The Efficiency of Indian Banks: A Non-Parametric DEA Approach with Panel Regression Based Feedback

Ather Hassan Dar
Somesh Kumar Mathur

There has been a shift towards the privatisation of public sector banks in the recent times in India. Therefore, an analysis of efficiency of the public and private sector banks is necessary to evaluate the effectiveness of the recent shift in the policy. We make use of the most recent data extracted from the website of the Reserve Bank of India. We analyse the technical efficiency and scale efficiency scores of various Indian banks using the non-parametric Data Envelopment Analysis (DEA) technique. We especially account for NPA in our non-parametric DEA model by incorporating it as an input that the banks want to minimise. Findings suggest that the nationalised banks have consistently been performing badly, on average, while their private sector counterparts have performed relatively better with or without NPA incorporated in our model. A small proportion of nationalised banks had a positive total factor productivity change over the time period of the study. We use a panel regression framework to get a feedback on the factors determining the efficiency of these banks. The second stage regression results confirm the underperformance of public sector banks. However, when the NPA are included in the DEA model as inputs the results show a greater adverse impact on efficiency of public sector banks. We also make use of the conventional Tobit regression so as to ensure that our results are robust.

Keywords: Bank Efficiency, Technical Efficiency, Data Envelopment Analysis, Non-performing Assets, Panel Regression, Undesirable Output, Malmquist Index.

JEL Classification: G21, G20, C14, D24

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Section I

Introduction

Banks are the most important part of the modern economic system. Tsolas and Charles (2015) argue that banking system has a pivotal role in the development process of an economy. They are the main driving forces of economic activity in any country given their capabilities to channelize the savings of the households and advancing loans to the firms for investments. For the different economic players in an economy, bank efficiency provides a valuable feedback. Therefore, evaluating the efficiency of banks is obvious for the greater development of a country. A bank is considered efficient when it cannot produce greater output from a given amount of inputs or a given output by utilising less and less inputs. In the economic terminology such kind of efficiency is defined as technical efficiency. Since India has been growing rapidly since the economic reforms and is now slowly aspiring to be a cashless economy, the efficiency of Indian banking system becomes a need of the hour. Banks can no longer afford to be inefficient in their operations when the country is heading towards the digital revolution. Banks act as intermediaries between the borrowers and the lenders and also facilitate the payments and transactions. An efficient banking system may generate larger positive externalities and enhance the efficiency of the financial system. Moreover, in today's digital and online payments era, an efficient banking sector would no doubt increase the well-being of people but at the same time boost the economic transactions taking place in an economy.

Indian banking system is characterized by the broad classification of commercial banks into three categories. We have the public sector banks or the nationalised banks (PSBs), the private sector banks and the foreign banks. The nationalised banks are largely owned by the government of India with majority of the stake (greater than 50 per cent) owned by the government. Whereas the nationalised banks are wholly subjected to the governmental regulations, the non-nationalised banks too are largely subjected to the extensive regulations in terms of their lending and other operations, Banerjee et al. (2003, 2004). There have been two large policy reforms toward the nationalisation of banks in India in 1969 and 1980. In the first round about 85 per cent of the banks came under the direct government control and in the later round of nationalisation this percentage went up to 90 per cent. There have been numerous studies in the past which attempted to evaluate different efficiencies of Indian commercial banks. Some of the studies have concluded that the nationalised banks in India have performed more efficiently than their private sector counterparts. Sathy M (2003) shows that the average efficiency scores of Indian banks is comparable with the mean world efficiency scores. He also shows that the efficiency of the private banks is paradoxically lower than the publically owned banks. Sengupta A and De S (2020) also find evidence that nationalised banks perform relatively better when compared to private and foreign banks. Mukta M (2016) finds that the public sector banks operate at a lower level of efficiency compared. Our primary objective in this study is
to evaluate the efficiency scores of the Indian public and private sector banks so as to analyse whether the privatisation of the major nationalised banks is justified. Ahmad HK et al. (2015), while analysing the bank performance in Pakistan using two-step double bootstrap DEA approach, show that the size of the bank is not a significant factor for the technical efficiency of the bank. They also show that the liabilities effect significantly and negatively the efficiency of banks. Their findings suggest that private ownership of banks is optimal in terms of efficiency analysis as they tend to do much better than the nationalised banks. Das A., et al. (2005) found Indian banks to be largely similar in terms of input-oriented and output-oriented technical and cost efficiencies but greatly differentiated when it comes of revenue and profit efficiencies. They find that bank size and ownership among others positively impact the profit efficiency of Indian banks. Studying the size efficiency of Indian banks using the non-parametric DEA technique for the period 1997-2003, Ray S (2007) found that many Indian banks to be large in various years. His findings suggest a global size inefficiency among banks and across years. He found some of the top Indian public sector banks, like State Bank of India, Punjab National Bank, Canara Bank, to be too large in size. His study suggests that large size banks be broken into smaller units to produce greater output. Therefore, from the perspective of size efficiency, mergers of the major nationalised banks seem to be a barren option. In this study, one of our goals is to find whether the recent policy shift of the government to merge the banks is justified based on the findings or not.

