ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

How Far Ownership and Coronavirus Affected Bootstrapped Efficiency: Empirical Study of Indian Banks

Nishi Sharma[1] and Shailika Rawat[2+]

[1, 2] University Institute of Applied Management Sciences, Panjab University, India

Abstract. *During the last two years, the entire world has experienced an unprecedented phase because of the pandemic. Devastating the economy, Coronavirus gradually took a toll on almost every sector. Not only did the impact of the pandemic influence the financial performance of the sector, but it also affected the level of their operating efficiency. Being at the forefront of the economy, the banking sector has also experienced oscillations during the last few years. In this context, the present paper examines the efficiency level of Indian domestic banks over the last three years, from 2018 to 2021 by applying the Bootstrapped Data Envelopment Analysis model. The efficiency scores of banks have been compared by using Mann-Whitney U test to investigate any possible impact of ownership, as well as the outbreak of the coronavirus, over banking efficiency. The analysis of efficiency scores revealed that banks exhibited a decline in the mean efficiency scores after the onset of coronavirus in January, 2020. However, as a sign of recovery, an increase in the mean efficiency scores was observed during 2020-2021, The results witness the significant impact of ownership as well as Covid-19 over banking efficiency. The findings proclaim that the public sector banks have been proven relatively more efficient than private sector banks. Further, the results indicate a significant impact of coronavirus on the efficiency of the public sector as well as private sector banks in India.*

Keywords: Bootstrapped DEA, Covid-19, Domestic banks, Efficiency, Ownership.

JEL Codes: G21

1. Introduction

Commercial banks are the backbone of the financial system. Traditionally, these commercial banks act as financial intermediaries but now banks are multi-taskers and enjoy a hefty amount as non-interest income in lieu of providing various services like investment advisory, factoring, custodial services, facilitating commodity exchange, trading of financial securities, etc. During the last few years, the Indian banking sector has witnessed huge changes at micro as well as macro front. Just two years back, during 2019, a decision was taken to merge 10 public sector banks into 4 major banks. This move was initiated because the bigger banks have more ability to face future uncertainty of financial nature and also have the capability to raise additional resources. Thereafter, 2020 brought unprecedent oscillations all over the world because of Covid-19. Since the pandemic has influenced the lives of almost every citizen, its impact over the bank where citizens used to deal was quite obvious. Due to the pandemic, different challenges came to the forefront, like digital banking, cyber security issues, crisis management and credit risk (Patel et.al, 2021). Presently, Indian commercial banks comprise 12 public, 21 private, and 45 foreign banks. According to Reserve Bank of India (RBI), the bank credits and deposits of Indian banks stood at Rs. 108.02 lakh crore (US$ 1.47 trillion) and Rs. 151.67 lakh crore (US$ 2.08 trillion), respectively, as of June 04, 2021 (IBEF, 2021). However, private sector banks' share in the total banks deposits have witnessed a continued rise and stood at 30.5% (29.5% a year ago). In 2020-2021, due to the Covid pandemic, a moratorium on loan was declared by RBI. As such, the balance sheet of the banks was likely to look healthy, but the ultimate recognition of NPAs would reduce profitability and increase the leverage of the banks (Sriram, 2021).

[2 +] **Corresponding author**: *E-mail address*: shailikarawat765@gmail.com; *ORCID ID*: https://orcid.org/0000-0002-4772-2049.

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

Measurement of efficiency could help the market regulators as well as bank managers to assess banking performance and to initiate remedial steps if needed (Svitalkova, 2014). Here efficiency can be defined as the level of performance that is achieved by using the least quantity of input in order to produce maximum quantity of output. Johonsen and Scholes (1997) remarked that efficiency of a business organization can be assessed through the number of inputs that have been used for producing a single unit of product. The efficiency is as an internal measure of the performance of a business unit and is usually measured through production, productivity, cost or profit**.** Higher efficiency indicates better performance of intermediation functions by banks. Banks with higher efficiency scores represent their proficiency to establish a suitable linkage between the lenders and borrowers, which leads to positive impact on the economic growth of the country. Efficient banks ensure better service quality, better loan and deposit rates and also lower service charges (Sanjeev, 2006; Tamatam et.al ,2019), whereas failure of the banking system can cause a serious threat to the entire financial system. The researchers observed that banks faced low efficiency prior to their failure, thus measuring efficiency being instrumental for policy makers and management towards maintaining soundness and safety measures for banks (Yang, 2014). During the last two years, the entire economy experienced unprecedented change in the demand as well as supply side of different products due to coronavirus and banking products are no more exception to it. The outbreak of Covid-19 brought an unforeseen change in the assets and liability structure of banks. Though the efficiency of Indian banks has been assessed by many researchers in the previous studies, in the current precarious times characterized by huge oscillations, it has become imperative to revisit the efficiency of banks. In this reference, the present paper intends to analyze whether the outbreak of this deadly contagious disease had any impact on the efficiency of Indian private as well as public sector banks.

2. Literature Review

Being a crucial aspect for every sector, the concept of efficiency has been anatomized widely across different sectors including healthcare, hospitality (restaurant, hotel), education, banking, etc. (Tamatam et.al, 2019). The techniques used for analyzing the efficiency range from the analysis of ratio, to parametric as well as non-parametric techniques. When it comes to banking, the efficiency analysis is a matter of great concern to the researchers due to the importance of the financial institutions in facilitating economic activity (Malikov et al. 2016). The analysis of operational efficiency of banks has been a crucial point of interest among different stakeholders as their efficiency level helps to determine whether banks are performing their primary functions of financial intermediary through bridging the gap between lender and borrower adequately (Jagwani, 2012). Some studies, like Ouenniche & Carrales, (2018) and Ram & Mesfin (2019), conducted single-country focused studies while few others, like Jimenez-Hernández et. al (2019), made an attempt to compare the efficiency level of different countries. The available literature pertaining to the efficiency of the banking sector remains focused on some crucial aspects like ownership, determinants of efficiency, model, corporate governance, sources of inefficiency, impact of crisis, etc., (Ahmad et.al 2020).

Since the importance of bank efficiency in a growing economy like India can hardly be overlooked (Mukherjee, 2002), many researchers made an attempt to explore various facets of banking efficiency in India. In this context, the divergent ownership structure of Indian domestic banks, i.e., public and private banks, offers an opportunity to test whether the efficiency of banks differ among these ownership structures. But the review of these studies indicates contradictory results as some researchers observed a better efficiency of public banks over privately owned banks (Bhattacharyya et al., 1997; Das and Ghosh, 2006; Jagwani, 2012). These studies found a significant impact of bank ownership over technical and scale efficiency in India. The results indicate that public sector banks have outperformed as compared to the private-domestic and foreign banks. But on the flip side, some studies found private banks relatively more efficient than the public sector banks in India (Chakrabarti and Chawla, 2005; Chatterjee and Sinha, 2006; Joshi and Bhalerao, 2016). By using DEA estimates, Kaur and Gupta (2015) found that the efficiency of nationalised banks is weaker compared to private banks. With reference to foreign banks, Sanjeev (2006) reported that the foreign banks have outperformed both

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

public sector and private sector banks. In Malaysia, Rahim (2015) found foreign banks as best performers. Sufian (2016) also reported the inefficient performance of the government-owned banks in Malaysia. The study used bootstrapped DEA for investigating the efficiency to add statistical precision to DEA estimates.

