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Performance of Commercial Banks in India: DEA Measurement and Determinants of Technical Efficiency

T. Lakshmanasamy*

Abstract

As commercial entities, commercial banks are expected to maintain profitability in the face of stiff competition, while serving the mandatory government priorities and policy commitments, and central bank regulations. The performance of commercial banks crucially depends on their technical efficiency of realising the full potential output, which the banks invariably do not. This paper measures the technical efficiency of 94 public, private, foreign, and small financial commercial banks in India in 2019 using the data envelopment analysis (DEA) method; the determinants of technical efficiency are analysed by applying the Tobit regression method. The estimated technical efficiency scores of public sector banks are below average and private banks do little better than average, while the technical efficiency of foreign banks varies widely. The Tobit estimates show that capital adequacy and return on assets positively influence technical efficiency, while bank size reduces the technical efficiency of the banks. The managerial quality, bank profitability, and diversification are irrelevant to the technical efficiency levels of commercial banks. The results suggest that the performance of commercial banks in India may be improved by choosing a proper input-output mix and an appropriate scale size.

Keywords: Commercial Bank Performance, Potential Output, Technical Efficiency, DEA Estimation, Determinants, Tobit Regression

JEL Classification: C4, C14, C24, D24, G2, G21, L25

Introduction

The banking sector is the backbone of the financial sector of the economy and the cornerstone for mobilising and allocating savings in an economy, thereby providing stability to the economy and raising the prospects of economic growth (Singh & Fida, 2015). The banks are the institutions that channel the funds to businesses and households, and therefore are strong determinants in the allocation of capital, financial stability, and the competitiveness and development of manufacturing and services (Beck et al., 2003). The banking sector consists broadly of public sector, private, and foreign sector banks. The public sector banks in India are the dominant sector in terms of lending and borrowing, with widely spread branches that help greatly in pooling resources and revenue generation for credit creation. Given the important place occupied by the banking sector in the economy, its health and performance are vital for a growing economy. An efficient banking system is crucial to strengthen productivity, profitability, safety, and soundness of banks, as well as innovations and improvements to channel capital buffers and absorb risk. Measuring efficiency is directly related to a bank management's success in controlling costs and generating revenue. However, the banking industry has been facing competitive pressure worldwide as the world financial structure has changed rapidly due to the deregulation of financial services and increasing use of information technology (Beck, 2006). In this context of increasing competition in the financial markets, it is imperative to understand and evaluate the

* Formerly Professor, Department of Econometrics, University of Madras, Chennai, Tamil Nadu, India.
Email: tlsamy@yahoo.co.in

performance of the banks in general, and the technical efficiency of these financial institutions in particular.

In economic theory, any business entity is viewed as producing units, producing one or more outputs using multiple inputs. Economic theory posits that the decision-making units (DMUs) are successful optimisers, aiming maximum profits by efficiently utilising the inputs to achieve maximum possible output to be able to survive the competition in the market. Technical efficiency is the cornerstone of economic profitability, as it measures the ability of the firm to produce maximal outputs from a given set of inputs. Hence, it affects the competitive position of a firm directly. If there exists any inefficiency, either in the inputs or in the output, or the unit uses a lesser technology, then the unit cannot sell its output at a competitive price in the market as other units and cannot reward the inputs their value of the marginal product. Therefore, the unit has to go out of the market due to its inefficiency. However, in practice, the inputs are not efficiently utilised and production entities do not always realise their potential output due to observed and unobserved factors behind the production environment. In reality, no two producing units will have the same quality inputs and accordingly, the output will not be the same for any two units in the same business using the same quantity of inputs. Therefore, units may be inefficient in realising their full potential, and inefficiency arises when firms produce output that is below the production potential, or technically, their frontiers. Technically stated, the production frontier is the locus of the technically efficient input-output combinations, wherein each point of the frontier shows how productive a business can be given the fewest inputs, or resources, necessary to do the job. Producing units that are on or close to this frontier is said to be technically efficient in that they use their inputs efficiently to realise the full potential in the inputs.

