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An Innovative Method to Measure The Efficiency of Indian Commercial Banks - Dea Approach

Statistics

KEYWORDS : DEA, Environmental Risk, Non-Performing Assets, Commercial Bank

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ABSTRACT

This study proposes a three stage data envelopment analysis model to assess the efficiency of Indian commercial banks. 65 commercial banks comprising public, private and foreign sector banks were evaluated. This study proposed a new methodology to evaluate the efficiency of banks. The performance indicator variable NPA has been used to identify the environment of a bank. The overall technical efficiency is decomposed to scale, environmental risk and pure technical efficiency. The empirical results reveal that public sector banks hurt more from environmental risk inefficiency.

INTRODUCTION:

Banking system plays a predominant role in the growth of any Country's Economy. Banks provide financial services to the customers and businesses. These banks were viewed as financial intermediaries in some efficiency studies as they channel funds between the savers and borrowers. In Indian context, banking business has been functioning under different ownerships. The policies to promote their assets are different from one management to another management. In India, the banks were functioning under public, private and foreign ownerships. The public sector banks are functioning under the government policies and regulations. The public sector banks have been functioning as the mediators between public and government to channel the credit for priority sectors. The major objective of the public sector banks is to channel the credit to optimize the social benefits and expand geographically to meet the growing needs of the people.

Private and foreign sector banks are mostly functioning in urban areas. The policies adopted by these banks are far away from the rural area people. These banks have their own policies to benefit the urban and rural people. There is a huge competition among these ownerships to strengthen their bank business. To promote their products these banks offering different schemes and finally some of the banks were committed to risk environment. There may the huge number of risk factors in banking system, to deteriorate the efficiency of the effective banks. To known which bank is working in effective environment, we need to assess the commercial banks in mathematical perspective.

There may be enormous literature on the efficiency evaluation of Indian commercial banks. From 1980's authors' explored one non-parametric method called Data Envelopment Analysis (DEA) to measure the relative efficiency of organizational units. This method is useful to measure the relative efficiency of profitable or non-profitable organizational units where multiple inputs and multiple outputs make comparison difficult.

In India, the banks were working in heterogeneous environment whose management policies, importance to urban and rural areas are extremely different among the managements. All the researchers assumed that the banks were working under same frontier and evaluated their efficiency (T. Subramanyam et.al, 2008, 2012). The efficiency of a particular bank is effective; if, we assess the efficiency in real working environment. The real working environment of a bank may determine with the joint effect of inputs, outputs and the environmental variables (risk factors).

NON-PERFORMING ASSETS:

An asset, including a leased asset, becomes non-performing when it ceases to generate income for the bank. A 'non-performing asset' (NPA) was defined as a credit facility in respect of which the interest and/ or installment of principal has remained 'past due' for a specified period of time. --- Reserve Bank of India.

Reserve bank of India classified these NPA into different categories based on different time periods:

Sub-standard Assets
Doubtful assets and
Loss assets

NPA is an example for undesirable variables. NPAs were commonly occurred when the banks provide loans for agriculture and business etc. Banks needs to proactive in these loans to minimize the risk, otherwise all these default loans together forms NPAs. The nonperforming asset doesn't yield any income to the lender in the form of principal and interest payments.

NPA requires provisions which lead to deterioration in profit and efficiency of particular bank. This risk is an integral part of the banking business. This risk may occur from internal or external non-discretionary factors. NPA is one of the major factors affecting the banking business. To measure the efficiency of a commercial bank, these NPAs provide environment of the bank with input and output variables.

OBJECTIVES:

The major objectives of this study are classified as:

- To measure the overall technical efficiency under common frontier
- To measure the scale and environmental risk efficiencies
- To develop a Three-Stage DEA model to measure the pure technical efficiency

EXISTING LITERATURE ON EFFICIENCY:

Worldwide, there is craze to measure the efficiency of banking system. Number of authors attempted to measure the efficiency of banks in different ways. Literature on environmental efficiency is restricted to some extent in Indian commercial banks. Some of the significant contributions in this area are discussed below:

JM Pastor (1999) decomposed provisions for loan losses (PLL) into two components; a fraction of it refers to internal factors and the other to external factors. The portion of PLL due to internal factors reflects risk management efficiency.

