Analysis of Technical Efficiency of Indian Banking Sector: An Application of Data Envelopment Analysis

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Abstract

The proactively evolved banking regulations in the Indian Banking sector under the authoritative directive of the Reserve bank of India (RBI) has often brought about a change in the business strategy, capital structure and operations of the banks in the Indian banking sector. During these events of continuous change and adoption of Basel norms, we analyse the efficiency of the Indian banking sector with using Data Envelopment Analysis across three economic eras and across the different ownership structures. The determinants of efficiency are selected on the basis of intermediation approach. We also attempt to identify whether the inefficiency arises from managerial incompetence or improper size and resource allocation. From our analysis, we identify the main cause of inefficiency in the Indian Banking sector to be arising out of improper size allocation.

Keywords: Efficiency, Basel norms, Data Envelopment Analysis, Intermediation Approach

JEL classification: M13

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1. Introduction

The need to measure the efficiency of the banking sector is spread across various stakeholders- regulators, bank management, share holders of banks, customers of the banks. From a regulators point of view, it is essential to measure the efficiency of the banks to assess the probability of default since banks are sources of funds in the economy and hence shapes the productivity of an economy. The bank management needs to estimate the efficiency to devise strategies for survival in the competitive environment. The shareholders are concerned about the returns generated by the banks where as the customers are concerned about the service quality and price of the products traded by the banks.

Earlier studies on efficiency of the banks mostly dealt with the study of financial ratios and the analysis of scale and scope efficiencies. However researchers later noted that there were more aspects of efficiency such as technical efficiency and allocative efficiency which needed to be taken into account when studying efficiency (Molyneux, Altunbas & Gardener, 1996). These two factors were introduced by Farrell (1957) and Leibenstein (1966) with the concept of X-efficiency which encompassed both these measures. Although the advantage of X-efficiency over scale and scope efficiencies were known for a long time, it is just a decade and a half since researchers has turned their attention to X-efficiency. The measurement of X-efficiency involves construction of the efficiency frontier from the

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sample data by using any parametric or non-parametric approach (Farel, 1957). Various parametric and non parametric approaches are used for estimating the technical efficiency.

The Indian banking sector can be broadly classified on the basis of four ownership structures- nationalised banks, private sector banks, foreign banks and state bank and its associates. These banks are regulated by the Reserve Bank of India (RBI). Although, most of the regulations are similar across the different ownerships, the RBI imposes some regulations which vary across the ownerships.

2. Literature Review

A comprehensive literature review of the studies on efficiency of banks is out of the scope of study. In this section, we shall mainly focus on the studies pertaining to the analysis of efficiency of banks in the Indian banking sector. The main objective of financial liberalization was to make the financial institutions more efficient and competent. Indian financial system continues to be a bank based financial system and the banking sector plays an important role as a resource mobiliser. It remains the principal source of resources for many households, small and medium enterprises and also caters the large industries.

Studies by Bhattacharya et. al (1997), Sathye (2003), Das & Ghosh (2006), Ray & Das (2009), Koeva (2003) have tried to measure the efficiency of the Indian banking sector. Bhattacharya et. al (1997), in their study examined the productivity efficiency of 70 Indian commercial banks between 1986 to 1991 using non-parametric DEA to estimate the cost and profit efficiency of the Indian banking sector in the post reform period. Ray and Das (2009) found that the public sector banks are more efficient than the private banks.

The latest study in this regard is that of Das and Drine (2011). The study revealed that the public sector banks and the private banks have the mean efficiency which is higher than the all banks mean efficiency. The foreign banks are found to be least efficient among the bank groups. The public sector banks are the most efficient, followed by the domestic private banks. Another set of literature comes from the works of Das and Ghosh (2006) and Ghosh (2009). In the first study, it was found that there was an asymmetry in the technical efficiency of the banks over the years. It was also found that there was a decreasing trend in the technical efficiency score during the sample period (1992-2002). The next study indicates high levels of efficiency in costs and lower levels in profits, reflecting the importance of inefficiencies on the revenue side of banking activity, the proximate determinants of profit efficiency appear to suggest that big state-owned banks performed reasonably well and are more likely to operate at higher levels of profit efficiency.