Technical efficiency relates to how much output can be obtained from a given input, such as a worker or a machine, or a specific combination of inputs. Maximum technical efficiency occurs when output is maximised from a given quantity of inputs. Technical efficiency is the ratio of actual output to potential output (Farrell, 1957). Suppose that a firm has a production plan (y^0, x^0), where the first argument is the set of outputs and the second is the set of inputs. Given the production function f(.), the firm is technically efficient if $y^0 = f(x^0)$ and technically inefficient if $y^0 < f(x^0)$. Thus, technical efficiency explains their ability to operate close to, or on the boundary of their production set. Hence, the technical efficiency is measured by the ratio $0 \leq [y^0/f(x^0)] \leq 1$, i.e. technical efficiency lies between 0 and 1. Therefore, technical inefficiency is measured as (1−TE). However, the measurement of technical efficiency requires estimation of the production frontier or the potential output, the maximum output from an input mix. Since the potential output is not observed directly like the actual output, it has to be estimated.

There are 2 common approaches to measure the efficiency of decision-making units, the non-parametric (mathematical) and parametric (econometric) techniques (Coelli et al., 1998). The popular parametric technique is the Stochastic Frontier Approach (SFA) (Aigner, Lovell and Schmidt, 1977; Meeusen & Broeck, 1977), while that of non-parametric is the Data Envelopment Analysis (DEA) (Farrell, 1957; Aigner & Chu, 1968; Charnes et al., 1978; Timmer, 1971). While the DEA method uses the linear programming approach to calculate the efficient deterministic frontier or potential output, the SFA methods use econometric functions, modelling inefficiency as an additional stochastic term. Under both approaches, the technical efficiency of DMUs is estimated in two ways, input-oriented or output-oriented measurement. The input-oriented technical efficiency approach aims at reducing the input amount at a given level of output, and the output-oriented approach tries to maximise the output level at given levels of inputs. The input-oriented approach is widely used to analyse the technical efficiency of service-oriented entities like the banks, as the output is less well defined and measuring service outputs is complex. Practically, one output or an index of multiple outputs is used. The technical inefficiency of each DMU is calculated taking the highly technically efficient output as the potential output. Under the assumption of efficient utilisation of inputs, the potential output-actual output gap is attributed to the inefficient use of the inputs, and then the determinants of this technical inefficiency are analysed using a set of covariates. The DEA method uses the linear programming approach to calculate the efficient deterministic frontier or potential output.

Generally, the performance of banks is measured either by using financial ratios or measuring its efficiency. This paper attempts to measure the efficiency performance of the banking sector in India and analyses the determinants of the inefficiency of commercial banks in India. The focus is on the estimation of the technical efficiency score of each bank in India. The main objectives of this paper are to estimate the technical efficiency of commercial banks and to identify the determinants of their technical efficiency. This paper uses secondary data obtained from the Reserve Bank of India. A 2 step estimation approach is followed in this paper. In the 1st step, the technical efficiency score of the commercial banks in India is estimated using the DEA approach. In the 2nd step, the determinants of the technical efficiency of commercial banks in India are analysed by applying the Tobit regression method.

Review of Literature

The application of DEA in measuring bank efficiency starts with the work of Sherman and Gold (1985), who used DEA to investigate the efficiency in the operation of bank branches. Early attempts to estimate the efficiency scores of the financial institutions are by Berger and Humphrey (1997) and Berger et al. (1997). They find that various efficiency methods do not necessarily yield consistent results and derive the implications of efficiency results for financial institutions in the areas of government policy, research, and managerial performance.

Assaf et al. (2011) examined the technical efficiency of Saudi banks using a panel data set of 81 observations over the period 1999-2007, applying the Wilson 2 stage DEA bootstrap procedure. At the 1st stage, the output-oriented DEA model is applied to estimate the relative efficiency scores of Saudi banks, and at the 2nd stage, the relationship between the efficiency scores and some key environmental variables is estimated using the truncated regression model. Following Sealey and Lindley (1977), the intermediation approach is used, with 4 outputs that cover both off-balance sheet activities, viz. total customer loans, securities, and interbank loans, and 3 inputs, viz. total employees, fixed assets, and total deposits. The estimates show that the average efficiency score of Saudi banks is 88.84% and has been increasing since 1999. The findings suggest that on average Saudi banks are nearly 9.79% away from their frontier maximum efficiency scores. In the 2nd stage bootstrap procedure, the results reveal that the Saudi banks' technical efficiency increases with the assets of banks, implying that large banks contribute to higher technical efficiency. Further, the net profit margin has a positive and significant impact on the efficiency of banks, and a negative relationship with efficiency for purely domestic banks and foreign banks.

