An Empirical Study to Compute the Efficiency of Indian Banks During the Pre and Post Periods of Recession with the Help of Data Envelopment Analysis

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Abstract

The present study was undertaken to measure the efficiency of Indian commercial banks during the pre and post periods of the recent global recession. Data envelopment analysis (DEA) as an operation research technique was utilized to measure the efficiency of commercial banks in the Indian scenario. Input oriented variable return to scale approach was used in this study. Linear program was formulated to compute the efficiency and super efficiency scores of different commercial banks. The banks were ranked according to the scores obtained by them during the period of the study. The pre recession period was taken from 2001-2002 to 2006-2007 and the post recession period was considered from 2007-2008 to 2012-2013. Further endeavor was made in this study to understand if there was a significant difference between the ranks obtained by commercial banks during pre and post periods of recession by utilizing Spearman's rank correlation. It was concluded from the study that recession had a little impact on the performance of Indian commercial banks in general, though private sector banks were able to fare better than their public sector counterparts during the post recession period as compared to the pre recession period.

Key words : **data envelopment analysis, decision making units, linear program, profitability, recession**

JEL Classification : C61, C67, G21

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Commercial banks are an integral part of any economy. In the Indian scenario, the real development of the banking sector started with the establishment of the central bank (Reserve Bank of India) in the year 1935. The Government of India took a major decision to nationalize commercial banks after independence. The first phase of nationalization took place in the year 1969 where around 14 banks were nationalized. In the year 1980, the next phase of nationalization took place.

The impact of globalization in the Indian economy coupled with the financial reforms in 1991 redefined the banking system in the Indian scenario. The nationalized banks had to face cut throat competition from their counterparts in private sectors. The survival of the fittest was the main motto in the Indian scenario. The recent global recession starting with the subprime crisis was a litmus test for the Indian banking system. As per the National Bureau of Economic Research, recession hit the global arena in the second half of 2007. Recessions always have a detrimental effect on any economy as these result in decrease in gross domestic product coupled with lower employment opportunities and industrial production. In this research paper, the entire period of the study has been segregated into pre period of recession from 2001-2002 to 2006-2007 and post recession period from 2007-2008 to 2012-2013.

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I utilized DEA as a non-parametric method to measure the efficiency and super efficiency scores of commercial banks in India during the pre and post period of recession. The sample banks taken for the study were derived from BSE 500, a major index of Bombay Stock Exchange.

Literature Review

Efficiency is defined as the ratio between output and input. Optimum efficiency can be achieved by either maximizing the output (keeping the input constant) or minimizing the inputs (keeping the output constant).The former is known as output oriented approach while the latter is known as input oriented approach. Efficiency can easily be calculated if there is one output and one input. The problem arises if there are more than one outputs or inputs.

DEA provides solution to this problem. It is an operation research technique developed by Charnes, Cooper, and Rhodes (1978) to measure the efficiency of the decision making units (DMUs) if there are multiple inputs or outputs. In this paper, one output and nine inputs are taken into consideration. Inputs are also known as independent variables and output is known as dependent variables. The details regarding the variables are given in the next section. Commercial banks are taken as decision making units (DMUs) for this paper.

In the case of multiple inputs and outputs, Charnes, Cooper, and Rhodes (1978) defined efficiency as the ratio between the weighted sum of outputs and weighted sum of inputs. Weights are assigned on the basis of suitable programming. They basically assumed constant return to scale. Later on Banker, Charnes, and Cooper (1984) in their paper established the variable return to scale which encompassed both increasing as well as decreasing return to scale.

Hence, to achieve optimum efficiency, DEA can resort to input or output oriented approach which can be explained by either constant return to scale or variable return to scale. In this paper, input oriented variable return to scale approach was utilized. Some of the other literature referred to while conducting this study has been mentioned in brief below.

Makkar and Singh (2013) used CAMELS rating methodology to gauge the financial performance of Indian commercial banks. *t*-test was utilized in the study to understand if there was any significant difference in the components of CAMELS (i.e. capital adequacy, asset quality, earning capacity, management, etc.) of public and private sector banks in India. It was concluded from the study that there was no statistical significant difference in the financial performance of public and private sector banks in India, but there was a need for an overall improvement of public sector banks to make their position strong in the market.

Bhattacharyya, Lovell, and Sahay (1997) investigated the efficiency of Indian banks through data envelopment analysis. It was revealed from the study that public sector banks were the best performers in terms of efficiency scores followed by foreign banks and private sector banks.

Feroz, Kim, and Raab (2003) demonstrated the advantages of using data envelopment analysis over financial ratio analysis to compute the overall efficiency of an entity. The article provided an insight into the disadvantages of using financial ratios as a means to compute the managerial efficiency of a company and emphasized how DEA can offset the disadvantage by providing reliable information, which can be extremely beneficial for the analyst.

Karimzadeh (2012) measured the efficiency of Indian commercial banks utilizing data envelopment analysis. A total of eight banks were taken into consideration for the study comprising of public as well as private sector banks. Efficiency scores were computed for these banks. It was revealed from the analysis that public sector banks were more efficient than private sector banks from the sample banks taken for the study.

Sharma and Kumar (2013) in their paper tried to investigate the impact of banking sector reforms in public, private, and foreign banks in the pre and post reform periods. The performance of the banks was measured by profitability, which is perhaps one of the important indicators in this ever changing business scenario.

Kumar and Singh (2014) computed the efficiency scores of five public sector banks and five private sector banks through DEA. The study revealed that the efficiency of the banks had increased in general due to induction of financial reforms in the banking sector. The paper highlighted that private sector banks were better performers than public sector banks. The main reason for lower efficiency of the banks was attributed to increase in non-performing assets in the banking sector.