Ruggiero (2002) proposed an enhanced DEA model to increase the peer set of the decision making unit under evaluation. By doing so a certain percentage of decision making units operating in superior environment are augmented to the peer set of DMUs which perform in equal and inferior environment.

T.Subramanyam and CS Reddy (2008), proposed a DEA methodology to measure the efficiency of Indian commercial banks under common frontier. Their study used multiplicative decomposition to measure scale efficiency and NPA impact in internal and external cases. The study infers that the inbuilt risk control

system is equally strong for public and foreign sector banks than private sector banks.

Camanho et al., (2009), discussed the impact of internal and external nondiscretionary factors. He argued that internal nondiscretionary factors are a part of the production process and they should be in the definition of the production possibility set.

T Subramanyam (2013), discussed about the efficiency comparison of Indian and Pakistan Banks. This study aimed to test if the common frontier production exists for Indian and Pakistan banks or not. Under different frontiers their performance compared with common frontier. Finally NPA impact was tested for understanding the better functioning of banks.

Apart from this studies there are number of studies discusses about the efficiency evaluation using DEA models (Kumbakar 1998, Fare and Grosskopf 2004, Fethi, M.D et.al, 2010, Paradi, J. C. et.al, 2011 and Wanke, P., et.al., 2014).

5. BANKING SYSTEM IN MATHEMATICAL PERSPECTIVE:

5.1. Modeling a Commercial Bank:

Two widely used methods to model the commercial banks are intermediation and production approaches. Under intermediation approach financial institutions are viewed as intermediate funds between depositors and borrowers; bank produce services using deposits and other liabilities (Piyu Y 1992, Kumar and Gulati, 2009). The production approach views a commercial bank as a financial institution that combines its inputs to produce services to the customers.

5.2. Choice of Input and Outputs:

Performance of banks and bank branches were studied by number of analysts, but there is no general concord on the selection of input and output variables. In both the approaches discussed prior, the input and output variable are significantly different. For example, the major difference in intermediation and production approach is deposits are viewed as input in intermediation approach and output in production perspective.

In this study, we follow production approach to model the commercial bank. The selected input variables are Number of employees, fixed assets and output variables are loans and advances and investments.

5.3. Basic DEA Models:

CCR (1978) and BCC(1984) are termed as basic DEA models to measure the efficiency of organizational units in a competitive environment where similar inputs are employed to produce similar outputs.

The CCR fractional programming problem is given by:

$$Z(CCR) = \sum_{r=1}^{s} \lambda_r u_{\theta}$$

$$\text{subject to} \quad \sum_{i=1}^{m} v_i x_{\theta} = 1$$

$$\sum_{r=1}^{s} \lambda_r u_j - \sum_{i=1}^{m} v_i x_j \ , j = 1,2,\ldots,n$$

$$\lambda_r \geq 0, \quad v_i \geq 0$$

The BCC programming problem is given by:

$$Z(BCC) = \text{Min } \lambda$$

$$\text{subject to} \quad \sum_{j=1}^{n} \lambda_j x_{ij} \leq \lambda x_{i0} \ , i = 1,2,\ldots,m$$

$$\sum_{j=1}^{n} \lambda_j u_{rj} \geq u_{r0} \ , r = 1,2,\ldots,s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

There are n DMUs, and each employs 'm' similar inputs to produce 's' similar outputs. Z(BCC) is an efficiency measure corrected for scale differences. The Banker et.al (1984) formulation is known as an envelopment problem since the production possibility set envelops all the observations tightly and hence the name, data envelopment analysis.

We know that,

$$Z(CCR) \leq Z(BCC) \quad \text{----------(1)}$$

6. ENVIRONMENTAL DEA MODELS:

When measuring the efficiency of commercial banks in competitive environment, not only discretionary but also nondiscretionary factors are to be considered, otherwise the estimated efficiency measured emerged to biased. The nondiscretionary factors may affect internally or externally. If ' z' is a nondiscretionary factor affecting internally or externally, then the constraints included in different environments are given as:

If 'z' is internal nondiscretionary input factor, its constraint in DEA may be expresses as

$$\sum_{j=1}^{n} \lambda_j z_j \leq \sum_{j=1}^{n} \lambda_j z_0$$

If 'z' is external nondiscretionary input factor, its constraint in DEA may be expresses as

$$\sum_{j=1}^{n} \lambda_j z_j \leq z_0$$

z_j is a nondiscretionary input factor employed by the jth Decision Making Unit (DMU) and z_0 is the nondiscretionary input employed by the DMU whose efficiency is under evaluation.