The onset of coronavirus significantly affected the performance, profitability, efficiency and other measures of every sector of the economy across the globe. Banking sector being the forefront of every economy could not remain isolated from the devastating impact of this contagious virus. Recently, a few researchers did a commendable job to investigate the possible impact of Covid-19 on the banking sector. Colak and Oztekin (2021) examined the impact of the pandemic on global lending by taking into account 125 countries. They revealed that the extent of the impact of Covid on bank credit depends on the bank and country specific characteristics. Market structure, regulatory environment, bank's financial soundness play an important role to regulate the impact of market shocks. In China, the increase in Covid-19 confirmed cases/deaths caused significant increase in domestic credit (Appiah-Otoo, 2020). Demirguc-Kunt, Pedraza and Claudia (2020) analysed the impact of Covid-19 on the publicly traded banking stocks across 52 countries between 2018-20, using an event study methodology. The study reported that the onset of coronavirus put the banking system under a great stress. In the light of the toll taken by pandemic on all economies across the globe, the study highlighted the need of monitoring liquidity support, prudential measures and borrower assistance. Katusiime (2021) investigated the influence of Covid-19 on the profitability of banks in Uganda. The study analysed the quarterly data spanning from first quarter 2000 to first quarter 2021 through autoregressive distributed lag bound approach. The findings revealed that Covid-19 negatively affected the profitability of Ugandan banks in the long run. Kozak (2021) analysed the effect of coronavirus over the equity of Central Eastern South European banks. The study observed that amid the negative impact of the Covid-19 pandemic, the resilience of banks of non-EU countries was higher. The study found that non-public banks had better ability to maintain the appropriate equity level. However, though the pandemic affected the Indian economy in all aspects - socially, economically as well as politically (Patel et.al, 2021) -, yet no prominent study was released with a special focus on the Indian banking sector. To bridge this research gap, the present study focusses on estimation of any possible impact of Covid-19 over the efficiency of Indian domestic banks. The study considers bootstrapped efficiency scores to get the bias corrected estimates, something which has not been used much in Indian context.

3. Research Elaborations

The present study makes an attempt to attain the following two objectives:

A) To identify the impact of bank ownership over the efficiency of Indian domestic banks.
B) To identify any possible impact of the onset of Covid-19 on the banking efficiency in India.

The research methodology comprising an analytical approach, null hypotheses, data set and variables for obtaining the pre-stated two objectives can be briefly explained as follows:

3.1. Data Analysis Approach

In common parlance, efficiency represents the ratio of outputs and inputs so it can be estimated through input and output variables of the business unit. These variables can be analysed to compute efficiency scores through two approaches viz., traditional approach and frontier-based approach. The traditional approach includes the use of a ratio analysis like return on asset, net interest margin, return on equity, non-performing loan etc., to get an idea of the overall picture of the financial soundness of a business unit (Ahmad et. al, 2020). In the frontier based approach, the concept of efficiency can be defined in terms of graphical representation of business units also. The pure technical approach can be explained in terms of graphical distance of a unit to

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

the production frontier, whereas the overall economic efficiency can be expressed in terms of distance to a cost, revenue or profit frontier (Krumbhakar and Lovell, 2004, p. 17). This approach measures the performance of a firm relative to the best practice firm located at frontier.

The comparison between the traditional and frontier-based approaches reveals that frontier approach is more sophisticated. Due to giving a fair idea about the efficacy of business unit, the frontier-based approach is more popular among researchers. The study of efficiency measurement models by Ahmad et.al, (2020) reported that out of 100 most cited papers during 1985-2018, around 74% of studies used frontier analysis and only 26% applied traditional ratio analysis. Besides the financial institutions where multiple inputs and outputs exist, ratio analysis is not suitable (Kilic, 2011). In the light of the above argument, the present study estimates efficiency of banks through frontier-based approach.

The frontier approach can be further classified into two categories on the basis of underlying assumptions. The two categories are parametric frontier techniques and non-parametric frontier techniques. As the name suggests, the parametric techniques assume that all parameters are in a finite dimensional parameter space. On the flip side, non-parametric techniques assume that the parameters are in an infinite dimensional parameter space. Some studies (Ajibefun 2008**)** observed that parametric techniques have certain limitations like the requirement of specifications is too restrictive for the estimation of efficiency. Further on, in the context of banks, the use of non-parametric techniques is more suitable (Svitalkova 2014). The study of Ahmad et.al, (2020) also noted that out of 74 studies using frontier approach for estimation of efficiency, 34 used parametric techniques whereas 40 applied nonparametric methods. In the present paper also, a non-parametric approach has been used for efficiency estimation. There are two popular techniques under non-parametric approach namely Free Disposal Hull and Data Envelopment Analysis (DEA). Since DEA is the most widely used model, the same has been applied in the present paper. Further on, in order to get unbiased estimates, bootstrapped DEA scores have been computed. The bootstrapped DEA methodology can be understood as follows:

3.2 DEA and Bootstrapped DEA (BDEA)

Data Envelopment Analysis (DEA) is based on linear programming that evaluates the relative efficiency of a business firm called decision-making unit. Under this analysis a non-parametric piecewise frontier is constructed and maximal performance measures for each unit are computed relatively. The model assumes that each unit lies on the efficient frontier or is enveloped by the frontier. The units with an efficiency score equal to one lie on the frontier and are regarded as best practice or benchmark units. On the other hand, the units attaining efficiency values between zero and one are termed as inefficient units which need to improve their performance. The improvement may be either through increasing current output levels or decreasing current input levels. The credit to popularise the concept of DEA goes to Charnes Cooper and Rhodes (1978) who gave mathematical models for efficiency estimation without any presupposed existence of any possible relationship between scale of operations and efficiency. The model calculates overall technical efficiency (OTE) under the assumption of constant returns to scale. But the assumption of constant returns to scale does not seem to be practical in all cases therefore in the year 1984, Banker, Charnes and Cooper extended the previous model with due consideration of variable returns to scale. The model estimates pure technical efficiency (PTE) of the business unit. A pure technically efficient firm i.e., a firm with high PTE score, is able to maximise its outputs by using a given set of inputs or is capable of using minimal input mix to produce the same level of output. Since OTE presupposes constant returns to scale whereas PTE assumes variable returns to scale between inputs and outputs, the two estimates may be used to have an idea about scale efficiency generated on account of operating at optimal size of operations (Jagwani. 2012). Scale efficiency is measured as a ratio of efficiency estimates under constant returns to efficiency estimates i.e., OTE to efficiency estimates under variable returns to scale i.e., PTE (Coelli, 1996).

