A COMPARATIVE ANALYSIS OF PROFIT PERFORMANCE OF BANKING SECTOR IN INDIA: A THREE STAGE APPROACH

R. MARIAPPAN

Assistant Professor, Department of Econometrics, University of Madras, Chennai, Tamil Nadu, India. E-mail: drrmmetrics@gmail.com

Abstract: The aim of this paper is to empirically explore a comparative profit efficiency of the banking sectors operating in India applying the DEA and SFA techniques and then the determinants of profit efficiency employing Logit technique over the period of 2005-2022. The DEA results indicate that public and private sectors banks have performed better in profit efficiency with the given technology. The overall profit inefficiency score is registered more in foreign sector banks followed by public and private sectors banks. During 2020-2021, the estimated results of DEA indicate that the commercial banks could not perform the profit efficiently in all banks groups which may be due to Covid-19. The estimated SFA parameters of the TLA, PPC, PL and PLF have positive and statistically significant effect on the total profit in all specifications by bank ownerships. The Logit regression results reveal that the coefficients of CR, ROA and DMR, OCE have expected signs and significant effect on the PTE of the commercial banks by bank ownerships. The empirical finding of the paper will be helpful to the policymakers and bank owners to improve the profit performance of commercial banks of India by choosing an appropriate input-output mix.

Keywords: Banking Sector, DEA, Logit, SFA, Profit Efficiency

JEL Classification: G21, C14, C21, H21, C33.

TO CITE THIS ARTICLE:

Introduction

The financial sector comprises the commercial banks, insurance companies, non-banking companies, cooperatives, mutual funds, smaller financial entities, etc. The Indian banking system is well established after independence of

India for serving the financial needs of the Indian people and economy. Still, the financial sector is dominated by banking sector (Banna, Ahmad & Koh, 2017) because the banking sector is the backbone of the financial sector. The commercial banks are the financial institutions that channel the funds to industries and households in the form of intermediate resources from the depositor to the lender for their mutual benefit, stable prices, high level of employment, needs of individuals, micro and macro-economic activities of the economy largely depend on banking sector (Rahman, et al, 2015). The economists Schumpeter (1952), Gurley & Shaw (1955) and Goldsmith (1969) have argued that financial sector particularly the banking sector plays a significant role in stimulating economic growth. Generally, the banking sector is classified into three categories viz. public sector, private sector and foreign sectors banks. Initially, the government of India nationalised 14 private banks in 1969 followed by 6 private banks in 1980. Since 1969, the nationalised banks have been playing a commendable role in terms of lending, borrowing and achieving the economic growth of India. The economic reforms with the liberalization of the Indian economy began in the 1990s. It has been allowing the private and foreign banks sectors banks enter into the Indian financial sector market. However, most of the nationalised commercial banks have been facing various pressures in the forms of internal and external competitions, technological innovation, information technology, modern banking services, internet banking, huge administrative expenses, non-performing assets, etc. (Shanmugam & Das, 2004 and Beck, 2006).

To solve these problems, the government of India has formed various banking sector reforms committees after 1991 to enhance efficiency and stability of the public sector banks and ensure the accessibility of adequate credit facilities for Indian economic growth. The various reforms committees have recommended the following key measures for public sector banks which include improving cash ratio, liquidity ratio, improving credit delivery to the small-scale sector, recapitalization of weak banks, the strengthening of bank management, promoting financial stability, reducing the government's stake in public sector banks to less than 33 per cent, capital adequacy, asset quality, increasing financial inclusion, regulatory framework, merger and consolidation and financial technology, etc.

In this context, increasing competition in the Indian banking sector and also impact of various banking reforms measures are essential to inspect whether the banking sector reforms are really beneficial to the Indian banking sector under the evaluation of the profit technical efficiency. The measurement of

banking sector performance in the form of technical efficiency, cost efficiency, revenue efficiency and profit efficiency has been receiving a significant interest among the Indian researchers. The term efficiency refers to the best allocation of resources to obtain the highest level of output. The efficiency reflects the ability of the banks to obtain maximum profit from the given cost of inputs (Farrell, 1957; Drucker, 1963). The efficiency of the banks depends on the bank-specific elements such as bank capitalization, profitability, inflation rate, real interest rate, competitions, and bank ownership effect (Banna, Ahmad & Koh, 2017). The present study has collected only closely related available existing Indian studies about profit-oriented efficiency covering the period 2005-2022.

Review of Literature

A large number of international studies have examined the banks efficiency in the form of technical efficiency, cost efficiency, revenue efficiency and profit efficiency using DEA and SFA techniques in the developing and developed countries in the world. Hence, it is very difficult to review all the existing literature in this study. In the Indian context, the study briefly reviews only the closely related available existing Indian studies conducted on the profit oriented efficiency of the banking by bank ownerships using Data Envelopment Analysis (DEA), Stochastic Frontier Analysis (SFA) and Logit techniques.

Das *et al.* (2005) examined the cost, revenue and profit efficiency of the Indian commercial banks for the period 1997-2003 using the DEA. The estimated results show that the input-oriented, output-oriented and cost efficiency measures are more or less similar, but the results of revenue and profit efficiencies differ sharply during this period. They find that bank size, ownership, and stock exchange have a positive impact on the profit efficiency and revenue efficiency. Sensarma (2005) examined the cost and profit efficiency of all scheduled commercial banks in India during the period 1986-2003 using the stochastic frontier analysis. The results show that the cost efficiency of the banking industry increased during the period, but profit efficiency underwent a decline. The results indicate that the domestic banks appear to be more efficient than foreign banks.