If the input factor is external nondiscretionary, according to Banker and Morey (1986), we formulate the following linear programming problem:

$$Z(BM) = \text{Min } \lambda$$

$$\text{subject to} \quad \sum_{j=1}^{n} \lambda_j x_{ij} \leq \lambda x_{i0} \ , \ i = 1,2,\ldots,m$$

$$\sum_{j=1}^{n} \lambda_j u_{rj} \geq u_{r0} \ , \ r = 1,2,\ldots,s$$

$$\sum_{j=1}^{n} \lambda_j z_{rj} \leq z_{r0}$$

$$\lambda_j \geq 0$$

Where z_{ij} is the level of rth nondiscretionary input of jth

DMU.

7. CORRECTION OF EFFICIENCY:

The effect of the environmental factors on production possibility set can be best understood from the following diagram:

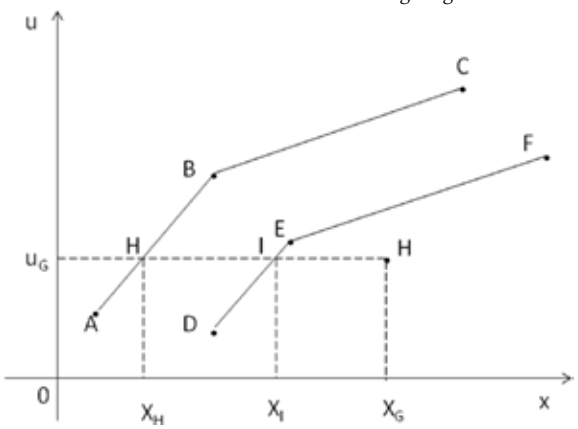

Figure (7.1)

The production units A, B and C enjoy superior environment than D, E, F and G. The DMUs A, B and C can produce more outputs for a given set of inputs. The decision making units D, E, F and G perform their activities in a similar environment. The production unit G is inefficient.

If environment is ignored its input technical efficiency is,

If environment is ignored its input technical efficiency is, $\frac{X_H}{X_G}$. But, given the environment of G its technical efficiency is $\frac{X_I}{X_G}$

Further, the efficient reference set of (X_G, u_G) when environment is ignored is given by (X_A, u_A), (X_B, u_B) and (X_C, u_C), all are technically efficient. However, if environmental differences are not ignored the reference set is given by (X_D, u_D), (X_E, u_E) and (X_F, u_F). Thus,

$$\frac{X_H}{X_G} \le \frac{X_I}{X_G} \quad \text{----------(A)}$$

If environment is ignored the true technical efficiency is not only under estimated but the decision making units D, E and F identified as technically inefficient.

From the above equation (A), to account for environmental difference the following linear programming problem is defined:

$$\text{Min } \theta$$

$$\text{subject to } \sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{i0} \quad , i = 1,2,\ldots,m$$

$$\sum_{j=1}^{n} \lambda_j u_{rj} \ge u_{r0} \quad , r = 1,2,\ldots,s$$

$$\sum_{j=J} \lambda_j = 1$$

$$\text{where } J = \{j : z_j \le z_0\}$$

The above formulation takes into account a single environmental variable which we call as external nondiscretionary variable viewed in input perspective.

The Ruggiero approach discussed elsewhere in a single stage approach to solve a DEA model restricting the reference set for each DMU under evaluation to DMUs presenting only equal or more disadvantageous conditions in terms of nondiscretionary factors. If the number of nondiscretionary factors increases, the chance that a unit being rated efficient will also increase. Ruggiero (2004), suggested a model to increase the peer set of DMUs, by doing so a certain percentage are augmented to the peer set of DMUs which perform in equal or inferior environment.