Tehrani, Mehragan, and Golkani (2012) in their study utilized DEA to explore the relevant model needed to evaluate the financial performance of the 36 private entities in the Iranian scenario. The study revealed that 75% of the entities were inefficient while the remaining were efficient. The paper also analyzed the weaknesses of different firms.

Nagaraju (2014) made an attempt to analyze the performance of Indian public and private sector banks by utilizing DEA. The results of the study reflected that public and private sector banks underperformed in terms of profitability and marketability efficiency. However, the banks performed relatively better in terms of profitability efficiency as compared to stock market performance.

Tandon and Malhotra (2014) investigated the efficiency of banks in the Indian scenario for the period from 2010 - 2012. They studied public as well as private sector banks, including foreign owned banks. The analysis revealed that only 16% of the total 48 banks were efficiently performing. The study also revealed that there was not much significant difference between the technical efficiency of public and private sector banks, but there was an ample scope of improvement for foreign banks.

Narayanaswamy and Muthulakshmi (2014) examined the relative efficiency of all the private sector banks in India using the DEA methodology. It was found from the study that the overall technical inefficiency score during the period of study (2008 to 2013) was found to be 6%.

Shukla (2016) in his article analyzed the performance of 46 scheduled commercial banks which included both private and public sector banks in India on the basis of the established four financial parameters namely size, growth, profitability, and soundness The study revealed that public and private sector banks were not very much different in terms of size and growth parameters, but significant differences were observed in terms of profitability and soundness of business.

The past works of Banker et al. (1984) and Anderson and Peterson (1993) were referred to while formulating the linear program to compute the efficiency and super efficiency scores of banks.

Objectives of the Study

The major objectives of this study are as follows:
The paper aims to examine the :

(1) Ranking of Indian commercial banks during the pre and post period of recession as per the efficiency and super efficiency scores obtained by them utilizing DEA.

(2) Identifying the top 10 banks (as per their ranks) in the Indian scenario (during pre and post period of recession).

(3) Identifying the number of public and private sector banks among the top 10 banks in the Indian scenario during pre and post recession period.

(4) Investigating whether there is a significant difference between the ranks obtained by the commercial banks (as above) during the pre and post period of recession.

Research Methodology

(1) Linear Program for DEA : DEA is used in this paper to compute the efficiency and super efficiency scores of different commercial banks. Lingo 13.0 and SPSS 20.0 software were utilized for analysis.

Linear program developed to compute the efficiency and super efficiency scores is as follows:

(i) To compute the efficiency score (Banker et al., 1984) :

Min Theta (Objective Function)

Subject to the following constraints: (Equation 1)

$$\sum_{j=1}^{n} w_j x_i^j \leq \theta x_i^t ; i = 1,2,3 \ldots m$$

$$\sum_{j=1}^{n} w_j y_r^j \geq y_r^t ; r = 1,2,3 \ldots s$$

$$\sum_{j=1}^{n} w_j = 1 ;$$

$$w_j \geq 0 (j = 1,2,3 \ldots n);$$

In the above, w_j= weight of j^{th} decision making unit ,
x_i^j= i^{th} input for j^{th} decision making unit,
y_r^j= r^{th} output for j^{th} decision making unit,
x_i^t = i^{th} input for t^{th} decision making unit,
y_r^t = r^{th} output for t^{th} decision making unit,
Theta = used to calculate the efficiency ; m = inputs ; s = outputs.

(ii) To compute the super efficiency score (Anderson & Peterson, 1993) :

Min θ (Objective Function)

Subject to the following constraints:

$$\sum_{j=1}^{n} w_j x_i^j \leq \theta x_i^t ; i = 1,2,3 \ldots m \quad \text{(Equation 2)}$$

$$\sum_{j=1}^{n} w_j y_r^j \geq y_r^t ; r = 1,2,3 \ldots s$$

$$\sum_{j=1}^{n} w_j = 1 ;$$

$w_j >= 0$ ($j = 1,2,3,4 \ldots n$), where j is *not equal* to t.

(2) Criteria for Appropriate Selection of Number of Decision Making Units (DMUs) : In this paper, different banks were taken as separate decision making units (DMUs).There is a restriction regarding the minimum number of DMUs that should be taken for optimum results. The thumb rule provided by different researchers were taken into consideration while deciding the number of DMUs to be taken. According to the thumb rule, the minimum number of DMUs to be taken should be equal or more than one of the following :

2 (number of outputs * number of inputs) (Golany & Roll, 1989) or

3 (number of outputs + number of inputs) (Bowlin, 1998)

In this paper, I have taken one output and nine inputs.

Hence, the number of DMUs >= {2(1*9) or 3(1 + 9)}= {18 or 30}

Thus, the minimum number of DMUs is 30. Hence, I have taken 30 DMUs (commercial banks) for the study.

(3) Sources of Data : Secondary data of the selected commercial banks listed in BSE 500 Index were taken into consideration for the study. CMIE Prowess Database software was utilized to derive the list of commercial banks. A total of 30 commercial banks were taken into consideration for the study. The data were collected for the pre-recession period from 2001-2002 to 2006-2007 and post-recession period of 2007-2008 to 2012-2013.

(4) Hypothesis Tested : The following null hypothesis is tested:

↳ **H0 :** There is not much significant difference between the ranks obtained by commercial banks during the pre and post period of recession.

(5) Variable Selection : Nine input (independent) variables and one output (dependent) variable are taken into consideration.

Output (Dependent Variable) : Profitability is taken as an output for this paper.

Profitability = Average profit after tax/Average net worth.

Here, average denotes the average value of the variable (profit after tax and net worth) taken for the period of study (i.e. pre-recession period from 2001-2002 to 2006-2007) and post recession period (from 2007-2008 to 2012-2013).