In the recent times the Indian commercial banks have been facing the problem of huge non-performing assets (K. Hafsal 2020). According to the financial survey report 2017, the bad loans problem has been a serious issues facing the public sector banks than the private banks. The gross NPA of public sector banks was 14.6 per cent of the total loans while it was 11.2 per cent for the other banks. Indira and Garima (2002) show that the public sector banks which have relatively higher NPAs also have less efficiency. The existing literature show that reducing the non-performing assets as well as optimizing on staff and bank branches will have efficiency gains (Sathye M 2002). Given the abysmal performance of the public sector banks, there have been numerous reforms that were undertaken to ameliorate the inefficiency of the said banks. These recent reforms started in 2015 and they range from mergers, recapitalisation, insolvency and bankruptcy code, asset quality review, privatisation, etc. There have been various developments in the banking sector in recent time in terms of modes of payments. These range from the payments banks, UPIs, internet banking, mobile banking among others. How these recent developments in the modern banking system have affected the efficiency of the Indian commercial banks is yet to be known.

In this study we intend to analyse the efficiency scores of various Indian public and private sector banks using the data on certain input and output variables, taken from the website of the Reserve Bank of India. We use the non-parametric
DEA technique to compute the efficiency scores of the banks. Ranking the banks based on their efficiency score, the non-parametric techniques have been found to be much powerful than the parametric methods (Svitalkova, 2014). According to Wanke et al. (2016a) among the non-parametric techniques, the data envelopment analysis takes the centre stage for efficiency evaluations. Daley J, Matthews K (2009) explore the relationship between the efficiency estimates arrived at by the traditional ratio analysis and through a sophisticated Data Envelopment Analysis (DEA) technique using the data on Jamaican banks for the period 1988-2007. Their results show that the efficiency estimates obtained from the non-parametric DEA technique are superior to the ones obtained from accounting ratios. The DEA model, developed by Charnes et al. (1978), is mathematical method of computing the efficiency scores of the otherwise similar decision making units that use the same inputs and outputs. The DEA essentially solves a linear programming problem and identifies the best practice (most efficient) decision making unit. There have been various developments in the DEA methodology in the past to widen the scope of DEA. For example, Dong G, Jie W (2013) have differentiated between the desirable and undesirable outputs. In their study they have extended the traditional data envelopment analysis model to rank the decision making units, accounting for the undesirables in arriving at the efficiency scores. They treat the undesirable outputs in their model as inputs based on the fact that these bad outputs incur costs to the decision making units and they want to reduce them while trying to hold the current level of output constant. In this study we will follow the traditional DEA model to evaluate the efficiency scores and we will also adopt the Dong's extended model to incorporate the NPA as a bad output in our DEA model.

The brief survey of the literature is indicative of the fact that a lot of research has already been done on the subject of bank efficiency in India. However, there are very few studies that have employed rich panel data techniques to explain the sources of technical efficiency. In this study, we use the conventional tobit regression as well as the more advanced and insightful panel regression to investigate the sources of bank efficiency in India. Also, in this study we have applied an extended version of the DEA to incorporate the non-performing assets in our efficiency estimation. We follow the methodology similar to Dong J and Jie W (2013) where we include NPA as input into the DEA model. The rest of the paper proceeds as follows; we present the data and methodology in Section II. The results are presented in Section III and the conclusion follows in Section IV.

Section II
Data and Methodology

Data and Input-Output Selection
There are two major approaches to the input and output selection in the data
envelopment analysis. Benston (1965) developed the Production Approach, which views banks primarily as the service providers. The inputs are mainly the labour, capital and other physical assets, while the outputs generally are the loans and deposits. Sealey and Lindley (1997) developed the Intermediation Approach which considers a bank as an intermediary between the lenders and borrowers. The main function of the bank, according to this approach, is thus to make funds available using its inputs. The major inputs under this approach include labour, capital, assets, etc. while outputs include loans, investments among other variables. According to Berger and Humphrey (1997), Intermediation approach is the more appropriate for evaluating the bank efficiency at an aggregated level while production approach is more suited at the branch level. Arrif and Can (2008) have used total deposits, number of employees and fixed assets as inputs and investments and total loans as outputs in their study. Luo (2003) also use number of employees, total assets and shareholders' equity as inputs and profits and revenue as outputs. In the Indian context, Kumar and Gulati (2010) have used advances and investment as output variables and physical capital (value of fixed assets), labour (number of employees) and loanable funds (deposits and borrowings) as inputs. In this study we run two different versions of the DEA model. Following Das A et al. (2005), Kumar and Gulati (2010) and Mukta M (2016) we use three output variables investment, loans, non-interest income and four input variables borrowings, labour, fixed assets and equity in one basic model. In the extended version of the DEA model we incorporate NPA, a bad output. (Mukta M 2016) as an input variable in the model to compute the technical and scale efficiency scores.

The data for the study has been extracted from the Statistical Tables relating to banks in India, issued by the Reserve Bank of India. The time period of the study is 2014-2019. The purpose of this paper is to analyse the efficiency score in the recent period so as to evaluate the recent policy shift toward privatisation/mergers of the nationalised banks. Table 1 gives the summary statistics of the various input and output variables over the time period 2014-19. Few of the data points that were missing in our sample were generated by taking the median of the series.