San et al. (2011) analysed the comparative efficiency of foreign and domestic banks in Malaysia using a panel data set of 9 domestic banks and 12 foreign banks over the period 2002-2009, applying the non-parametric DEA method. The intermediation approach is used to define the inputs and outputs in estimating the efficiency scores. Surprisingly, the findings are inconsistent with the findings of the literature, where the foreign banks outperform their domestic peers in terms of efficiency. Conversely, domestic banks have a higher efficiency level than foreign banks, implying that domestic banks are relatively more managerially efficient in controlling their costs. The 2nd stage Tobit estimates suggest that capital strength, loan quality, expenses, and asset size significantly influence the pure technical efficiency of banks in Malaysia.

In the Indian context, Bhattacharya et al. (1997) studied the efficiency of Indian commercial banks over a 5 year period, 1986-1991, using data of 70 banks. A 2 step estimation procedure is followed; 1st, the DEA technique to measure the technical efficiency of banks, and then the stochastic frontier approach is used to explain the bank efficiency variations using a set of variables to account for time, ownership, and regulatory policy. The results show that the public sector banks are more efficient than foreign banks, which in turn are marginally more efficient than private sector banks. About 78% of banks operate with decreasing returns to scale, while 16% show increasing returns to scale. The study also observed that public sector bank efficiency declined over time, whereas that of foreign banks improved over time. The performance of private banks remained almost unchanged.

Ray and Ram Mohan (2004) compare the performance of public, private, and foreign banks using physical quantities of inputs and outputs, and evaluate the revenue maximisation efficiency of Indian banks during 1992-2001. The findings of the study show that the public sector banks perform significantly better than private sector banks, but not differently from foreign banks; there is convergence in performance between public and private sector banks with respect to technical efficiency, but not with respect to allocative efficiency in the post-reform era.

Ataullah and Le (2006) investigated the effect of economic reforms, viz. fiscal, financial, and private investment liberalisation reforms on the efficiency of Indian banks for the period 1992-1998, applying the DEA, OLS, and GMM estimations. The results show an improvement in the efficiency of banks after the economic reforms, especially that of foreign banks. The study finds a positive relationship between the level of competition and bank efficiency, and a negative relationship between the presence of foreign banks and bank efficiency, attributable to a short-run increase in costs due to the introduction of new banking technology by foreign banks. The study also finds a negative effect of fiscal deficits on bank efficiency. The results further suggest that the gap between the efficiency of public sector banks and private sector banks declines in the post-economic reforms era.

Kumar and Gulati (2008) analyse technical efficiency and scale efficiency of the Indian public sector banking industry for 1992-2005 using the input-oriented DEA approach, a method that minimises inputs while keeping output constant. The paper uses the logistic regression method to estimate the effect of a set of environment variables on the overall technical efficiency of public sector banks. The output measure is the number of deposits and loan accounts, and the input vector included physical capital measured by fixed assets, wages of labour, and loanable funds that include borrowings and deposits. The estimated technical efficiency of public sector banks is above 75%, except Bank of India with 63.2%, while most of the state banks show 100% technical efficiency.

Dimpy and Gulati (2010) examined the significance of the effect of ownership on the efficiency of 27 public sector banks during the financial years 2005-2006 and 2006-2007, applying the DEA approach. The results show that the new private sector banks dominate the formation of the efficient frontier of the Indian domestic banking industry. The overall technical inefficiency stems primarily from managerial inefficiency and not from scale inefficiency. The study finds insignificant efficiency differences between the public and private sector banks. The study concludes that ownership does not matter in the Indian domestic banking industry.

Dwivedi and Charyulu (2012) seek to determine the impact of various market and regulatory initiatives on efficiency improvements of Indian banks in the post-reform era. The input variables of the study include the number of bank branches, total operating expenses, and deposits, while the output of banks is advances and non-interest income. The DEA-Constant Returns to Scale model estimates show mean technical efficiency of 95.6% in 2005, and an improved 97.9% in 2010. It is observed that the national banks, new private banks, and foreign banks have high efficiency over the period.

Sharma, Sharma and Barua (2012) studied the determinants of the efficiency of commercial banks in India during the period 2000-2010, with a sample of 64 banks, using the DEA approach. The results reveal that the age and profitability of the banks have a positive impact, while bank diversification has a negative impact on the efficiency levels of the banks in India.

Lakshmanasamy and Shanmugam (2001; 2003) estim-ated the alternative methodologies of frontier techniques to measure the technical efficiency of single as well multi-outputs of 58 commercial banks in India for 1999. The estimated models include the non-parametric DEA method, parametric stochastic frontier, random coefficients, and stochastic ray frontier approaches. 2 outputs, interest margin, and other non-interest income, and 3 inputs, namely deposits, borrowings, and labour employed, are considered in the study. The study reveals that the mean technical efficiency estimate by DEA is 65%, RCA 51.71%, SFA ranges from 52 to 81%, and RAY 81.32%. The estimated ray coefficients suggest that the elasticity of Euclidean output with respect to deposits is 89.5%, labour 0.5%, and borrowing 0.046%. The inclusion of non-interest income as a 2nd output of banks adds about 2% efficiency in ray estimates.

