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Trends in Indian Private Sector Bank Efficiency: Non-Stochastic Frontier DEA Window Analysis Approach

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Abstract

The study examines the efficiency of private sector banks in India with the help of Window DEA (Data Envelopment Analysis) for a period from 2005 to 2017. With a window of three years, the period was divided into 11 windows. The study outcomes show that 59.9% of all private sector banks in India operate at more than 0.9 level of efficiency, and there are only three occasions when banks were operating at the efficiency value between 0.6 to 0.7. Further, the consistency in the efficiency scores of the banks has also been analyzed using an efficiency mapping matrix, and the mean efficiency score of the bank in each window is studied. The score of standard deviation was interpreted accordingly for these banks. Banks that are showing the highest efficiency scores also have a higher variance of efficiency scores. There was no bank identified in the matrix that promises high-efficiency ratings with low variability. The study concludes that the analysis of the efficiency mapping matrix indicates that, as a DMU escalates in the efficiency scores, the standard deviation reflecting the risk in overall efficiency scores also tends to rise. The findings complement the concept of higher risk to higher return or greater efficiency.

Keywords: Bank Efficiency, DEA, Window Analysis, Indian Banking Sector

JEL Classification Code: C67, D24, G21, O33

1. Introduction

The efficiency of the banking system is quintessential for the growth of a country as only an efficient bank can promise healthy and sustainable growth for the country's financial sector. A profitable bank is also perceived to be less risky and is more promising for the growth of the financial sector of the economy. Therefore, stakeholders and regulators need to evaluate from time to time the health of the bank system

to eliminate anomalies and support the country's economic growth. The Indian banking system has a mixed blend of private, public, and foreign banks, and the contribution of any category of banks to the overall growth of the Indian economy and stability of its financial system cannot be ignored. The government has rightly understood that without the support of private banking players, the Indian banking system cannot be improved. The reports of Reserve Bank of India (RBI) also indicate that lending by the private sector in India has soared substantially in the past couple of years in different sectors. The skewed distribution of the number of branches of private sector banks in rural and urban areas has also been altered significantly. Many empirical studies carried out in the past have shown that banks in the private sector are more efficient and better administered in comparison to their peers in the public sector. Private sector banks have also helped in raising the benchmark level of their public sector peers (Das & Kumbhakar, 2016; Hassan, 2019; A. Kumar, 2011). Given the importance of private sector banks in promising economies like India, it is crucial to examine the efficiency, productivity, and performance of these banks from time to time. Studies of (Arora, 2017; A. Mukherjee, Nath, & Pal, 2003; Singh & Thaker, 2016)

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validate that globally there is an ever-increasing contribution of private sector banks in the financial sector especially in the banking sector of a developing country.

In recent years of research and development, there is a growing inclination amongst the researchers towards the area of efficiency and performance mapping of the banking sector, to which India is no exception. Researchers have long studied the cause of poor efficiency of the Indian banking system. Some of the famous studies (Lovell, Bhattacharyya, Lovell, & Sahay, 1997) have examined various issues related to it, and the results of these studies have shown a gap in analyzing the efficiency of the banks. Since then, there has been ample empirical evidence (Anand & Kumar, 2020; Mutiga, Mushongi, & Kangéthe, 2019; Sensarma, 2008; Singh & Thaker, 2016), which focus on building an efficiency frontier and a mapping system in the banking sector, but there are only a few microeconomic studies that attempt to measure the efficiency using window analysis and, fewer have focused their attention on developing nations. Besides this, most of the earlier studies have been carried out in the context of public sector banks only, and separate studies for private sector banks are very few in number to establish a valid conclusion. Our study intends to bridge these gaps. Further, banks' efficiency mapping studies could potentially help policymakers, researchers, industry leaders, and many others affected by this sector.

Against this backdrop our study aims to measure trends in Indian private banks' efficiency scores from 2005 to 2017 using window data envelopment analysis. Such rigorous analysis of private-sector Indian banks with a scope of covering both pre-recession and post-recession periods has not been carried out earlier in the Indian banking sector, which is also the novelty of our study.