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
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<td>Investment</td>
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<td>70554.93</td>
<td>102647</td>
<td>1139.74</td>
<td>1060987</td>
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<tr>
<td>Loans</td>
<td>240</td>
<td>167587.9</td>
<td>225902.4</td>
<td>2437.043</td>
<td>2185877</td>
</tr>
<tr>
<td>Non-Interest Income</td>
<td>240</td>
<td>6162.383</td>
<td>10585.43</td>
<td>25.9453</td>
<td>61267.27</td>
</tr>
<tr>
<td>Borrowings</td>
<td>240</td>
<td>26772.27</td>
<td>47629.3</td>
<td>0.0028</td>
<td>403017.1</td>
</tr>
<tr>
<td>Labour</td>
<td>240</td>
<td>2438.584</td>
<td>3695.52</td>
<td>63.3152</td>
<td>41054.71</td>
</tr>
<tr>
<td>Fixed Assets</td>
<td>240</td>
<td>2499.323</td>
<td>4069.654</td>
<td>17.9595</td>
<td>39992.25</td>
</tr>
<tr>
<td>Equity</td>
<td>240</td>
<td>746.1112</td>
<td>1228.404</td>
<td>0.0152</td>
<td>10516.69</td>
</tr>
</tbody>
</table>

Note: All variables are in Rs. Crore.
**Research Method**

**First Stage: Computing Efficiency Scores of Banks**

**CCR DEA Model**

The CCR model generalizes the Farrel (1957)'s concept of efficiency by utilizing multiple inputs and outputs to compute the efficiency of a decision making unit. The basic input oriented constant returns to scale model developed by Charnes, Cooper and Rhodes (1978) tries to maximize the output without increasing the inputs. The CCR CRS input oriented DEA model is given by

\[
Max \; \emptyset = \sum_{j=1}^{l} v_j y_{jk} \tag{1}
\]

Subject to

\[
\sum_{i=1}^{l} u_i x_{ik} = 1
\]

\[
\sum_{j=1}^{l} v_j y_{ijn} - \sum_{i=1}^{l} u_i x_{in} \leq 0 \; ; n = 1,2, ..., N
\]

\[
u_i, v_j \geq 0 \; ; i = 1,2, ..., l \; j = 1,2, ..., J
\]

where \(y\) = outputs, \(x\) = inputs, \(v\) and \(u\) are weights. \(I\) inputs and \(J\) outputs.

The dual of the output-maximizing CCR model is the input minimising model which tries to minimise the inputs while keeping the output levels constant. CCR CRS output oriented DEA model is given by

\[
Min \; \emptyset = \sum_{j=1}^{l} u_j x_{jk} \tag{2}
\]

Subject to

\[
\sum_{i=1}^{l} v_i y_{ik} = 1
\]
Dar & Mathur: The Efficiency of Indian Banks

\[ \sum_{j=1}^{I} v_j y_{jn} - \sum_{i=1}^{I} u_i x_{in} \leq 0 \; ; \; n = 1, 2, ..., N \]

\[ u_i, v_j \geq 0 \; ; \; i = 1, 2, ..., I ; j = 1, 2, ..., J \]

where \( y \) = outputs, \( x \) = inputs, \( v \) and \( u \) are weights. \( I \) inputs and \( J \) outputs.

The DEA using the linear programming problem calculates the efficiency score of each decision making unit which use identical inputs and outputs are find the best practice DMU. The best practice DMU is most efficient in the sense that it produces relatively greater outputs given the same levels of inputs or uses relatively lesser inputs by keeping the level of outputs constant. The best practice or the efficient decision making units lie on an efficient frontier while all other relatively inefficient DMUs lie under the efficient frontier. The DEA assigns a value of 1 to the best practice DMU and values less than unity are assigned to the relatively inefficient DMUs.

**BCC DEA Model**

The BCC model which is the extension of the basic CCR CRS model allows for the variable returns to scale technologies in the calculation on efficiency scores. It was created by Banker et al. (1984). This is the same as the above model but it is augmented to account for the convexity assumption, that is, we allow for the variable returns to scale. The BCC VRS model decomposes the overall CCR technical efficiency score in two – the pure technical efficiency and the scale efficiency. The pure technical efficiency is linked only to technical as well as the administrative issues. The input-oriented BCC model is given by

\[ \text{Max } \phi = \sum_{j=1}^{J} v_j y_{jk} - v_k \]  

(3)

Subject to

\[ \sum_{i=1}^{I} u_i x_{ik} = 1 \]

\[ \sum_{j=1}^{J} v_j y_{jn} - \sum_{i=1}^{I} u_i x_{in} - v_k \leq 0 \; ; \; n = 1, 2, ..., N \]
\[ u_i, v_j \geq 0 \; ; \; i = 1,2, ..., I ; j = 1,2, ..., J \]

where \( y = \) outputs, \( x = \) inputs, \( v \) and \( u \) are weights. We have \( I \) inputs and \( J \) outputs.