Applying the stochastic frontier production function approach, Shanmugam and Das (2004) analysed the efficiency of 94 commercial banks in the four different ownership groups in India during the period 1992-1999. The estimated results indicate that the efficiency score of private banks is highly influenced by the size of investments. The state bank group (48.7-51.4%) and foreign banks (38.7-41.3%) are more efficient than other public sector and private sector banks. Still, there exists larger gaps between the actual and potential performances of all groups of banks in India.

Lakshmanasamy (2018) estimated bank technical efficiency using the multiple input-multiple output mix technology approach, applying the stochastic ray frontier function method, and the determinants of the level of technical efficiency of 47 commercial banks in India for the period 2014-2017, were observed. The maximum likelihood estimates of the ray frontier function show that the mean technical efficiency of Indian scheduled commercial banks is, on average, 33%, with a range for individual banks fluctuating between 23% and 77%. The high technical inefficiency of banks is attributed to the high non-performing assets, priority sector lending, and the age of the banks.

Data and Methodology

This paper uses cross-sectional data of the banking sector in India for the year 2019 collected from the Reserve Bank of India, consisting of 94 observations. The variables used in this study are interest income, non-interest income, advances, interest expenses, non-interest expenses, deposits, capital, bank size, and return on asset.

Data Envelopment Analysis (DEA)

In the empirical analysis, this paper follows the output-oriented data envelopment analysis method. The DEA calculates efficiency by the comparison of aggregate input/output ratios of all units having piecewise frontier surface constructed by the linear programming method. The efficiency or inefficiency score of each bank is derived from the gap to this frontier surface. The efficiency scores derived from the DEA method lie between 0 and 1, as they are calculated as the ratio between the actual and potential or the technically efficient output. Farrell (1957) proposed the deterministic frontier model (for n factors). The method consists of plotting input/output ratios of firms in a space of a suitable number of dimensions forming the convex closure of the set of points. Taking the appropriate part of the surface of this convex closure provides an estimate of the efficient production function.

The convex hull method may be characterised by a sequence of a linear programming (LP) problem. Let $d(x,y;i=1,\dots,n;j=1,\dots,m) = (x, y)$ be the input and output data set, where x_{ij} is the input j for the i^{th} bank and y_i is the single output of each bank i. The efficiency frontier is then specified by the optimal solution of the following LP model:

$$\begin{aligned} &Min: \sum x_{kj}\beta_j \\ &subject\ to: \sum x_{kj}\beta_j \geq y_i \\ &\beta_j \geq 0 \end{aligned} \tag{1}$$

Where, the inputs of the reference unit k are used in the objective function. For a fixed k, where k belongs to the set $I_n = \{1, \dots, n\}$ let β^*_k be the optimal solution of the model. The unit k is efficient if it holds that $\sum x_{kj}\beta^*_k = y_k$ and $s_k = (y^*_k - y_{k)}) = 0$, where s_k is the slack variable representing the excess of potential output over actual output $y^*_k = \sum x_{kj}\beta^*_i(k)$ By varying k over the set I_n, the whole efficiency surface can be generated and the associated values of the production parameter $\beta^* = \{\beta^*_k, k = 1, \dots, n\}$.

Following Farrell's initiatives, Aigner and Chu (1968) proposed a procedure for computing a parametric convex hull of the observed input and output ratios using the Cobb-Douglas production frontier function as:

$$y_i = y^*_i \exp(-u_i) \tag{2}$$

Where, y_i is the actual output and y_i^* is the potential (frontier) output, and u_i is a non-negative random variable associated with firm specific factors, which contribute to the i^{th} firm not attaining maximum efficiency of production. The presence of the non-negative random variable u_i in the model is associated with the technical inefficiency of the firm and implies that the value of the random variable lies between zero and one. Thus, it follows that the possible production y is bounded above by the non-stochastic, i.e. deterministic quantity, y_i^*. Hence, the model is referred to as the deterministic frontier function. Taking logarithms on both sides of the equation yields:

$$lny_i = lny^*_i - u_i \tag{3}$$

Given $u_i = y^*_i - y_i$, equation (3) can be written as:

$$y_i = y^*_i - u_i \tag{4}$$

For an efficient firm, u = 0 or $y^* = y$. For an inefficient firm, u > 0 or $y < y^*$. Imposing a minimising constraint on the sum of the error terms, $\sum u_i$ will place the production surface to lie as close as possible to the actual set of output points. Hence, the problem can be stated as:

$$Min \sum u_i = \sum y_i^* - \sum y_i \quad \text{subject to}: y_i^* = y_i \tag{5}$$