Inputs (Independent Variables) : Nine variables related to capital structure decisions were taken as inputs for the study. These variables were extracted after a thorough survey of past literatures that have an impact on profitability.

(i) Bank Size : Bank size is measured in this research paper by two proxies: (a) Size_1 = Logarithm of average total income ; (b) Size_2 = Logarithm of average total assets.
(ii) Financial Leverage = Average total debt/Average total assets.
(iii) Interest Coverage Ratio = Average earnings before interest and tax/average interest paid.
(iv)Non debt tax shield = Average depreciation/Average total assets.
(v) Current ratio =Average current assets/Average current liability.
(vi)Tangibility = Average net fixed assets/Average total assets.
(vii) Business Risk = Standard deviation of earning before interest and tax/ Average earning before interest and tax.
(viii) Retention Ratio = 1- Dividend payout ratio.
where, Dividend payout ratio = Average dividend/Average profit after tax.

Empirical Analysis and Results

As discussed earlier, efficiency is measured as the ratio of output and inputs. At the initial stage of our study, I took into consideration one output (dependent) variable and nine input (independent) variables for both pre and post period of recession. It is necessary that the correlation among independent variables needs to be checked before

we proceed with the DEA. The correlation among independent variables should be minimum. If the correlation among the independent variables is very high, then the multicollinearity problem may exist among independent variables which may yield incorrect results. On the other hand, there should be a strong correlation between dependent and independent variables.

(1) Choosing the Appropriate Inputs for the Study : A separate analysis is made in this section relating to the pre and post recession period.

(i) Pre Recession Period : Nine independent variables (namely, retention ratio, interest coverage ratio, tangibility, size_1 (log total income), size_2 (log total assets), business risk, financial leverage, non debt tax shield, and current ratio) are considered as inputs for the study. The correlation matrix has been derived by using SPSS 20.0 between the independent variables. The result of the correlation is produced in the Table 1.

The independent variables that have a very high correlation with each other are retained, others are identified and removed. It is observed from the Table 1 that size_1 (log total income) and size_2 (log assets) have very high positive correlation (0.999). It is also observed that retention ratio and financial leverage also have a very high negative correlation of 0.866.

Variance inflation factor (VIF) is also utilized in this paper to check the multicollinearity problem. SPSS 20 was utilized to run the collinearity diagnostic test. VIF of the independent variables having high correlation is compared and the test results indicate the following :

Table 1. Correlation Matrix (Pre Recession Period) to Check the Multicollinearity Problem

	RR	*ICR*	*TAN*	*Size_1*	*Size_2*	*BR*	*FL*	*NDTS*	*CR*
Correlation	1.000	0.477	-0.366	-0.154	-0.145	-0.141	-0.866	0.355	0.234
	0.477	1.000	-0.352	-0.019	-0.007	0.294	-0.278	0.423	-0.180
	-0.366	-0.352	1.000	0.081	0.092	0.484	0.504	0.270	0.017
	-0.154	-0.019	0.081	1.000	0.999	-0.032	0.237	-0.350	-0.221
	-0.145	-0.007	0.092	0.999	1.000	-0.011	0.233	-0.337	-0.206
	-0.141	0.294	0.484	-0.032	-0.011	1.000	0.457	0.320	-0.206
	-0.866	- 0.278	0.504	0.237	0.233	0.457	1.000	-0.085	-0.487
	0.355	0.423	0.270	-0.350	-0.337	0.320	-0.085	1.000	-0.135
	0.234	-0.180	0.017	-0.221	-0.206	-0.206	-0.487	-0.135	1.000

Note : *RR* = Retention Ratio, *ICR* = Interest Coverage Ratio, *TAN* = Tangibility, *SIZE_1* = Log Total Income, *SIZE_2* = Log Total Assets, *BR* = Business Risk, *FL*= Financial Leverage, *NDTS* = Non Debt Tax Shield, *CR* = Current Ratio

Table 2. Correlation Matrix (after Removal of Size_2 and Financial Leverage) During the Pre Recession Period

		RR	*ICR*	*TAN*	*SIZE_1*	*BR*	*NDTS*	*CR*
Correlation	*RR*	1.000	0.477	-0.366	-0.154	-0.141	0.355	0.234
	ICR	0.477	1.000	-0.352	-0.019	0.294	0.423	-0.180
	TAN	-0.366	-0.352	1.000	0.081	0.484	0.270	0.017
	SIZE_1	-0.154	-0.019	0.081	1.000	-0.032	-0.350	-0.221
	BR	-0.141	0.294	0.484	-0.032	1.000	0.320	-0.206
	NDTS	0.355	0.423	0.270	-0.350	0.320	1.000	-0.135
	CR	0.234	-0.180	0.017	-0.221	-0.206	-0.135	1.000

VIF of size_2 > VIF of size_1
and
VIF of financial leverage > VIF of retention ratio

Hence, the independent variables namely size_2 (log total assets) and financial leverage were removed to minimize the multicollinearity problem existing among the independent variables.

The correlation matrix is again derived by using SPSS after the removal of size_2 (log total assets) and financial leverage. It is observed from the Table 2 that all the independent variables have correlation of less than 0.50. Hence, we can assume that the multicollinearity problem does not exist among the independent variables. Thus, the final inputs and output selected for DEA for the pre period of recession is produced as follows (Table 2) :

Inputs: retention ratio, interest coverage ratio, tangibility, size_1 (log total income), business risk, non debt tax shield, and current ratio.
Output: Profitability

It is observed from the Table 3 that *R* square is 0.878 meaning that 87.8% of the dependent variable (profitability) is explained by seven independent variables taken together. Hence, it can be inferred that a strong *R* square exists between the dependent variable and the independent variables.