Here we assumed NPA is an environmental variable which is determined by the interaction of exogenous and endogenous nondiscretionary factors. Since smaller values of NPA or its associated ratio implies superior environment, it is treated as an output and the set $J = \{j : z_j \le z_0\}$ replaced by the set $J = \{j : z_j \ge z_0\}$ reveals that the DMU_j in the reference set operates under inferior environment compared to DMU_0.

The following linear programming problem is suitable for the above set:

$$Z(\text{CCR}, \mathbf{R}) = \text{Min } \theta$$

$$\text{subject to } \sum_{j=J} \lambda_j x_{ij} \le \theta x_{i0} \quad , i = 1,2,\ldots,m$$

$$\sum_{j=J} \lambda_j u_{rj} \ge u_{r0} \quad , r = 1,2,\ldots,s$$

$$\text{where } J = \{j : z_j \ge z_0\}$$

The above problem dealt with only inferior DMUs compared to the DMU under evaluation DMU_0.

In statistical perspective, any unknown value is estimated with certain intervals. To identify the efficiency of a DMU, we suggest a minimum α% DMUs in inferior and superior environments.

The proposed approach provides adequate number of DMUs to form a reference set of DMUs operating in inferior environment.

To the reference set of the each DMU, we augmented a minimum of α =10% DMUs operating in superior environment to the DMUs operating in the same and inferior environment.

Therefore, the proposed reliable reference set to evaluate the efficiency of Indian commercial banks is:

$$J_0 = \{j : z_j \ge z_0 \text{ and first } \alpha = 10\% \text{ DMUs for which } z_j \le z_0\}$$

To measure the efficiency of a DMU under evaluation, we restricted the reference set of DMUs in inferior and superior environments at least α =10% for each DMU.

To measure the exogenous environmental efficiency, we defined the following problem:

$$Z(\text{BCC}, \text{ENV}) = \text{Min } \theta$$

$$\text{subject to } \sum_{j=J_0} \lambda_j x_{ij} \le \theta x_{i0} \quad , i = 1,2,\ldots,m$$

$$\sum_{j=J_0} \lambda_j u_{rj} \ge u_{r0} \quad , r = 1,2,\ldots,s$$

$$\sum_{j=J_0} \lambda_j = 1$$

Since the production possibility set of $Z(\text{BCC}, \text{ENV})$ is a subset of Z(BCC), we get the inequality,

$$Z(BCC) \le Z(BCC, ENV) \quad \text{----------(2)}$$

From equations (1) and (2), we get the following inequality:

$$Z(CCR) \le Z(BCC) \le Z(BCC, ENV)$$

To evaluate the scale efficiency and environmental risk efficiency, we decomposed the overall technical efficiency Z(CCR) into the product of scale efficiency, environmental risk efficiency and pure technical efficiency.

$$Z(CCR) = \left[\frac{Z(CCR)}{Z(BCC)}\right]\left[\frac{Z(BCC)}{Z(BCC, ENV)}\right][Z(BCC, ENV)]$$

$\left[\frac{Z(CCR)}{Z(BCC)}\right]$ measures scale efficiency

$\left[\frac{Z(BCC)}{Z(BCC, ENV)}\right]$ measures environmental risk efficiency

and $[Z(BCC, ENV)]$ measures pure technical efficiency.

8. DATA: In the present study, we modeled a commercial bank in production approach. The study modeled deposits as outputs. Therefore, this work is a blend of production and use cost approaches. The data of Indian commercial banks were collected from RBI Bulletins., for the academic year 2012-13.

9. EMPIRICAL ANALYSIS:

In India soil, commercial banks have been functioning under different ownerships. We have been segregated the Indian commercial banks into 26 public, 19 private and 20 foreign sector banks. Under the assumption of common frontier production function, we evaluated the efficiency of these commercial banks.

Under CCR and BCC models the efficiencies are evaluated and the results shown that there is great deviation in scale differences.

