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Empirical Analysis of Banks in India using DBA and DEA

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The aim of this paper is to evaluate the performance of the banks in India using the Distance Based Analysis (DBA) and Data Envelopment Analysis (DEA), and compare the ranking of banks based on DBA and DEA. DBA uses the I-distance method to classify the banks according to their performance based on several indicators. As the indicators are weighted, this paper uses the discriminatory capacity of the indicators to calculate the I-distance. Correspondingly, the profit model of DEA has been used to measure the performance of the banks. The ranking of banks based on DBA and DEA suggests that, in general, there is an agreement in the ranking provided by these two approaches. The variation in the rankings of banks is either because of closeness to the reference unit or due to sub-optimal level of utilizing the inputs.

Keywords: Distance Based Analysis, Efficiency, Data Envelopment Analysis, Banking, Ranking, I-distance

1. Introduction

Indian banking system consists of schedule commercial banks and cooperative banks, of which the Schedule Commercial Banks (SCBs) account for around 95 percent of banking system assets. SCBs are grouped into: 1) public sector banks comprising the State Bank of India and its associates, and nationalized banks, 2) private sector banks comprising old and new private sector banks, 3) regional rural banks and 4) foreign banks. The banking system in India underwent a metamorphic change with the introduction of the first phase of reform in 1991. The objective of the early phase of the reform was to create an efficient, productive and profitable financial service industry operating within the environment of operating flexibility and functional autonomy. The second phase of financial sector reforms in 1998 focused on the strengthening of the financial system and introduction of structural improvements with an aim to align Indian banking standards with the internationally recognized best practices.

A key achievement of the banking sector reform is the sharp improvement in the financial health of banks which was reflected in a significant improvement in capital adequacy and improved asset quality (Mohan, 2005). The business and financial performance of banks in India during 2005-2008 was underpinned by strong macroeconomic environment and supporting monetary and financial policies. The adoption of a counter-cyclical prudential regulations framework during the credit boom and slowdown periods helped the Indian banking industry to face the global financial crisis, but it was not completely insulated from the effects of the crisis. This is evident from a sharp increase in provisions and contingencies, high interest rates, tight liquidity conditions, high inflation and deterioration of asset quality and growing NPAs during 2009-2012.

Chakraborty (2013) emphasizes that the banks have to effectively use their human capital, skills and technology to increase the productivity and lower the transaction costs, for which they would need to acquire both allocative and operational efficiency. The measurement of efficiency helps banks direct their focus to

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remain competitive, profitable and viable. Also, it would help to benchmark an individual bank against the 'best practice' bank(s) as well as evaluate the impact of various policy measures on the efficiency and performance of these institutions (Das et al., 2005).

The Data Envelopment Analysis (DEA) is a most widely used nonparametric technique to measure the efficiency of banks. The technique of measuring technical efficiency of decision making units (DMUs) was first proposed by Charnes, Cooper and Rhodes in 1978 and later extended by Banker, Charnes and Cooper in 1984. In literature, there are numerous studies on measuring the efficiency of financial institutions. Berger and Humphrey (1997) reviewed 130 studies that applied frontier efficiency analysis to financial institutions in 21 countries. Berger and Mester (1997), Maudos and Pastor (2003), Resende and Silva (2007), Drake et al. (2009) also studied the efficiency of financial institutions. In the Indian context, there are a number of studies on the technical / cost efficiency of banks in India (Das, 2002; Shanmuagm and Das, 2004; Ram Mohan and Ray, 2004; Das and Ghosh, 2006 & 2009; Kumar and Gulati, 2008; Jayaraman and Srinivasan, 2009; Gulati and Kumar, 2011). Das *et al.* (2005) analyzed the cost, revenue and profit efficiency of Indian banks for 1997-2003 using the DEA and observed that the bank's size, ownership, listing in stock exchange had a positive impact on the profit efficiency and to some extent on the revenue efficiency. Ray and Das (2010) studied the cost and profit efficiency of Indian banks using the DEA during the post reforms period and observed that there is a strong evidence of ownership explaining the efficiency differentials of the banks. Das and Kumhakar (2012) studied the productivity and efficiency of Indian banks using a hedonic aggregator function and observed that the efficiency of public sector banks is better than that of the private sector banks during 1996-2005. Savic et al. (2012) analyzed the efficiency of Serbian banks before and after the global financial crisis using the DEA window analysis.