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

Since DEA is a deterministic model, it does not explicitly consider random error and overall deviation from the technology frontier. In other words, the DEA efficiency scores may be affected by sampling variations (Munim, 2020). To overcome this limitation, bootstrapped DEA (BDEA) is needed to be conducted. The concept of bootstrap was first introduced by Efron (1979), then method for implementing bootstrapping in data envelopment analysis (DEA) was given by Simar and Wilson (1998). Under bootstrapping, the inferences drawn from a sample are modeled by resampling. For instance, if any researcher wants to know the average efficiency of banks across the globe, he will take a sample of a few banks for some years and will measure the efficiency. But in reality, to reason about the population, it is pertinent to have knowledge regarding variance chrematistics of the average. The bootstrap method resamples the data using replacement with thousands of iterations and computes bootstrapped efficiency scores of the selected banks. The reliability of the estimates would be enhanced by employing BDEA because it allows the estimation of sampling distribution of every statistic through random sampling. Moradi-Motlagh and Saleh (2014) argued that application of bootstrapped DEA assists in obtaining bias-corrected estimates of banking efficiency.

3.3. Null Hypotheses

To investigate any possible influence of ownership and the coronavirus over banking efficiency, two null hypotheses have been framed:

- Null hypothesis (H_{o1}): There is no significant difference in BDEA efficiency scores of public sector and private sector banks. In other words, ownership has no significant impact on the efficiency of banks.
- Null hypothesis (H_{o2}): There is no significant difference in BDEA efficiency scores of domestic banks during pre-covid period and post-covid period. In other words, the outbreak of coronavirus had no significant impact on the efficiency of banks.

In order to test the framed null hypothesis, either parametric or non-parametric test can be used. Since based *on the Shapiro–Wilk test, the normality assumption for the data is not met, Mann-Whitney U test has been used to test the null hypothesis at 5% level of significance.*

3.4. Data

The present study aims at exploring the impact of ownership and outbreak of coronavirus over Indian domestic banks. Therefore, the data of private as well as public sector banks have been collected from Reserve Bank of India and moneycontrol.com. Further, to eliminate any possible influence of other factors like demonetisation, changes in regulatory policy, mergers of public sector banks etc., data of only three recent years from 2018-21 has been taken into account. To assess the effect of Covid-19, the total period must have been divided into two periods i.e., pre-covid period and post-covid period. But the outbreak of Covid-19 in India was brought into the notice in January 2020, thus the year 2019-20 was a hybrid period which comprised nine months of pre-covid period and three months of post-covid period. To overcome the limitation of the hybrid period, two options were available. Either the entire data can be segregated into the ratio of 3:9 or 2019-20 can be analyzed standalone as a hybrid period. The first option works only under the assumption of constant performance of banks which is practically not possible. Therefore, the present study considers 2019-20 as a hybrid period and assesses the impact of Covid-19 through comparing 2018-19 with 2020-21. In other words, the three sub-periods considered in this paper are:

- Pre-Covid period: 1st April 2018 to 31st March 2019
- Hybrid Period: 1st April 2019 to 31st March 2020
- Post-Covid Period: 1st April 2020 to 31st March 2021

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

The data has been analysed through the 'Benchmarking' package of the R software.

3.5. Variables

The measurement of efficiency and productivity is based upon the various input variables and outputs produced by the bank. There is generally no consensus in literature for selection of input and output variables and selection is left to the choice of researchers. (Jayaraman and Srinivasan, 2014). The selection of inputs and outputs depends upon the approach to be followed. The review of available literature suggests the prevalence of six approaches viz., production approach, intermediation approach, asset approach, user cost approach, operating approach (income-based approach) and value-added approach. The review of top 100 most cited papers during 1985–2018 by Ahmad et.al, (2020) found that the intermediation approach is the most popular approach among researchers. Berger and Humphrey (1997) also pointed out that the production approach is more suited for evaluation of agencies, but for banks, the intermediation approach is more suitable. Moreover, for the comparison of results of the study with previous study, it is advisable to opt for an intermediation approach as the same has been followed in most of the previous studies (Sanjeev ,2006; Yang 2014; Rahim 2015; and Tamatam et.al 2019). Therefore, in this study, an intermediation approach has been used for the selection of inputs and outputs. Following the available studies, below-mentioned frequently used input and output variables have been taken to estimate efficiency:

- **Input variables**: Following, three variables have been taken as input variables:
  - Labour measured through number of employees,
  - Physical Capital proxied by fixed assets and
  - Loanable funds measured by summing deposits and borrowings.
- **Output variables**: Following, two variables have been taken as output variables:
  - Net Interest Income which represents the excess of interest earned over interest paid and
  - Non-interest i.e., other income.

While using the Data Envelopment Analysis model, it has to be decided whether to implement an input-oriented model or an output-oriented model. Input oriented models guide the inputs that may be minimized in order to maintain the same level of output. On the other hand, the output-oriented model gives an idea about the output level that may be increased without having any alteration in inputs. Since banks mostly have a better control over their inputs, the input-oriented model is more suitable (Sanjeev, 2006; Yilmaz and Gunes, 2015). Furthermore, the outputs produced by the banks could be influenced by external environmental factors that are beyond their control. Following the said argument, the input-oriented model has been considered for analysis in the present study.

4. Results and Discussions

The bank is said to be fully efficient when it lies on the efficient frontier i.e., bank efficiency score is equal to one. An efficient bank is a benchmark bank that portrays best practices to minimise inputs for producing a given level of output. The scores of overall technical, pure technical and scale efficiencies of banks have been displayed in Table 1. The OTE scores have been computed under the assumption of constant returns to scale, PTE scores have been computed under the assumption of variable returns to scale and SE scores have been computed by taking the ratio of OTE to PTE.