Minimisation of $\sum u_i$ is approximately equal to the minimisation of the sum of estimated values of output. Therefore, the objective function can be modified as:

$$Minimise \sum u_i = Minimise \sum y_i^* \tag{6}$$

For computational purposes, it is desirable to divide equation (6) by the number of observations in the sample. Thus, the arithmetic mean of observations of the ith input is used instead of the input:

$$\sum \frac{y_i^*}{n} = \sum \beta_j \bar{x}_j \tag{7}$$

Where, β_j are the parameters to be estimated. Aigner and Chu (1968) suggest that β_j can be estimated by using the linear (or quadratic) programming method. The vector y_i/y_i* is the index of technical efficiency, with a separate measure for each firm *i*.

Following Timmer (1971), the deterministic frontier function defined above can also be transformed into a probabilistic frontier function. According to him, the initial linear programming exercise is solved and values are noted. The constraints or observations representing the efficient firms, i.e., extreme observations or outliers are then removed from the initial linear programming exercise, reducing it for the 2nd linear programming exercise. The procedure continues until the estimated parameters are stabilised.

Thus, the efficiency surface may be viewed as a set of efficiency facets, one facet for each k, where k = 1, …, j is one of the n units. Hence, an independent measure of technical efficiency can be obtained for each sample observation. Thus, TE can be measured as:

$$TE_i = \left(\frac{y_i}{y_i^*}\right) \text{ or in percentage terms, } TE_i = \left(\frac{y_i}{y_i^*}\right) \text{x}100 \tag{8}$$

Therefore, technical inefficiency is measured as (1 – TE). The estimates of input-specific efficiency measures for individual firms can also be obtained as the ratio of actual response coefficients to the frontier response coefficients. In percentage terms, the efficiency of using jth input by the ith firm (TE_{ij}) is given as:

$$TE_{ij} = \left(\frac{\beta_{ij}}{\beta_j^*}\right) \text{x } 100 \tag{9}$$

Tobit Regression Method

As the estimated efficiency scores are ratios of actual output to potential output that lie between 0 and 1, the censored regression method is the appropriate estimation procedure. Hence, the Tobit regression method is used to estimate the effects of the determinants on the bank technical efficiency. As the potential output is unknown, the index or latent output-input regression function is specified as:

$$y^* = \beta x + u \tag{10}$$

The y^* is a latent variable that is censored for values lesser than some threshold, say c. The actual or observed output is specified by a measurement equation:

$$y = \begin{Bmatrix} c & if\ y^* \geq 0 \\ y^* & otherwise \end{Bmatrix} \tag{11}$$

Normally, $E[y|x] = 0$. With censoring, $E[y|x] \neq 0$, and OLS estimation is biased. Defining the density function for u condition on $y \leq c$:

$$\phi = \phi(\text{u} \mid \text{y} \leq \text{c}) = \phi(\text{u} \mid \text{u} \leq \text{c} - \beta x) = \frac{\phi(u)}{P(\text{u} \leq \text{c} - \beta x)} \tag{12}$$

$$\phi = \frac{\phi(u)}{P\left(\frac{u}{\sigma} \leq \frac{\text{c}-\beta x}{\sigma}\right)} = \frac{\phi(u)}{\Phi\left(\frac{\text{c}-\beta x}{\sigma}\right)} = \frac{1}{\Phi\left(\frac{\text{c}-\beta x}{\sigma}\right)} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{u^2}{2\sigma^2}} = \frac{\frac{1}{\sigma}\phi\frac{u}{\sigma}}{\Phi\left(\frac{\text{c}-\beta x}{\sigma}\right)} \tag{13}$$

Thus, $E[\,y \mid x\,] = \Phi\left(\frac{\beta x}{\sigma}\right)(\beta x + \sigma\lambda)$ (14)

Where, $\lambda = \phi(\beta x/\sigma)/\Phi(\beta x/\sigma)$, ϕ and Φ denote density and cumulative distribution functions of u.