Das and Ghosh (2009) revealed that high levels of cost efficiency and lower levels of profit efficiency reflect the inefficiencies on the revenue side of banking activity. The decomposition of profit efficiency shows that a large portion of outlay lost is due to allocative inefficiency of banks. Ray and Das

(2010) investigated the cost and profit efficiency of Indian banks during the post-reform period using the nonparametric DEA methodology. The results indicate that there is a significant variation in average level of profit efficiency across various bank ownerships. The results also indicate that public sector banks are more efficient when compared to private sector banks, and small banks. They find that the state owned banks to be more efficient than their private counter parts. The results reveal a rightward-shift of the efficiency distribution over the years. The study finds strong evidence of ownership explaining the efficiency differential of banks

Reddy & Nirmala (2013) examined profit efficiency and its determinants in Indian commercial banks during the post-reform period (1996-2008) using the SFA. The study finds that profit efficiency of Indian commercial banks is increasing over the study period. However, in average, Indian banks could meet only three-fourths of their profit-generating potentialities relative to the best-practice bank, due to technical inefficiency, which is arising within the banks. Among the bank groups, it is revealed that the state-owned banks are relatively more efficient than their counterparts. The technical inefficiency effects model shows that bank-specific, market, and organizational characteristics play an important role in determining the profit efficiency of banks.

Jayaraman & Srinivasan (2014) examined the profit efficiency of banks using Nerlovian profit indicator approach. The study indicates that profit inefficiency of banks is primarily due to allocative inefficiency and technical inefficiency. The results indicate that the public sectors banks are more efficient when compared to private sector banks and small banks. The decomposition results of profit efficiency show that a large portion of outlay loss is due to allocative inefficiency of banks. Mahendru & Bhatia (2017) analysed the cost, revenue and profit efficiency performance of Indian scheduled commercial banks. The study also finds differences if any related to efficiency among banks on the basis of ownership pattern .The Indian scheduled commercial banks have not been able to maintain their input-output synchronization in terms of cost, revenue and profits in the year 2012-2013. Foreign sector banks have higher cost and profit efficiency as compared to their counterparts in private and public sector, whereas public sector banks are found to have been more revenue efficient.

Suzan *et al.* (2022) examined the impact of banking efficiency on the profitability of the Indian banking division using RBI data sets from 2001 to 2020. They used pooled panel regression; univariate analysis and correlation with unbalanced cross-sectional data (panel data) comprising 527 bank-year

observations for 33 Indian banks. The results reveal that the cost of income ratio has a significant negative impact on the bank return on assets and net interest margin ratio. The ratio of staff expenses to total expenses have a significant positive impact on the bank return on assets and have a positive non-significant impact on the bank net interest margin ratio.

Rakshit (2023) analysed the effects of cost, revenue and profit efficiency on bank performance of Indian banking sector using SFA in the first stage over the period 1997 to 2017. In the second stage, this study further examined the effect of several efficiency measures on bank profitability across different ownership groups for a panel of 70 Indian commercial banks. The SFA results show that the public sector banks are most cost-efficient compared to private and foreign banks. The results of generalized-method of moments indicate that a higher level of cost, revenue and efficiency significantly improved India's bank profitability. The results indicate that the macroeconomic and institutional variables have played a significant role in determining bank profitability.

A cursory glance at the available literature indicate that a larger number of studies have mainly focused on the technical & cost efficiency of banks in India. Few empirical studies concentrated on profit efficiency of the banking sector in India using DEA technique and they are out dated. Available literature reveals that any Indian study never attempted a comparative analysis of profit efficiency of the banking sectors and its determinants using DEA, SFA and Logit techniques. The present study differs from the existing Indian studies in three ways: (i) the time period (2005-2022) taken in the analysis (ii) the SFA and Logit techniques and (iii) a comparative analysis banks ownerships operating in India. Therefore, the present study differs from these and fulfils this literature gap in the Indian banking sector. The study's findings will be helpful to the economists, policymakers and bank ownerships to take appropriate strategies to improve the inefficiency of the commercial banks are operating in India.

Econometric Methodology

Sample Banks

The present study has selected the following public sector (nationalised banks) commercial banks, private sector commercial banks and foreign sector commercial banks operating in India since 2005 based on the RBI data source which are presented in Table 1.

Table 1: List of the Selected Sample Banks Operating in India

Public Sector Banks	Private Sector Banks	Foreign Sector Banks
Allahabad Bank(ALB)	Axis Bank Ltd(AXIS)	AB Bank Limited(AB)
Andhra Bank(ANB)	Catholic Syrian Bank Ltd(CSB)	Abu Dhabi Commercial Bank PJSC (ACB)
Bank of Baroda(BOB)	City Union Bank Ltd(CUB)	Bank of America, National Association(BOA)
Bank of India(BOI)	DCB Bank Ltd(DCB)	Bank of Bahrain & Kuwait B.S.C.(BBK)
Bank of Maharashtra(BOM)	Federal Bank Ltd(FB)	Bank of Ceylon(BOC)
Canara Bank(CNB)	HDFC Bank Ltd.(HDFC)	Bank of Nova Scotia(BONS)
Central Bank of India(CBI)	ICICI Bank Ltd(ICICI)	Barclays Bank PLC(BBPLC)
Corporation Bank(CB)	Indusind Bank Ltd(IBL)	BNP Paribas(BNPP)
Dena Bank (DNB)	Jammu & Kashmir Bank Ltd(J &K)	CitiBank N.A (CITI.N)
IDBI Bank Limited(IDBI)	Karnataka Bank Ltd(KB)	Credit Agricole Corporate And Investment Bank (CACI)
Indian Bank(IB)	KarurVysya Bank Ltd(KVB)	Credit Suisse Ag(CSAG)
Indian Overseas Bank(IOB)	Kotak Mahindra Bank Ltd. (KMB)	CTBC Bank Co., Ltd.(CTBC)
Oriental Bank of Commerce (OBC)	Lakshmi Vilas Bank Ltd(LVB)	DBS Bank India Ltd(DBS)
Punjab Sind Bank(PSB)	Nainital Bank Ltd(NB)	Hongkong And Shanghai Banking Corpn.Ltd.(HSBC)
Punjab National Bank(PNB)	RBL Bank Limited(RBLB)	JPMorgan Chase Bank National Association(JCBNA)
State Bank of India (SBI)	South Indian Bank Ltd(SIB)	MIZUHO Bank Ltd(MIZUHO)
Syndicate Bank (SYB)	Tamilnad Mercantile Bank Ltd(TMB)	MUFG Bank Ltd (MUFG)
Union Bank of India (UOB)	Dhanalakshmi Bank Ltd(DB)	Royal Bank of Scotland PLC (RBS)
United Bank of India (UBI)	YES Bank Ltd.(YB)	Shinhan BANK(SHINHAN.B)
Vijaya Bank (VB)		Standard Chartered Bank (SCB)

Source: Reserve Bank of India

Source of Data

The study collected the required inputs and outputs data sets of commercial banks for this analysis over the period 2005-2022 from the Statistical Tables relating to banks published by the Reserve Bank of India (RBI). The essential data sets are not available consistently for all banks for all years since many private and foreign sectors banks are established after 2005. As a result, the present study has an unbalanced panel of 59 banks for 18 years. The bank sectors are

classified into public (nationalised banks), private and foreign sectors banks. Due to the non-availability of data sets for some banks, the study limits only 59 banks including 20 public sector banks, 19 domestic private sector banks and 20 foreign sector banks.