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

Table 1: Efficiency Scores of Indian Domestics Banks

Bank	**2018-19**			**2019-20**			**2020-21**		
	OTE	**PTE**	**SE**	**OTE**	**PTE**	**SE**	**OTE**	**PTE**	**SE**
Public Sector Banks									
State Bank of India	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Allahabad Bank	0.835	0.851	0.981	0.774	0.798	0.970	NA*	NA	NA
Andhra Bank	1.000	1.000	1.000	1.000	1.000	1.000	NA*	NA	NA
Bank of Baroda	0.981	0.998	0.983	0.896	1.000	0.896	1.000	1.000	1.000
Bank of India	0.852	0.872	0.977	0.876	0.893	0.981	0.786	0.803	0.978
Bank of Maharashtra	0.915	1.000	0.915	0.944	1.000	0.944	1.000	1.000	1.000
Canara Bank	0.848	0.854	0.992	0.730	0.802	0.911	0.853	1.000	0.853
Central Bank of India	0.782	0.783	0.999	0.820	0.829	0.989	0.882	0.888	0.993
Corporation Bank	1.000	1.000	1.000	1.000	1.000	1.000	NA*	NA	NA
Dena Bank	0.861	1.000	0.861	NA*	NA	NA	NA*	NA	NA
Indian Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Indian Overseas Bank	1.000	1.000	1.000	0.879	0.886	0.992	1.000	1.000	1.000
Oriental Bank of Commerce	0.883	0.915	0.965	0.847	0.856	0.990	NA*	NA	NA
Punjab and Sind Bank	0.801	1.000	0.801	0.740	1.000	0.740	0.822	1.000	0.822
Punjab National Bank	0.912	1.000	0.912	0.838	0.873	0.960	0.952	0.954	0.998
Syndicate Bank	0.811	0.812	1.000	0.789	0.792	0.996	NA*	NA	NA
UCO Bank	0.735	0.764	0.962	0.884	0.906	0.977	0.944	0.945	0.999
Union Bank of India	0.936	0.980	0.955	0.823	0.836	0.984	0.978	0.987	0.991
United Bank of India	1.000	1.000	1.000	1.000	1.000	1.000	NA*	NA	NA
Vijaya Bank	0.938	0.990	0.947	NA*	NA	NA	NA*	NA	NA
Average Efficiency of Public Sector Banks	0.905	0.941	0.963	0.880	0.915	0.963	0.935	0.965	0.969
Private Sector banks									
Axis Bank	0.908	1.000	0.908	0.722	0.778	0.929	0.772	0.957	0.806
Bandhan bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
City Union Bank	0.819	0.879	0.932	0.767	0.808	0.949	0.824	0.870	0.948
CSB Bank	0.526	0.761	0.691	0.630	0.802	0.785	0.845	1.000	0.845
DCB Bank	0.667	0.745	0.895	0.651	0.709	0.918	0.692	0.757	0.915
Federal Bank	0.737	0.760	0.970	0.774	0.813	0.952	0.850	0.879	0.967
HDFC Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

ICICI Bank	0.837	0.984	0.850	0.722	0.829	0.871	0.838	1.000	0.838
IDBI Bank	0.789	0.864	0.914	0.835	0.873	0.956	1.000	1.000	1.000
IDFC First Bank	0.531	0.557	0.953	0.847	0.870	0.973	1.000	1.000	1.000
Indusind Bank	1.000	1.000	1.000	0.945	1.000	0.945	0.968	1.000	0.968
Jammu & Kashmir bank	0.763	0.787	0.969	0.738	0.739	0.999	0.722	0.731	0.989
Karnataka Bank	0.656	0.691	0.949	0.583	0.609	0.957	0.792	0.810	0.978
Karur Vysya Bank	0.833	0.878	0.948	0.758	0.783	0.967	0.750	0.770	0.973
Kotak Mahindra Bank	0.905	0.905	1.000	0.843	0.885	0.952	0.974	0.981	0.993
Lakshmi Vilas Bank	0.405	0.542	0.746	0.406	0.603	0.673	NA*	NA	NA
Nainital Bank	0.653	1.000	0.653	0.629	1.000	0.629	0.655	1.000	0.655
RBL Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
South Indian Bank	0.509	0.548	0.929	0.553	0.571	0.968	0.611	0.625	0.978
Tamilnad Mercantile Bank	0.734	0.853	0.861	0.788	0.969	0.814	0.916	1.000	0.916
The Dhanalakshmi Bank	0.612	0.821	0.745	0.630	0.892	0.707	0.558	0.919	0.607
Yes Bank	1.000	1.000	1.000	1.000	1.000	1.000	0.716	0.719	0.996
Average Efficiency of Private Sector Banks	0.767	0.844	0.905	0.765	0.842	0.907	0.832	0.906	0.922

(Source: Author's calculation)
* NA = Depicts the unavailability of data due to the mergers. Dena Bank and Vijay Bank were merged in 2019. Lakshmi Vilas Bank merged with DBS Bank in 2020.

As shown in the Table, in the year 2018-2019, the public sector banks, on average, are 90.5% overall technically efficient. It depicts that the wastage of the inputs done by the banks on average stood at 9.5%. The average efficiency level of private sector banks in the year 2018-19 is observed to be less than the public sector banks. The average OTE score of private sector banks comes at 76.7% representing the wastage of the inputs by 23.3%. The average PTE and SE scores of public sector banks are respectively 94.1% and 96.3% whereas the same for private sector banks are 84.4% and 90.5% respectively. This clearly shows that in the year 2018-19, the managerial efficiency (measured through PTE scores) of private sector banks was far behind the same of public sector banks. The difference in the PTE and SE scores contributed to the difference in the OTE scores of two sets of banks. In terms of OTE, 6 out of 20 public banks (30% public sector banks) were perceived to be fully efficient while only 5 out of 22 private banks (approximately 22.73%) were perceived to have an efficiency score equal to one. The mean PTE score of 7 out of 22 private banks has been found to be efficient.

The OTE and PTE level of public sector banks fell down in the year 2019-2020 to 88% and 91.5% respectively. However, no change was observed in the SE score. The scale efficiency represents the capability of a bank to operate near to its most productive scale size. In that context, public sector banks could maintain their resilience after the immediate outbreak of Covid-19. In the context of private sector banks, there was a slight decline in OTE and PTE scores but not much change was witnessed. Bandhan bank, HDFC Bank, RBL Bank and Yes Bank could maintain their proficiency by maintaining the status of fully efficient banks. However, the OTE and SE of Indusind bank declined in the year 2019-20 by 5.5% from one to 0.945. The downfall was observed in the profit level of the banks also due to a sharp increase in gross non-performing assets from ₹3,947 crore to ₹5,147 crore for the reporting period. The bank created a floating provision also to protect against future losses arising out of the nationwide lockdown that has adversely impacted business activities (The Hindu 2020).

In the year, 2020-21, when coronavirus was at full swing, the public sector banks registered an improvement in efficiency. This can be attributed to the strategic decision of mergers of ten public sector banks into four w.e.f. April 1, 2020. Oriental Bank of Commerce and United Bank of India were amalgamated in Punjab

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

National Bank and this turned a loss amounting to 8310.93 crore into a profit of 2021.62 crore in the year 2020-21 (The Hindu 2021). Similarly, the merger of Andhra Bank and Corporation Bank with Union Bank of India; Allahabad Bank with Indian Bank; Syndicate Bank with Canara Bank resulted in a large capital base allowing opportunities for technological innovations. Four out of 12 public-sector banks (33.33%) became fully efficient with an efficiency score of one. The number of private banks in the year 2020-21 fell down from 22 to 21 due to the amalgamation of Lakshmi Vilas Bank with a foreign bank DBS Bank India Limited as on November 27, 2020. In the context of private banks also improvement was observed during 2020-21. The average OTE score depicted a noticeable improvement from 76.5% to 83.2%. In terms of OTE, five private banks (Bandhan Bank, HDFC Bank, IDBI, IDFC First Bank and RBL Bank) reached the efficient frontier whereas the managerial efficiency of 10 private banks out of 21 revealed a PTE efficiency score equal to one. During the entire study period, three private sector banks viz., Bandhan, HDFC and RBL observed to be fully efficient in all years. State Bank of India and Indian Bank were observed to be fully efficient among public sector banks throughout the study period. As discussed in the methodology, to get unbiased scores, bootstrapped DEA has been conducted. Table 2 reveals the BDEA scores for banking efficiencies.