Kumar and Gulati (2008) analysed the pure technical efficiency and scale efficiency of the nationalised banks and found that the technical efficiency of the Indian banking sector is not affected by the asset quality. Sarkar et al. (1998) had suggested a privatization of the banking sector in the emerging economies like India to increase the efficiency in the sector. However Ray and Das (2009) also argue that privatization has not increased the efficiency of the Indian banking sector. The reason for this may be due to the fact that the stock market and other forms of financial markets have not yet grown in India. In another recent study, Das (2010) had compared the efficiency scores of different sectors of the banks and found that the domestic private sector banks were becoming more efficient compared to that of the public sector banks and the foreign banks. It was also found that unlike other countries where the banking sector reforms were able to increase the cost efficiency, there has been no significant change in the Indian public sector banks in the post reform period.

Although this area is widely researched, there exists no literature which compares the efficiency of the Banks across the eras of three different economic reforms i.e. Banking Sector reforms, Basel I and Basel II. In this section, we try to compare the efficiency of the Indian banking sector across the three economic era separately.

3. Research and Methodology

3.1 Research Objective

Analysis of efficiency of the banking sector has been of great interest to the researchers all over the world. The existing set of literature also contains a rich volume of research pertaining to the Indian Banking sector. However, these researches comprise of the study of the efficiency of the banking sector in the post liberalization era. Even after the financial liberalization of 1991. The Indian Banking sector has undergone a series of reforms in order to comply with the Basel Norms. A comparative analysis of efficiency of the Indian Banking sectors across the different eras of economic reforms remains unexplored. In this paper we divide the time period of our study into three economic eras: pre Basel, Basel I and Basel II (detailed in the later section) and analyse the overall technical efficiency of the Indian Banks across these three eras. Further we also analyze the causes of inefficiency by decomposing the overall Technical efficiency into pure technical efficiency and scale efficiency and construct a set of efficient leaders of the Indian Banking sector.

The most widely used non-parametric approach is the Data Envelopment Analysis (DEA) while Stochastic Frontier Approach (SFA) and Distribution Free Approach (DFA) are the most frequently used parametric approaches (Kosak&Zajc, 2006). However there is no general consensus about the choice of methodology. The different approaches for measurement of efficiency is expressed in figure 1 as documented by Kumar and Gulati (2008).

Figure 1: Frontier Approaches for measurement of Bank Efficiency

Before proceeding any further, it is essential to elaborate certain concepts of technical, pure and scale efficiency. Technical Efficiency related to the productivity of inputs (Sathye, 2003) and is the measure of the bank's ability of transforms multiple resources into multiple financial services (Bhattacharya et al., 1997; Kumar and Gulati, 2008). A bank is said to be technically efficient if it operates along the frontier. The measure of technical efficiency under constant returns to scale is termed as Overall technical efficiency (OTE) which can be further decomposed into two components - pure technical efficiency (PTE) and scale efficiency (SE). The PTE is the measure of technical efficiency under variable returns of scale and reflects the managerial competence for proper allocation of resources. The SE is a measure of the ratio of OTE to PTE and reflects the ability of the management to choose the optimum size of resources or in other words to choose the scale of production to attain the expected production level.

3.2. Choice of Methodology

In this study we shall try to measure efficiency of Indian Banking Sector with DEA. We prefer this methodology over the parametric approaches for the following reasons:

- i. *DEA easily accommodates multiple-inputs and multiple-outputs of the banks*
- ii. *It allows the estimation of overall technical efficiency (OTE) and decomposes it into two mutually exclusive and non-additive components, namely, pure technical efficiency (PTE) and scale efficiency (SE)(Kumar and Gulati, 2008).*
- iii. *There is no need to select a priori functional form relating to inputs and outputs like Cobb-Douglas and Translog production/cost functions (Banker, 1984)*
- iv. *DEA provides a scalar measure of relative efficiency, and the areas for potential addition in outputs and reduction in inputs (Kumar and Gulati,2008)*
- v. *It is not necessary to provide values for weights associated with input and output factors, although the user may exert influence in the selection of weight values*
- vi. *DEA works particularly well with small samples (Evanroff and Israilevich, 1991)*

However one major shortcoming of DEA is that it assumes the data to be free of measurement error and may give unreliable results if the integrity of the data source is not assured.