The input-oriented BCC model is given by

\[
\min \theta = \sum_{j=1}^{J} u_j x_{jk} - u_k
\]

Subject to

\[
\sum_{i=1}^{I} v_i y_{ik} = 1
\]

\[
\sum_{j=1}^{J} v_j y_{jn} - \sum_{i=1}^{I} u_i x_{in} - u_k \leq 0 \; ; \; n = 1,2, ..., N
\]

\[ u_i, v_j \geq 0 \; ; \; i = 1,2, ..., I ; j = 1,2, ..., J \]

**Scale Efficiency**

Scale efficiency is simply given by the ratio of TE with CRS technology and TE with VRS technology. Thus

\[
SE_i(C) = \frac{TE_i^C}{TE_i^V} \quad \text{\&} \quad SE_0(C) = \frac{TE_0^C}{TE_0^V}
\]

**Modelling Undesirable Outputs**

Next we attempt to incorporate the bad output in our DEA model in a way that the bank's choice of minimizing the bad loans is consistent with the model. The efficiency scores of the decision making units arrived at by DEA technique can be conflating and it can extremely confound any attempt to rank the DMUs based on their efficiency scores when there are desirable as well as undesirable outputs being produced by the DMU. To account for the undesirables in DEA methodology, a common practice is to consider the undesirable (bad) outputs as inputs. This is due to the fact that both the bad outputs and the inputs incur costs to the decision making unit and in they would want to reduce these
costs to every possible extent while trying to hold the level of production of desirable outputs constant. Following Dong and Wu (2013), we augment the models such that the undesirable outputs enter the constraints. That is,

Let there be $N$ decision making units, each $DMU_n (n=1, 2, \ldots, N)$ employs $m$ inputs to produce $s$ desirable outputs and $k$ undesirable outputs. The inputs, desirable outputs and undesirable outputs of $DMU_n$ are respectively given by $x_n(i = 1, \ldots, m), y_n(r = 1, \ldots, s), b_n(t = 1, \ldots, k)$. Assuming strong disposability and that the inputs and bad outputs can be reduced proportionately while holding desirable output constant, we can find the relative efficiency of $DMU_n$ as follows.

**Input Oriented CCR model incorporating undesirable outputs**

$$\min \theta \quad \text{subject to}$$

$$\sum_{n=1}^{N} \lambda_n x_{in} \leq \theta x_{ip}, \quad i = 1, 2, \ldots, m;$$

$$\sum_{n=1}^{N} \lambda_n y_{rn} \geq y_{rp}, \quad r = 1, 2, \ldots, s;$$

$$\sum_{n=1}^{N} \lambda_n b_{tn} \geq \theta b_{tp}, \quad t = 1, 2, \ldots, k;$$

$$\lambda_n \geq 0, n = 1, 2, \ldots, N$$

Imposing the restriction, $\sum \lambda_n = 1$ we get the input oriented BCC VRS model.

The dual of above input oriented CCR model is given by the following output oriented CCR model.

**Output Oriented CCR model incorporating undesirable outputs**

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

Subject to
\[ \sum_{i=1}^{s} u_i y_{tr} - \sum_{i=1}^{m} v_i y_n - \sum_{t=1}^{k} \omega_t b_{tn} \leq 0, \forall_n \]

\[ \sum_{i=1}^{m} v_i x_{tp} + \omega_t b_{tp} = 1, \]

\[ u_r, v_i, \omega_t \geq 0, \forall_r, \forall_i, \forall_t \]

**Productivity Change: DEA and the Malmquist Productivity Index**

Malmquist productivity index gives the change in the Total Factor Productivity (TFP) and subsequently decomposes this change into the change due to the technology and change due to technical efficiency. The Malmquist index requires a panel data set to run a DEA linear programming problem and arrive at the change in the total factor productivity.

The output oriented Malmquist Index is specified as follows:

\[ m_o(y_{t+1}, x_{t+1}, y_t, x_t) = \left[ \frac{d_r^o(x_{t+1}, y_{t+1})}{d_r^o(x_t, y_t)} \times \frac{d_r^{t+1}(x_{t+1}, y_{t+1})}{d_r^{t+1}(x_t, y_t)} \right]^{1/2} \]

If the value of the index is greater than one, then it means a positive change in the total factor productivity from period \( t \) to period \( t+1 \). Malmquist index is nothing but a composite index that is found by taking the geometric mean of the two indices, one using the technology of initial time period \( t \) and another using the technology of later time period \( t+1 \).

**Second Stage Regression Feedback**

**Tobit Regression**

After getting the efficiency scores from the first part of the study we run a panel regression as well as a tobit regression to look for the sources of this efficiency, regressing the TE score on the explanatory variables like size, profits, NPA, and ownership of the bank.

\[ OCRSTE_b = \beta_0 + \beta_1 size_e + \beta_2 profit_b + \beta_3 NPA_b + \beta_4 ownership_b + \epsilon_b \]

Where size refers to the total assets of the bank, profit is the net profit of the bank. NPA refers to the net NPAs of the bank. Ownership is the dummy variable taking value 1 if the bank is public sector bank and zero otherwise.