Assuming the normal distribution of the error term u, the likelihood function for the maximum likelihood estimation of the censored regression model is specified as:

$$L = \prod_i^N \left[\frac{1}{\sigma}\phi\left(\frac{y-\mu}{\sigma}\right)\right]^c \left[(1-\phi)\left(\frac{y-\mu}{\sigma}\right)\right]^{(1-c)} \tag{15}$$

Where, c is the censoring point. In the Tobit model, with c = 0 and parameter rising μ as βx, the likelihood function for the Tobit model is specified as:

$$L = \prod_i^N \left[\frac{1}{\sigma}\phi\left(\frac{y-\beta x}{\sigma}\right)\right]^c \left[(1-\phi)\left(\frac{y-\beta x}{\sigma}\right)\right]^{\hat{(1-\text{c})}} \tag{16}$$

The log-likelihood function for the Tobit model is specified as:

$$lnL = \sum_{i=1}^{N}\left\{c\left[-ln\sigma + ln\phi\left(\frac{y-\beta x}{\sigma}\right)\right] + (1-c)ln\left[(1-\phi)\left(\frac{\beta x}{\sigma}\right)\right]\right\} \quad (17)$$

In the log-likelihood function, the 1st part corresponds to the classical regression for the uncensored observations and the 2nd part is relevant for the censored observation. The estimated Tobit equation is specified as:

$$\hat{y} = \beta_0 + \beta_1 Capital + \beta_2 Bank\ size + \beta_3 Return\ on\ assets + \varepsilon \quad (18)$$

Where, $\hat{y}$ is the estimated technical efficiency score of banks.

Empirical Analysis

Table 1 presents the description and summary statistics of the variables. The average interest income of commercial banks in India was ₹12135.39 crores in 2019 and the average non-interest income was ₹1946.31 crores. The average size of advance is ₹103345.4 crores, the average interest expense is ₹7562.655 crores, and non-interest expenses is ₹3270.818 crores. The average bank deposit is ₹137099 crores. The log mean of capital is 6.583 and the log average of bank size is 10.081. The log average return on assets is 0.257.

Table 1: Descriptive Statistics of Variables

Variable	*Description*	*Mean*
Interest income	Bank revenue earned through interest on lending (₹ crores/pa)	12135.39 (29179.17)
Non-interest income	Bank revenues from other banking services like commission, brokerage, and so on (₹ crores/pa)	1946.31 (4703.66)
Advances	Bank loans, the extension of money from a bank to another party with the agreement that the money will be repaid (₹ crores/pa)	103345.40 (260525.60)
Interest expense	Bank cost of borrowed funds, the non-operating expense derived from such lending arrangements as lines of credit, loans, and bonds (₹ crores/pa)	7562.65 (18253.56)
Non-interest expense	Bank operational expenses, other than interest payments on deposits and bonds, such as salaries and bonuses to staff, marketing, and equipment expenses (₹ crores/pa)	3270.82 (8135.98)
Deposits	Bank deposits, the liability rather than the actual funds that have been deposited (₹ crores/pa)	137099.01 (341189.60)
ln(Capital)	Bank capital, the difference between the bank's assets and its liabilities, representing the net worth of the bank or its equity value to investors; the asset portion of the bank's capital includes cash, government securities, and interest-earning loans	6.583 (1.533)
ln(Bank size)	Total market value of the securities in a fund, the assets under management	10.081 (2.45)
Return on asset	Bank profitability relative to its total assets	0.257 (2.524)

Note: Standard deviations in parentheses.

The DEA estimates of the technical efficiency scores of the public sector, private sector and foreign commercial banks, and small finance banks are presented in Table 2. The estimated efficiency scores show that the public sector banks have low technical efficiency scores in the year 2019, hovering around 41% to 50% of technical efficiency. Among the public sector banks, Andhra Bank has the highest efficiency score of 49.5%, while the United Bank of India has the lowest efficiency score of 37%. The efficiency score of private sector banks, though high relative to public sector banks, varies substantially from 42% to 76% in 2019. The Bandhan Bank has a high efficiency of 75.7%, while Catholic Syrian Bank has a lower level of efficiency, with a score of 42%. Comparatively, foreign banks performed both efficiently and inefficiently in India in 2019. The Abu Dhabi Commercial Bank, National Australia Bank and the Royal Bank of Scotland have a perfect efficiency score and are fully efficient. The Bank of Ceylon has achieved a 97% efficiency level, followed by the Industrial Bank of Korea, with 92% efficiency. The JSC VTB Bank is the most inefficient foreign bank, while Sonali Bank, SBM Bank (India), and DBS Bank India had less than 20% technical efficiency in 2019. The performance of the small finance banks is slightly better. The Suryoday Small Finance Bank has achieved the highest efficiency score of 77%, while the Capital Small Finance Bank has the lowest efficiency score of 45%.

