What Explains Technical Inefficiency in Indian Banking Industry? An Investigation Using a Two-Stage DEA

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Abstract

The study endeavours to identify factors explaining the technical inefficiency of Indian banks using an unbalanced panel dataset of 109 commercial banks for 16 years, from 2005-06 to 2020-21.A two-stage DEA (Data Envelopment Analysis) is used in the present study. In this analysis, firstly, DEA measures efficiency and secondly, the Tobit model estimates the significant factors causing Indian banks' inefficiency. According to the DEA estimates of Indian banking Industry, technical inefficiency is primarily caused by scale inefficiency. In addition, the Tobit regression analysis reveals that profitability, financial soundness, bank ownership, market concentration, inflation, and economic growth cause the technical inefficiency negatively and significantly. The present study recommends that the banks under evaluation, regardless of their types of ownership, need to develop a new production technology to reduce the adverse effects of diseconomies of scale. The findings also point to the need for Indian banking regulators and policymakers to enhance the performance of public sector undertaking banks, which account for a larger share of the industry's technical inefficiency.

Keywords: Technical inefficiency, Scale inefficiency, Data Envelopment Analysis, Tobit, Indian Banking Industry

JEL Code: G21, H21

Introduction

Banks perform a variety of roles in the growth and development of economies. Banks, which are specialized in the financial intermediation process, are responsible for distributing excess liquidity to the market participants carrying economic activities. Banks channelize the accumulated funds from the general public or organizations to the market participants who need funds in the form of loans and advances (Jiménez-Hernández et al., 2019). Thus, as a monetary policy transmission mechanism, banks facilitate the flow of money in the economy. Banks being the modern financial system's major constituent also provide other services, such as trade clearing and settlement systems and risk and uncertainty management solutions.

During the post-financial liberalization era, the Indian banking sector has progressed at a breakneck pace. The greater rate of credit expansion, rising profitability and efficiency in line with developed markets, decreased incidence of NPA, and an emphasis on financial inclusion have led to the sector being dynamic and resilient (Goyal and Joshi, 2012). For a strong and sustainable banking system, the industry has undergone major structural changes in recent years, particularly in terms of mergers and acquisitions. Besides, the entry of FinTechs has increased the demand for further boosting their operational performance to compete in the global market. This demands competitive analysis in the industry.

In order to effectively function as an economy's growth engine, banks must transform their input resources efficiently into a variety of financial products and services. An efficient bank is always better able to serve the diverse needs of its stakeholders. A well-functioning banking sector is also seen to be more capable to confront economic downturns and contribute to financial system stability (Delis and Papanikolaou, 2009). As a result, it is vital to investigate bank efficiency and its determinants. Having this backdrop, the study seeks to evaluate the relative performance and identify factors explaining the technical inefficiency of Indian banks.

Literature Review

Kumbhakar and Wang (2007) concluded that capital adequacy has a negative association with technical inefficiency of Chinese banks. Similarly, Chiu et al. (2008) affirmed that capital adequacy caused favourably to technical efficiency in Taiwanese banks during the period 2000-2002. According to Sufian (2009), Chinese banks' technical efficiency level augmented due to diversification, lending intensity, capitalization and economic growth from1997 to 2006, but adversely associated with size and expenditure preference behaviour. Gardener et al. (2011) stated that efficiency was highly and positively associated with banking development and economic growth between 1998 and 2004, but adversely correlated with inflation. Ab-Rahim et al. (2012) concluded that efficiency of Malaysian banks improved between 1995 and 2010 because of market concentration (HHI),size, population density and government bank ownership. On the other hand, factors such as mergers, GDP per capita, equity ratio, credit risk, and managerial quality had a negative influence. Sufian et al. (2016) measured efficiency of Malaysian banks during 1999-2008 and confirmed the limited form of the global advantage and the liability of unfamiliarity theories while refuting the home field advantage hypothesis. Tesfay (2016) investigated the economic variables determining the efficiency of Ethiopian commercial banks during 2003-2012 and found deposit and liquidity to be the most influential factors in enhancing bank efficiency. Lema (2017) discovered that liquidity, capitalization, profitability, and market share affect efficiency significantly and positively. Jelassi and Delhoumi (2021) investigated the Tunisian commercial banks' technical efficiency determinants during 1995-2017. The study concluded that efficiency increases with an increasing rate of capitalization and higher inflation rate but falls with greater bank size, increasing number of branches, the higher rate of loan-to-asset ratio and management-to-staff ratio.