Further, this study contrasts and compares the deviation in efficiency scores for the period of 2005 to 2017 and formulates an efficiency mapping matrix. The results of the study are of high relevance to the respective bank management, policymakers, researchers, and academicians in understanding the operating and intermediate efficiency.

1.1. About Indian Banking

Indian banking is led by RBI, the apex institution that governs the operations of all banks in India. Indian banks can further be classified under the ownership structure as the private sector, public sector, and other regional rural banks. The industry has experienced a wide variety of reforms and changes since its inception in the 18th century. It is only recently that this industry has recognized the importance of private ownership and foreign capitalization.

Despite the reforms in the Indian financial sector, there are still many challenges in the banking system. Some of the significant difficulties in current banking scenario are the technological gap observed across various ownership

in the banks, increasing non-performing assets, corporate governance issues in private sector banks lack autonomy for public sector banks, heightened competition within the sector especially from foreign banks and lastly, meager services provided by several public sector banks.

2. Literature Review

In the banking sector, there had been many incidences that conclude comprehensive research, focusing on assessing the bank's resource utilization capabilities. The most prominent one and popular way of quantifying performance is the 'frontier efficiency approach.' In this approach, the frontier is formed by the locus of efficiency scores of most efficient banks. Further, studies of (Akhigbe et al., 2017; Doan et al., 2018; Forcadell et al., 2019; Saad & El-Moussawi, 2009; Tecles & Tabak, 2010) had used various applications of the traditional frontier analysis, namely 'stochastic frontier analysis,' 'thick frontier analysis,' 'data envelopment analysis,' etc.

A compilation of a study on 'Literature of efficiency of the financial institution' (Berger & Mester, 1997) showed that less than 5% researches had studied the efficiency of the bank in a developing nation and that majority of the research are directed to developed countries such as the US and the European nations. Some of the studies, which have helped understand the banking system of developing nations include (Asmild et al., 2018; Baten et al., 2015), which are some of the prominent studies from Bangladesh, (Barros & Wanke, 2014; Tecles & Tabak, 2010; Wanke & Barros, 2014) are studies from Brazil, (Avkiran, 2015; Ji et al., 2019; Ma et al., 2019; Zhou et al., 2008) are studies from China, (Anand & Kumar, 2020; Bawa et al., 2019; Behera, 2019; George, 2016; Kumar & Dhingra, 2016b; Kumar, 2013; Padake & Soni, 2015) are some prevalent studies in Indian banking sector, (Abbas et al., 2019; Ahmad, 2011; Akhtar, & Nishat, 2002; Tahir et al., 2016) are some studies in Pakistan, (Miencha & Selvam, 2013) is study from Kenya, (Seelanatha, 2010; Wijesiri et al., 2015) are studies from Sri Lanka, (Mahathanaseth & Tauer, 2014; Sufian et al., 2010) are some studies from Thailand, (Eyceyurt et al., 2017; Gunes & Yilmaz, 2016) are some studies from Turkey, and many other similar studies (Banna et al., 2017; Le, 2020; Nguyen, 2020) from different countries. These studies have highlighted the inefficiencies and their causes for the banking sector of developing nations.

Researchers have devised a wide variety of methods for efficiency measurement. Initial Efficiency Measurement Approach was narrowed to ratio testing to assess the efficiency of banks (Almumani, 2013; Gaganis et al., 2009; Gemar et al., 2019; Gupta et al., 2008; Martín & Román, 2001; Mukherjee et al., 2002; Padake & Soni, 2015; Pham Thien et al., 2015). Despite multiple traces for the use of ratio analysis in the literature, the technique suffers a significant

limitation of subjective yardsticks and standards that may deceive the forecaster (Yeh, 1996).