Table 2: BDEA Efficiency Scores of Public Sector banks

Bank	2018-19			2019-20			2020-21		
	OTE	**PTE**	**SE**	**OTE**	**PTE**	**SE**	**OTE**	**PTE**	**SE**
Public Sector Banks									
State Bank of India	0.923	0.928	0.995	0.919	0.913	1.007	0.928	0.956	0.970
Allahabad Bank	0.810	0.831	0.975	0.747	0.767	0.974	NA	NA	NA
Andhra Bank	0.913	0.931	0.981	0.888	0.913	0.972	NA	NA	NA
Bank of Baroda	0.931	0.957	0.974	0.837	0.921	0.909	0.940	0.962	0.977
Bank of India	0.820	0.843	0.973	0.838	0.851	0.985	0.762	0.786	0.969
Bank of Maharashtra	0.876	0.948	0.925	0.898	0.921	0.975	0.942	0.956	0.985
Canara Bank	0.816	0.823	0.991	0.693	0.766	0.905	0.820	0.958	0.856
Central Bank of India	0.766	0.766	1.001	0.793	0.800	0.991	0.868	0.874	0.993
Corporation Bank	0.942	0.948	0.994	0.886	0.913	0.971	NA	NA	NA
Dena Bank	0.841	0.944	0.891	NA	NA	NA	NA	NA	NA
Indian Bank	0.939	0.941	0.997	0.920	0.915	1.006	0.971	0.977	0.993
Indian Overseas Bank	0.908	0.929	0.977	0.835	0.848	0.985	0.928	0.956	0.971
Oriental Bank of Commerce	0.842	0.880	0.957	0.803	0.813	0.988	NA	NA	NA
Punjab and Sind Bank	0.775	0.926	0.837	0.711	0.912	0.779	0.808	0.955	0.846
Punjab National Bank	0.869	0.936	0.928	0.795	0.822	0.966	0.925	0.935	0.990
Syndicate Bank	0.782	0.787	0.993	0.741	0.752	0.985	NA	NA	NA
UCO Bank	0.719	0.741	0.970	0.854	0.877	0.974	0.916	0.925	0.991
Union Bank of India	0.895	0.940	0.952	0.768	0.788	0.974	0.938	0.966	0.971
United Bank of India	0.906	0.928	0.977	0.918	0.915	1.003	NA	NA	NA
Vijaya Bank	0.894	0.954	0.937	NA	NA	NA	NA	NA	NA
Average	0.858	0.894	0.961	0.825	0.856	0.964	0.895	0.934	0.959
Standard Deviation	0.065	0.069	0.041	0.073	0.063	0.054	0.065	0.054	0.052
Minimum	0.719	0.741	0.837	0.694	0.752	0.779	0.762	0.786	0.846
Maximum	0.942	0.957	1.001	0.920	0.921	1.007	0.971	0.977	0.993
Private Sector banks									
Axis Bank	0.796	0.871	0.914	0.632	0.700	0.904	0.697	0.896	0.778
Bandhan bank	0.801	0.847	0.945	0.804	0.855	0.940	0.847	0.894	0.948
City Union bank	0.742	0.808	0.918	0.694	0.736	0.943	0.771	0.824	0.936
CSB Bank	0.482	0.696	0.691	0.580	0.737	0.787	0.781	0.937	0.834
DCB Bank	0.613	0.693	0.885	0.602	0.658	0.915	0.652	0.719	0.907
Federal Bank	0.651	0.691	0.941	0.673	0.733	0.918	0.767	0.824	0.930

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

HDFC Bank	0.841	0.847	0.994	0.852	0.851	1.001	0.870	0.892	0.975
ICICI Bank	0.759	0.892	0.850	0.654	0.754	0.868	0.796	0.922	0.863
IDBI Bank	0.701	0.794	0.884	0.748	0.799	0.936	0.910	0.907	1.004
IDFC First Bank	0.478	0.515	0.930	0.784	0.807	0.971	0.927	0.935	0.991
Indusind Bank	0.858	0.868	0.989	0.851	0.909	0.936	0.902	0.912	0.989
Jammu & Kashmir Bank	0.705	0.727	0.969	0.689	0.684	1.008	0.695	0.704	0.987
Karnataka Bank	0.601	0.639	0.940	0.524	0.558	0.940	0.731	0.764	0.957
Karur Vysya Bank	0.768	0.824	0.933	0.697	0.726	0.960	0.713	0.736	0.969
Kotak Mahindra Bank	0.809	0.812	0.997	0.755	0.806	0.936	0.904	0.917	0.986
Lakshmi Vilas Bank	0.374	0.502	0.746	0.354	0.546	0.647	NA	NA	NA
Nainital Bank	0.582	0.848	0.687	0.569	0.854	0.667	0.607	0.893	0.679
RBL Bank.	0.852	0.865	0.986	0.868	0.881	0.986	0.887	0.899	0.987
South Indian Bank	0.451	0.499	0.904	0.497	0.519	0.957	0.579	0.590	0.981
Tamilnad Mercantile Bank	0.642	0.771	0.833	0.688	0.880	0.782	0.832	0.916	0.908
The Dhanalakshmi Bank	0.572	0.743	0.771	0.593	0.812	0.731	0.531	0.865	0.613
Yes Bank	0.821	0.859	0.955	0.801	0.854	0.938	0.686	0.680	1.008
Average	0.677	0.755	0.894	0.678	0.757	0.894	0.766	0.839	0.916
Standard Deviation	0.143	0.123	0.094	0.129	0.112	0.104	0.116	0.100	0.108
Minimum	0.374	0.499	0.687	0.354	0.520	0.647	0.531	0.590	0.614
Maximum	0.858	0.893	0.997	0.869	0.909	1.008	0.927	0.937	1.008

(Source: Author's calculation)