Trehan and Soni (2003) asserted that the profitable banks owned by the government are also technically efficient. Kaur and Jyoti (2005) concluded that among their counterparts, foreign banks are the most efficient and privately owned banks are inefficient in managing the size of their operations. Kumar and Gulati (2009) discovered that in India, the efficiency frontier is largely formed by privately owned banks; technical inefficiency is primarily caused by pure technical inefficiency, and profitability has a substantial impact on efficiency. Bhattacharyya and Pal (2013) outlined that public undertakings, i.e. government-owned banks are more efficient in comparison to their counterparts. Arora (2014) found empirical evidence of the effects of different bank ownership groups and reforms on technical efficiency and concluded that profitable and productive banks are technically efficient, whereas inefficient banks have greater levels of NPAs. Virtual assistants, AI in chatbots, and ATMs, according to Mor and Gupta (2021), decline the extent of technical inefficiencies of banks.

Research Gap

Researchers explored significant determinants of efficiency across countries from time to time, as evidenced by previous studies. Further, each study is different in terms of the methodology used to measure efficiency, the sorts of variables included in the investigation, and the period employed to evaluate it. Therefore, the current study seeks to make value addition to the existing literature by identifying significant determinants of inefficiency in Indian banks.

Objectives of the Study

1. To measure the technical efficiency and its components of Indian commercial banks.
2. To compare the technical efficiency scores across the different ownership bank groups.
3. To investigate factors explaining the technical inefficiency of Indian commercial banks.

Hypotheses of the Study

It is evident from the existing literature that there is a variation in respect of efficiency measures for different bank groups. Therefore, with regard to comparative evaluation of efficiency based on bank ownership, the current study has tested the following null hypotheses:

H1: There is no significant difference across the different ownership bank groups in respect of the efficiency measures.

H2: There is no significant difference between the pairwise bank ownership groups in respect of the efficiency measures.

Furthermore, conforming to the previous studies, the current study presumes that apart from managerial incompetencies and diseconomies of scale, a bank's technical inefficiency can be also attributed to a variety of other economic variables, commonly grouped as "bank-specific," "industry-specific" and "macroeconomic". Therefore, the study has also formulated the following null hypotheses:

H3: Bank-specific variables, namely, bank size, profitability, diversification, employees' productivity, credit risk, managerial quality, liquidity and financial soundness do not have a significant influence on technical inefficiency.

H4: Industry-specific variables, namely, market concentration and ownership do not have a significant influence on technical inefficiency.

H5: Macroeconomic variables, namely, economic growth and interest rate do not have a significant influence on technical inefficiency.

Research Methodology

Study Period

Under the present study, the estimation of a causal relationship between technical inefficiency and its determinants is based upon the unbalanced panel dataset for the years 2005–2006 to 2020–21.

Sample selection

The sample banks considered in the DEA model, which are usually called Decision-Making Units (DMUs)include major three categories of banks, namely the public sector banks (PSBs), private sector banks (PVTs), and foreign banks (FBs). Accordingly, a panel of 109 Indian commercial banks for 16 years forms an unbalanced panel data set under the study.

Sources of Data

The source of the requisite secondary data for the analysis under the current study is the database of Reserve Bank of India, which is available it its official website.

Tools used in the Study

The study makes use of statistical methods such as mean, minimum, maximum, and range to describe the data. Additionally employed non-parametric tests are Kruskal-Wallis and Mann-Whitney.

Estimation Model

The study has performed a two-stage analysis of the unbalanced panel dataset for the period considered under the study. Firstly, the technical efficiency of each bank has been estimated following the DEA approach. Secondly, the technical inefficiency scores have been regressed against the economic variables using the Tobit regression model

(Gardener et al., 2011; Ab-Rahim et al. 2012; Tesfay, 2016; Lema, 2017).