Two popular techniques namely the non-parametric (mathematical) and parametric (econometric) approaches are commonly proposed to measure the efficiency of decision-making units (DMUs) (Farrell, 1957; Aigner, Lovell and Schmidt, 1977; Timmer, 1971; Coelli *et al.*, 1998). The parametric technique is the Stochastic Frontier Approach (SFA) and non-parametric is the Data Envelopment Analysis (DEA). In this study, both DEA and SFA approaches are applied for assessing the profit efficiency of the commercial banks operating in India during the period 2005-2022 with help of the DEA-Frontier, and STATA Software.

The DEA-CCR and DEA-BCC techniques convert the multiple inputs of the DMU into scalar efficiency score by assigning weights to the inputs and outputs of the DMU. The input-oriented DEA-CCR model under the assumptions of the Constant Returns to Scale (CRS) is developed by Charnes, Cooper, and Rhodes (1978). Similarly, DEA-BCC model under the assumptions of the variable returns to scale (VRS) is developed by Banker, Charnes and Cooper (1984). Both techniques are most frequently applied by empirical studies to compute the efficiency score. The input-oriented BCC model is an extension of the CCR model, where the efficient frontiers set to represent a convex curve passing through all efficient DMUs. The input-oriented CCR and BCC for profit technical efficiency models are specified in equations (1) and (2).

DEA-CCR (1)

$$\pi = \text{Max } \Sigma_{r=1}^{s}. \text{ PrqYrq} - \Sigma_{i=1}^{m}. \text{ Wiq.Xiq}$$

Subject to Conditions

$$\Sigma_{j=1}^{n}. \lambda j X_{ij} \leq \text{Xiq}$$

$$\Sigma_{j=1}^{n} \lambda j \ Y_{rj} \geq \text{Yrq}$$

$$\lambda j \geq = 0$$

DEA-VRS (2)

$$\pi = \text{Max } \Sigma_{r=1}^{s} \text{ PrqYrq} - \Sigma_{i=1}^{m}. \text{ Wiq.Xiq}$$

Subject to Conditions

$$\Sigma_{j=1.}^{n} \lambda j X_{ij} \leq \text{Xiq}$$

$$\Sigma_{j=1}^{n} \lambda j \ Y_{rj} \geq \text{Yrq}$$

$$\Sigma_{k=1}^{n} \lambda j \ =1$$

$$\lambda j \geq = 0$$

Where, λ_{jj} =1,2,…n are weights of DMUs, W_{iq}- is a vector of input prices of DMUq, X_{ij} is the amount of ith input used by j^{th} DMU, Y_{rj} is the amount of

r^{th} profit produced by j^{th} DMU, γ_j is Profit Efficiency score for the DMUp, i = 1, 2, ...m^{th} input observation, r = 1, 2, ...s^{th} output observation, j = 1, 2, ...n^{th} DMU observation, Each DMU takes 'm' different inputs to produce 's' different profit.

Stochastic Frontier Analysis Model

The earlier empirical studies have broadly employed the SFA technique to measure the profit technical efficiency parameters of the commercial banks. This technique is considered to be more sophisticated when compared to DEA technique. Both techniques differ according to the assumptions of the data set and technology. The DEA ignores the composite random error terms that can influence the efficiency (V) and inefficiency (U) of the banks. But we obtain these two error terms applying SFA. The stochastic frontier Transcendental profit function is specified as:

$$\ln T\pi_{it} = \alpha_0 + \alpha_1 \ln(TLA) + \alpha_2 \ln(OLA) + \alpha_3 \ln(PPC) + \alpha_4 \ln(PFA) + \alpha_5 \ln(PL) + \alpha_6 \ln(PLF) + \tfrac{1}{2} \alpha_7 \ln(TLA)^2 + \alpha_8 \ln(TLA) * \ln(OLA) + \alpha_9 \ln(TLA) * \ln(PPC) + \alpha_{10} \ln(TLA) * \ln(PFA) + \alpha_{11} \ln(TLA) * \ln(PL) + \alpha_{12} \ln(TLA) * \ln(PLF) + \tfrac{1}{2} \alpha_{13} \ln(OLA)^2 + \alpha_{14} \ln(OLA) * \ln(PPC) + \alpha_{15} \ln(OLA) * \ln(PFA) + \alpha_{16} \ln(OLA) * \ln(PL) + \alpha_{17} \ln(OLA) * \ln(PLF) + 1/2 \alpha_{18} \ln(PPC)^2 + \alpha_{19} \ln(PPC) * \ln(PFA) + \alpha_{20} \ln(PPC) * \ln(PL) + \alpha_{20} \ln(PPC) * \ln(PLF) + \alpha_{21} \ln(PFA)^2 + + \alpha_{22} \ln(PFA) * \ln(PL) + \alpha_{23} \ln(PFA) * \ln(PLF) \ 1/2 \alpha_{24} \ln(PL)^2 + \ln(PL) * \ln(PLF) + 1/2 \alpha_{25} \ln(PLF)^2 + v_{it +(} -u_{it)}$$

(3)

Where; $T\pi_{it}$ denotes the total profit for sample bank (i), α_s are vectors of unknown parameters. v_{it} and u_{it} are technical error terms. The non-negative random variable u_{it} lies between 0 and 1 and it is associated with technical inefficiency of the banks. For the efficient banks, the values of u_{it} are equal to 0, it means that the banks produce potential output. For the inefficient banks, the values of u_{it} are greater than 0, which means that the banks produce below the potential output. In order to capture the effects of omitted variables, the random noise error terms (v_{it}) can also be included in the equation (3). The v_{it} are the random variables which are assumed to be independently distributed as truncations with mean 0 and variance $\sigma^2 v$. The measurement of SFA method is in the form of score between 0–1.