3.3 Data Envelopment Analysis (DEA)

DEA is a linear programming technique which converts multiple inputs and outputs (measured in any unit) of each Decision Making Unit into a scalar measure of efficiency by assigning weights to the inputs and outputs of a DMU that give it the best possible efficiency (Ray,2004).The mathematical expression for DEA can be expressed as :

- Maximize $\mu Y_k / v X_k$ for each value of k from 1 to n, subject in each case to

- $\mu Y_j / v X_j \leq 1, j= 1 \text{ to } n$, where
 - μY_k means $\sum_i \mu_i * Y_{ki}, i = 1 \text{ to } s$,
 - $v X_k$ means $\sum_i v_i * X_{ki}, i = 1 \text{ to } m$
 - μY_j means $\sum_i \mu_i * Y_{ji}, i = 1 \text{ to } s \text{ and } j = 1 \text{ to } n$
 - $v X_j$ means $\sum_i v_i * X_{ji}, i = 1 \text{ to } m \text{ and } j = 1 \text{ to } n$
- $\mu_i, v_i \geq 0$

The solution is the set of maximum values for $\mu Y_k / v X_k$ and the associated values for μ and v .

DEA computes the scores by comparing the performance of a Decision Making Unit (DMU) with respect to its peers. Hence the efficiency scores reflect the comparison of a DMU with respect to the best performance in the industry. The orientation of DEA is on the basis of two approaches- Input orientation and Output orientation. In Input orientation, we explore the possibility of reducing inputs to produce a given level of output level. It is the measure of the ratio of the actual output to the maximum possible output. In the output oriented approach we explore the possibility of a possible expansion of outputs for a given set of input variables measured by the ratio of minimum possible input to actual input. The two approaches comprise of the primal and dual solution of the optimization problem.

3.4 Choice of Variables

The choice of the input and output variables play an important role in the studies of efficiency. Although there is no general consensus in the literature about the variables which constitute the input and output variables (Casu and

Girardone, 2002; Sathye, 2003), there exists two approaches for the choice of variables in the studies of efficiency of the banking sector– Production Approach and Intermediation Approach (Bauer et al, 1998).

In the production approach, banks are viewed as service providers to customers (Benston, 1965) where as in the intermediation approach banks are viewed as channels between depositors and creditors (Gupta et al, 2008). In the production approach emphasis is given to operating cost by completely ignoring interest expenses. The variables that are commonly used in this approach are proxies of services provided to the customers and are best measured by the number and type of transactions, documents processed or specialized services provided over a given time period and costs related to labour, technology, material space etc. The widely set of variables in this approach comprises of data on the number of deposits and loan accounts, as a surrogate for the level of services provided as the output variables (Kumar and Gulati, 2008). In the production approach, banks produce intermediation services through the collection of deposits and other liabilities and their application in interest-earning assets, such as loans, securities, and other investments and consider both operating cost and interest cost. Thus Deposits are considered to input variable compared to the production approach where deposits are taken as output. In the real scenario, banks function as providers of services as well as financial intermediaries (Berger & Humphrey, 1991). However intermediation approach is suitable for analysing Bank level efficiency whereas production efficiency is suitable for analysing branch level efficiency (Kumar and Gulati, 2008; Berger & Humphrey, 1991).

In this study our choice of variables is on the basis of intermediation approach. Although various factors have been used by researchers to measure the efficiency as inputs and outputs, the performance of a bank is determined by monetized value of a set of inputs and outputs. In this study the output variables are (i) Net Interest Income (ii) Non interest income and the set of input variables are (i) Operating Expenses (iii) Number of Employees (iii) Physical Capital- measured as the sum of fixed assets and other assets (iv) Loanable Funds- measured as the sum of deposits and borrowings.

DEA results are influenced by the number of inputs and output variables. Our choice of the input and output variables is in agreement with the rule of thumb laid down by Cooper et al. (2007). The rule of thumb can be mathematically expressed as: $n > \max \{m \times s; 3(m+s)\}$; where : n = Number of Banks; m = Number of Input variables ; s = Number of Output variables

3.5. Data Set and Time period

The data set of our study comprises of an unbalanced panel of 62 scheduled commercial banks divided across the four ownership structures: Nationalised banks(20), Private sector banks(21), Foreign banks(13) and the State bank of India (SBI) and its associates(8). We have divided the time period into three eras: pre Basel era (1999-2002) which marks the era in between the banking sector reforms and the implementation of Basel I norms with the market risk amendment; Basel I era (2003-2008) and Basel II era (2009-2012). The dataset is not a balanced panel owing to the mergers and entry of new banks in the study period.