Table 9.1: Overall Efficiency Scores

Statistics	CCR	BCC
Average Efficiency Score	0.3682	0.6859
SD	0.2292	0.2628
No. of efficient Banks	3	16
Efficient%	4.6154	24.6154

In CCR, only 3 banks are efficient and if we invoke the scale differences 16 banks were emerge to efficint. The average efficiency score in CCR model is only 0.3682 and in BCC model it seems to be 0.6859. Under CCR, the banks experienced 63% input losses due to overall technical inefficiency while in BCC environment it seems to be 31% only. It shows that the banks need to adjust their scale of operations towards optimal scale, towards strengthining the internal risk control system. The sector wise efficiency scores were presented in the following table.

Table 9.2: Efficiency Scores- Sector wise

	Public Sector			Private Sector			Foreign Sector		
	CCR	BCC	E-BCC	CCR	BCC	E-BCC	CCR	BCC	E-BCC
MEAN	0.3486	0.7469	0.7947	0.2391	0.4776	0.4922	0.5164	0.8044	0.8207
SD	0.1578	0.1722	0.1589	0.1009	0.2546	0.2484	0.3070	0.2625	0.2538
MAX	0.7826	1.0000	1.0000	0.5370	1.0000	1.0000	1.0000	1.0000	1.0000
MIN	0.1727	0.3890	0.3992	0.1233	0.1731	0.1731	0.0930	0.1340	0.1340

The above table represents the efficiency scores in sector wise. In CCR, foreign sector banks are functioning better with 48% input losses and public sector banks experienced 65% input losses stud in second place. In BCC environment, the input losses of public, private and foreign sector banks are 25%, 52% and 20% respectively. Foreign sector banks are functioning better among the three sectors. In CCR and BCC environments the private sector banks experienced more input losses. Low efficiency scores of public and private sector banks reveals that these banks need to adjust their scale of operation from strengthening the internal risk control system and adjust their operations suitably to face the exogenous risk factors.

The banks are working in different environments like urban and rural areas. The public sector banks spread throughout the areas. The private and foreign sector banks are almost functioning in urban areas only. These banks are practicing different policies to sanction the loans to the public. The performance indicator variable NPA shows the working environment of the banks. To get accurate efficiency scores, it is necessary to evaluate the efficiency of each bank under its homogenous real working environment.

The NPA has been used to identify the homogenous environment of Indian commercial banks. Under homogenous environment we evaluated the efficiency of Indian commercial banks. The E-BCC, explains the efficiency of banks after disentangling the environmental effects. Under E-BCC, the input losses for public, private and foreign sector banks are 20%, 51% and 18% percent respectively.

Table 9.3: Efficient Banks under Different Environments

Environment	Public Sector Banks	Private Sector Banks	Foreign Sector Banks
CCR	0 (0%)	0(0%)	3 (15%)
BCC	5 (19%)	2 (11%)	9 (45%)
E-BCC	5 (19%)	2 (11%)	10 (50%)

The above table reveals that there is no public and private sector bank with 100% efficiency in CCR environment. In BCC and E-BCC environments only 5 public and 2 private sector banks attain 100% efficiency. The numbers in parentheses shows the efficient banks in percentages. Overall, 19% of the public sector banks are working under efficient environment and 50% of the foreign sector banks are working in efficient environment. The least number of banks i.e., 11% of private sector banks working in efficient environment.

The following diagram shows the efficiency of banks under different environments.

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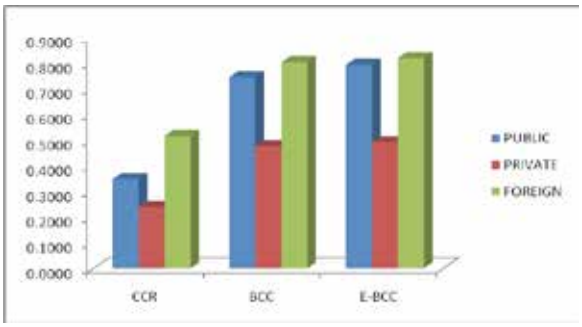
Figure 9.1: Mean Efficiency of Banks under Different Environments



From the above diagram, we reveal that the average efficiency for foreign sector banks is more in all environments. In CCR environment, public sector banks and private sector banks are ahead comparing to foreign sector banks mean efficiency. In BCC environment, there is a drastic increase in public sector banks mean efficiency. Comparing to public and foreign sector banks, private sector banks are working in inferior environment.