Table 3. Computation of R^2 (after Removal of Size_2 and Financial Leverage) During the Pre Recession Period

Model	*R*	*R* Square	Adjusted *R* Square	Std. Error of Estimate
1	0.937[a]	0.878	0.839	0.00131

a.Predictors: (Constant), Current Ratio , Tangibility, Log Sales, Interest Coverage Ratio , Retention Ratio, Business Risk, Non Debt Tax Shield

(ii) Post Recession Period : Similar analysis is done for the post recession period. It is observed from the Table 4 that the following independent variables have a very high correlation.

Size_1 and Size_2 : Correlation of 0.986
Business Risk and Non Debt Tax Shield : Correlation of 0.606.

Table 4. Correlation Matrix (Post Recession Period) to Check the Multicollinearity Problem

		RR	*ICR*	*TAN*	*SIZE_1*	*SIZE_2*	*BR*	*FL*	*NDTS*	*CR*
Correlation	*RR*	1.000	0.397	0.059	-0.031	-0.042	0.345	0.170	0.187	-0.174
	ICR	0.397	1.000	-0.055	0.221	0.167	0.411	0.330	0.474	-0.191
	TAN	0.059	-.055	1.000	-0.018	-0.124	0.180	0.458	0.454	-0.020
	SIZE_1	-0.031	0.221	-0.018	1.000	0.986	-0.392	0.314	-0.251	0.002
	SIZE_2	-0.042	0.167	-0.124	0.986	1.000	-0.436	0.206	-0.367	0.068
	BR	0.345	0.411	0.180	-0.392	-0.436	1.000	0.115	0.606	-0.038
	FL	0.170	0.330	0.458	0.314	0.206	0.115	1.000	0.524	-0.488
	NDTS	0.187	0.474	0.454	-0.251	-0.367	0.606	0.524	1.000	-0.423
	CR	-0.174	-0.191	-0.020	0.002	0.068	-0.038	-0.488	-0.423	1.000

Table 5. Correlation Matrix (After the Removal of Size_2 (Log Assets) and Non Debt Tax Shield) [Post Recession Period]

		RR	*ICR*	*TAN*	*SIZE_1*	*BR*	*FL*	*CR*
Correlation	*RR*	1.000	0.397	0.059	-0.031	0.345	0.170	-0.174
	ICR	0.397	1.000	-0.055	0.221	0.411	0.330	-0.191
	TAN	0.059	-0.055	1.000	-0.018	0.180	0.458	-0.020
	SIZE_1	-0.031	0.221	-0.018	1.000	-0.392	0.314	0.002
	BR	0.345	0.411	0.180	-0.392	1.000	0.115	-0.038
	FL	0.170	0.330	0.458	0.314	0.115	1.000	-0.488
	CR	-0.174	-0.191	-0.020	0.002	-0.038	-0.488	1.000

Table 6. Computation of R^2 During the Post Recession Period

Model	*R*	*R* Square	Adjusted *R* Square	Std. Error of the Estimate
1	0.947[a]	0.898	0.865	0.00224

a.Predictors: (Constant), Current Ratio , Log Sales , Tangibility, Retention Ratio, Interest Coverage Ratio , Business Risk , Financial Leverage

When collinearity diagnostic test is performed in SPSS 20 to check the variance inflation factor, the following result is observed :

VIF of size_2 > VIF of size_1
and
VIF of non debt tax shield > VIF of business risk

Hence, size_2 and non debt tax shield is removed to reduce the multicollinearity problem. The correlation matrix is obtained after removal of the independent variables namely size_2 and non debt tax shield. It is observed from the Table 5 that none of the independent variables have correlation greater than 0.50. Thus, we can safely assume that the multicollinearity problem is nonexistent among the independent variables.

The output and inputs selected for the post recession period are as follows:

Inputs: Retention ratio, interest coverage ratio, tangibility, size (log total income), business risk, financial leverage and current ratio.
Output: Profitability

Further, it is observed from the Table 6 that the coefficient of determination is 0.898 which represents a high *R* square between the dependent and the seven independent variables.

(2) Ranking of the Commercial Banks : DEA was utilized to rank commercial banks as per their efficiency and super efficiency scores. DEA is basically a non-parametric approach of linear programming. For the banks whose efficiency scores are 1 (100%), the super efficiency score was taken into consideration for providing them with ranks. Sample linear program of Allahabad Bank is provided in Annexure A for efficiency score and Annexure B for super efficiency score during the pre-period of recession.

A brief description of the variables used in the Annexure is as follows:
30 DMU (decision making units) are taken into consideration for the study. The decision making units represent commercial banks.

Table 7. Ranking of Commercial Banks (Pre-Recession Period) on the Basis of Efficiency and Super Efficiency Scores