One approach to evaluating a bank's efficiency is to see how close it is to the best practice frontier. Following this approach, the DEA estimates the frontier by enveloping the piecewise linear combinations of best-performing banks in the industry that lie over the observations. DMUs that are technically efficient lie on the best-practice frontier, whereas all others are technically inefficient. A technical efficient DMU obtains a score of one, whereas for a technical inefficient DMU's the efficiency score varies from less than one to zero. CCR and BCC are the two fundamental DEA Models. The CCR model estimates overall technical efficiency(OTE)assuming constant returns to scale, whereas the BCC model estimates pure technical efficiency (PTE) and scale efficiency(SE) based on the variable returns to scale measurement. The managerial competency to effectively implement a production plan is measured by pure technical efficiency, while the decision of choosing the right scale of operation is assessed by scale efficiency. Under the study, the BCC model has been used in the first-stage analysis to identify the sources of technical inefficiency.

Based on orientation, there may be either input- or output-oriented DEA models. The input-oriented model estimates the maximum proportionate decrease in input with constant levels of output, whereas the output-oriented model describes the maximum proportional rise in output with constant input levels (Ab-Rahim et al., 2012). Under the study, the input-oriented DEA is used because demand-side limitations do not let the banking sector get the maximum output reachable (Jiménez-Hernández et al., 2019). Therefore, the present study emphasizes that banks should focus on the causes of input waste (Isik& Hassan, 2003).

The selection of the variables used in the DEA model for measuring technical efficiency has followed the intermediation approach of the banking operation. Following Trehan and Soni (2003), Kaur and Jyoti (2005), Avkiran (2000) Kaur and Jyoti (2005) and Lema (2017), under the present study, banks are assumed to produce two given levels of outputs, viz., interest income and non-interest with optimal utilization of three inputs, viz., labour, physical capital and loanable funds (deposits and borrowings). As a result, the current study takes into account the following intermediation function:

Output (Interest Income, Non-interest Income) =f(No. of employees, physical capital, loanable fund)

Table 1: Explanatory Variables used in Tobit Regression Model

Variable Name	Notation	Measurement
Bank-specific variables:		
Bank Size	SIZE	Natural logarithm of Total Assets
Profitability	PROF	Return on Assets
Diversification	DIV	Non-interest Income to Total Assets
Employee’s Productivity	EMP	Natural logarithm of Business Per Employee
Credit Risk	CDR	Net NPA to Net Advances
Managerial Quality	MGQ	Non-interest Expenses to Total Assets
Liquidity	LQDT	Credit-Deposit Ratio
Financial Soundness	FSDN	Z score= $\frac{ROA + Equity / Assets}{\sigma ROA}$
Industry-specific variables:		
Market Concentration	MRKC	Herfindahl - Hirschman Index (HHI) = Sum of squares of market share of Deposits
Ownership	OWNP	0=PSBs in India; 1=PVTs and FBs
Macroeconomic variables:		
Economic Growth	EGRW	Natural logarithm of GDP
Inflation	INFN	CPI for Industrial workers

Source: Compiled from literature

According to the literature, the Tobit regression model is more appropriate in the situation of a dependent variable whose censored value lies between zero and one because it handles skewed and truncated data. In this estimation model, a bank's overall technical inefficiency (OTIE), determined as one minus the overall technical efficiency score following the CCR model, has been considered as the dependent variable for the regression analysis because the study intends to increase technical efficiency in banks by addressing the reasons for inefficiency. The following random-effects Tobit regression model based on maximum likelihood estimation and bootstrap standard error method has been adopted for the unbiased and consistent estimation result:

$$(1\text{-}OTE_{it}) = TIE_{it} = \beta_0 + \beta_1 SIZE_{it} + \beta_2 PROF_{it} + \beta_3 DIV_{it} + \beta_4 EMP_{it} + \beta_5 CDR_{it} + \beta_6 MGQ_{it} + \beta_7 LQDT_{it} + \beta_8 FSDN_{it} + \beta_9 MRKC_{it} + \beta_{10} OWNP_{it} + \beta_{11} EGRW_{it} + \beta_{12} INFN_{it} + \varepsilon_{it}$$

Where, bank is denoted by i(i=1,......N,), time is denoted by t (t=1,.....,T),β are the vectors of the coefficient variables, E_{it} is the disturbance term. The details of the variables used in the model are presented in Table 1.