The statistical significance among public, private and foreign sector banks has been performed using one-way ANOVA under the assumption:

H_0: The average efficiency scores of public, private and foreign sector banks are homogenous.

ANOVA reveals that, there is a high significant difference among the mean efficiency scores of public, private and foreign sector banks.

Table 9.4: Significance values

t-test	CCR	BCC	E-BCC
Public-Private	p=0.01*	p=0.00*	p=0.00*
Public-Foreign	p=0.02**	p=0.38^{NS}	p=0.67 ^{NS}
Private-Foreign	p=0.00*	p=0.00*	p=0.00*

***indicates significant at 1% level of significance.**
****indicates significant at 5% level of significance.**
NS indicates insignificant at 5% level of significance.

The independent sample t-statistic shows that in CCR environment there is high significant difference between all pairs of the banks. In BCC and E-BCC environments, there is no significant difference between Public-Foreign sector banks. It indicates that, public sector banks are equally performed comparing to foreign sector banks.

Table 9.5: Scale and Environmental Risk Efficiency

	Public Sector		Private Sector		Foreign Sector	
	SE	ERE	SE	ERE	SE	ERE
MEAN	0.4631	0.9422	0.5575	0.9595	0.6613	0.9789
SD	0.1585	0.1080	0.1627	0.0633	0.2931	0.0741
MAX	0.7826	1.0000	0.7958	1.0000	1.0000	1.0000
MIN	0.2691	0.5457	0.2040	0.7751	0.0930	0.6702
CV	34.2226	11.4637	29.1847	6.5936	44.3216	7.5651

10. SCALE EFFICIENCY:

The input scale efficiency is measured by the ratio $\frac{Z(CCR)}{Z(BCC)}$. Due to scale inefficiency public sector banks experienced 54% input losses. While foreign sector banks experienced 34% and private sector banks experienced 44% input losses. Public sector banks operating more distantly from the optimum scale. The public sector banks needs to adjust their scale of operation towards optimum scale.

11. ENVIRONMENTAL RISK EFFICIENCY:

$\frac{Z(BCC)}{Z(BCC, JR, EXO)}$ measures the environmental risk efficiency. In environmental risk efficiency, public sector banks hurt more comparing to private and foreign sector banks. Due to environmental risk inefficiency public, private and foreign sector banks experienced 6%, 4% and 2% input losses respectively. There is no statistical significance difference between public-private, private-foreign and public-foreign sector banks at 0.05 level.

$Z(BCC, JENV)$ measures the pure technical efficiency after removing the influence of scale and environmental inefficiencies. Due to input pure technical inefficiency private sector banks experienced more input losses than public and foreign banks. The mean pure technical efficiency differences are not significantly different from zero between all sectors at 0.05 level.

12. CONCLUSIONS:

In this study, we decomposed the overall input technical efficiency of Indian commercial banks into scale efficiency, environmental risk efficiency and pure technical efficiency. 65 commercial banks comprising public, private and foreign sector banks are under evaluation. The pure technical efficiency is the product of the scale and environmental risk efficiency.

In risk free environment inputs are freely disposable to produce the outputs. Private sector banks experienced more input losses in risk free environment and next the public sector banks experienced more input losses. In variable return to scale environment private sector banks experienced more input losses. The public sector banks recovered their input losses with scale adjustments. It reveals that public sector banks need to adjust their scale of operation towards optimum scale.

The environment of a bank is defined by minimum α% inferior and superior DMUs. NPAs are used as an indicator variable to identify the environment of the bank. The public sector banks experienced more input losses in scale efficient environment. Under environmental risk efficiency, public sector banks hurt more comparing to private and foreign sector banks. The analysis reveals that public sector banks affecting more from the NPAs comparing to private and foreign sector banks.

In scale and environmental risk free environment public and foreign sector banks are working effectively with the mean efficiency scores 80% and 82% respectively. The private sector banks working poorly with 49% mean efficiency. Overall, foreign sector banks working effectively in all environments. Public sector banks are also equally functioning after removing the scale and environmental risk from overall technical efficiency.

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