Ivanovic (1963) proposed and developed an I-distance method to classify the countries according to their level of development based on several indicators. Mihailovic *et al*. (2009) used both the I-distance method and Andersen-Petersen's super-efficiency model to rank the Serbian banks. Milica Bulajic *et al.* (2012) used the I-distance method to study the efficiency of the Serbian banks. Jeremic *et al.* (2011) and Jovanovic *et al.* (2012) used the I-distance method to evaluate the Academic Ranking of World Universities (ARWU) and compared the ARWU ranking with an I-distance ranking. Jeremic *et al.* (2011) observed that the weight of the variables significantly alters the ranking of the universities and the I-distance method overcomes this issue. Jeremic *et al.* (2012) evaluated the health system performances of the European Union countries by proposing a new measure of efficiency based on Ivanovic-Jeremic Distance Based Analysis using the I-distance.
In this paper, we propose to evaluate the performance of banks in India during 2005-2012 using the above two approaches, namely, the DBA and the DEA, and compare the results of both the methods. Further, this paper analyzes the ranking of banks given by these two approaches. The rest of the paper is organized as follows: Section 2 discusses both the I-distance method and the DBA and Section 3 discusses the profit efficiency model of the DEA used in this paper to measure the efficiency of banks. The selection of variables has been discussed in Section 4 and Section 5 discusses the empirical results of the DEA model and the I-distance method. Section 6 summarizes the findings and conclusions.

2. I-distance Method

The I-distance method is proposed and developed by Ivanovic (1963) to classify and rank countries according to their level of development on the basis of several indicators. The problem of classification of countries is difficult and complicated because of the fact that a large number of attributes are involved as well as the various attributes which are not of equal economic importance, which makes the problem even more complex. The I-distance method devised by Ivanovic, uses the concept of total discriminant effect to classify the entities. Selection of attributes is the first and one of the most important steps in the ranking procedure. In this method, correlation analysis has been used to order the set of the attributes relevant to the analysis. It is suggested that the attributes should be ranked according to their importance. The first attribute is the most important, while the last one has the smallest influence (Mihajlovic *et. al*, 2009). The values of the I-distance depend on the order of the chosen attributes.

Let $X = \{X_1, X_2, \cdots, X_n\}$ be a set of 'n' indicators / variables being considered for the performance evaluation of 'm' banks. Let x_{ij} denote the value of the *i-th* variable for the *j-th* bank (*i=1,2,…,n* and *j=1,2,…,m*). The I-distance for the *r-th* and *s-th* bank is defined as:

$$D\,(r,s) = \sum_{i=1}^{n} \frac{|d_i\,(r,s)|}{\sigma_i} \prod_{k=1}^{i-1} (1 - r_{ki.1,2,\ldots,i-1}) \tag{1}$$

where $d_i\,(r,s) = x_{ir} - x_{is}\ (i = 1,2,\ldots,n)$ is *discriminate effect*, e.g. difference between values of attribute x_i for *r-th* and *s-th* bank. σ_i is standard deviation of x_i, and $r_{ki.1,2,\ldots,i-1}$ is partial correlation coefficient for x_i and x_k, $(k<i)$. The I-distance is calculated through the following steps:

1) Calculate the value of discrimination effect of attribute x_1, (the most significant indicator).
2) Add value of discrimination effect of x_2 *which* is not covered by x_1.
3) Add value of discrimination effect of x_3 which is not covered by x_1 and x_2.
4) Repeat the procedure for all indicators.

A squared I-distance that is used in order to eliminate negative values of partial correlation coefficients is defined as

$$D\,(r,s) = \sum_{i=1}^{n} \frac{d_i^2\,(r,s)}{\sigma_i^2} \prod_{k=1}^{i-1} (1 - r_{ki.1,2,\ldots,i-1}^2) \tag{2}$$

In order to rank the units in the observed set using the I-distance methodology, it is necessary to fix one unit as a referent. A unit with minimal value for each indicator, or some fictive maximal or average values unit, can be set up as the referent unit (Jeremic *et al.*, 2011; Jovanovic *et al.*, 2012). The ranking of the units in the set is based on the calculated distance from the referent unit (Jeremic *et al.*, 2011).