Apart from ratio computations, an alternative approach of assessing efficiency is centered on the application of the quantitative technique and linear programming models. Data Envelopment Analysis (DEA) propounded by (Charnes & Cooper, 1984) is a linear programming technique and is more prevalent than the conventional ratio analysis. It is a tool for measuring effectiveness based on a non-parametric approach on a set of given decision-making units (DMUs), which are homogenous in nature by linking the ratio of several outputs to relevant inputs (Charnes & Cooper, 1984). The prominent studies, which have used DEA in this area are contributed by (Asmild et al., 2013; Avkiran, 1999; Banya & Biekpe, 2018; Barros et al., 2012; Das et al., 2004; A. Kumar, 2011; A. Kumar & Dhingra, 2016a; Kumar & Gulati, 2009; Nandi, 2013; Nausshad et al., 2020; Paradi et al., 2018; Saha & Ravisankar, 2000; Sathye, 2005; Sathye & Khankhoje, 2009; Wanke et al., 2016).

Although DEA is an extensively used and well-acknowledged technique for measuring efficiency in any given set of decision-making units, this approach is often referred to as the black-box approach for studying effectiveness, which faces some severe limitations. One of the primary limitations of the traditional black-box approach of studying DEA is that it neglects the internal linkages between variables (Gulati & Kumar, 2017). The study of (Yang & Paradi, 2006) had referred this technique as ‘handicap data envelopment analysis,’ but there is no denying that there is a vast scope of application of this technique to a wide variety of data. An edifice of traditional DEA, known as window DEA, has been used in the current paper.

Most of the studies that have measured competency of DMUs with DEA are limited to the efficiency measurement of the DMUs for a single set of efficiency scores for a given time (Moghaddas & Vaez-Ghasmi, 2016; Ramanathan, 2007; Yan et al., 2008; Yang & Paradi, 2006). There are very few studies that have determined the efficiency trends using window analysis. Further, it has also been observed that the scope of the research for most of the literature in this discipline is limited to developed nations like the USA and European countries while neglecting the developing nations like India. The present study seeks to bridge this gap and focuses on the identification of the trend of efficiency scores among 18 Indian private banks for the period of 2005 to 2017.

3. Research Data and Methodology

3.1. Data Envelopment Analysis

The methods foster a piecewise-linear convex is the quant curve, which represents the best practicing DMUs located over the curve and other inefficient DMUs under it. The range of the score varies between 0 to 1, which means

one is for the most efficient unit, whereas a unit with a score of less than 1 is called an inefficient unit. By studying the distance relationship of the DMUs under the frontier with that of the efficient peer DMU, located on the frontier, one can quickly analyze the scope to enhance the output or limiting the inputs. In recent years, this method has gained the attention of many researchers and academicians, and thus there has been plenty of studies on the theoretical as well as practical applications of DEA (Bapat, 2012; Huguenin, 2013; Klimberg & Ratick, 2008; Silva et al., 2018; Wanke & Barros, 2014; Yeh, 1996). Further (Sufian, 2007) stated that one of the major rewards of using the DEA technique for measuring efficiency differentials is that the technique is independent of the sample sizes and can be equally utilitarian for research, which comprises of less data for analysis. There are several other advantages of this technique also. Firstly, All DMUs are identified by a unique score for efficiency, which makes it easier to benchmark and identify the most efficient DMU from the sample. Secondly, it underscores the key area of improvement for each DMU by comparing the relevant scores of DMU with the most efficient one, thus implying ways to develop the performance. Thirdly, to quantify the performance, using this technique is independent of any predefined functional form that is to be treated to the data in order to derive the efficiency scores. Finally, based on the efficiency scores, researchers can profile the DMU and its performance as compared to that of the DMU, which is lying on the efficient frontier. DEA is also flexible in the choice of input and output and does not require any kind of standardization of input and output units (Avkiran, 1999).

One of the most significant caveats attached to the approach of the data envelopment analysis is that the represented efficiency scores are not the actual determiner of efficiency as they are relative to the performance of the banks. It may be the case that any DMU not accounted for in the sample DMU could have better efficiency and better performance (Sathye, 2003).