Results and Discussion

Table 2 shows the measurement result of OTE, PTE and SE of Indian banks. The table provides that, the aggregate OTE of all the sample banks during the study period was only 56 per cent. Thus, the Indian banking industry's OTE for the period is estimated to be 44 per cent during the study period. There is a mixed trend in all types of efficiency measures across the study period. Both OTE and SE indicate a similar trend during the research period, with the highest score in 2009 and the lowest in 2005. However, as evidenced by the range value of 49.8 per cent, the volatility is highest in the case of SE.

As for OTE, there is a sharp decline in efficiency level from 74 per cent in 2009 to 53.6 per cent in 2021. A similar deceleration can be observed in the case of SE from 83.9 per cent in 2009 to 67.5 per cent in 2021. However, the banks' inefficiency level reduced at the end of the period compared to the beginning period, and varied from 26 per cent to 72.3 per cent, and 16.1 per cent to 65.9 per cent respectively during the period. The PTE measure, on the other hand, had the maximum score of 89.7% in 2014 and the lowest score of 77.9 per cent in the final year of the study period. However, variation in the efficiency level is only estimated to be 11.8 per cent, with inefficiency levels ranging from 10.3 per cent to 22.1 per cent.

Throughout the study period, the components of OTE demonstrate that PTE outweighs bank SE. This finding appears to indicate that banks operating in India are efficient on the managerial front despite not being working at the optimal scale of operation. In other words, in the Indian banking industry, the increased level of scale inefficiency contributed to its technical inefficiency during 2005-06 to 2020-21.

Table 2: Summary of efficiency scores (2005-06 to 2020- 21)

Year	OTE	PTE	SE
2005-06	0.277	0.825	0.341
2006-07	0.624	0.856	0.738
2007-08	0.673	0.850	0.787
2008-09	0.670	0.839	0.793
2009-10	0.740	0.880	0.839
2010-11	0.714	0.889	0.808
2011-12	0.587	0.870	0.680
2012-13	0.559	0.873	0.654
2013-14	0.584	0.887	0.662
2014-15	0.518	0.897	0.581
2015-16	0.493	0.875	0.572
2016-17	0.385	0.783	0.527
2017-18	0.454	0.853	0.540
2018-19	0.505	0.824	0.622
2019-20	0.635	0.816	0.776

Year	OTE	PTE	SE
2020-21	0.536	0.779	0.675
Mean	0.560	0.850	0.662
Minimum	0.277	0.779	0.341
Maximum	0.740	0.897	0.839
Range	0.463	0.118	0.498

Source: Author's calculation

In terms of bank ownership group-wise comparative analysis, Table 3 presents that foreign banks have the maximum mean score of OTE (72.5%), followed by PVTs (43.4%) and PSBs (41.4%) in India. Thus, the estimated 59.6 per cent inefficiency level of PSBs has contributed significantly to the industry's OTIE of 44 per cent. Similarly, the mean SE score of FBs results to 84.8 per cent, followed by PVTs with 69.7% and PSBs with 48.3 per cent. Consequently, during the study period, the PSBs' scale inefficiency level to the extent of 52.7 per cent has undermined the Indian banking industry's technical efficiency score. On the other hand, in terms of PTE, PSBs perform somewhat better, on average, with a margin of 0.3 per cent, than FBs, which are followed by PVTs in India.

Further, it is evident from the results that scale inefficiency has been the primary source of technical inefficiency across the different ownership bank groups. Thus, PTE has contributed largely toward the technical efficiency across the different ownership bank groups during the study period. The minimum and maximum efficiency scores reveal that FBs are more consistent players with the lowest range value of each efficiency measure in the performance followed by PSBs and PVTs. The result of Kruskal–Wallis Test shows that there is a significant difference in respect of each efficiency measure across the different ownership bank groups at 0.01level of significance. Furthermore, the Mann-Whitney Test results support the findings with statistical proof showing that there is a significant difference between the two different ownership bank groups in terms of each efficiency measure, except for PTE, where there is no such statistical proof of significant difference.