Jeremic *et al*. (2012) proposed a novel approach, namely, the Distance Based Analysis approach to measure the efficiency of the entities. In this approach, the I-distance method is applied to the input and output indicators independently to get the input and output I-distance values. The obtained input and output I-distance values are brought to 0-1 level by using the normalization process. The efficiency of a bank will then be calculated as the ratio of the I-distance output to the I-distance input i.e. Efficiency = I-distance $_{output}$ / I-distance $_{input}$. Any bank with an efficiency of at least 1 is to be considered efficient.

Ivanovic (1974) proposed a measurement of the discriminatory capacity of the indicator when the indicators are weighted. Let $W = [w_{ij}]$ denote the weights of the matrix X. Then the weighted arithmetic mean is defined as

$$\bar{x}_i = \frac{1}{\sum_j w_{ij}} \sum_{i=1}^{n} w_{ij}\; x_{ij} \qquad i = 1,2,\ldots,n \tag{3}$$

Using the covariance of the indicators X_i and X_k, the normal correlation coefficients and partial correlation coefficients are calculated for the indicators. Ivanovic proposed a measurement of the discriminatory capacity of the indicator X_i in 'm' banks by means of a coefficient of discrimination which has the following algebraic form:

$$CD_i(m) = \frac{2}{n(n-1)} \sum_{r,s>r}^{m} w_{ir} w_{is} \frac{|x_{ir} - x_{is}|}{\bar{x}_i} \qquad i = 1,2,\ldots,n \tag{4}$$

where $|x_{ir} - x_{is}|\ (i = 1,2,\ldots,n)$ is the absolute difference between the values of attribute x_i for *r-th* and *s-th* bank and the $\bar{x}_i$ is a weighted mean. Given the set of indicators already arranged in the ascending order of their importance, the overall contribution of this set of indicators to the evaluation of the banks under observation is defined as:

$$D\,(r,s) = \sum_{i=1}^{n} CD_i(m) \prod_{k=1}^{i-1} (1 - r_{ki.1,2,\ldots,k-1}) \tag{5}$$

In this paper, we have used coefficient of discrimination i.e. $CD_i(m)$ to measure the input and output distance values of the indicators. The obtained input and output I-distance values are brought to 1-2 level by using the normalization process to avoid the division by zero. Using the I-distance norm values of input and output indicators, distance based efficiency is measured for each bank using the DBA approach proposed by Jeremic *et al*. (2012).

3. Profit model of DEA

In literature, there is a number of studies on the technical efficiency of financial institutions, however, whereas the number of empirical studies related to profit efficiency is rather limited (Maudos and Pastor, 2003). The technical efficiency was originally developed to be used in a non-market environment where prices are either not available or are not reliable, even if they are available (Ray, 2004). In the input / output oriented technical efficiency approach, the objective of a firm is to contract all inputs / expand all outputs at the same rate to the extent possible without reducing any output / without increasing any input. Both approaches measure the technical efficiency without using the market prices of inputs and outputs. If market prices of inputs / outputs are available, then a firm would either try to minimize its cost or try to maximize its revenue / profit. In the cost minimization process, a firm would seek to minimize the total input cost for a given level of output and in the revenue maximization it would look for maximizing the output, thereby total revenue, for a given level of input. In the profit maximization, the objective of the firm would be to select such an input-output bundle that generates a maximum revenue with a minimum cost, for the given input and output prices. Thus, maximizing revenue is as much a necessary condition as cost minimization for the maximizing profit. Hence for a profit making firm, profit efficiency is a more important source of information than the cost efficiency, which provides partial information (Ray & Das, 2010). In this paper, the profit model of the DEA has been used to measure the performance of the banks and ranking instead of the super efficiency model of the DEA for ranking, since the profit model uses both input costs and output prices into consideration while measuring the performance of the banks.