4. Results and Findings

The average OTE of the Private sector banks was found to be the highest in all the eras and that of the Nationalised banks was found to be the least. However in the Basel II era, there was an increase in the average OTE of the foreign banks and it matched up with that of the private sector banks. There were maximum number of foreign banks which were significant throughout our study period although the number of foreign banks in our sample was the least. In some years, there was not a single nationalised bank or SBI and its associates which was efficient

Although there has been an increase in the efficiency of the nationalised banks after the adoption of the Basel accords during the Basel I era, it reduced to a great extent in the Basel II era. There was not much significant change in the efficiency scores of SBI and its associates and the private sector banks in the Basel I era compared to that of the pre - Basel era but reduced significantly in the Basel II era. The efficiency scores of the foreign banks were found to increase over the three eras. Although there has been an increase in the efficiency of the nationalised banks after the adoption of the Basel accords during the Basel I era, it reduced to a great extent in the Basel II era. There was not

much significant change in the efficiency scores of SBI and its associates and the private sector banks in the Basel I era compared to that of the pre -Basel era but reduced significantly in the Basel II era. The efficiency scores of the foreign banks were found to increase over the three eras.

Insert Table 1 Here

The next step in the analysis of technical efficiency is to analyse the causes of inefficiency. We therefore decompose the overall technical efficiency into pure technical efficiency (PTE) and scale efficiency (SE). The pure technical efficiency is calculated using variable returns to scale. The summary of the results are illustrated in Table 2 below. We have further calculated the scale efficiency, a measure of the ratio of PTE to OTE. The summary is detailed in Table 3.

The mean PTE of the nationalised banks increased from pre-Basel era to Basel I era but decreased in the Basel II era. There was no variation in the mean PTE from pre-Basel era to Basel I era but it reduced in the Basel II era for the SBI group. There was a gradual increase in the mean PTE of the foreign banks across the three eras and marginal variation in case of the domestic private sector banks.

Insert Table 2 Here

In the pre-Basel era, the mean PTE of the foreign banks were observed to be the highest whereas that of the nationalised banks were observed to be the least. However in the Basel I era, the domestic private sector banks were observed to be the least efficient whereas the foreign banks maintained their highest position in terms of average PTE. However, in case of scale efficiency analysis, we observed that the scale efficiency of the domestic private sector banks were highest in the pre-Basel era and Basel I era and that of the nationalised banks were the least. In the Basel II era, the SE of the foreign banks were observed to be the highest and the nationalised banks were observed to be the least. There was a huge decrease in the mean SE scores of the nationalised banks and the SBI group over the years.

Insert Table 3 Here

On the basis of the number of efficient banks across the different ownerships, we can identify the cause of inefficiency. In all cases, we noted a considerable amount of inefficiency arising from both managerial incompetence and improper size. However the number of banks which were found to be inefficient on the basis of improper size was much more compared to the banks that were found to be inefficient on the basis of managerial incompetence.

5. Conclusion and Implications

Our analysis suggests that the efficiency of the foreign banks have increased through manifolds over the three eras and were consistently efficient in terms of pure technical efficiency and scale efficiency across the three eras. The private sector banks showed marginal variation across the three eras in case of all the efficiencies. However, in case of the SBI group and the nationalised banks, there was a significant decrease in the OTE scores with the major cause of the inefficiency being improper size allocation. The problem of improper size and resource allocation remains an area of concern for the banks across all the four ownership structures.

The following study only measures the efficiency scores and compares it across the different economic eras and different ownerships. However, discrimination of the efficient banks on the basis of the analysis of slacks remains to be explored for getting a clear picture about the cause of inefficiency. This process would also allow us to build a reference set of the efficient banks which could be viewed as an example for the inefficient banks in order to devise

their business strategies to maximise their efficiency. Further, this study refers to the Indian banking sector and hence the results cannot be generalised without further analysis, although the framework of the study can be used for analysis for any study on efficiency of the banks.