S.No.	Name of the Bank		Efficiency	Super Efficiency	Ranking
1	Allahabad Bank	DMU1	1	1.06368	15
2	Andhra Bank	DMU2	1	1.26891	5
3	Axis Bank Ltd.	DMU3	0.911675		30
4	Bank of Baroda	DMU4	0.957047		27
5	Bank of India	DMU5	0.993783		22
6	Bank of Maharashtra	DMU6	1	1.14214	7
7	Canara Bank	DMU7	0.988596		23
8	City Union Bank Ltd.	DMU8	1	1.45234	3
9	Corporation Bank	DMU9	0.930284		29
10	Federal Bank Ltd.	DMU10	0.957481		26
11	HDFC Bank Ltd.	DMU11	1	1.18981	6
12	ICICI Bank Ltd.	DMU12	1	1.12596	9
13	IDBI Bank Ltd.	DMU13	1	2.17798	1
14	ING Vysya Bank Ltd.	DMU14	1	1.06208	16
15	Indian Overseas Bank	DMU15	1	1.00121	20
16	Indusind Bank Ltd.	DMU16	1	1.02962	18
17	Jammu & Kashmir Bank Ltd.	DMU17	1	1.0639	14
18	Karnataka Bank Ltd.	DMU18	0.979753		25
19	Kotak Mahindra Bank Ltd.	DMU19	1	1.0654	13
20	Lakshmi Vilas Bank Ltd.	DMU20	1	1.08696	11
21	Oriental Bank of Commerce	DMU21	1	1.02829	19
22	Punjab National Bank	DMU22	0.933009		28
23	South Indian Bank Ltd.	DMU23	1	1.06701	12
24	State Bank of Bikaner & Jaipur	DMU24	0.983418		24
25	State Bank of India	DMU25	1	1.6703	2
26	State Bank of Mysore	DMU26	1	1.05913	17
27	State Bank of Travancore	DMU27	1	1.28898	4
28	Syndicate Bank	DMU28	1	1.13308	8
29	Union Bank of India	DMU29	0.997621		21
30	Vijaya Bank	DMU30	1	1.114	10

w_j is the weight of j^{th} DMUs (j = 1 to 30 as there are 30 DMUs)
Theta in the linear program denotes the efficiency of the DMUs.
For the present study, nine inputs and one output is taken into consideration.
Hence, the $x_i^t = i^{th}$ input for t^{th} decision making unit,
$y_r^t = r^{th}$ output for t^{th} decision making unit.
Example, in Annexure A, if we take the first program for input, that is,
Min = theta;
0.767661*w1+0.670661*w2+0.764671*w3+0.760523*w4+0.795514*w5+0.704352*w6+0.803032*w7+

Table 8. Ranking of the Commercial Banks (Post Recession Period) on the Basis of Efficiency and Super Efficiency Scores

S.No.	Name of the Bank		Efficiency	Super Efficiency	Ranking
1	Allahabad Bank	DMU1	0.9565649		26
2	Andhra Bank	DMU2	1	1.08919	11
3	Axis Bank Ltd.	DMU3	0.9180731		29
4	Bank of Baroda	DMU4	0.888848		30
5	Bank of India	DMU5	0.966229		25
6	Bank of Maharashtra	DMU6	1	1.00313	19
7	Canara Bank	DMU7	0.9580867		27
8	City Union Bank Ltd.	DMU8	1	1.33555	2
9	Corporation Bank	DMU9	1	1.1471	5
10	Federal Bank Ltd.	DMU10	1	1.01037	18
11	HDFC Bank Ltd.	DMU11	1	1.30362	4
12	ICICI Bank Ltd.	DMU12	1	2.55768	1
13	IDBI Bank Ltd.	DMU13	1	1.03103	17
14	ING Vysya Bank Ltd.	DMU14	0.99101		21
15	Indian Overseas Bank	DMU15	0.987873		23
16	Indusind Bank Ltd.	DMU16	0.9904133		22
17	Jammu & Kashmir Bank Ltd.	DMU17	1	1.321815	3
18	Karnataka Bank Ltd.	DMU18	1	1.07517	12
19	Kotak Mahindra Bank Ltd.	DMU19	1	1.0543	15
20	Lakshmi Vilas Bank Ltd.	DMU20	1	1.09955	10
21	Oriental Bank of Commerce	DMU21	0.992079		20
22	Punjab National Bank	DMU22	0.97398		24
23	South Indian Bank Ltd.	DMU23	1	1.03495	16
24	State Bank of Bikaner & Jaipur	DMU24	1	1.0564	14
25	State Bank of India	DMU25	1	1.13007	6
26	State Bank of Mysore	DMU26	1	1.06194	13
27	State Bank of Travancore	DMU27	1	1.10198	9
28	Syndicate Bank	DMU28	1	1.1173	8
29	Union Bank of India	DMU29	0.950993		28
30	Vijaya Bank	DMU30	1	1.11933	7

0.751219*w8+0.773367*w9+0.863039*w10+0.768276*w11+0.644495*w12+1.187193*w13+0.761046*w14 +0.789665*w15+0.625862*w16+0.831332*w17+0.814025*w18+0.766252*w19+0.771885*w20+0.8124* w21+0.829849*w22+0.798898*w23+0.806944*w24+0.825217*w25+0.844548*w26+0.822155*w27+ 0.751447*w28+0.758038*w29+0.614731*w30<= 0.767661*theta;

Then, w1 = weight of the 1st DMU (Allahabad Bank),

0.767661 = input value for 1st decision making unit,

Theta = denoting the efficiency of the DMU.

The ranking of the banks during the pre-recession period is given in the Table 7. It can be observed from the Table 7 that IDBI Bank with a super efficiency score of 2.17798 is ranked as the number one bank followed by State Bank of India. The ranking of the banks is done on the same parameters for the post recession period. It can be observed from the Table 8 that ICICI Bank with a super efficiency score of 2.55768 has been ranked as the top bank followed by City Union Bank.

(3) Identifying the Top 10 Banks in the Indian Scenario : The Table 9 and Table 10 deal with the top 10 commercial banks as per their efficiency scores during the pre and post periods of recession.

It is observed from the Table 9 that out of the top 10 commercial banks, seven banks (namely IDBI Bank Ltd., State Bank of India, State Bank of Travancore, Andhra Bank, Bank of Maharashtra, Syndicate Bank, and Vijaya Bank) are public sector banks, while the remaining three banks are private sector banks during the pre-recession period.

The Table 10 reveals that of the top 10 commercial banks, five banks (namely Corporation Bank, State Bank of India, Vijaya Bank, Syndicate Bank, and State Bank of Travancore) are public sector banks and the remaining five banks are private sector banks.