Suppose there are K DMUs producing m outputs $\boldsymbol{y} = (y_{\downarrow}1, \dots, y_{\downarrow}m) \in (^{\uparrow}(M+)$ from the given n inputs $\boldsymbol{x} = (x_{\downarrow}1, \dots, x_{\downarrow}n) \in (^{\uparrow}(N+)$. Then the production possibility set (PPS) is defined as a collection of all feasible input–output vectors and represented as: $T = \{(\boldsymbol{x}, \boldsymbol{y})$: $\boldsymbol{x}$ can produce $\boldsymbol{y}\}$. It is assumed that T is closed and convex with freely disposable inputs and outputs. Let $\boldsymbol{p}$ be the output prices of $\boldsymbol{y}$ denoted as $\boldsymbol{p} = (p_{\downarrow}1, \dots, p_{\downarrow}m) \in (^{\uparrow}(M+)$ and $\boldsymbol{w}$ be the input prices of $\boldsymbol{x}$ denoted as $\boldsymbol{w} = (w_{\downarrow}1, \dots, w_{\downarrow}n) \in (^{\uparrow}(N+)$. Using the given input and output prices, the actual profit for the *k-th* DMU is defined as

$$\pi(p,w) = \sum_{j=1}^{m} p_j y_j - \sum_{i=1}^{n} w_i x_i$$

and profit efficiency is defined as $\pi(p,w) / \pi^*(p,w)$, where $\pi^*(p,w)$ is the maximum profit obtained by solving the following model (Zhu, 2009; Das et al., 2005):

$$\boldsymbol{\pi^*(p,w)} = Max\left(\sum_{j=1}^{m} p_j^k\, y_j^{k^*} - \sum_{i=1}^{n} w_i^k\, x_i^{k^*}\right)$$

subject to

$$\sum_{k=1}^{K} \lambda^k y_j^k \geq y_j^{k^*} \qquad j = 1,2,\dots,m \qquad \textbf{(6)}$$
$$\sum_{k=1}^{K} \lambda^k x_i^k \leq x_i^{k^*} \qquad i = 1,2,\dots,n$$
$$\sum_{k=1}^{K} \lambda^k = 1\,;\ \lambda^k \geq 0 \qquad k = 1,2,\dots,K$$

4. Selection of variables

The selection of input-output variables plays a crucial role in measuring the efficiency of banks. Because of the inter-connectedness of various products and services, the selection of input-output variables for banks has not been straightforward. In general, there is no consensus in literature about the selection of input-output variables for bank studies so the selection is left to the choice of researchers. Following Fare et al. (2004), Das et al. (2005), Resende and Silva (2007) and Ray and Das (2010), this paper uses borrowed funds (deposits and borrowing) and deployed funds (advances and investments) as input-output variables to measure the efficiency of a bank. Considering the emerging importance of non-traditional activities of banks, the non-interest income from fee, commission, brokerage etc. has been included as one of the output variables. Bank branch networks, which contribute to the business performance of the banks, have been included as one of the input variables.

In this paper, we have used four input and two output variables to evaluate the performance of the bank using DBA and DEA. The two output variables are: 1) deployed funds (DFund) comprise performing loans and investments and 2) non-interest income (NInc) from fee, commission, brokerage etc. The return on deployed funds (RDF) is the associated output price for deployed funds, which is the ratio of interest income from performing loans and investments to the total deployed funds, and the associated output price for non-interest income is unity (Das *et al.,* 2005). The four input variables are: 1) equity (capital plus reserves & surplus), 2) borrowed funds (BFund) that comprise deposits and borrowings, 3) work force i.e., the number of employees (NStaff) and 4) the total number of bank branches (NBR). Equity is treated as fixed inputs with no associated cost and the associated cost for borrowed funds (CBF) is the ratio of interest expenses on deposits and borrowings to the total borrowed funds. The staff cost (SC) is the associated cost for work force, which is the ratio of payments to and provisions for employees to total staff strength and the per branch cost (PBC) is the associated cost for the number of bank branches which is the ratio of operating expenses excluding payments to and provisions for employees to the total number of bank branches. For the calculation of the I-distance, equity and non-interest income are taken as they are. The data for this study have been collected from various publications of the Reserve Bank of India (RBI) and the Database on Indian Economy. To make it comparable, banks with total assets of more than Rs.100 billion and operating during 2005-2012 period have been selected for the study. Foreign banks are excluded from this study due to their nature of operation being different from the public and private sector banks.