As discussed in the methodology section, bootstrapped efficiency estimates have been computed for public sector as well as private sector banks (Table 2). The results of bootstrap efficiency are asymptotically more accurate than the standard intervals that have been observed through sample variance under the normality assumption. Since bootstrapping assigns accuracy measures to sample estimates, the bootstrapped scores are more valuable in drawing the inferences. During the bootstrapping process, a decrease in efficiency level of efficient banks have been observed. The bias-corrected results revealed that some of the banks that have been proclaimed as fully efficient, in reality, are not the benchmark banks with an efficiency score of one. For instance, State Bank of India and Indian Bank were found to be fully efficient (in terms of OTE, PTE, SE), but their efficiency levels dropped during the bootstrapping process. Similarly, for private sector banks also, we deduced the same results. The efficiency level of Bandhan Bank, HDFC Bank and RBL Bank dropped after bootstrapping. The bootstrapped results revealed that neither any public sector nor any private sector bank is fully efficient in terms of OTE as well as PTE. It can be noted that in all the three years the average OTE as well as PTE scores of public sector banks were better than those of private sector banks. This indicates that public sector banks are relatively more efficient than private sector banks. It is also interesting to note that during the entire study period, the variability in efficiency scores of public sector banks, as measured through standard deviation, is relatively less than the variation in private sector banks. The comparative analysis of pre-covid and post-covid period unveils that in context of PTE, the variance of public as well as private sector banks declined, this indicating the improving resilience of Indian banks.

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

Table 3: Top and Last performer domestic banks based on bootstrapped efficiency scores

Bank	Rank	2018-19			2019-20			2020-21		
		OTE	PTE	SE	OTE	PTE	SE	OTE	PTE	SE
Public Sector	Top Ranked (Benchmarked)	Corporation Bank (0.94)	Bank of Baroda (0.96)	Central Bank of India (1.00)	Indian Bank (0.92)	Bank of Baroda (0.92)	State Bank of India (1.01)	Indian Bank (0.97)	Indian Bank (0.98)	Indian Bank (0.99)
	Last Ranked	Uco Bank (0.72)	Uco Bank (0.74)	Punjab and Sind Bank (0.84)	Canara Bank (0.69)	Syndicate Bank (0.75)	Punjab and Sind Bank (0.78)	Bank of India (0.76)	Bank of India (0.79)	Punjab and Sind Bank (0.85)
Private Sector	Top Ranked (Benchmarked)	Indusind Bank (0.86)	ICICI Bank (0.89)	Kotak Mahindra Bank (1.00)	RBL Bank (0.87)	Indusind Bank (0.91)	Jammu & Kashmir bank (1.01)	IDFC First Bank (0.93)	CSB Bank (0.94)	Yes Bank (1.01)
	Low Performer	Lakshmi Vilas Bank (0.37)	South Indian Bank (0.50)	Nainital Bank (0.687)	Lakshmi Vilas Bank (0.35)	South Indian Bank (0.52)	Lakshmi Vilas Bank (0.65)	The Dhanalakshmi Bank (0.53)	South Indian Bank (0.59)	The Dhanalakshmi Bank (0.61)

(Source: Author's calculation)

Table 3 shows the banks that were either at the top or at the bottom in terms of BDEA efficiency scores. Top performer banks have achieved the higher efficiency score as compared to other banks in the respective group whereas, last performer banks have achieved least efficiency score in the same group. With reference to public sector banks, Bank of Baroda consistently performed well in terms of managerial efficiency (measured through PTE scores) during pre-covid as well as hybrid period. There was a spectacular performance of the bank during December 2018 (Q3 FY19). The Bank of Baroda reported three times higher net profits along with the stability in gross NPA and good loan book. The splendid performance of the Bank motivated the merger with Vijay Bank and Dena Bank. The ratio of the bank's gross non-performing assets to gross advances dropped from 9.61% as of March 31, 2019 to 9.40% on March 31, 2020. During 2020-21, Indian Bank emerged out to be the best performer in all the three scores. With the successful amalgamation of Allahabad Bank on April 1, 2020, the Indian Bank emerged in a better financial state and laid down its vision as a future-ready bank (Ramnarayan et., al. 2021). The synergy benefits are well reflected in the form of decrease in cost-to-income ratio of the Bank (40.86% for Q1 June 2021). The increase in net profit was witnessed by Indian Bank to Rs 3004.68 crores in March 2021 as compared to ₹ 753.36 crores in March 2020 (approx. increase 298.83%). Panjab and Sindh bank performed low constantly for three years in terms of scale efficiency. The bank witnessed consistent occurrence of net loss i.e., ₹543.48, ₹990.80, ₹2732.90 in three years 2018-19, 2019-2020 and 2020-21 respectively. The bank's earnings got impacted by deterioration in asset quality, also credit cost increased to 4% for financial year 2020-21 from 2.5% for the financial year 2018-19 on account of large provisioning requirements (CRISIL, 2021).

Among private sector banks, IDFC bank witnessed a huge improvement in the efficiency scores from 0.478 in 2018-19 to 0.927 in 2020-2021. The bank reported a net profit of ₹ 452 crore during 2020-21 as against a net loss of ₹ 2,864 crore in 2019-20. Another bank with major improvement was CSB Bank, which witnessed improved managerial efficiency (PTE) from 0.696 in 2018-19 to 0.937 in 2020-21. The bank could demonstrate better performance owing to an exponential rise in net profit of ₹ 218.40 crore in 2020-21 as against ₹ 12.72 crore in 2019-20. This could happen due to better management of non-performing assets of the bank. Lakshmi Vilas bank (LVB) witnessed the lowest score consecutively for two years 2018-19 and 2019-20. The troubles with LVB started when it shifted its focus from SMEs to large business in 2016-17. In 2018, Religare Finvest filed a case against LVB for diversion of funds, owing to which the RBI kept LVB under

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

prompt corrective action in September 2019. This has resulted in restraining LVB from issuing fresh loans or opening new branches (Economic Times, 2020). Finally, LVB was merged with Singapore's largest lender DBS Bank, due to unhappiness of shareholders with the bank's bad loans and value erosion (Business Standard,2020).

In order to identify the possible impact of ownership and coronavirus on the efficiency scores of domestic banks in India, non-parametric Mann-Whitney test has been applied. To identify the impact of ownership, the BDEA efficiency scores of public sector banks have been compared with the BDEA efficiency scores of private sector banks for each year. To analyse the impact of Covid-19 over the bank efficiency, the scores of pre-covid period (2018-19) have been compared with the scores of post-covid period (2020-21). The test has been conducted for public sector banks, private sector banks and overall domestic banks. Table 4 depicts the estimates of test statistics with the probability. The respective null hypothesis will be accepted only when the probability is more than 5% otherwise the same will be rejected.