Table 2: DEA Estimates of Technical Efficiency of Commercial Banks in India

Bank	*Technical Efficiency*	*Bank*	*Technical Efficiency*
Public Sector Banks			
Allahabad Bank	0.448 (2.69)	Indian Overseas Bank	0.444 (2.66)
Andhra Bank	0.495 (2.97)	Oriental Bank of Commerce	0.443 (2.66)
Bank of Baroda	0.474 (2.84)	Punjab and Sind Bank	0.466 (2.79)
Bank of India	0.449 (2.69)	Punjab National Bank	0456 (2.73)
Bank of Maharashtra	0.443 (2.658)	State Bank of India	0.461 (2.77)
Canara Bank	0.454 (2.72)	Syndicate Bank	0.446 (2.68)
Central Bank of India	0.432 (2.59)	UCO Bank	0.441 (2.64)
Corporation Bank	0.482 (2.89)	Union Bank of India	0.463 (2.78)
Dena Bank	0.411 (2.46)	United Bank of India	0.370 (2.22)
Indian Bank	0.479 (2.87)	Vijaya Bank	0.464 (2.87)
Private Sector Banks			
Axis Bank	0.503 (3.01)	Jammu & Kashmir Bank	0.479 (2.87)
Bandhan Bank	0.757 (4.54)	Karnataka Bank	0.467 (2.80)
Catholic Syrian Bank	0.422 (2.53)	Karur Vysya Bank	0.506 (3.03)
City Union Bank	0.533 (3.20)	Kotak Mahindra Bank	0.531 (3.19)
DCB Bank	0.509 (3.06)	Lakshmi Vilas Bank	0.434 (2.60)
Federal Bank	0.479 (2.88)	Nainital Bank	0.499 (2.94)
HDFC Bank	0.564 (3.38)	RBL Bank	0.504 (3.02)
ICICI Bank	0.510 (3.06)	South Indian Bank	0.465 (2.79)
IDBI Bank	0.472 (2.83)	Tamilnad Mercantile Bank	0.502 (3.01)
IDFC First Bank	0.451 (2.70)	Dhanlaxmi Bank	0.466 (2.79)
IndusInd Bank	0.525 (3.15)	Yes Bank	0.551 (3.30)
Foreign Banks			
AB Bank	0.218 (1.31)	Industrial Bank of Korea	0.922 (5.53)
Abu Dhabi Commercial Bank	0.452 (2.71)	JP Morgan Chase Bank National Association	0.712 (4.31)
American Express Banking Corp.	0.196 (1.17)	JSC VTB Bank	0.005 (0.003)
Australia & New Zealand Banking Group	0.4744 (2.84)	KEB Hana Bank	0.614 (3.69)
Bank of America	0.582 (2.84)	Krung Thai Bank Public Company	0.551 (3.31)
Bank of Bahrain & Kuwait	0.479 (2.87)	Mashreq Bank	0.516 (3.10)
Bank of Ceylon	0.969 (5.81)	Mizuho Bank	0.646 (3.87)
Bank of Nova Scotia	0.519 (3.11)	Mufg Bank	0.521 (3.13)
Barclays Bank	0.638 (3.83)	National Australia Bank	1.000 (6.00)
BNP Paribas	0.548 (3.29)	PT Bank Maybank Indonesia	0.448 (2.69)
Citibank N.A	0.565 (3.39)	Qatar National Bank	0.581 (3.48)
Cooperatieve Rabobank	0.473 (2.84)	SBER Bank	0.466 (2.80)
Credit Agricole Corporate and Investment Bank	0.602 (3.61)	SBM Bank (India)	0.176 (1.06)
Credit Suisse	0.819 (4.91)	Shinhan Bank	0.495 (2.97)
CTBC Bank Co.	0.475 (4.91)	Societe Generale	0.496 (2.98)
DBS Bank India	0.101 (0.61)	Sonali Bank	0.200 (1.20)
Deutsche Bank	0.552 (3.31)	Standard Chartered Bank	0.538 (3.23)