Table 3: Summary of efficiency scores across the different ownership bank groups

Measures		OTE			PTE			SE		
		PSBs	PVTs	FBs	PSBs	PVTs	FBs	PSBs	PVTs	FBs
Statistics	Mean	0.414	0.434	0.725	0.858	0.833	0.855	0.483	0.697	0.848
	Minimum	0.159	0.135	0.523	0.707	0.648	0.709	0.172	0.194	0.641
	Maximum	0.666	0.678	0.880	0.930	0.915	0.928	0.734	0.806	0.957
	Range	0.507	0.543	0.357	0.223	0.267	0.219	0.562	0.611	0.316
Kruskal–Wallis Test	PSBs vs. PVT s vs. FBs	443.211*			18.986*			620.500*		
Mann-Whitney Test	PSBs vs. PVTs	-1.276			-1.778***			-2.573**		
	PVTs vs. FBs	-16.512*			-3.734*			-19.188*		
	PSBs vs. FBs	-18.391*			-3.302*			-21.988*		

Source: Author's calculation

Note: *, ** and *** indicate significance levels at .01, .05 and .10 respectively

The correlation matrix in Table 4 demonstrates that the explanatory factors have a weak correlation. The presence of a multicollinearity problem is generally indicated by a correlation coefficient value of more than .70. The current study lacks multicollinearity problem since there is no high correlation between the explanatory variables.

Table 4: Result of Correlation Matrix

	SIZE	**PROF**	**DIV**	**EMP**	**CDR**	**MGQ**	**LQDT**	**FSDN**	**OWNP**	**MRKC**	**EGRW**	**INFN**
SIZE	1.000											
PROF	-0.134	1.000										
DIV	-0.273	0.313	1.000									
EMP	-0.002	-0.023	-0.323	1.000								
CDR	0.067	-0.293	-0.046	-0.071	1.000							
MGQ	-0.303	-0.084	0.776	-0.401	0.044	1.000						
LQDT	-0.085	-0.056	0.060	0.069	0.042	0.241	1.000					
FSDN	-0.329	0.192	0.015	0.212	-0.107	0.053	0.148	1.000				
OWNP	-0.536	0.229	0.207	0.136	-0.182	0.232	0.093	0.313	1.000			
MRKC	-0.053	-0.116	-0.017	0.201	0.104	-0.017	-0.011	0.033	0.043	1.000		
EGRW	-0.020	0.045	-0.008	-0.281	0.000	-0.020	-0.021	-0.024	-0.057	-0.224	1.000	
INFN	0.097	0.155	0.045	-0.216	-0.199	0.009	-0.014	-0.072	-0.042	-0.605	-0.111	1.000

Source: Author's calculation

The Wald 2 value is 696.56 with a p-value of 0.000, which is less than the statistical significance threshold of 0.05, according to the results of the Tobit regression model, which are shown in Table 5. As a result, the estimation model is statistically significant and captures well the impact of fluctuation inthe independent variable on the dependent variable.The regression results demonstrate that bank size (SIZE) is positively related to technical inefficiency (OTIE), implying, therefore that giant banks are at a distance from the efficient frontier, which further indicates their inability of carrying out operations at optimal scale.Technical inefficiency is positively but insignificantly related to diversification (DIV). The result could be viewed as Indian banks have gradually diversified their industries toward fee-based business over time, although interest income has always been the primary source of revenue. Furthermore, a technically efficient bank relies more on traditional revenue streams like loans and advances. Surprisingly, employee productivity (EMP) as measured by business per employee is positively related to technical inefficiency, however, the effect is insignificant. The results show that efficient bank performance is dependent on employees' productivity; nevertheless, replacing employees' roles with modern technology-based services may contradict the corporate social responsibility principle, which could weaken bank performance further. Credit risk(CDR), as calculated by the net NPA to net advances ratio, and liquidity(LQDT), as assessed by the credit-deposit ratio, are both positively but insignificantly related to technical inefficiency. This finding implies that a large amount of non-performing loans and a greater degree of liquidity reduce bank efficiency.