Table 9. Top 10 Commercial Banks During the Pre Recession Period

S. No.	Bank	Rank
1	IDBI Bank Ltd.	1
2	State Bank of India	2
3	City Union Bank Ltd.	3
4	State Bank of Travancore	4
5	Andhra Bank	5
6	HDFC Bank Ltd.	6
7	Bank of Maharashtra	7
8	Syndicate Bank	8
9	ICICI Bank Ltd.	9
10	Vijaya Bank	10

Note : Compiled from Table 7

Table 10. Top 10 Commercial Banks During the Post Recession Period

S. No.	Bank	Rank
1	ICICI Bank Ltd.	1
2	City Union Bank Ltd.	2
3	Jammu & Kashmir Bank Ltd.	3
4	HDFC Bank Ltd.	4
5	Corporation Bank	5
6	State Bank of India	6
7	Vijaya Bank	7
8	Syndicate Bank	8
9	State Bank of Travancore	9
10	Lakshmi Vilas Bank Ltd.	10

Note : Compiled from Table 8

Table 11. Spearman Rank Correlation Coefficient

			Rank Pre Recession	Rank Post Recession
Spearman's rho	Rank Pre recession	Correlation Coefficient	1.000	0.579**
		Sig. (2-tailed)	.	0.001
		N	30	30
	Rank Post Recession	Correlation Coefficient	0.579**	1.000
		Sig. (2-tailed)	0.001	.
		N	30	30

**. Correlation is significant at the 0.01 level (2-tailed).

(4) Testing of the Hypothesis : The ranks assigned to the commercial banks are derived from the Table 7 and Table 8 for the pre and post periods of recession. Spearman rank correlation technique is used to investigate into the correlation existing between the ranks assigned to the banks during both the periods of the study. SPSS 20 was utilized for the analysis purpose. It is observed from the Table 11 that the correlation coefficient is 0.579. As the correlation coefficient of ranks during pre and post periods of recession is more than 0.50, hence it can be assumed that there is not much significant difference between the ranks obtained by the commercial banks during the pre and post periods of recession. Thus, the null hypothesis is accepted. The results of Spearman's rank correlation are produced in the Table 11.

Discussion and Conclusion

I utilized DEA as a non-parametric method to rank 30 commercial banks in the Indian scenario during the pre and post periods of recession. I further derived the top 10 banks. If a comparison is made between the proportion of public sector and private sector banks among the top 10 commercial banks during the pre and post periods of recession, the following results are obtained:

Pre-Recession: Public sector banks (70%) and private sector banks (30%).
Post-Recession: Public sector banks (50%) and private sector banks (50%).

Thus, if we investigate into the proportion of public and private sector banks among the top 10 banks of India, we can conclude that the proportion of public sector banks have decreased by 20% and the private sector banks have increased by 20% during the post period of recession as compared to the pre period of recession.

It is also observed from the Table 9 that out of top five banks, four banks are public sector banks, and the remaining one bank (City Union Bank Limited) is a private sector bank during the pre-period of recession. Similarly, it can be seen from the Table 10 that out of the top five banks, four banks belong to the private sector, while one bank (Corporation Bank) belongs to the public sector during the post period of recession. Hence, it can be observed that private sector banks were better performers compared to their public sector counterparts during the post period of recession as compared to the pre period of recession.

It can be concluded from the results of Spearman's rank correlation that there is not much significant difference between the ranks obtained by the commercial banks during the pre and post periods of recession. Hence, it may be concluded that recession did not have a major impact on the performance of the commercial banks in the Indian scenario in general, though the private sector banks fared better than their public sector counterparts during the recession period.

Research Implications

An endeavor has been made in the present study to measure the efficiency of the commercial banks in the Indian scenario through the application of DEA during the pre (6 years) and post (6 years) periods of recession. A further attempt is also made to understand if recession had any major impact upon the performance of commercial banks by using the Spearman rank correlation ; 30 commercial banks were taken into consideration for the study for which linear program was developed for the pre and post periods of recession. The present study will greatly benefit the managers of corporates, prospective investors, as well as researchers in understanding the changes in the ranks obtained by commercial banks during the pre and post recession periods on the basis of the efficiency scores obtained by them. Furthermore, the study also throws light on the fact whether recession had any impact on the performance of banks during the pre and post periods of recession.

Limitations of the Study and Scope of Further Research

The present study was conducted to measure the efficiency of Indian commercial banks by utilizing the technique of DEA by taking into consideration nine inputs and one output during the pre and post recession periods. The inputs were selected from past studies related to capital structure decisions. The efficiency scores thus computed are on the basis of inputs and output selected for the study. Further, the study is basically sector and country specific (as it concentrates on the banking sector in India) and is also somewhat time specific (pre and post recession periods).

The present study is confined to the banking sector in India. Further analysis can be done to investigate the performance efficiency of foreign banks in comparison to that of their Indian counterparts during pre and post periods of recession. The present study can also be extended to other sectors in the Indian scenario to compute the technical and scale efficiency through DEA. Further, the study can also be extended to the global context.