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Table 1: Summary of OTE across different ownerships for different years

	Pre- Basel				Basel I						Basel II			
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Nationalised Banks														
Average OTE	0.65	0.66	0.69	0.73	0.69	0.80	0.82	0.75	0.79	0.62	0.59	0.58	0.75	0.69
Average OTE of Era	0.68				0.75						0.65			
No of Banks	20	20	20	20	20	20	20	20	20	20	20	20	20	20
No. of efficient Banks	0	0	0	1	1	2	2	0	1	0	0	0	0	1
Pvt Sector Banks														
Average OTE	0.87	0.95	0.95	0.96	0.92	0.98	0.97	0.88	0.96	0.87	0.88	0.82	0.99	0.90
Average OTE of Era	0.93				0.93						0.90			
No of Banks	16	16	16	16	16	17	16	16	14	13	14	14	13	13
No. of efficient Banks	3	3	2	3	3	5	4	3	2	2	2	2	2	1
Foreign Banks														
Average OTE	0.86	0.86	0.77	0.82	0.83	0.90	0.85	0.82	0.89	0.86	0.93	0.88	0.90	0.88
Average OTE of Era	0.83				0.86						0.90			
No of Banks	9	9	10	10	11	11	13	13	13	13	13	13	13	13
No. of efficient Banks	4	5	4	7	5	6	7	5	6	5	6	6	6	7
SBI and its Associates														
Average OTE	0.81	0.78	0.78	0.86	0.79	0.88	0.91	0.77	0.73	0.65	0.77	0.64	0.73	0.63
Average OTE of Era	0.81				0.79						0.69			
No of Banks	8	8	8	8	8	8	8	8	8	8	7	7	6	6
No. of efficient Banks	2	0	1	1	1	1	3	1	0	1	1	0	0	0

Table 2: Summary of PTE across different ownerships for different years

	Pre- Basel				Basel I						Basel II			
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Nationalised Banks														
Average OTE	0.76	0.82	0.83	0.84	0.86	0.87	0.92	0.94	0.92	0.86	0.78	0.84	0.89	0.89
Average OTE of Era	0.81				0.89						0.85			
No. of efficient Banks	4	7	8	6	4	5	8	11	8	7	2	2	6	6
Pvt Sector Banks														
Average OTE	0.77	0.84	0.85	0.87	0.84	0.87	0.86	0.82	0.86	0.82	0.79	0.77	0.87	0.86
Average OTE of Era	0.83				0.84						0.82			
No. of efficient Banks	4	8	6	5	5	7	6	7	6	8	6	6	6	6
Foreign Banks														
Average OTE	0.92	0.95	0.89	0.89	0.90	0.93	0.95	0.94	1.00	0.96	0.99	0.98	0.96	0.93
Average OTE of Era	0.91				0.95						0.96			
No. of efficient Banks	6	5	6	7	8	7	11	10	12	10	11	12	10	10
SBI and its Associates														
Average OTE	0.90	0.86	0.89	0.92	0.92	0.92	0.95	0.92	0.83	0.77	0.77	0.86	0.85	0.84
Average OTE of Era	0.89				0.89						0.83			
No. of efficient Banks	3	3	3	3	4	2	5	2	1	2	1	1	1	1

Table 3: Summary of SE across different ownerships for different years

	Pre- Basel				Basel I						Basel II			
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Nationalised Banks														
Average OTE	0.86	0.82	0.84	0.88	0.80	0.93	0.89	0.79	0.86	0.73	0.77	0.69	0.85	0.77
Average OTE of Era	0.85				0.83						0.77			
No. of efficient Banks	0	0	0	1	1	3	3	0	1	0	0	0	0	1
Pvt Sector Banks														
Average OTE	0.95	0.95	0.94	0.93	0.92	0.96	0.94	0.90	0.92	0.88	0.93	0.92	0.94	0.87
Average OTE of Era	0.94				0.92						0.92			
No. of efficient Banks	4	3	2	3	5	6	4	3	2	2	3	2	3	1
Foreign Banks														
Average OTE	0.93	0.90	0.88	0.93	0.91	0.96	0.89	0.88	0.89	0.89	0.95	0.90	0.94	0.95
Average OTE of Era	0.91				0.90						0.93			
No. of efficient Banks	4	5	5	7	5	6	7	5	6	5	6	6	6	9
SBI and its Associates														
Average OTE	0.91	0.92	0.88	0.93	0.86	0.96	0.96	0.83	0.89	0.85	0.82	0.75	0.87	0.76
Average OTE of Era	0.91				0.89						0.80			
No. of efficient Banks	2	0	1	1	1	1	3	1	0	1	0	0	0	0