Table 4: Results of Statistical Tests Performed on Efficiency Differences

Particulars	**Efficiency Parameter**	**Mann-Whitney (U) Scores**	**Z statistics**	**Probability**	**Null Hypothesis**
Ho1: No significant difference in the bootstrapped efficiency scores of public and private sector banks.					
2018-19	OTE	48.5	-4.319	0	Rejected
	PTE	65	-3.904	0	Rejected
	SE	108	-2.821	0.005	Rejected
2019-20	OTE	64	-3.643	0	Rejected
	PTE	85.5	-3.06	0.002	Rejected
	SE	87.5	-3.006	0.003	Rejected
2020-21	OTE	36	-3.368	0.001	Rejected
	PTE	30.5	-3.576	0	Rejected
	SE	94	-1.198	0.231	Accepted
Ho2: No significant difference in the bootstrapped efficiency scores of domestic banks during pre-covid period and post-covid period.					
Public Sector Banks	OTE	76	-1.713	0.087	Accepted
	PTE	57	-2.454	0.014	Rejected
	SE	118	-0.078	0.938	Accepted
Private Sector Banks	OTE	151.5	-1.932	0.053	Accepted
	PTE	115	-2.819	0.005	Rejected
	SE	178	-1.288	0.198	Accepted
Indian Domestic Banks	OTE	557.5	-1.446	0.148	Accepted
	PTE	495	-2.114	0.035	Rejected
	SE	619	-0.790	0.43	Accepted

(Source: Author's calculation)

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

With reference to the impact of ownership, it has been observed that for the years 2018-2019, 2019-2020, the null hypothesis is rejected. The similar results have been observed for the year 2020-2021, however for SE, the hypothesis is accepted. Therefore, it can be concluded that there is a significant impact of bank ownership on the efficiency of banks. Public sector banks are relatively more technically efficient than private sector banks in managing inputs. With reference to the effect of Covid-19 over banks, results reported though PTE scores have got a significant impact of Covid-19 but no significant influence of pandemic was observed on the overall efficiency (OTE) as well as scale efficiency of domestic banks. The results in confirmation are aligned to the report of KPMG (2020). The report stated that banks globally were resilient in facing pandemic as they kept continuous flow of credit and better liquidity. Similar findings were revealed by Mohan (2021) in case of Indian banks. The Financial Stability Report of RBI published in July 2021, also reported that the Indian banking system was affected less due to two waves of Covid-19 as feared by the people.

5. Conclusions

The present study revisited the efficiency level of Indian domestic banks i.e., public and private sector banks, with a view to investigating any possible impact on bank ownership by the outbreak of Covid-19. The analysis of efficiency scores of 2018-2019 to 2019-2020 revealed that banks exhibited a decline in the mean efficiency scores after the onset of coronavirus in January, 2020. But within a couple of months, it showed signs of recovery and during 2020-2021, an increase in the mean efficiency scores was observed. The results of Mann-Whitney test revealed that there was no significant influence of pandemic on the bootstrapped scores of overall and scale efficiencies of domestic banks. The results are in confirmation to the previous studies (KPMG, 2020; Mohan, 2021 and RBI 2021). When bank ownership impact was explored, the study noticed a significant impact and found that public sector banks are relatively more technically efficient in managing inputs than private sector banks. Jagwani (2012) and Nandi (2013) in their studies also indicated public banks as better performers as compared to private banks. This confirms the success of strategic decisions of mergers of major public sector banks in India. The results are useful for policy makers as well as stakeholders to imitate the practices set by benchmark banks. The study can be further extended by improving the sample size like inclusion of foreign banks operating in India. Furthermore, a study can be conducted to compare the effect of ownership and pandemic over banks of different countries. Furthermore, besides ownership and covid factors, other determinants can be examined to study the impact on banking efficiency.

6. Funding

This research is supported by the University Grant Commission in the form of Senior Research Fellowship (Grant number: 190510128831)

7. References

[1] Ahmad, N., Naveed, A., Ahmad, S., & Butt, I. (2020). Banking sector performance, profitability, and efficiency: A citation-based systematic literature review. Journal of Economic Surveys, 34(1), 185–218.

[2] Ajibefun, I. A. (2008). An evaluation of parametric and non-parametric methods of technical efficiency measurement : Application to small scale food crop production in Nigeria. Journal of Agriculture & Social Sciences, 4(3), 95–100.

[3] Appiah-Otoo, I. (2020). Does COVID-19 affect domestic credit? Aggregate and bank level evidence from China. Asian Economics Letters, 1–5. https://doi.org/10.46557/001c.18074

[4] Berger, A. N., & Humphrey, D. B. (1997). Efficiency of financial institutions: International survey and directions for future research. European Journal of Operational Research, 98(2), 175–212.

[5] Bhattacharyya, A., Lovell, C. A. K., & Sahay, P. (1997). The impact of liberalization on the productive efficiency of Indian commercial banks. European Journal of Operational Research, 98(2), 332–345.

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

[6] Business Standard (2020), What went wrong with Lakshmi Vilas Bank? Here is all you need to know, October 01, 2020 retrieved from https://bfsi.economictimes.indiatimes.com/news/banking/here-is-all-you-need-to-know-about-what-went-wrong-with-lakshmi-vilas-bank/78404094

[7] Chakrabarti, R., & Chawla, G. (2005). Banking efficiency in India since the reforms: An assessment. Money and Finance, 9(2), 31–47.

[8] Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision-making units. European Journal of Operational Research, 2(6), 429–444. https://doi.org/10.1016/0377-2217(78)90138-8

[9] Chatterjee, B., & Sinha, R.P. (2006). Cost efficiency and commercial bank lending: Some empirical results. The Indian Economic Journal, 54(1), 145–165.

[10] Coelli, T.J. (1996). A guide to DEAP version 2.1: a data envelopment analysis (computer) program. Centre for efficiency and productivity analysis (CEPA).

[11] Colak, G., & Oztekin, O. (2021). The impact of COVID-19 pandemic on bank lending around the world. Journal of Banking and Finance, July 2020, 106207.

[12] CRISIL, (2021), Ratings, August 31,2021, retrieved from https://www.crisil.com/mnt/winshare/Ratings/RatingList/RatingDocs/PunjabandSindBank_August%2031,%202021_RR_277110.html

[13] Das, A., & Ghosh, S. (2006). Financial deregulation and efficiency: An empirical analysis of Indian banks during the post reform period. Review of Financial Economics, 15(3), 193–221.

[14] Demirgüç-Kunt, A., Pedraza, A., & Ruiz-Ortega, C. (2021). Banking sector performance during the COVID-19 crisis. Journal of Banking and Finance, 133, 1-22. https://doi.org/10.1016/j.jbankfin.2021.106305

[15] Efron, B. (1979). Bootstrap methods: Another look at the Jackknife. The Annals of Statistics, 7(1), 1–26. doi:10.1214/aos/1176344552

[16] Financial Stability Report (2021), Financial Stability Report Issue No. 23, July 2021 retrieved from https://rbidocs.rbi.org.in/rdocs//PublicationReport/Pdfs/FSRJULY20210595CD3BEDFA466EBE9169BCE426E32C.PDF

[17] IBEF. Banking; 2021. https://www.ibef.org/download/Banking-Ma-2021.pdf.Accessed August 19, 2021.