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Annexure A. Sample DEA Program of Allahabad Bank for Input Oriented VRS Model for Computing Efficiency Score [During the Pre Recession Period]

Min = theta;
0.767661*w1+0.670661*w2+0.764671*w3+0.760523*w4+0.795514*w5+0.704352*w6+0.803032*w7+0.751219*w8+0.773367*w9+0.863039*w10+0.768276*w11+0.644495*w12+1.187193*w13+0.761046*w14+0.789665*w15+0.625862*w16+0.831332*w17+0.814025*w18+0.766252*w19+0.771885*w20+0.8124*w21+0.829849*w22+0.798898*w23+0.806944*w24+0.825217*w25+0.844548*w26+0.822155*w27+0.751447*w28+ 0.758038*w29+0.614731*w30<= 0.767661*theta;

1.267202*w1+1.401585*w2+1.347229*w3+1.29226*w4+1.248846*w5+1.199342*w6+1.282625*w7+1.357274*w8+1.468472*w9+1.266965*w10+1.564461*w11+1.249653*w12+1.016003*w13+1.085165*w14+1.338086*w15+1.187204*w16+1.383031*w17+1.34023*w18+1.510445*w19+1.117385*w20+1.352655*w21+1.352609*w22+1.20254*w23+1.359568*w24+1.281307*w25+1.332424*w26+1.277189*w27+1.244788*w28 +1.264837*w29+1.246952*w30<=1.267202*theta;

0.01412*w1+0.005314*w2+0.011994*w3+0.008577*w4+0.007783*w5+0.005842*w6+0.009382*w7+0.006938*w8+0.007116*w9+0.010139*w10+0.012925*w11+0.021996*w12+0.017356*w13+0.022896*w14+0.007477*w15+0.016289*w16+0.008045*w17+0.00777*w18+0.012338*w19+0.007791*w20+0.005133*w21+0.007941*w22+0.007347*w23+0.005235*w24+0.005666*w25+0.005466*w26+0.004288*w27+0.008102*w28+0.01121*w29+0.006903*w30<=0.01412*theta;

4.585892*w1+4.478957*w2+4.454423*w3+4.915405*w4+4.901325*w5+4.436397*w6+4.981526*w7+3.53472*w8+4.471544*w9+4.191217*w10+4.629339*w11+5.174351*w12+4.856681*w13+4.123543*w14+4.683047*w15+4.117403*w16+4.251682*w17+4.057642*w18+3.836793*w19+3.590156*w20+4.64177*w21+5.012229*w22+3.944065*w23+4.338047*w24+5.597761*w25+4.198914*w26+4.368503*w27+4.641388*w28+4.780152*w29+4.388575*w30<=4.585892*theta;

0.3007*w1+0.130687*w2+0.470846*w3+0.16413*w4+0.181275*w5+0.079143*w6+0.185346*w7+0.166742*w8+0.183516*w9+0.212357*w10+0.43917*w11+0.531965*w12+0.311142*w13+0.133609*w14+0.219272*w15+0.260144*w16+0.108811*w17+0.134732*w18+0.711372*w19+0.179651*w20+0.180987*w21+0.158678*w22+0.152971*w23+0.19848*w24+0.071659*w25+0.238994*w26+0.199228*w27+0.32654*w28+0.229298*w29+0.206271*w30<=0.3007*theta;

0.000919*w1+0.001658*w2+0.001867*w3+0.001222*w4+0.001015*w5+0.001457*w6+0.001 153*w7+0.001237*w8+0.001579*w9+0.001317*w10+0.002685*w11+0.00136*w12+0.000388*w13+0.002781*w14+0.00108*w15+0.00191*w16+0.001559*w17+0.001346*w18+0.002518*w19+0.001408*w20+0.001262*w21+0.001451*w22+0.001046*w23+0.001719*w24+0.001108*w25+0.001925*w26+0.001275*w27+0.000832*w28+0.001007*w29+0.001304*w30<=0.000919*theta;

3.461675*w1+2.560983*w2+4.630064*w3+2.998749*w4+3.029136*w5+2.59662*w6+3.159787*w7+1.92248*w8+2.267628*w9+5.192383*w10+1.11534*w11+1.816557*w12+1.23808*w13+2.335703*w14+2.247863*w15+4.610697*w16+4.336413*w17+3.701734*w18+1.205398*w19+3.617512*w20+3.81638*w21+2.41813*w22+3.585921*w23+1.330104*w24+1.348352*w25+1.259883*w26+1.002103*w27+2.763443*w28+2.566562*w29+2.867127*w30<=3.461675*theta;

0.01116*w1+0.014417*w2+0.010843*w3+0.008975*w4+0.008816*w5+0.007082*w6+0.011311*w7+0.014

776*w8+0.014192*w9+0.009945*w10+0.015212*w11+0.014713*w12+0.002303*w13+0.003202*w14+0.01
25*w15+0.009043*w16+0.012496*w17+0.012236*w18+0.01646*w19+0.006495*w20+0.012024*w21+0.01
0933*w22+0.007065*w23+0.011257*w24+0.010189*w25+0.012099*w26+0.010002*w27+0.009132*w28+
0.010098*w29+0.010391*w30>=0.01116;
w1 + w2 + w3 + w4 + w5 + w6 + w7 + w8 + w9 + w10 + w11 + w12 + w13 + w14+w15+w16+w17+w18+w19+w20+w21+w22+w23+w24+w25+w26+w27+w28+w29+w30= 1;
w1 >= 0; w2 >= 0; w3 >= 0; w4 >= 0; w5 >= 0;
w6 >= 0; w7 >= 0; w8 >=0; w9 >= 0; w10 >= 0;
w11 >=0; w12 >=0; w13 >=0; w14 >=0; w15 >=0;
w16>=0; w17>=0; w18>=0;w19>=0;w20>=0;w21>=0;
w22>=0;w23>=0;w24>=0;w25>=0;w26>=0;w27>=0;
w28>=0; w29>=0;w30>=0;

Annexure B. Sample DEA Program of Allahabad Bank for Computing Super Efficiency Score (for Efficiency Score Being 1) [During Pre Recession Period]

Min = theta;
0.670661*w2+0.764671*w3+0.760523*w4+0.795514*w5+0.704352*w6+0.803032*w7+0.751219*w8+0.73
367*w9+0.863039*w10+0.768276*w11+0.644495*w12+1.187193*w13+0.761046*w14+0.789665*w15+0.6
25862*w16+0.831332*w17+0.814025*w18+0.766252*w19+0.771885*w20+0.8124*w21+0.829849*w22+0.
798898*w23+0.806944*w24+0.825217*w25+0.844548*w26+0.822155*w27+0.751447*w28+0.758038*w2
9+0.614731*w30<= 0.767661*theta;