Logit Regression Model

Available empirical studies (Singh & Fida, 2015; Lema, 2017) have estimated the determinants of the technical efficiency of the banks applying Tobit model since the DEA technical efficiency score falls within the interval 0 and 1. Therefore,

McDonald (2009) considered the Tobit as an inappropriate model and it is also known as the censored regression model since the value of technical efficiency is a fraction of continuous variable (dependent variable), which is not generating a censoring process. The following empirical studies (Kumar & Gulati, 2008; Adusei, 2016) recommended that the Logit model would be a suitable model to examine the determinants of profit technical efficiency of the banks. In the Logit model, dependent variable (Profit efficiency) is a binary variable. It takes the value equal to 1 for an efficient bank and it takes the value equal to 0 for an inefficient bank. Therefore, the study uses the Logit model to examine the determinants of profit efficiency. The specification of the Logit Model can be written as:

$$PE_{i,t}\left[\frac{Pi}{1-Pi}\right] = \alpha + \beta_1 FC_{i,t} + \beta_2 AC_{i,t} + \beta_3 TA_{i,t} + \beta_4 IM_{i,t} + \beta_5 MS_{i,t} + \beta_6 CR_{i,t} + \beta_7 OS_{i,t} + \mu \quad (4)$$

Where, Pi denotes the probability of occurrence of events (Bank profit efficiency), 1-Pi denotes the probability of non-occurrence of events (Bank profit inefficiency) in the observation, the subscript 'i' denotes i^{th} observation of bank, the subscript 't' denotes the time series data t^{th} observation, β_0 denotes the 'intercept', from β_1 to β_7 denotes unknown coefficients corresponding to input variable and μ denotes the stochastic 'error' term.

Definition and Measurement of the Variables

The definitions and measurements of the dependent and independent variables used in the DEA, SFA and Logit techniques analyses are reported in Table 2. All the input variables and output variables are measured in Indian Rupees.

Table 2: Measurement of Output-input Variables used in the DEA, SFA and Logit Analyses

Data Envelopment Analysis		
Variable Name &Notation		Measurement of the Variable (in Crore)
OV	Total Investments (TI)	Investments inside & outside in India by Banks
	Total Advances (TA)	Advances by banks (loans)
IV	Total Deposits (TD)	Sum of demand, time and saving deposit.
	Total Borrowings (TB)	Borrowing by Banks
	Total Fixed Assets (TFA)	Fixed assets of the banks
	Total Workers (TW)	Number of workers
Stochastic Frontier Analysis		
DV	Total Profit (TP)	Total profit is, before tax, total cost deducted from total income

IV	Total Loans &Advances (TLA)	Payment on gross advances or loans by banks (loans)
	Other Earning Assets (OEA)	Total earning assets-loans
	Price of Physical Capital (PPC)	Operating expenditure for salaries and allowances
	Price of Labour (PL)	Price of Labour cost is calculated as total staff expenses
	Price of Loanable funds (PLF)	Interest of loanable funds
	Price of Fixed Assets (PFA)	Price of assets such as buildings, furniture, computers, etc
Logit Analysis		
DV	Profit Technical Efficiency (PTE)	The efficiency score derived from DEA
IV	Credit Risk (CR)	Ratio of Loans to Deposits
	Return on Assets (ROA)	Ratio of net income to Total assets
	Diversify Mitigate Risk (DMR)	Ratio of Non-interest income to Total assets
	Operating costs efficiency (OCE)	Ratio of Total deposit to Total asset
	Organization's efficiency (OE)	Ratio of Total cost to Total income
	Cash and Short Term Investments (CSI)	Ratio of Cash to Total assets
	Management Operating Expense (MOE)	Ratio of Operating expenses to Total assets
	Leverage ratio (LR)	Ratio of Debt to Assets

Note: OV = Output Variables, IV = Input Variables, DV= Dependent Variable, IV= Independent Variables

Results and Discussions

The estimated DEA results of Profit technical Efficiency (PTE), Profit Pure technical Efficiency (PPTE) and Profit Scale Efficiency (PSE) scores for 20 public sector banks, 19 domestic private sector banks and 20 foreign sector banks are reported in Tables 3. The estimated results of input-oriented efficiency scores obtained from CCR and BCC models during the period of study are asymmetrical among the bank ownerships. The DEA results reveal that the public and private sectors banks have performed the highest profit technical efficiency scores during 2005-2022. The estimated results of DEA show that the public, private and foreign sector banks' PTE scores are not equal to 100 per cent, although all bank groups got their components of efficiency scores more than 90 per cent. The overall mean efficiency (OME) of the banks in the entire sample is 0.948 which indicates that most of the public sector (nationalised) banks are close to the maximum possible profitability. A lowest profit efficiency scores are recorded in all banks ownerships during 2020-2021. One of the main reasons that the commercial banks could not perform efficiently is due to Covid-19.