5. Empirical Results and Discussions

In this section, we discuss in detail the performance of the banks based on the DBA and DEA approaches and the ranking of banks based on these two approaches. Table 1 presents the summary statistics (mean and standard deviation) of the input-output variables used in this study. It is evident from Table 1 that there is a sharp increase in the business of banks from 2005 to 2012 in terms of borrowed funds and deployed fund. On the other hand, though there is a marginal increase in the staff force of banks, the staff cost of banks has increased sharply during this period.

Table 1: Summary Statistics – Mean & (Standard Deviation)

(Amount in Rs. Billion)

Year	2005	2006	2007	2008	2009	2010	2011	2012
Equity	32.1 (39.7)	40.1 (50.2)	47.7 (60.4)	62.5 (85.7)	79.8 (115.0)	93.5 (128.2)	110.3 (136.3)	132.0 (153.3)
BFund	478.2 (610.6)	570.7 (694.8)	689.4 (805.8)	850.2 (968.4)	1068.8 (1239.8)	1301.2 (1494.2)	1545.0 (1702.5)	1816.6 (1953.6)
NBR	1454.3 (1632.2)	1496.6 (1639.6)	1565.0 (1648.7)	1675.0 (1787.7)	1796.9 (1976.3)	1932.8 (2143.1)	2099.6 (2292.4)	2277.4 (2385.9)
NStaff ('000)	23.3 (34.9)	23.6 (33.7)	23.7 (31.5)	24.2 (30.5)	25.4 (34.6)	25.7 (33.7)	27.2 (37.4)	28.5 (36.7)

Year	2005	2006	2007	2008	2009	2010	2011	2012
CBF	0.04 (.01)	0.04 (.01)	0.05 (.01)	0.06 (.01)	0.06 (.01)	0.05 (.01)	0.05 (.01)	0.06 (.01)
PBC	59.31 (98.85)	70.82 (129.99)	66.85 (125.66)	66.96 (98.31)	65.63 (77.43)	64.20 (64.30)	64.13 (56.32)	67.22 (56.40)
SC (in lakhs)	3.34 (0.53)	3.66 (0.74)	3.71 (0.46)	3.95 (0.58)	4.67 (0.75)	5.24 (0.84)	7.09 (1.49)	7.04 (1.73)
DFund	464.9 (611.3)	561.9 (701.8)	678.9 (811.4)	838.9 (978.3)	1042.3 (1229.8)	1256.8 (1472.0)	1494.1 (1671.9)	1763.9 (1898.9)
NInc	3.5 (6.5)	4.4 (8.1)	5.6 (10.5)	7.0 (13.4)	8.6 (15.8)	9.8 (18.2)	11.7 (21.7)	12.8 (23.0)
RDF	0.08 (.01)	0.08 (.00)	0.09 (.00)	0.09 (.01)	0.10 (.01)	0.09 (.01)	0.09 (.01)	0.10 (.01)

Using the profit model of the DEA discussed in Section 2, the average efficiency for each bank is obtained from the year-wise efficiency score. Similarly, using the I-distance method, the input and the output I-distances are calculated for each bank for each year and the distance based efficiency for each bank is obtained from the ratio of the output I-distance to the input I-distance. As mentioned above, the average efficiency for each bank is obtained from the year-wise distance based efficiency. Bank-wise average efficiency scores based on DBA and DEA is shown in Table 2. It can be seen from Table 2 that the input I-distance, the output I-distance, the DBA efficiency and the profit efficiency of banks are in the range of (1-1.9911), (1.0006-2), (0.9034-1.0210) and (0.3723-1) respectively.