Panel Regression

\[ OCRSTE_{it} = \beta_0 + \beta_1 size_{it} + \beta_2 profit_{it} + \beta_3 NPA_{it} + \beta_4 ownership_{it} + \mu_t + \epsilon_{it} \]

Where we have bank specific individual heterogeneity included in the model as well.

Ahmad HK et. al. (2015) find that the size is not a significant factor explaining the efficiency scores of the banks. Taking the total assets as the proxy for size of the bank, Kumar and Gulati (2019) find that smaller banks perform better than the larger banks. Along the similar lines, Ariff and Can (2008) also find that large sized banks perform less efficiently than the smaller banks. Goswami R et al. (2019) also find that bank size is not a significant factor. Thus, existing literature suggests that the sign of the coefficient of size is expected to be negative and insignificant. Sharma et. al. (2012) find a positive and significant relationship between profits of a bank and the efficiency. Therefore, we expect estimate of coefficient on profit to be positive and significant. Similarly, Ahmad K et. al. (2015) and Sharma et. al. (2012) find a positive and significant relationship between public ownership and technical efficiency of banks. Das and Ghosh (2006) show using a tobit regression that the banks with fewer non-performing assets are more efficient than those with very high NPAs. They also find public ownership of banks as a positive and significant factor explaining the efficiency.

Section III

Empirical Results

The Figures 1 and 2 present the median and mean CRS technical efficiency scores of the Indian public and private sector banks. The median efficiency score of public sector banks has consistently declined over the years from 2014 to 2017 only to rise in the latter two years. The overall median technical efficiency score of Indian public sector banks over the 2014-2019 period has been 0.8495. In contrast the overall median technical efficiency of private sector banks was 1.0. In both the versions of our model, the nationalised banks have performed worse than their private sector counterparts. The private sector banks 15 percentage points higher efficient than the publically owned banks. The mean technical efficiency score of public sector banks is less than that of Indian private banks for almost all years but 2019. Overall mean efficiency of public sector banks was 0.828 while it was 0.883 for private sector banks. With NPA included as an input, the median efficiency scores rise slightly but follow the same declining pattern over the years. From the simple t-test in Table 2 the mean technical efficiency score of private sector banks is statistically greater than the public sector banks. We find that private sector banks' performance is higher by 5.5 percentage points.
The results from the extended model suggest that the median technical efficiency scores, both median and mean, of the banks doesn’t change substantially when we incorporate the bad output (NPA) as an input in our basic CCR DEA model. However, from Figure 3 the percentage of technical efficient public sector banks is very low when the banks do not take NPA into account. A maximum of 33 per cent of nationalised banks were technically efficient. In contrast, a maximum of 58 per cent of private banks were technically efficient. From the graph, it is evident that public sector banks have immensely underperformed in the study period. With NPA as an input in the non-parametric estimation procedure we see a rise in the per cent of technical efficient public and private sector banks. At most, there is an increase of 15 percentage points in the private banks and 14 percentage points in public banks. This suggests that when accounting for the bad loans, the banks try to minimise the non-performing assets and thus become more efficient as otherwise. From Figure 4 the story of the percentage of scale efficient banks is the same. A greater proportion of Indian private sector banks were scale efficient than the public sector banks. In addition, accounting for NPAs, a still greater proportion of banks are scale efficient than otherwise. Thus we find that the banks in general in India over the time period of the study were not operating at an optimal scale. Public sector banks in particular need to reduce their scale of operations to operate at an optimal scale. From the results, it is clear that the public sector banks in the most recent past have been managerially and administratively lagging behind private banks as suggested by their worse relative performance.

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**Figure 1**

**Median Efficiency Scores**
**Figure 2**

Mean Efficiency Scores

**Table 2**

Two Sample t-test with Equal Variances

<table>
<thead>
<tr>
<th>Group</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>Std. Dev.</th>
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<td>PSB</td>
<td>126</td>
<td>0.8285794</td>
<td>0.0124358</td>
<td>0.1395913</td>
</tr>
<tr>
<td>PVB</td>
<td>114</td>
<td>0.8835351</td>
<td>0.0136242</td>
<td>0.145467</td>
</tr>
<tr>
<td>Combined</td>
<td>240</td>
<td>0.8546833</td>
<td>0.0093435</td>
<td>0.1447494</td>
</tr>
</tbody>
</table>

Difference: mean (PSB) – mean (PVB) = –0.0549557

Ho: difference = 0
Ha: difference < 0
Ha: difference ≠ 0
Ha: difference > 0

Pr(T < t) = 0.0016
Pr(T > t) = 0.0031
Pr(T > t) = 0.9984

**Figure 3**

Percentage of Technical Efficient Banks
Malmquist Productivity Index Results

Table 3 presents the results of annual means from the Malmquist productivity index. The average productivity growth for the year 2015 was as high as 198.3 per cent \(2.983 \times 100\). This change in the total factor productivity has largely come from the large change in the technical efficiency. The productivity growth has been negative for the rest of the years except 2018 (14.9 per cent). Overall, the mean productivity change, over the 6-year time period of the study, was negative 3.5 per cent. From the results of Table 4 only 9 public sector banks had a positive total factor productivity change out of 21 banks. In contrast, 10 out of 19 private banks had a positive TFP change in the same period. The Punjab National Bank, Central Bank of India, Indian Overseas Bank and the Union Bank of India are the top performers among nationalised banks which have a positive TFP growth as well as a positive efficiency change. Among private banks, the City Union Bank Limited, DCB Bank Limited, Dhanlaxmi Bank, Federal Bank were the top performers.