<p align="center">Table 3: Estimated DEA Results of the Mean Profit Efficiency of Commercial Banks</p>

Public Sector Banks				*Private Sector Banks*				*Foreign Sector Banks*			
Banks	*PTE*	*PPTE*	*PSE*	*Banks*	*PTE*	*PPTE*	*PSE*	*Banks*	*PTE*	*PPTE*	*PSE*
ALB	0.966	0.973	0.991	AXIS	0.960	0.994	0.965	AB	0.918	0.989	0.924
ANB	0.940	0.965	0.944	CSB	0.980	0.991	0.988	ACB	0.728	0.890	0.819
BOB	0.945	0.950	0.948	DCB	0.915	0.959	0.940	BOA	0.927	0.943	0.931
BOI	0.908	0.930	0.932	FB	0.962	0.986	0.976	BBK	0.817	0.908	0.865
BOM	0.932	0.984	0.937	HDFC	0.973	1.000	0.973	BOC	0.966	0.998	0.967
CNB	0.928	0.950	0.944	ICICI	0.961	1.000	0.961	BONS	0.931	0.951	0.936
CBI	0.961	0.997	0.963	IBL	0.958	0.958	1.000	BB PLC	0.950	0.951	0.994
CB	0.996	1.000	0.996	J & K	0.915	0.920	0.991	BNP	0.868	0.938	0.903
DNB	0.979	0.997	0.983	KBL	0.952	0.973	0.976	CITI.N	0.872	0.945	0.873
IDBI	0.997	0.998	0.999	KVB	0.980	0.994	0.986	CACI	0.937	0.956	0.943
IB	0.951	0.972	0.961	KMB	0.943	0.950	0.967	CS AG	0.926	0.973	0.933
IOB	0.943	0.970	0.951	LVB	0.942	0.956	0.949	CTBC	0.860	0.926	0.903
OBC	0.933	0.956	0.953	NB	0.981	0.989	0.992	DBS	0.808	1.000	0.808
PSB	0.948	1.000	0.948	RBLB	0.976	0.995	0.982	HSBC	0.878	0.938	0.882
PNB	0.937	0.947	0.951	SIB	0.928	0.952	0.969	JCBNA	0.941	0.946	0.941
SBI	0.942	0.944	0.962	TMB	0.958	0.977	0.981	MIZUH	0.936	1.000	0.936
SYB	0.930	0.954	0.938	DBL	0.944	1.000	0.944	MUFG	0.853	0.867	0.877
UOB	0.942	0.968	0.942	YBL.	0.882	0.891	0.882	RBS	0.873	0.889	0.927
UBI	0.942	0.955	0.950					SHINH	0.871	0.932	0.883
VB	0.939	1.000	0.939					SCB	0.947	1.000	0.947
OME	**0.948**	**0.971**	**0.957**		0.951	0.971	0.968		0.890	0.947	0.910
OMIE	0.052	0.030	0.043		0.049	0.029	0.032		0.110	0.053	0.090

Source: *Author's calculations,*
Note: OME = Overall Mean Efficiency, OMIE= Overall Mean Inefficiency

The estimated DEA results of trends (time-varying) mean profit efficiency scores along with its components of PTE, PPTE and PSE are reported in Table 4. The results show that the PTE scores have more or less similar trends observed both in private and private sector banks. The results show that the profit technical efficiency (PTE) scores of foreign sector banks are lower than that of public and private sector banks. This finding is similar to the previous empirical studies of Jayaraman & Srinivasan (2014), but dissimilar to the previous empirical studies of Mahendru & Bhatia (2017).

Table 4: Estimated DEA Results of the Time-varying Mean Profit Efficiency of Commercial Banks

Year	Efficiency Types	Public Sector Banks			Private Sector Banks			Foreign Sector Banks		
		Min	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*
2005	PTE	0.947	1.000	0.991	0.875	1.000	0.982	0.648	1.000	0.936
2006	PTE	0.886	1.000	0.993	0.913	1.000	0.983	0.586	1.000	0.946
2007	PTE	0.978	1.000	0.998	0.895	1.000	0.987	0.449	1.000	0.928
2008	PTE	0.955	1.000	0.997	0.878	1.000	0.977	0.836	1.000	0.973
2009	PTE	0.974	1.000	0.998	0.891	1.000	0.976	0.629	1.000	0.952
2010	PTE	0.931	1.000	0.989	0.921	1.000	0.981	0.772	1.000	0.983
2011	PTE	0.958	1.000	0.994	0.902	1.000	0.978	0.326	1.000	0.834
2012	PTE	0.992	1.000	0.999	0.911	1.000	0.988	0.383	1.000	0.913
2013	PTE	0.926	1.000	0.993	0.922	1.000	0.989	0.405	1.000	0.942
2014	PTE	0.908	1.000	0.985	0.902	1.000	0.986	0.811	1.000	0.980
2015	PTE	0.956	1.000	0.993	0.929	1.000	0.995	0.848	1.000	0.992
2016	PTE	0.888	1.000	0.982	0.934	1.000	0.991	0.762	1.000	0.979
2017	PTE	0.815	1.000	0.979	0.863	1.000	0.979	0.736	1.000	0.965
2018	PTE	0.956	1.000	0.997	0.938	1.000	0.990	0.734	1.000	0.925
2019	PTE	0.856	1.000	0.965	0.811	1.000	0.978	0.695	1.000	0.922
2020	PTE	0.006	1.000	0.159	0.000	1.000	0.425	0.010	1.000	0.114
2021	PTE	0.931	1.000	0.986	0.877	1.000	0.971	0.020	1.000	0.865
2022	PTE	0.985	1.000	0.999	0.840	1.000	0.965	0.100	1.000	0.860
OME :2005-2022		0.880	1.000	0.944	0.845	1.000	0.951	0.534	1.000	0.889
2005	PPTE	0.949	1.000	0.994	0.965	1.000	0.998	0.688	1.000	0.972
2006	PPTE	0.896	1.000	0.994	0.923	1.000	0.992	0.621	1.000	0.962
2007	PPTE	1.000	1.000	1.000	0.901	1.000	0.988	0.603	1.000	0.971
2008	PPTE	0.994	1.000	1.000	0.889	1.000	0.982	0.949	1.000	0.997
2009	PPTE	0.993	1.000	1.000	0.906	1.000	0.988	0.657	1.000	0.970
2010	PPTE	0.955	1.000	0.996	0.926	1.000	0.985	0.985	1.000	0.999
2011	PPTE	0.958	1.000	0.997	0.905	1.000	0.990	0.521	1.000	0.961
2012	PPTE	1.000	1.000	1.000	0.949	1.000	0.995	0.406	1.000	0.954
2013	PPTE	0.942	1.000	0.995	0.979	1.000	0.999	0.448	1.000	0.965
2014	PPTE	0.936	1.000	0.996	0.952	1.000	0.995	0.816	1.000	0.990
2015	PPTE	0.992	1.000	1.000	0.942	1.000	0.996	1.000	1.000	1.000
2016	PPTE	0.922	1.000	0.990	0.976	1.000	0.998	0.860	1.000	0.993
2017	PPTE	0.974	1.000	0.996	1.000	1.000	1.000	0.887	1.000	0.994
2018	PPTE	1.000	1.000	1.000	1.000	1.000	1.000	0.750	1.000	0.966
2019	PPTE	0.911	1.000	0.991	0.967	1.000	0.998	0.843	1.000	0.970
2020	PPTE	0.040	1.000	0.493	0.139	1.000	0.609	0.006	1.000	0.388
2021	PPTE	0.947	1.000	0.992	0.878	1.000	0.988	0.800	1.000	0.989
2022	PPTE	1.000	1.000	1.000	0.850	1.000	0.977	0.889	1.000	0.994
OME :2005-2022		0.911	1.000	0.968	0.892	1.000	0.971	0.707	1.000	0.946
2005	PSE	0.971	1.000	0.997	0.875	1.000	0.984	0.648	1.000	0.963
2006	PSE	0.989	1.000	0.999	0.920	1.000	0.991	0.777	1.000	0.980