3.2. Analysis of Window Efficiency Scores

The window analysis is a tool to study the variations in the efficiency scores of a DMU over a period. The technique of window analysis has been derived from a statistical method known as moving averages. This technique examines a DMU over different periods as separate units for analyzing the scores. It provides a comparison of similar DMU across different periods. Each DMU with multiple inputs and outputs across different years is considered as a distinct individual DMU. Thus, the application of data envelopment analysis associated with the time series data analysis is known as window analysis. A researcher can contrast the efficiency scores of banks across different periods through a sequence of windows that overlap each other for a given period.

This technique assumes that there is no technical change for all DMUs during the period within each window. Thus, these results are better analyses of the performance of the DMU and a higher degree of freedom (Avkiran, 2004). The assumption of no technical change during the window period brings limitations that the tool cannot be applied for a large window. However, this limitation can be overcome by keeping the window size narrow. As such, there is no theoretical justification for the most appropriate size of the window period. For the current paper, the size of the window for using window analysis is three years. The breakdown of 11 windows is shown in Table 1. Thus, for the present study, the performance of 18 private sector banks is analyzed for 13 years using a window size of 3 years. A 3-year window of 18 private sector banks counts to a total of 54 separate DMUs. Subsequently, by applying

Table 1: Window breakdown for DEA window analysis on private sector banks for 2005-2017

	Year 1	Year 2	Year 3
Window 1	2005	2006	2007
Window 2	2006	2007	2008
Window 3	2007	2008	2009
Window 4	2008	2009	2010
Window 5	2009	2010	2011
Window 6	2010	2011	2012
Window 7	2011	2012	2013
Window 8	2012	2013	2014
Window 9	2013	2014	2015
Window 10	2014	2015	2016
Window 11	2015	2016	2017

Table 2: The selected set of 18 private sector banks

DMU Code	The Bank's Name	DMU Code	The Bank's Name
PR001	Axis Bank	PR010	Karnataka Bank Ltd
PR002	Catholic Syrian Bank Ltd	PR011	Karur Vysya Bank Ltd
PR003	City Union Bank Limited	PR012	Kotak Mahindra Bank Ltd.
PR004	DCB Bank Limited	PR013	Lakshmi Vilas Bank Ltd
PR005	Federal Bank	PR014	Nainital Bank Ltd
PR006	YES, Bank Ltd.	PR015	RBL Bank Limited
PR007	ICICI Bank Limited	PR016	South Indian Bank Ltd
PR008	IndusInd Bank Ltd	PR017	Tamil Nadu Mercantile Bank
PR009	Jammu & Kashmir Bank Ltd	PR018	YES, Bank Ltd.

this technique on 18 private sector banks for the period of 2005-2017 with 3 years taken together, the total number of observations increases to 594, which provides a better degree of freedom for the research.

The banking sector in India currently consists of 94,384 rural along with 1,562 urban cooperative banks. Further, the sector comprises 27 public, 21 private, 49 foreign, and 56 regional rural banks. This study focuses on a subset of 18 private sector banks that were operating in India from 2005 to 2017. The list of selected banks mentioned in Table 2. In order to determine the efficiency scores using windows analysis, we have used EMS software version 1.3.

3.3. Selection of Input and Outputs

While there have been numerous researches and publications in the Indian banking sector, the choice and variety of input and output to study efficiency scores has been a disputed issue amongst researchers. The selection of the right type of input and output depends on the nature of the banking business. The literature in the area states that there are two broad approaches, which are used for capacity measurement of DMUs called production approach and intermediation approach. A hybrid of both production approach and the intermediary approach has also been suggested in the literature. Table 3 given below contrast various inputs and outputs that researchers generally used to study the effectiveness of the banks under the above mentioned two approaches.

The hybrid method, which is a mix of two approaches, as discussed above, extracts the merits of both approaches. The efficiency scores in our study have been calculated using this approach by using the following inputs and outputs (see Table 4).

The descriptive statistics for the various input and output variables used in the study given in Table 5.

The descriptive statistics of the data indicates that interest income is a major part of their earnings. The average interest income is 4.76 times of non-interest income. Further, this ratio of interest income to non-interest income was maximum for Nainital bank in the year 2007, where interest income was 26.98 times more than non-interest income. Also, the descriptive statistics indicate that there is more considerable variability in the interest income over non-interest income. During the period of study, it has also been observed that in the year 2017, Yes bank is having the maximum number of employees, and also produces the maximum amount of loanable funds in comparison to its peers.