Table 2: Efficiency Scores of DBA & DEA

Bank Name	I-distance (Input)	I-distance (Output)	DBA	DEA
Allahabad Bank	1.0886	1.0562	0.9704	0.5503
Andhra Bank	1.0707	1.0224	0.9550	0.4627
Axis Bank	1.1934	1.2189	1.0210	1.0000
Bank of Baroda	1.2028	1.0875	0.9044	0.4325
Bank of India	1.1958	1.1153	0.9330	0.8420
Bank of Maharashtra	1.0539	1.0244	0.9721	0.5459
Canara Bank	1.1968	1.0809	0.9034	0.6119
Central Bank of India	1.1137	1.0585	0.9506	0.4507
Corporation Bank	1.0766	1.0283	0.9553	0.5383
Dena Bank	1.0418	1.0108	0.9702	0.5334
Federal Bank	1.0264	1.0091	0.9831	0.8627
HDFC Bank	1.3534	1.2804	0.9483	1.0000
ICICI Bank	1.6700	1.6610	1.0002	1.0000
IDBI Bank	1.0681	1.0805	1.0118	1.0000
Indian Bank	1.0722	1.0208	0.9521	0.5386

Bank Name	I-distance (Input)	I-distance (Output)	DBA	DEA
Indian Overseas Bank	1.0968	1.0664	0.9723	0.5918
IndusInd Bank	1.0000	1.0090	1.0090	1.0000
ING Vysya Bank	1.0319	1.0288	0.9972	1.0000
Jammu & Kashmir Bank	1.0207	1.0057	0.9853	0.5765
Karnataka Bank	1.0123	1.0076	0.9954	1.0000
Oriental Bank of Commerce	1.0946	1.0476	0.9573	0.5321
Punjab and Sind Bank	1.0234	1.0006	0.9778	0.7449
Punjab National Bank	1.2340	1.1812	0.9575	0.6261
State Bank of Bikaner and Jaipur	1.0456	1.0500	1.0042	0.9493
State Bank of Hyderabad	1.0556	1.0543	0.9990	0.7919
State Bank of India	1.9911	2.0000	1.0046	1.0000
State Bank of Mysore	1.0338	1.0332	0.9994	0.9199
State Bank of Patiala	1.0451	1.0495	1.0043	0.7732
State Bank of Travancore	1.0379	1.0359	0.9981	1.0000
Syndicate Bank	1.0973	1.0339	0.9424	0.8123
UCO Bank	1.0709	1.0257	0.9578	1.0000
Union Bank of India	1.1449	1.0365	0.9054	0.5961
United Bank of India	1.0475	1.0122	0.9664	0.3723
Vijaya Bank	1.0468	1.0045	0.9597	0.4617

Out of the 34 banks, 7 banks are DBA efficient, 10 banks are DEA efficient and 5 banks are both DBA and DEA efficient. Also, 22 banks out of the 34 are below the efficient frontier under both DBA and DEA. The five banks which are efficient under both DBA and DEA include four private sector banks, namely, the Axis Bank, the ICICI Bank, the IDBI Bank and the IndusInd Bank, and one public sector bank, namely, the State Bank of India.

Table 3 presents the ranking of banks based on the input I-distance, the output I-distance, the DBA, the DEA and the difference between the DBA and DEA ranking. Though the performance and ranking of some of banks are better under the input and the output I-distance individually, their performance is lower and ranked high under the DBA. For example, the HDFC Bank and the Punjab National Bank which are ranked as (3, 3) and (4, 5) under input and output I-distance respectively are ranked as 29 and 23 respectively under DBA. On the other hand, the State Bank of Mysore and the State Bank of Patiala Bank which are ranked as (28, 20) and (25, 15) under the input and the output I-distance respectively are ranked as 8 and 5 respectively under the DBA. Table 3 shows that there is a minor variation in the ranking of banks under DBA and DEA, except for six banks and the Kendall's Tau ($r = 0.446$, $p < 0.01$) suggests that there is an agreement between the rankings given by two approaches.