Year	Efficiency Types	Public Sector Banks			Private Sector Banks			Foreign Sector Banks		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
2007	PSE	0.978	1.000	0.998	0.991	1.000	0.999	0.492	1.000	0.953
2008	PSE	0.955	1.000	0.997	0.967	1.000	0.994	0.863	1.000	0.976
2009	PSE	0.974	1.000	0.998	0.904	1.000	0.988	0.760	1.000	0.981
2010	PSE	0.931	1.000	0.993	0.974	1.000	0.996	0.772	1.000	0.984
2011	PSE	0.979	1.000	0.998	0.915	1.000	0.987	0.446	1.000	0.861
2012	PSE	0.992	1.000	0.999	0.911	1.000	0.993	0.650	1.000	0.955
2013	PSE	0.983	1.000	0.998	0.922	1.000	0.990	0.819	1.000	0.975
2014	PSE	0.908	1.000	0.988	0.902	1.000	0.991	0.842	1.000	0.990
2015	PSE	0.956	1.000	0.994	0.985	1.000	0.999	0.848	1.000	0.992
2016	PSE	0.943	1.000	0.992	0.934	1.000	0.993	0.762	1.000	0.986
2017	PSE	0.815	1.000	0.983	0.863	1.000	0.979	0.815	1.000	0.971
2018	PSE	0.956	1.000	0.997	0.938	1.000	0.990	0.743	1.000	0.957
2019	PSE	0.856	1.000	0.974	0.811	1.000	0.980	0.700	1.000	0.949
2020	PSE	0.021	1.000	0.248	0.100	1.000	0.655	0.100	1.000	0.186
2021	PSE	0.964	1.000	0.993	0.925	1.000	0.983	0.200	1.000	0.874
2022	PSE	0.985	1.000	0.999	0.939	1.000	0.988	0.100	1.000	0.865
OME :2005-2022		0.898	1.000	0.953	0.871	1.000	0.971	0.608	1.000	0.911

Source: Author's calculations
Note: OME: Overall Mean Efficiency

Results of SFA

The estimated results of the Stochastic Frontier Translog Profit functions are presented in Table 5. The estimated parameters of the TLA, PPC, PL and PLF have positive and significant effect on the total profit in all the specifications by bank ownerships. The estimated results suggest that 1 per cent increase in TLA leads to increase of 0.53 units, 0.32 units and 0.17 units in the total profit of public, private and foreign sector banks respectively, ceteris paribus. The estimated results suggest that 1 per cent increase in PPC leads to increase of 0.30 units, 0.34 units and 0.43 in the total profit of public, private and foreign sectors banks respectively. Additional 1 per cent increase in PL also leads to increase of 0.29 units, 0.17 units and 0.18 units in total cost of public, private and foreign sectors banks respectively. The results implies that 1 per cent increase in price of PLF leads to 0.43 units and 0.58 units, and 0.12 units increase in the total profit of public, private and foreign sectors banks respectively. The results suggest that the institutional variables TLA, PPC, PL and PLF have played a significant role in determining bank profitability. This finding confirms the finding by Rakshit (2023**).**

The estimated results of σ^2 showed that the total amount of variance in the profit functions. Gamma gives the ratio of variance of the inefficiency term

over the total amount of variance. The σ^2 values are positive and strongly significant in all specifications by types of bank ownership. The estimated results show that the parameters of all the interaction and square terms have mixed effect on the total profit functions by bank ownerships in India. The estimated technical terms σ^2 and γ are positive and statistically significant at 1 per cent level, indicating that the observed total profit significantly differ from frontier profit due to factors, which are within the control of banks by bank ownerships. The estimated σ^2 values are (not close to unity) 0.727 for profit function which showed the strong impact of inefficiency score to the private banks' profit variance.

To assess the performance of efficiency factors, the present study uses the γ parameter, which is the ratio of the change due to inefficiency to the total change in the residuals of the regression model. The estimated γ values 0.823, 0.747 and 0.505 imply that about 74.7 per cent, 82.3 per cent and 50.5 per cent of the difference between the actual profit and potential profit are mainly due to profit inefficient performance of banks public, private and foreign sector banks respectively. The value of must lie between 0 and 1. If the closer rate of γ is equal to 1, then there is smaller the impact of the random error term (v), which means that γ is determined by non-negative error term (u). Conversely, if the closer rate of γ is equal to 0, then it means that the profit and cost functions are explained as pure noise.