At the other extreme, bank profitability(PROF) measured by the ratio of return on assets, has a negative relationship with technical inefficiency, implying that more profitable banks have higher technical efficiency scores. Managerial quality (MGQ), as measured by non-interest expenses to total assets, has a negative impact on technical inefficiency, implying that a bank that is tolerant of non-interest expenses will be more technical efficient. Non-interest expenses could include salaries and benefits, regulatory compliance, loan monitoring and administration (Samad, 2014). The explanation for this impact could be that these expenses pave the way for attracting more depositors and improving asset quality (Oredegbe, 2020). However, its insignificant impact emphasizes the importance of the managerial function of cost control in increasing efficiency.

The negative and significant association of financial soundness(FSDN) as evaluated by the Z-score with technical inefficiency demonstrates that a sound financial bank performs efficiently in producing the given level of outputs with the least amount of inputs. Technical inefficiency is found to be positively and significantly associated with the ownership dummy variable(OWNP). This finding implies that public sector banks' inefficient performance in relative to private counterparties in terms of optimal input resource utilization and appropriate scale of operation has adversely affected the industry's performance in India. The negative and significant influence of market concentration (MRKC) as indicated by the HHI variable, on technical inefficiency, appears to infer that a greater extent of market power improves efficiency.

As regards macroeconomic factors, both economic growth (EGRW) and inflation(INFN) are found to be negatively and significantly associated with technical inefficiency.. Due to the increasing demand for financial services and the flow of funds during the economic boom period, the finding suggests that an increase in economic activity enhances bank efficiency. According to Batayneh et al. (2021), during inflationary periods, a lack of finances and higher expenditure on goods and services owing to inflated prices constrain investments for production expansion andeconomic growth. However, the negative impact of inflation on a bank's technical inefficiency in the present study implies that Indian banking regulators efficiently adjusted interest rates during the inflationary period, and accordingly, banks took necessary measures to control the use of input resources, resulting in a lower level of inefficiency.

Table 5: Result of Tobit Regression Analysis

Explanatory Variables	**Coefficient**	**Bootstrap Std. Error**	**z**	**p-value**
Bank-specific variables				
SIZE	0.0039	0.0053	0.73	0.4680
PROF	-0.0218**	0.0068	-3.21	0.0010
DIV	0.0090	0.0095	0.95	0.3430
EMP	0.0033	0.0223	0.15	0.8840
CDR	0.0036	0.0028	1.28	0.2000
MGQ	-0.0190	0.0159	-1.2	0.2310
LQDT	0.0082	0.0126	0.65	0.5180
FSDN	-0.0024*	0.0007	-3.58	0.0000
Industry-specific variables				
OWNP	-0.1486*	0.0381	-3.9	0.0000
MRKC	-0.0383*	0.0056	-6.81	0.0000
Macroeconomic variables				
EGRW	-0.1579*	0.0260	-6.07	0.0000
INFN	-0.0413*	0.0025	-16.35	0.0000
Constant	1.1114*	0.2392	4.65	0.0000
Number of observation	1140			
Log likelihood	399.36724			
Wald chi2	696.56*			
p-value	0.0000			

Source: Author's calculation

Note: * and **indicate significant at the .01 and .05 levels of significance, respectively

Conclusion

The objective of the present study is to determine what causes technical inefficiency in the banking sector of India. For this purpose, a two-stage analysis has been conducted employing DEA in the first-stage to measure technical efficiency and the Tobit regression model in the second-stage to examine what explains the variation in technical inefficiency scores. According to the DEA findings, the primary cause of technical inefficiency is scale inefficiency in India. Thus, it is recommended that the banks under evaluation, regardless of their types of ownership, need to develop a new production technology to reduce the adverse effect of diseconomies of scale. The public sector banks, which are responsible for a larger share of the industry's technical inefficiencies are suggested to follow the best practices of their private counterparties to minimize the wastage of input resources in the process of earning income. The Tobit regression analysis results, further, recommend enhancing profitability and financial soundness to improve technical efficiency. The study confirms that highly concentrated markets, rising demand for financial services and the flow of cash during the period of economic boom, and efficiently regulated inflationary crises lead to an increase in banks' technical efficiency.

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