Table 3: Intermediate and production inputs and outputs

Intermediate and Production Inputs and Outputs	
Inputs	Outputs
Number of Employees	Loans
Fixed Assets	Deposits
Capital	
Inputs and Outputs used as per Intermediation Approach	
Inputs	Outputs
Interest Expenses	Interest Income
Non-Interest Expenses	Non-Interest Income

Table 4: Input and Outputs used in the study

Input Variables	Output Variables
Fixed Assets (X1)	Interest Income (Y1)
Number of employees (X2)	Non-interest Income (Y2)
Loanable Fund (X3)	

Table 5: Descriptive Statistics of the Input and Outputs used in the study

Descriptive Statistics	Fixed Assets {I}	No. of employees {I}	Loanable Funds {I}	Interest Income {O}	Non-Interest Income {O}
Mean	6990.27	11671.47	744848.75	68581.69	14399.75
Median	2014.53	4624.50	241528.60	23395.92	2947.30
Standard Deviation	12469.36647	17814.85673	1293086.663	118473.4504	29048.53441
Quartile 1	965.881	2652	94491.88425	8132.84225	1170.97375
Quartile 3	5303.497	9392.75	638799.7085	61770.68575	7817.95125
Min.	56.41	207.00	7845.76	299.79	45.63
Max.	78052.07	87555.00	7176685.23	693059.58	195044.83
Range	77995.66	87348.00	7168839.47	692759.79	194999.20

4. Empirical Results

Using the software EMS 1.3 window analysis tool, the observation and scores for all 18 private sector banks for the period of 2005-2017, comprising of 11 windows of 3 years size, has brought insight on the trends of the efficiency amongst the Indian private sector banks. The mean efficiency scores of private sector banks across different windows are illustrated below in Table 6. It indicates that the mean efficiency score of PR018 – YES Bank Ltd. is showing a score of more than 1 across all 11 window periods. The mean efficiency score of the YES bank is 1.1064, which is higher than all other banks. It indicates that YES bank is the most efficient private sector bank across all window periods based on the mean efficiency score for all windows. Second to YES bank in terms of mean scores is PR007 – ICICI Bank Ltd. with a mean efficiency score of 1.032. Thus, the peer to peer comparison of the mean efficiency scores indicates that ICICI bank can increase its revenue further by 6.44% to compete the benchmark scores set by YES Bank Ltd.

The efficiency scores indicate the appreciable performance of PR012 – Kotak Mahindra Bank and PR017- Tamil Nadu Mercantile Bank Ltd as both these banks are having an average efficiency score above 1. The mean efficiency scores across all windows are found to be minimum at 0.748 in the case of PR015- RBL Bank Ltd. The mean efficiency score of RBL Bank Ltd indicates that there is a scope to increase the earnings of the bank further by 25.2% if inputs are optimized wisely. Further, it has also been observed that the efficiency score of most of the banks declined during the period of windows 3 and 4, which may be attributed to the global recession during that period. Overall for all private sector banks, the average efficiency score was found to be 0.8963, which indicates that private sector banks in India operating between 2005 and 2017 are underutilizing their inputs and have a scope to further increase the outputs