Table 3

<table>
<thead>
<tr>
<th>Year</th>
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<th>Pech</th>
<th>sech</th>
<th>Tfpch</th>
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<tr>
<td>2015</td>
<td>0.961</td>
<td>3.105</td>
<td>0.966</td>
<td>0.994</td>
<td>2.983</td>
</tr>
<tr>
<td>2016</td>
<td>1.004</td>
<td>0.315</td>
<td>1.035</td>
<td>0.971</td>
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<td>2017</td>
<td>1.008</td>
<td>0.929</td>
<td>0.966</td>
<td>1.044</td>
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<tr>
<td>2018</td>
<td>1.062</td>
<td>1.083</td>
<td>1.067</td>
<td>0.995</td>
<td>1.149</td>
</tr>
<tr>
<td>2019</td>
<td>0.962</td>
<td>0.860</td>
<td>0.974</td>
<td>0.988</td>
<td>0.827</td>
</tr>
<tr>
<td>Mean</td>
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<td>0.967</td>
<td>1.001</td>
<td>0.998</td>
<td>0.965</td>
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</tr>
<tr>
<td>State Bank of India</td>
<td>0.958</td>
<td>0.972</td>
<td>1</td>
<td>0.958</td>
<td>0.932</td>
</tr>
<tr>
<td>Allahabad Bank</td>
<td>1.019</td>
<td>0.969</td>
<td>0.983</td>
<td>1.036</td>
<td>0.987</td>
</tr>
<tr>
<td>Andhra Bank</td>
<td>0.987</td>
<td>0.971</td>
<td>1</td>
<td>0.987</td>
<td>0.958</td>
</tr>
<tr>
<td>Bank of Baroda</td>
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<td>0.992</td>
<td>0.991</td>
<td>1.025</td>
<td>1.007</td>
</tr>
<tr>
<td>Bank of India</td>
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<td>0.959</td>
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<td>Bank of Maharashtra</td>
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<td>0.985</td>
<td>1.015</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>Canara Bank</td>
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<td>0.997</td>
<td>1</td>
<td>1.016</td>
<td>1.013</td>
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<td>Central Bank of India</td>
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<td>0.999</td>
<td>1.038</td>
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<tr>
<td>Corporation Bank</td>
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<td>1</td>
<td>1</td>
<td>0.957</td>
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<tr>
<td>Dena Bank</td>
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<td>0.984</td>
<td>0.975</td>
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<td>Indian Bank</td>
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<td>Indian Overseas Bank</td>
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<td>1.054</td>
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<td>Oriental Bank of Commerce</td>
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<td>0.989</td>
<td>1.013</td>
<td>0.974</td>
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<td>0.978</td>
<td>0.978</td>
<td>0.991</td>
<td>0.948</td>
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<td>1.101</td>
<td>1.065</td>
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<td>Syndicate Bank</td>
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<td>0.94</td>
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<tr>
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<td>1</td>
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<td>1.011</td>
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<td>Union Bank of India</td>
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<td>1.044</td>
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<tr>
<td>Vijaya Bank</td>
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<td>0.936</td>
<td>0.904</td>
</tr>
<tr>
<td>Axis Bank</td>
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<td>0.995</td>
<td>1</td>
<td>1</td>
<td>0.995</td>
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<tr>
<td>Catholic Syrian Bank Ltd</td>
<td>0.918</td>
<td>0.882</td>
<td>1</td>
<td>0.918</td>
<td>0.81</td>
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<tr>
<td>City Union Bank Limited</td>
<td>1</td>
<td>1.074</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Deb Bank Limited</td>
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<td>1.056</td>
<td>0.986</td>
<td>1.033</td>
<td>1.076</td>
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<tr>
<td>Dhanlaxmi Bank</td>
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<td>1.043</td>
<td>1</td>
<td>1.046</td>
<td>1.091</td>
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<tr>
<td>Federal Bank</td>
<td>1.06</td>
<td>1.036</td>
<td>1.06</td>
<td>1</td>
<td>1.098</td>
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<tr>
<td>HDFC Bank</td>
<td>1</td>
<td>0.991</td>
<td>1</td>
<td>1</td>
<td>0.991</td>
</tr>
<tr>
<td>ICICI Bank</td>
<td>0.984</td>
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<td>0.966</td>
<td>1.019</td>
<td>0.955</td>
</tr>
<tr>
<td>IndusInd Bank</td>
<td>1</td>
<td>1.039</td>
<td>1</td>
<td>1</td>
<td>1.039</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir Bank Ltd</td>
<td>0.883</td>
<td>1.015</td>
<td>0.922</td>
<td>0.958</td>
<td>0.896</td>
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<tr>
<td>Karnataka Bank Ltd</td>
<td>0.999</td>
<td>1.003</td>
<td>1</td>
<td>0.999</td>
<td>1.002</td>
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<tr>
<td>Karur Vysya Bank</td>
<td>1.044</td>
<td>1.011</td>
<td>1.074</td>
<td>0.972</td>
<td>1.056</td>
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<tr>
<td>Kotak Mahindra Bank Ltd</td>
<td>1.024</td>
<td>1.005</td>
<td>1.025</td>
<td>0.998</td>
<td>1.029</td>
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<tr>
<td>Lakshmi Vilas Bank</td>
<td>0.963</td>
<td>0.956</td>
<td>0.956</td>
<td>1.007</td>
<td>0.921</td>
</tr>
<tr>
<td>Nainital Bank</td>
<td>0.859</td>
<td>0.551</td>
<td>1</td>
<td>0.859</td>
<td>0.473</td>
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<tr>
<td>RBL</td>
<td>0.982</td>
<td>0.732</td>
<td>1</td>
<td>0.982</td>
<td>0.719</td>
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<tr>
<td>South Indian Bank</td>
<td>1.034</td>
<td>0.978</td>
<td>1.027</td>
<td>1.007</td>
<td>1.011</td>
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<tr>
<td>Tamilnad Mercantile Bank Ltd</td>
<td>0.95</td>
<td>0.957</td>
<td>1</td>
<td>0.95</td>
<td>0.909</td>
</tr>
<tr>
<td>Yes Bank Ltd.</td>
<td>1</td>
<td>1.047</td>
<td>1</td>
<td>1</td>
<td>1.047</td>
</tr>
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</table>
In the second stage of our empirical analysis we investigate which are the important determinants of the technical efficiency scores of these banks. We run a panel regression model as well as the tobit regression model. From the Hausman test we conclude that random effects model is appropriate for this second stage analysis. Table 6 also presents the results of the Lagrange Multiplier test of randomness. The results from the test suggest that random effects model is the appropriate to use than the simple OLS regression model. The Table 5 below presents the summary statistics of the regression variables. The output and input oriented technical efficiency scores are the same in our analysis with mean efficiency score of 0.85. This is in line with the existing literature on technical efficiency of Indian banks (DAS A et. al. 2005). The size of the bank is a proxy for the value of the total assets a bank owns. The mean value of the total assets in our sample is ₹274030.8 crores. The average profits are ₹300 crores. 52 per cent of the banks in our sample are the nationalised banks. The average movement in the NET NPA in our sample is ₹8180 crores.