1.401585*w2+1.347229*w3+1.29226*w4+1.248846*w5+1.199342*w6+1.282625*w7+1.357274*w8+1.468
472*w9+1.266965*w10+1.564461*w11+1.249653*w12+1.016003*w13+1.085165*w14+1.338086*w15+1.1
87204*w16+1.383031*w17+1.34023*w18+1.510445*w19+1.1 17385*w20+1.352655*w21+1.352609*w22+
1.20254*w23+1.359568*w24+1.281307*w25+1.332424*w26+1.277189*w27+1.244788*w28+1.264837*w2
9+1.246952*w30<=1.267202*theta;

0.005314*w2+0.011994*w3+0.008577*w4+0.007783*w5+0.005842*w6+0.009382*w7+0.006938*w8+0.00
7116*w9+0.010139*w10+0.012925*w11+0.021996*w12+0.017356*w13+0.022896*w14+0.007477*w15+0.
016289*w16+0.008045*w17+0.00777*w18+0.012338*w19+0.007791*w20+0.005133*w21+0.007941*w22
+0.007347*w23+0.005235*w24+0.005666*w25+0.005466*w26+0.004288*w27+0.008102*w28+0.01121*w
29+0.006903*w30<=0.01412*theta;

4.478957*w2+4.454423*w3+4.915405*w4+4.901325*w5+4.436397*w6+4.981526*w7+3.53472*w8+4.471
544*w9+4.191217*w10+4.629339*w11+5.174351*w12+4.856681*w13+4.123543*w14+4.683047*w15+4.1
17403*w16+4.251682*w17+4.057642*w18+3.836793*w19+3.590156*w20+4.64177*w21+5.012229*w22+
3.944065*w23+4.338047*w24+5.597761*w25+4.198914*w26+4.368503*w27+4.641388*w28+4.780152*w
29+4.388575*w30<=4.585892*theta;

0.3007*w1+0.130687*w2+0.470846*w3+0.16413*w4+0.181275*w5+0.079143*w6+0.185346*w7+0.16674
2*w8+0.183516*w9+0.212357*w10+0.43917*w11+0.531965*w12+0.311142*w13+0.133609*w14+0.21927
2*w15+0.260144*w16+0.108811*w17+0.134732*w18+0.711372*w19+0.179651*w20+0.180987*w21+0.15
8678*w22+0.152971*w23+0.19848*w24+0.071659*w25+0.238994*w26+0.199228*w27+0.32654*w28+0.2
29298*w29+0.206271*w30<=0.3007*theta;

0.001658*w2+0.001867*w3+0.001222*w4+0.001015*w5+0.001457*w6+0.001 153*w7+0.001237*w8+0.00
1579*w9+0.001317*w10+0.002685*w11+0.00136*w12+0.000388*w13+0.002781*w14+0.00108*w15+0.00
191*w16+0.001559*w17+0.001346*w18+0.002518*w19+0.001408*w20+0.001262*w21+0.001451*w2
w22+0.001046*w23+0.001719*w24+0.001108*w25+0.001925*w26+0.001275*w27+0.000832*w28+0.0010
07*w29+0.001304*w30<=0.000919*theta;

2.560983*w2+4.630064*w3+2.998749*w4+3.029136*w5+2.59662*w6+3.159787*w7+1.942248*w8+2.267
628*w9+5.192383*w10+1.11534*w11+1.816557*w12+1.23808*w13+2.335703*w14+2.247863*w15+4.610
697*w16+4.336413*w17+3.701734*w18+1.205398*w19+3.617512*w20+3.81638*w21+2.41813*w22+3.58
5921*w23+1.330104*w24+1.348352*w25+1.259883*w26+1.002103*w27+2.763443*w28+2.566562*w29+
2.867127*w30<=3.461675*theta;

0.014417*w2+0.010843*w3+0.008975*w4+0.008816*w5+0.007082*w6+0.011311*w7+0.014776*w8+0.01
4192*w9+0.009945*w10+0.015212*w11+0.014713*w12+0.002303*w13+0.003202*w14+0.0125*w15+0.00
9043*w16+0.012496*w17+0.012236*w18+0.01646*w19+0.006495*w20+0.012024*w21+0.010933*w22+0.
007065*w23+0.011257*w24+0.010189*w25+0.012099*w26+0.010002*w27+0.009132*w28+0.010098*w2
9+0.010391*w30>=0.01116;

w2 + w3 + w4 + w5 + w6 + w7 + w8 + w9 + w10 + w11 + w12 + w13 + w14 + w15+w16+w17+w18+w19+w20+w21+w22+w23+w24+w25+w26+w27+w28+w29+w30= 1;

w2 >= 0; w3 >= 0; w4 >= 0; w5 >= 0;
w6 >= 0; w7 >= 0; w8 >=0; w9 >= 0; w10 >= 0;
w11 >=0; w12 >=0; w13 >=0; w14 >=0; w15 >=0;
w16>=0;w17>=0;w18>=0;w19>=0;w20>=0;w21>=0;
w22>=0;w23>=0;w24>=0;w25>=0;w26>=0;w27>=0;
w28>=0;w29>=0;w30>=0;

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Dr. Arindam Banerjee received his PhD degree from Department of Management Studies, National Institute of Technology (NIT), Durgapur, West Bengal. He is also a Fellow Member of Institute of Cost Accountants of India and has a Master's Degree in Commerce. He has also qualified the UGC - NET exam.