[18] Jagwani, B. (2012). Efficiency measurement in the Indian banking industry: An application of data envelopment analysis. Vision: The Journal of Business Perspective, 16(4), 315–331.

[19] Jayaraman, A. R., & Srinivasan, M. R. (2014). Analyzing profit efficiency of banks in India with undesirable output - Nerlovian profit indicator approach. IIMB Management Review, 26(4), 222–233.

[20] Jimenez-Hernández, I., Palazzo, G., & Sáez-Fernández, F. J. (2019). Determinants of bank efficiency: Evidence from the Latin American banking industry. Applied Economic Analysis, 27(81), 184–206.

[21] Johonsen, & Scholes. (1997). Exploring corporate strategy: Test and essay. New York: Prentice Hall.

[22] Joshi, P. V. & Bhalerao, J. V (2011). Efficiency evaluation of banking Sector in India based on data envelopment analysis. Indian Journal of Commerce & Management Studies, March 2011, 31–40.

[23] Katusiime, L. (2021). COVID 19 and bank profitability in low income countries: The case of Uganda. Journal of Risk and Financial Management, 14, 1-19. https:// doi.org/10.3390/jrfm14120588

[24] Kaur, S., & Gupta, P. K. (2015). Productive efficiency mapping of the Indian banking system using data envelopment analysis. Procedia Economics and Finance, 25(15), 227–238.

[25] Kiliç, M. (2011). Cross-border bank acquisitions and banking sector performance: An empirical study of Turkish banking sector. Procedia - Social and Behavioral Sciences, 24, 946–959.

[26] Kozak, S. (2021). The impact of covid-19 on bank equity and performance: The case of Central Eastern South European countries. Sustainability (Switzerland), 13(19), 1-15, https:// doi.org/10.3390/su131911036

[27] KPMG (December 2020). Financial resilience in banking: A balancing act, retrieved from https://home.kpmg/xx/en/home/insights/2020/12/financial-resilience-in-banking.html

[28] Krumbhakar S.C., Lovell C.A.K. (2004) Stochastic Frontier Analysis. Cambridge 13 University Press, United Kingdom, Cambridge.

[29] Mohan, T.T.R. (2021). Banking sector resilient in the face of pandemic. Economic & Political Weekly, 56(33), 10-11.

ISSN: 2247-6172
Review of Applied Socio- Economic Research
(Volume 26, Issue 2/ 2023), pp. 153 - 167
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

[30] Malikov, E., Kumbhakar, S.C., Tsionan, M.G. (2016). A cost system approach to the stochastic directional technology distance function with undesirable outputs: The case of US banks in 2001- 2010. Journal of Applied Econometrics. 31(2016), 1407-1429.

[31] Moradi-Motlagh, A., & Saleh, A. S. (2014). Re-examining the technical efficiency of Australian banks: A bootstrap DEA approach. Australian Economic Papers, 53(1–2), 112–128. https://doi.org/10.1111/1467-8454.12024

[32] Mukherjee, A., Nath, P., & Nath Pal, M. (2002). Performance benchmarking and strategic homogeneity of Indian banks. International Journal of Bank Marketing, 20(3), 122-139.

[33] Munim, Z. H. (2020). Does higher technical efficiency induce a higher service level? A paradox association in the context of port operations. Asian Journal of Shipping and Logistics, 36(4), 157–168. https://doi.org/10.1016/j.ajsl.2020.02.001

[34] Nandi, J. K. (2013). Efficiency analysis of selected public and private sector banks in India through data envelopment analysis. Vidyasagar University Journal of Commerce.18, 1-11.

[35] Ouenniche, J., & Carrales, S. (2018). Assessing efficiency profiles of UK commercial banks: A DEA analysis with regression-based feedback. Annals of Operations Research, 266(1–2), 551–587.

[36] Patel, A., Debnath, N. C., Mishra, A. K., & Jain, S. (2021). Covid19-IBO: A Covid-19 impact on Indian banking ontology along with an efficient schema matching approach. New Generation Computing, 39(3), 647–676.

[37] Ram & Mesfin, E. A. (2019). Estimating technical efficiency of selected commercial banks in Ethiopia using data envelopment analysis. Journal of Emerging Technologies and Innovative Research (JETIR) 6(3), 959-969.

[38] Ramnarayan, S., Sindhwani, S., Shah, G., and Parihar, A. (2021), Merger of equals: The amalgamation story of Indian bank and Allahabad bank, Harvard Business Review, By: Length: 33 page(s), Publication Date: Aug 4, 2021, https://hbsp.harvard.edu/product/ISB274-PDF-ENG

[39] Rahim, R. A. (2015). Ranking of Malaysian commercial banks: Super-efficiency data envelopment analysis (DEA) approach. Asian Academy of Management Journal of Accounting and Finance, 11(1), 123–143.

[40] Sanjeev, G. M. (2006). Data Envelopment Analysis (Dea) for measuring technical efficiency of banks. Vision: The Journal of Business Perspective, 10(1), 13–27.

[41] Simar, L. and Wilson, P.W. (1998). Sensitivity analysis of efficiency scores: How to bootstrap in nonparametric frontier models. Management Science, 44(1), 49–61.

[42] Sriram, M. S. (2021). TIF - Indian banking reforms forums — The earnest steps. 1–8.

[43] Sufian, F. (2016). Determinants of efficiency in the Malaysian banking sector: Evidence from semi-parametric data envelopment analysis method. Studies in Microeconomics, 4(2), 151–172.

[44] Svitalkova, Z. (2014). Comparison and evaluation of bank efficiency in selected countries in EU. Procedia Economics and Finance, 12(March), 644–653.

[45] Tamatam, R., Dutta, P., Dutta, G., & Lessmann, S. (2019). Efficiency analysis of Indian banking industry over the period 2008–2017 using data envelopment analysis. Benchmarking, 26(8), 2417–2442.

[46] The Hindu (2020), IndusInd bank profit drops, retrieved from https://www.thehindu.com/business/indusind-bank-profit-drops/article31448250.ece

[47] The Hindu (2021), Public sector banks' profitability improved post-merger, December 22, 2021, retrieved from https://www.thehindubusinessline.com/money-and-banking/public-sector-banks-profitability-improved-post-merger/article38006544.ece

[48] Yang, C. C. (2014). Evaluating the performance of banking under risk regulations: A slacks-based data envelopment analysis assessment framework. Expert Systems, 31(2), 176–184.

[49] Yilmaz, A., & Güneş, N. (2015). Efficiency comparison of participation and conventional banking sectors in Turkey between 2007-2013. Procedia - Social and Behavioral Sciences, 195, 383–392.

Manuscript received: 21.07.2022

Manuscript received in revised form: 29.08.2023

Manuscript accepted: 30.08.2023