### Table 5

**Summary of Regression Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCRSTE</td>
<td>240</td>
<td>0.8560035</td>
<td>0.1442971</td>
<td>0.455</td>
<td>1</td>
</tr>
<tr>
<td>ICRSTE</td>
<td>240</td>
<td>0.8560035</td>
<td>0.1442971</td>
<td>0.455</td>
<td>1</td>
</tr>
<tr>
<td>Size</td>
<td>240</td>
<td>274030.8</td>
<td>371449.9</td>
<td>5342.59</td>
<td>3454752</td>
</tr>
<tr>
<td>Profit</td>
<td>240</td>
<td>300.1768</td>
<td>3757.647</td>
<td>-12282.82</td>
<td>17486.73</td>
</tr>
<tr>
<td>NPA</td>
<td>240</td>
<td>8180.095</td>
<td>12949.94</td>
<td>27.73</td>
<td>110854.7</td>
</tr>
<tr>
<td>Ownership</td>
<td>240</td>
<td>0.5208333</td>
<td>0.5006098</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

We use various specifications in our analysis. We run the regressions on the balanced panel where we have 40 banks in total for the 6 years of the study. We have a total of 45 banks for four years from 2014 to 2017, that is before the mega merger of SBI and its associate banks. To make a balanced panel, we merge the SBI and its associate banks before the merger actually happened in 2017 by taking the average of their input and output variables. When we do this, we get a balanced panel of 40 banks over the 6 years, comprising a total of 240 observations. We run the panel regression separately for the unbalanced panel as well. In addition, we run a tobit regression model on both the balanced and unbalanced panels to see whether they result conforms with the panel regression results. Next, we separately run panel and tobit regressions for the extended DEA model where NPA is included as an input in the model.

Table 6 below presents the regression results from the empirical specifications used in the study. In column first we have the regression results from the random effects panel model with balanced panel. From column one, size, profit and NPAs are not statistically different from zero. Thus they do not determine
the efficiency scores of the banks. The signs on coefficients of size and profit are in contrast to what the literature suggests. From our sample it, the results suggest a positive relation of size with the efficiency and negative relation with the profits. However, our point estimates are very close to zero and are not statistically significant, so they do not impact bank performance. The public ownership of banks is statistically significant and impacts the technical efficiency scores negatively. This means that the technical efficiency score of a public sector banks is lower by about 6.4 per cent compared to that of a private sector counterpart. The results from the panel regression in column one are confirmed by the tobit model in column two also. Size, profit and NPA do not matter for efficiency while ownership is still a significant factor determining the relative efficiency of public banks. However, the point estimate is less than that of random effects model. Because the panel regression takes into account the individual bank heterogeneity, our point estimates from random effects model are more accurate than the tobit model. When we correct standard errors for serial correlation in our random effects model, the point estimates remain the same and $p$-values do not change significantly. Non-performing assets of a bank impact their performance negatively but it is not statistically significant.