Table 3: Ranking of Banks using Distances, DBA and DEA

Bank Name	I-distance (Input)	I-distance (Output)	DBA	DEA	Diff = DBA-DEA
Allahabad Bank	14	12	18	15	3
Andhra Bank	18	25	26	21	5
Axis Bank	8	4	1	1	0
Bank of Baroda	5	7	33	24	9
Bank of India	7	6	31	5	26

Bank Name	I-distance (Input)	I-distance (Output)	DBA	DEA	Diff = DBA-DEA
Bank of Maharashtra	21	24	17	16	1
Canara Bank	6	8	34	11	23
Central Bank of India	10	11	28	23	5
Corporation Bank	15	22	25	18	7
Dena Bank	26	28	19	19	0
Federal Bank	30	29	14	4	10
HDFC Bank	3	3	29	1	28
ICICI Bank	2	2	7	1	6
IDBI Bank	19	9	2	1	1
Indian Bank	16	26	27	17	10
Indian Overseas Bank	12	10	16	13	3
IndusInd Bank	34	30	3	1	2
ING Vysya Bank	29	21	11	1	10
Jammu & Kashmir Bank	32	32	13	14	-1
Karnataka Bank	33	31	12	1	11
Oriental Bank of Commerce	13	16	24	20	4
Punjab and Sind Bank	31	34	15	9	6
Punjab National Bank	4	5	23	10	13
State Bank of Bikaner and Jaipur	24	14	6	2	4
State Bank of Hyderabad	20	13	9	7	2
State Bank of India	1	1	4	1	3
State Bank of Mysore	28	20	8	3	5
State Bank of Patiala	25	15	5	8	-3
State Bank of Travancore	27	18	10	1	9
Syndicate Bank	11	19	30	6	24
UCO Bank	17	23	22	1	21
Union Bank of India	9	17	32	12	20
United Bank of India	22	27	20	25	-5
Vijaya Bank	23	33	21	22	-1

Further, it is observed that banks which operate on the efficient frontier in the DEA with top ranking are given lower ranks under the DBA. For example, the HDFC bank and the UCO Bank ranked as 1 under the DEA are ranked 29 and 22 respectively under the DBA. The other banks with larger difference in ranking include the Bank of India, the Canara Bank, the Syndicate Bank and the Union Bank of India. The major differences in the ranking given by DBA and DEA are examined by finding out the correlation between the input I-distance, the output I-distance and the DEA scores with the original data. This is crucial, as it provides information about how the variables contribute to the overall performance of the banks. Table 4 shows that the input I-distance and the output I-distance are highly correlated with the original data while the DEA scores are relatively less correlated, however both correlations are significant.

Table 4: Correlation between variables and input & output I-distances and DEA

Input / Output Variables	I-distance (Input)	I-distance (Output)	DEA
Non-Interest Income		0.901**	0.289**
Deployed Funds		0.798**	0.181**
No. of Staff	0.846**		0.105
Equity	0.809**		0.210**
Borrowed Funds	0.790**		0.169**
No. of Branches	0.732**		- 0.014

*** Correlation is significant at the 0.01 level*
**   Correlation is significant at the 0.05 level*

As mentioned earlier, the DBA based efficiency depends on the ordering of the variables based on correlation. The procedure of calculating the I-distance is repeated until the new order of variables introduced is identical with the previous ordering of variable. That is, when the order of significance of correlation between the I-distance and the variables is not identical to present ordering of variables, the new order is introduced and the procedure is repeated. It can be seen from Table 4 that the most significant variable that provides the largest amount of information in the calculation of DBA efficiency using the input and the output I-distance is the non-interest income. It correlates highly with the output I-distance with r = 0.901.

On the other hand, the correlation between input variables and input I-distances and DEA efficiency scores shows that the order of importance of variables is the number of staff, equity, the borrowed fund and the number of bank branches, while under the DEA the equity and borrowed funds are in the first two places. It is observed that the number of staff, which is a most significant (correlated) variable under the input I-distance, is not significant under the DEA. It means that the number of staff differently affects the final rankings of the banks under DBA and DEA. Table 3 shows that out of 34 banks, six banks rankings differ largely, of which five are the public sector banks. It is observed that the public sector banks staff expenses had gone up over and above that of the private sector banks though their staff strength declined sharply during the last decade. Chakrabarty (2012) stressed that there is a need for human resources transformation in the public sector banks because of the absence of the cost advantage coupled with the problem of lower productivity. Table 1 also shows that there is a marginal increase in the staff force of banks during 2005-2012, while the staff cost has increased sharply during this period.