Table 5: Estimated SFA Results of the Profit Efficiency of Commercial Banks

Variables	Dependent Variable : Total Profit					
	Public Banks		Private Banks		Foreign Banks	
	Coefficient	T-value	Coefficient	T-value	Coefficient	T-value
Intercept	-0.33	-0.30	2.58*	4.23	1.68	2.95
TLA	0.53**	1.61	0.32*	2.67	0.17**	1.70
OEA	-0.26	-0.84	0.66*	4.40	0.22	1.69
PPC	0.30**	0.44	0.34*	0.83	0.43*	3.31
PFA	-0.38	-0.93	-0.14	-1.00	-0.06	-1.20
PL	0.29**	0.39	0.17**	0.43	0.18**	1.13
PLF	0.43**	1.95	0.58*	3.41	0.12	1.20
0.5 *(TLA)^2	0.02	0.40	0.08**	4.00	0.04**	2.00
(TLA) x OEA	0.002	0.007	-0.55	-27.5	-0.03	-1.50
(TLA) x (PPC)	-0.23*	-2.09	0.12	1.71	-0.03	-1.50

(TLA) x (PFC)	0.02	0.40	-0.01	-0.50	0.004	0.001
(TLA) x (PL)	0.18**	1.80	-0.07	-0.88	0.03	1.00
(TLA) x (PLF)	-0.03*	-1.00	-0.05	-1.25	0.03**	1.50
0.5 x (OEA)^2	0.01	0.17	0.05	1.00	0.04	1.00
(OEA) x (PPC)	0.22**	2.44	-0.09	-1.13	-0.03	-1.50
(OEA) x (PFC)	-0.03	-0.75	0.01	0.50	0.001	0.001
(OEA) x (PL)	-0.22*	-2.75	0.02	0.22	0.002	0.001
(OEA) x (PLF)	0.03	1.50	-0.04	-1.00	0.01	0.50
0.5 x (PPC)^2	0.66**	1.83	0.21	0.95	0.03	1.50
(PPC) x (PFC)	-0.05	-0.45	-0.11*	-1.83	0.02	2.00
(PPC) x (PL)	-0.47	-1.38	-0.27	-1.13	0.05**	1.67
(PPC) x (PLF)	-0.05	-0.83	0.13	1.63	-0.10*	5.00
0.5 x (PFC)^2	-0.01	-0.17	-0.01	-0.50	0.003	0.27
(PFC) x (PL)	0.11	1.10	0.09	1.29	-0.03	-1.50
(PFC) x (PLF)	-0.01	-0.33	0.10	3.33	0.003	0.004
0.5 x (PL)^2	0.35	1.03	0.34	1.06	-0.02	-0.33
(PL) x (PLF)	0.03	0.60	0.02	0.25	0.07*	2.33
0.5 x (PLF)^2	0.005	0.50	-0.01	-1.00	0.002	12.0
$\sigma^2 = \sigma^2_u + \sigma^2_v$)	0.120	8.64	0.571	8.93	1.832	16.3
$\gamma = (\sigma^2 u / \sigma^2$)	0.823		0.727		0.505	
Log-Likelihood	-81.6		-421		-1205	
Sample Size	360		360		360	

Source: Author's estimation

Note: (i). * Significant at 1 per cent level, ** Significantat 5 per cent level and *** Significant at 10 per cent level

(ii) Sigma^2 denotes the total amount of variance in the model.

(iii) Gamma gives the ratio of variance of the inefficiency term over the total amount of variance.

Results of Logit

The estimated Logit coefficients of determinants of profit efficiency for the public, private and foreign sectors banks are reported in Table 5. The DEA technical efficiency scores under PTE are regressed on the LR, ROA, DMR, OCE, OE, CSI, MOE and LR. The results reveal that the coefficients of LR, ROA, DMR, OCE and CSI have expected signs and significant effect on the PTE of the commercial banks by bank ownerships. It is also found that LR has a significant positive impact on PTE which reveals that banks with a high level of liquidity earn more.

Table 6: Estimated Logit Results of Determinants of Profit Efficiency of Commercial Banks

Variables	Dependent Variable : Profit Technical Efficiency					
	Public Banks		Private Banks		Foreign Banks	
	Coefficient	T-Value	Coefficient	T-Value	Coefficient	T-Value
Constant	7.978*	3.86	18.430*	6.26	2.088*	1.11
LR	-0.234	0.122	-6.569*	3.54	0.333	8.84
ROA	7.490*	3.37	7.327*	3.86	4.039***	13.7
OCE	3.855*	0.78	0.448***	0.00	0.015	0.20
CR	0.002**	0.001	0.001*	0.00	0.001***	0.00
OE	-0.291*	0.14	1.426*	0.74	-0.018	0.07
CSI	3.43*	1.873	1.160**	1.175	8.331**	23.12
MOE	-1.175***	7.59	-1.523	7.498	8.225	13.5
DMR	2.568*	1.031	5.65**	6.72	0.320	0.245
2lOG LIKELIHOOD	-72.333		-40.246		-58.367	
LR-Chi^2	46.34		29.95		2.95	
Pseudo R^2	0.2426		0.2712		0.0246	
Sample Size	356		341		377	

Source: Author's computation

Note: Standard Errors are given in parenthesis)
* Significant at 1 per cent level, ** Significant at 5 per cent level and *** Significant at 10 per cent level.

The estimated Logit regression results suggest that if all other variables hold constant, then there is an increase in ROA by one per cent, it increases the probability of PTE score by 7.490 per cent in public sector banks, 7.327 per cent in private sector banks and 4.039 per cent in foreign sector banks. ROA implies how effectively a commercial Bank manages its assets to generate revenue. The results suggest that if all other variables hold constant, then there is an increase in OCE by one per cent, it increases the probability of PTE score by 3.855per cent in public sector banks, by 0.448 per cent in private sector banks and by 0.015per cent in foreign sector banks. It indicates that the banks' deposits are the main sources of funds that they can invest to generate income. Therefore, it is a positive association between total deposits and total asset ratio.

Likewise, an increase in CR by one per cent increases the probability of PTE score by about 0.001 per cent in all banking sectors. In the same way, if one per cent increases in the DMR, the probability of PTE score increases by 2.568 per cent in public sector banks, 5.65 per cent in private sector banks and 0.320 per cent in foreign sector banks. The analysis shows that the ROA is a dominant factor in determining the PTE score in all the groups of banks.

The results suggest that if 1 per cent increases in the CR, then it increases the probability of OTE score by approximately 0.272 per cent in public sector banks, 5.09 per cent in private sector banks and 0.93 per cent in foreign sector banks. The results show that LR, OE and MOE have negative effect on PTE and are statistically significant in all baking sector.