In columns three and four, we run the panel and tobit regression on the unbalanced panels where we have 45 banks in total for years 2014-17 and 40 banks in total for 2018-19. The results are similar to the results in column two in the tobit framework. However, we have no significant effect on ownership in panel regression framework. With the unbalanced panel, our point estimates are in line with the existing literature where size affects efficiency scores negatively and profit affects positively but they are not significant. NPA and ownership both adversely affect the efficiency scores.

In columns 5 and 6 we have random effects and tobit regression results from the extended DEA model with NPA as an input. Since NPA is included in the model in first stage, we cannot include it in the second stage regression framework. The results are similar with ownership as the only significant factor determining the technical efficiency scores. The mean efficiency score of public sector banks is about 9 percentage points less than the private banks. Thus NPA seems to be a greater problem in state owned banks than the private sector banks. This has strong policy implications. The government in the recent times has actively engaged itself in bank mergers, privatisation, etc. to make banking system in India more efficient and competitive. In an attempt to overhaul the banking industry in India, the government is mulling to privatise the state owned banks and reduce the number of such banks significantly from 21 to 5 (The Economic Times, 21 July 2020).
Table 6
Regression Results

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>2.22e-08 (1.04e-07)</td>
<td>9.13e-08 (9.89e-08)</td>
<td>-3.99e-08 (9.18e-08)</td>
<td>3.37e-08 (8.91e-08)</td>
</tr>
<tr>
<td>Profit</td>
<td>-4.59e-06 (6.12e-06)</td>
<td>-1.96e-06 (5.62e-06)</td>
<td>2.07e-06 (5.64e-06)</td>
<td>-1.29e-07 (5.48e-06)</td>
</tr>
<tr>
<td>NPA</td>
<td>-8.37e-07 (3.38e-06)</td>
<td>-3.46e-06 (3.18e-06)</td>
<td>-9.91e-08 (3.02e-06)</td>
<td>-2.22e-06 (2.96e-06)</td>
</tr>
<tr>
<td>Ownership</td>
<td>-0.072469*** (0.0331037)</td>
<td>-0.041076* (0.0214232)</td>
<td>-0.0344173 (0.0255057)</td>
<td>-0.035639* (0.020238)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.89457*** (0.0243955)</td>
<td>0.87990*** (0.01462)</td>
<td>0.88617*** (0.0193606)</td>
<td>0.883115*** (0.0883115)</td>
</tr>
<tr>
<td>Observations</td>
<td>240</td>
<td>240</td>
<td>260</td>
<td>240</td>
</tr>
</tbody>
</table>

LM Test of Test: Var(u) Test: Var(u) Test: Var(u)
Randomness       = 0                                  = 0                                  = 0
chibar2(01)      = 95.01                             = 29.02                             = 76.40
Prob>             = Prob>                              = Prob>                             = Prob>
chibar2          = 0.00                               = 0.00                              = 0.00

***p < 0.01; **p < 0.05; *p < 0.1

Section IV
Conclusion

In this paper, using a two-stage non-parametric technique of Data Envelopment Analysis we have analysed 40 Indian public and private sector banks. The data for the study was taken from the statistical tables relating to the banks published by the Reserve Bank of India. We used three outputs, investments, loans (performing), non-interest income and four input variables, borrowings (deposits and other borrowings), labour (No. of employees), fixed assets (physical capital) and equity. In the extended model we also included NPA as an input in our model. The findings from the first stage of DEA suggest that the public sector banks have performed badly as compared to private banks. The overall median efficiency scores of public sector banks was 85 per cent. They have been 15 per cent less efficient than the private banks which have an overall median efficiency of 100 per cent. The overall mean efficiency of nationalised banks was also lesser than private banks. The findings also reveal that when NPAs are accounted for in the DEA efficiency score calculation, the median and mean efficiency does not change substantially. However, a larger
proportion of public banks were technically inefficient compared to private banks. We see a 14 per cent rise in the technical efficient public sector banks and 15 per cent rise in private banks when NPAs are included as inputs, which banks try to minimise. The results for the scale efficiency are similar. Only a small proportion of public sector banks had a positive total factor productivity change over the study period.

From the second stage of panel regression based feedback, we find that size of the bank is not a significant factor determining technical efficiency of Indian banks during the time period 2014-2019. We did not find any evidence of profit and NPA being the statistically significant factors of efficiency. However, our results show a negative and significant impact of public ownership of banks in India for the time period 2014-19. We find that public sector banks are about 8 percentage points less efficient than private sector banks from our random effects model. When NPAs are also included as input, the proportion rise to about 9 per cent. In sum we conclude that for the time period 2014-2019, the Indian public sector banks have performed less efficiently than Indian private banks. NPA further exacerbate the problems of public sector banks, when incorporated in the model as input the number of scale and technical efficient banks rise considerably.

References