The ranking of banks under the DBA also depends on the calculated I-distance from the reference unit. As the input and output variables used in this study are weighted (i.e. associated cost and prices of input and output variables respectively), the weights also equally contribute to the overall performance of banks as well as to their ranking. It is observed that the variation in the ranking of some of the banks is due to the fact that they are closer to the reference unit. For example, the Karnataka Bank which is efficient under DEA with a rank 1 is inefficient under DBA with rank 12. This is because of the Karnataka Bank being a reference unit for the input variables for most of the years. Further, it is observed that though a bank is away from the reference unit, there is still a variation in the ranking, which implies that such banks need to optimize their inputs and outputs. For example, though the HDFC Bank ranking based on the input and the output I-distance shows that the bank is away from the reference unit, the ranking based on DBA indicates that the bank needs to optimize its inputs and associated cost, in particular, staff strength and number of branches and the associated costs. The major variations in the ranking of banks require further research.

It may be pointed out that under the DEA, banks which are efficient are ranked as first rank and the remaining banks are ranked according to the efficiency scores. In the case of the DBA, banks are ranked based on the descending order of the DBA scores. Under the DBA, a bank is said to be efficient when the DBA score is greater than or equal to one. If the DEA procedure of ranking the banks is followed in the DBA i.e. ranking the efficient bank as first rank and the remaining banks accordingly, then the consistency between the DBA and the DEA rankings would be even better.

Conclusion

It is well known that the Data Envelopment Analysis (DEA) is widely used in measuring the efficiency of banks. Ivanovic (1963) proposed and developed the I-distance method to classify the countries according to their level of development based on several indicators and Mihailovic *et al*. (2009) and Milica Bulajic *et al.* (2012) used the I-distance method to study the performance of the Serbian banks. □□r□mic *et al.* (2012) evaluated the health system performances of the European Union countries by applying an Ivanovic-Jeremic Distance Based Analysis (DBA) which uses I-distance values. In this paper, we have used both Ivanovic-Jeremic Distance Based Analysis and the Data Envelopment Analysis to evaluate the performance of banks in India during 2005-2012 and compared the rankings given by these two approaches.

Analyses show that out of the 34 banks, 7 banks are DBA efficient, 10 banks are DEA efficient and 5 banks are both DBA and DEA efficient. The ranking of banks based on the input I-distance, the output I-distance, and the DBA shows that the performance and ranking of some of the banks are better under the input and output I-distance individually, but their performance is lower and ranked high jointly under the DBA. Also, banks which are efficient in the DEA with top ranking are given lower ranks under the DBA. In general, there is a minor variation in the ranking of banks under the DBA and the DEA, except for six banks. The Kendall's Tau ($r = 0.446$, $p < 0.01$) suggests that there is an agreement between the ranking given by the DBA and the DEA.

Banks with major variations in the ranking given by the DBA and the DEA have been further examined by finding out the correlation between the input I-distance, the output I-distance and the DEA scores with the original data, which provide information about how the variables contribute to the overall performance of the banks. It is observed that the non-interest income is the most significant variable that provides the largest amount of information in the calculation of the output I-distance. Also, it is observed that the number of staff is a most significant (correlated) variable under the input I-distance, which means that the number of staff differently affects the final rankings of the banks under the DBA and the DEA. It is observed that out of 34 banks, six banks ranking under the DBA and the DEA differ largely, of which five are the public sector banks. Chakrabarty (2012) observed that the public sector banks staff expenses had gone up though their staff strength declined sharply during the last decade, which supports the findings. Further, the variation in the rankings is also due to the fact that the banks are closer to the reference unit. In few cases, though a bank is away from the reference unit, the variations in the ranking is due to a sub-optimal level of utilizing inputs / outputs (e.g. HDFC Bank). The major variations in the ranking of banks require further research. It may be pointed out that in the DBA approach, ranking of banks is based on the descending order of DBA scores, while in the DEA approach, banks which are efficient are ranked as first rank and the remaining banks are ranked accordingly. If the same procedure is followed in the DBA, i.e., ranking the efficient bank as first rank and the remaining banks accordingly, then the consistency between the DBA and the DEA rankings would be even better.

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