Bank	Technical Efficiency	Bank	Technical Efficiency
Doha Bank	0.381 (2.29)	Sumitomo Mitsui Banking Corporation	0.577 (3.46)
Emirates NBD Bank	0.534 (3.20)	Royal Bank of Scotland	1.000 (6.00)
First Abu Dhabi Bank	1.000 (6.00)	United Overseas Bank	0.771 (4.62)
FirstRand Bank Ltd.	0.477 (2.86)	Westpac Banking Corporation	0.719 (4.31)
Hongkong and Shanghai Banking Corpn.	0.558 (3.35)	Woori Bank	0.459 (2.75)
Industrial and Commercial Bank of China	0.595 (3.57)		
Small Finance Banks			
AU Small Finance Bank	0.556 (3.39)	Suryoday Small Finance Bank	0.774 (4.64)
Capital Small Finance Bank	0.459 (2.75)	Ujjivan Small Finance Bank	0.595 (3.57)
Equitas Small Finance Bank	0.596 (3.58)	Utkarsh Small Finance Bank	0.671 (4.03)
ESAF Small Finance Bank	0.625 (3.75)		

Note: Standard deviations in parentheses.

The Tobit estimates of the determinants of technical efficiency of commercial banks in India in 2019 are presented in Table 3. The results show that all the independent variables are statistically significant at 5% in all the specifications except profitability and bank diversification. The variable return on assets has the highest positive effect on bank efficiency, contributing about 38% to the technical efficiency of the bank. Similarly, an increase in bank capital increases bank efficiency on average by 30%. However, bank size significantly reduces the efficiency of commercial banks by 20%, indicating that the larger the bank size, more the inefficiency of the bank. Bank management quality, though significantly positive, has a negligible contribution to the efficiency of commercial banks. The variables profitability and bank diversification are negatively related to technical efficiency, but statistically insignificant, and hence have no effect on the technical efficiency of commercial banks in India in 2019.

Table 3: Tobit Regression Estimates of Technical Efficiency of Commercial Banks

Dependent variable: Technical efficiency score

Variable	Speci.1	Speci.2	Speci.3	Speci.4
ln(Capital)	0.285* (3.42)	0.298* (3.31)	0.313* (3.40)	0.304* (3.26)
ln(Bank size)	−0.170* (2.97)	−0.197* (2.84)	−0.214* (2.73)	−0.206** (2.53)
Return on asset	0.464* (4.80)	0.465* (4.83)	0.385* (3.74)	0.374* (3.59)
Management quality	-	2.92** (0.72)	0.0001** (1.72)	0.0003** (1.38)
Profitability	-	-	−0.00006 (1.71)	−0.0001 (1.60)
Bank diversification	-	-	-	−0.0002 (1.05)
Constant	2.398* (3.67)	2.537* (3.75)	2.699* (3.83)	2.713* (3.82)

Note: Absolute t-values in parentheses. *,** significant at 1, 5% levels.

Conclusion

This paper examines the performance of 94 commercial banks in India in 2019, in terms of technical efficiency, employing the non-parametric data envelopment analysis technique and the determinants of technical efficiency using the Tobit regression method. The results of the DEA indicate that the technical efficiency score of the performance of the private sector and foreign banks are relatively higher than that of the public sector banks. The estimated efficiency scores of public sector banks are below average, Andhra Bank being technically more efficient and the United Bank of India being the least efficient commercial bank. Among the private sector banks, the Bandhan Bank is the most efficient, while Catholic Syrian Bank is the least efficient bank. In the foreign banks, Abu Dhabi Commercial Bank, National Australia Bank, and the Royal Bank of Scotland are fully efficient, whereas the JSC VTB Bank is the most inefficient foreign bank. The efficiency scores of the public sector banks are below average. It is reasonably understandable that the technical efficiency in the Indian public sector banks is low as they are plagued by certain policy commitments, regulatory constraints, poor utilisation of inputs, and failure to operate at the most productive scale size.

The results of the Tobit regression show that the most important parameters for banks to be technically efficient are capital adequacy and return on assets. The positive effect of bank capital on efficiency implies the existence of the moral hazard, i.e., banks with less capital leave the owners with less incentive to run the bank efficiently. The significant positive effect of return on assets shows that the higher profitability of banks incentivises the banks to be more technically efficient. While the bank size reduces the technical efficiency of banks, managerial quality has little relevance to the efficiency level of banks. The negative effect of bank size on the efficiency score implies the existence of 'too big to fail' theory in the Indian banking industry. Bank profitability and diversification are insignificant with respect to the technical efficiency of commercial banks in India. Overall, the estimated results of this paper suggest that there is adequate opportunity for improvement in the performance of commercial banks in India, by choosing a proper input-output mix and an appropriate scale size.

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