Table 6: Mean Efficiency scores of private sector banks across different windows

	WIN-01	WIN-02	WIN-03	WIN-04	WIN-05	WIN-06	WIN-07	WIN-08	WIN-09	WIN-10	WIN-11	Avg.
PR001	83.2	75.6	77.6	90.3	95.4	97.6	103.3	100.1	101.1	97.5	94.3	92.4
PR002	82.7	74.1	68.2	68.1	68.9	78.4	78.9	84.4	87.1	87.0	89.2	78.8
PR003	85.1	81.5	86.9	89.7	89.3	88.5	86.3	89.8	92.9	95.4	97.5	89.3
PR004	86.5	80.8	91.9	93.4	90.1	84.6	80.6	79.3	81.2	84.8	91.3	85.9
PR005	82.7	82.2	78.8	84.4	85.9	89.5	82.0	85.3	85.2	86.4	84.9	84.3
PR006	90.8	82.3	89.2	89.2	92.3	95.3	97.4	96.8	94.8	91.9	94.1	92.2
PR007	108.6	98.8	109.7	108.9	109.0	107.0	106.4	88.7	93.9	100.4	103.9	103.2
PR008	97.8	83.9	84.6	84.7	82.5	91.1	94.9	101.7	103.2	103.3	101.5	93.5
PR009	80.9	78.8	74.4	78.4	76.9	77.2	73.6	78.7	84.1	85.3	86.2	79.5
PR010	92.0	84.3	82.2	83.4	82.2	82.9	80.4	83.6	84.6	85.8	86.9	84.4
PR011	87.1	79.7	77.7	80.7	83.0	83.6	79.1	84.4	89.6	94.3	96.9	85.1
PR012	101.6	96.4	101.5	105.6	106.1	100.9	97.2	100.7	100.9	98.5	96.9	100.6
PR013	81.9	77.7	77.8	80.9	79.2	87.1	84.7	87.2	86.9	87.2	87.2	83.4
PR014	107.3	102.0	97.0	99.2	94.3	88.5	88.7	89.3	89.0	89.1	89.4	94.0
PR015	78.9	75.0	71.1	72.0	71.0	77.8	71.0	71.4	75.4	77.4	81.9	74.8
PR016	81.0	78.1	73.1	76.1	75.9	80.4	77.9	83.8	84.9	85.3	84.0	80.1
PR017	104.9	96.1	93.6	99.1	99.8	98.4	101.4	98.5	98.1	111.4	114.0	101.4
PR018	100.7	106.6	111.2	121.9	126.2	113.8	102.2	108.4	106.8	106.1	113.2	110.6

by 10.37% with the given level of data. Also, the average overall efficiency score for 11 banks for all window period at 89.63% is also a healthy sign for the growth in sample private sector banks.

Table 7 depicts the frequency distribution for the efficiency scores of the banks in all 11 window periods for 18 banks. Therefore, the product of 11 window results of 18 banks represents 198 outcomes. DMUs having an efficiency score of 1 are termed as efficient, and those having an efficiency score of less than one are termed as under efficient. DMUs with an efficiency score of greater than 1 are called super practical. The above-given frequency distribution for the efficiency scores suggests that as much as 35.9% of all DMUs have operated at an efficiency score of more than 0.9, which depicts an appreciable performance of private sector banks. There are only 3 occasions when DMUs scored between 0.6 to 0.7, which is illustrated by PR002 (Catholic Syrian Bank Ltd.) from 2007 to 2009. It may be due to disturbances in the economic environment during that period. With 19.7% of banks operating at a super efficiency score of greater than one, it ensures growth prospects for the banks. Further, it can also be observed from the mean efficiency scores that out of 18 private sector banks, seven banks were having a score of greater than one. Out of these

seven banks, YES bank Ltd. is found to be super-efficient for all the window periods, and this represents that YES Bank can be an ideal benchmark for all other private sector banks. All these banks have been evaluated as per suggested methods by which banks having high mean efficiency scores and relatively low standard deviation treated to be best in banking practices (Charnes & Cooper, 1984).

It can be observed from Table 8 that PR010 (Karnataka Bank Ltd) is having a minimum standard deviation of 0.056, which represents consistency in the efficiency scores for the bank. The maximum standard deviation is accounted for PR018 (Yes Bank Ltd), which is 0.174. It indicates a high risk of deviated expected efficiency score for Yes Bank Ltd. The positioning score of 0.063 for the first quartile results includes four banks (Karnataka, Lakshmi Vilas, Federal, and South Indian Bank). It can be observed from Table 8 that PR010 (Karnataka Bank Ltd) is having a minimum standard deviation of 0.056, which represents consistency in the efficiency scores for the bank. The maximum standard deviation is accounted for PR018 (Yes Bank Ltd), which is 0.174. It indicates a high risk of deviated expected efficiency score for Yes Bank Ltd. The positioning score of 0.063 for the first quartile results includes four banks (Karnataka, Lakshmi Vilas, Federal, and South Indian Bank).