Summary and Conclusion

An attempt has been made in this paper to empirically evaluate a comparative profit efficiency of the public, private and foreign sectors banks operating in India covering the period of 2005-2022. To achieve this, the present study applied a Three-Stage approach. In the first stage, profit technical efficiency of each commercial bank is assessed applying DEA and similarly Maximum Likelihood Stochastic Frontier production function is applied in the second stage. The determinants of profit efficiency are estimated using the Maximum Likelihood Logit technique in the third stage. The estimated results show that the public and private sector banks have operated more efficiently during the period 2005 to 2022 with the given technology. The estimated empirical results confirm that the public sector (nationalised) banks have operated more efficiently, because of the impact of the banking sector reforms in India. The results show that the foreign sector banks operated relatively inefficiently when compared to the public and domestic private sectors banks in India. The results of DEA show that the banks could not perform the profit efficiently in all banks ownerships operating in India during 2020-2021which may be due to Covid-19. The estimated SFA parameters of the TLA, PPC, PL and PLF have significant positive effect on the banks' profit in all specifications by bank ownerships. The estimated Logit results show that the coefficients of DMR, LR, OCE and ROA have expected positive signs and significant effect on the PTE of the commercial banks by bank ownerships. The estimated results of the present paper indicate that most of the nationalised banks operating in India are really promoted due to the banking sector reforms. However, there are still certain gaps between the actual and potential profit performance of banks. Therefore, the findings of the present paper will be helpful to the policy-makers and bank owners to make appropriate strategies to resolve the weak efficiency of banks operating in India.

References

Adusei, M. (2016). Determinants of bank technical efficiency: Evidence from rural and community banks in Ghana. *Cogent Business and Management,3*, 1-15.

Aigner, D. J., Lovell, C. A. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6(1), 21-37.

Banker, R.D., Charnes, A., & Cooper, W.W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, *30*(9), 1078–1092.

Banna, H., Ahmad, R., &Koh, E. H.Y. (2017). Determinants of commercial banks' efficiency in Bangladesh: Does crisis matter? *The Journal of Asian Finance, Economics, and Business*, *4*(3), 19–26.

Beck, T. (2006). Creating an efficient financial system: Challenges in a global economy. *Policy Research Working Paper*, World Bank.

Charnes, A., Cooper, W.W., & Rhodes, E. (1978).Measuring the efficiency of decision marking units. *European Journal of Operational Research*, 2, 429-444.

Coelli, T., Prasada Rao, D. S., & Battese, G. E. (1998). An introduction to efficiency and productivity analysis, Springer.

Das, A., Nag, A., & Ray, S. C. (2005). Liberalization, ownership and efficiency in Indian banking: a non-parametric analysis. *Economic and Political Weekly*, 40(12), 1190-1197.

Das, A., & Ghosh, S. (2009). Financial deregulation and profit efficiency: A nonparametric analysis of Indian banks. *Journal of Economic and Business*, *61*(6), 509-528.

Drucker, P.F. (1963).Managing for business effectiveness. *Harvard Business Review*, *41*, 53–60.

Farrell, M.J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society. Series A, 120 (3)*, 253-281.

Goldsmith, R.W. (1969). Financial Structure and Development. Yale University Press, New Haven, CT.

Gurley, J.G. & Shaw, E.S. (1955). Financial aspects of economic development. *American Economic Review*, Issue 45, 515-538.

Jayaraman, A.R. & Srinivasan, M.R. (2014). Analyzing profit efficiency of banks in Indiawith undesirable output Nerlovian profit indicator approach. *IIMB Management Review*. 26, 222-233.

Kumar, S., & Gulati, R. (2008).An examination of technical, pure technical, and scale efficiencies in Indian public sector banks using data envelopment analysis. *Eurasian Journal of Business and Economics*, *1*(2), 33-69.

Lema, T.Z. (2017). Determinants of bank technical efficiency: Evidence from commercial banks in Ethiopia, *Cogent Business & Management, 4*, 1-13.

Mahendru, M. & Bhatia, A. (2017). Cost, revenue and profit efficiency analysis of Indian scheduled commercial banks: Empirical evidence across ownership. *International Journal of Law and Management*, 59 (3), 442-462.

McDonald, J. (2009). Using least squares and Tobit in second stage DEA efficiency analyses. *European Journal of Operational Research*, *197*, 792-798.

Reddy, K.S., & V. Nirmala, V. (2013). Profit efficiency and its determinants: Evidence from Indian commercial banks. *Journal of Transnational Management*, 18 (2), 125-163

Rahman, M.M., Hamid, M.K., &Khan, M.A. (2015).Determinants of bank profitability: Empirical evidence from Bangladesh. *International Journal of Business and Management*, 10 (8), 135-150.

Rakshit, B. (2023). Assessing the effects of cost, revenue and profit efficiency on bank performance: empirical evidence from Indian banking. *International Journal of Organizational Analysis*, 31(5), 1867-1898.

Ray, S., & Das, A. (2010). Distribution of cost and profit efficiency: evidence from Indian banking. *European Journal of Operational Research*, 201(1), 297-307.

Sensarma, R. (2005). Cost and profit efficiency of Indian banks during 1986-2003: A stochastic frontier analysis. *Economic and Political Weekly*, Vol. 40 (12), 1198-1209.

Shanmugam, K.R & Das, A. (2004).Efficiency of Indian commercial banks during the reform period. *Applied Financial Economics*, *14*, 681-686.

Singh, D., & Fida, B.A. (2015).Technical efficiency and its determinants: An empirical study on banking sector of Oman. *Problems and Perspectives in Management*, *13*(1), 168-175.

Suzan, D., Rabbani, M.R., Hawaldar, I.T., & Jain, A.K. (2022). Impact of Bank Efficiency on the Profitability of the Banks in India: An Empirical Analysis Using Panel Data Approach. *International Journal of Financial Studies*, 10 (93), 1-18.

Schumpeter, J.A. (1952). Theory of economic development. Cambridge: Harvard University press.

Timmer, C. P. (1971). Using a probabilistic frontier production function to measure technical efficiency. *Journal of Political Economy*, 79(4), 776-794.