in Bangladesh". *Journal of Politics & Governance*, 1 (2/3), 16-25.

Mishra Aswini Kumar, G., Harsha, H., Anand, SH., & Dhruva, N. (2012). Analyzing Soundness in Indian Banking: A CAMEL Approach. *Research Journal of Management Sciences,* 1(3), 9-14.

Mishra Aswini Kumar, G., Sri Harsha, Sh.A., & Dhruva, N. (2012). "Analyzing Soundness in Indian Banking: A CAMEL Approach . *Research Journal of Management Sciences*, 1(3), 9-14.

Mohan, T. R., & Ray, S. C. (2004). Comparing performance of public and private sector banks: a revenue maximisation efficiency approach. *Economic and Political Weekly*, 1271-1276.

Pathak, B. (2003). "A Comparison of the Financial Performance of Private Sector Banks". *Finance India,* 17(4), 1345-1356.

Prasada, K.V.N., & Ravinder, G. (2012). A Camel Model Analysis of Nationalized Banks in India. *International Journal of Trade and Commerce-IIARTC*, 1(1), 23-33.

Prasuna, D. G. (2004). Performance Snapshot 2003-04. *Chartered Financial Analyst*, 10(11), 6-13.

Ramudu, J., & Rao, D. (2006). "A Fundamental Analysis of Indian Banking Industry". *The ICFAI Journal of Bank Management,* 5(4),

68-79.
Rao, Suryachandra D. (2007). "Reforms in Indian Banking Sector: Evaluation Study of the Commercial Banks". *Finance India*, 21(2), 591-597.
Ritika et al. (2014). "Application of DEA for performance evaluation of Indian Micro finance institutions", *Asian Journal of Management Research*, 4 (3), 597-605.
Ruchi Gupta, CA.(2014). An Analysis of Indian Public Sector Banks Using Camel Approach. I*OSR Journal of Business and Management* (IOS-JBM), 16(1),94-102;
Sarker, A. (2005). CAMELS rating system in the context of Islamic banking: A proposed 'S' for Shariah framework. *Journal of Islamic Economics and Finance*, 1(1), 78-84.
Sekhar, S. D. (2007). "Trends in Growth and Development: Nationalised Banks in India". *The Indian Banker*, 11(10), 28-32.
Subbaiah, V. K., Narayana Rao. K. (2004). "Supplier selection in Supply Chain Management through AHP". I*n Proceedings of VIII Annual International Conference, The Society of Operations Management, Mumbai* (pp. 72-80).
Vierstraete,V. (2012). "Efficiency in Human Development: a DEA". *The European Journal of Comparative Economics*, 9 (3), 425-443.
Yang, J., & Jiang, H. (2012). Fuzzy Evaluation on Supply Chains' Overall Performance Based on AHM and M (1, 2, 3). *JSW*, 7(12), 2779-2786.