Table 7: Efficiency distribution of 18 private sector banks in 11 windows Efficiency values

Efficiency Scores	Frequency	%	Cumulative Percentage
Less than 0.6	0	0.00%	0.00%
Between 0.6 to 0.7	3	1.52%	1.52%
Between 0.7 to 0.8	35	17.68%	19.19%
Between 0.8 to 0.9	79	39.90%	59.09%
Between 0.9 to 1	42	21.21%	80.30%
1	0	0.00%	80.30%
Greater than 1	39	19.70%	100.00%

Table 8: Standard Deviation of the efficiency scores in 11 windows from 18 private sector banks

Code	Name of the Bank	σ	Code	Name of The Bank	σ
PR001	Axis Bank	0.122	PR010	Karnataka Bank Ltd	0.056
PR002	Catholic Syrian Bank Ltd	0.088	PR011	Karur Vysya Bank Ltd	0.076
PR003	City Union Bank Limited	0.074	PR012	Kotak Mahindra Bank Ltd.	0.102
PR004	DCB Bank Limited	0.100	PR013	Lakshmi Vilas Bank Ltd	0.059
PR005	Federal Bank	0.060	PR014	Nainital Bank Ltd	0.142
PR006	Yes, Bank Ltd.	0.065	PR015	RBL Bank Limited	0.063
PR007	ICICI Bank Limited	0.151	PR016	South Indian Bank Ltd	0.062
PR008	IndusInd Bank Ltd	0.101	PR017	Tamil Nadu Mercantile Bank Ltd	0.106
PR009	Jammu & Kashmir Bank Ltd	0.068	PR018	Yes, Bank Ltd.	0.174

Table 9: Efficiency Mapping Matrix for the efficiency scores of private banks in India

Quartile Positioning for Efficiency Scores	Above Q_3			Kotak Mahindra Bank	Nainital Bank, Tamil Nadu Mercantile Bank, ICICI Bank YES Bank
	$Q_2 - Q_3$		City Union Bank	IndusInd Bank	Axis Bank
	$Q_1 - Q_2$	Federal Bank Karnataka Bank	Karur Vysya Bank	DCB Bank	
	Below Q_1	South Indian Bank Lakshmi Vilas Bank	RBL Bank Jammu & Kashmir Bank	Catholic Syrian Bank	
	Below Q_1	$Q_1 - Q_2$	$Q_2 - Q_3$	Above Q_3	
Quartile Positioning for Standard Deviation Scores					

Based on the position of banks' efficiency values and standard deviations of efficiency scores throughout the entire study period, a 4 x 4 matrix has been formed. The values of the standard deviation of efficiency scores are shown on the x-axis, and the efficiency scores are shown on the y-axis. This matrix evaluates the consistency in the efficiency scores of the selective banks for the period of study. One can interpret that the bank with good efficiency scores, along with the least standard deviation scores, are the leaders or benchmarks for all other private sector banks. Thus, plotting the values of the selective banks on the matrix, it was observed there is no such bank that is producing a consistently high-efficiency score.

The matrix representation (Table 9) of the window analysis results for efficiency scores depicts that South Indian Bank and Lakshmi Vilas Bank are having the least efficiency values and are also consistent on the measure of standard deviation. Further, it is Nainital Bank, Tamil Nadu Mercantile Bank, ICICI Bank, and Yes banks that are having maximum efficiency scores. Still, the scores are not constant as per the values of standard deviation. It implies that the operations of such banks are risky, and despite being the most efficient banks, they must focus on bringing consistency to the efficiency scores.

5. Conclusion

The paper employs a window DEA to evaluate the efficiency of selective private sector banks from 2005 to 2017. Using the panel data and window analysis, the technique helps to identify the trends in efficiency scores of Indian private sector banks. The window analysis measures the trends in efficiency using the window period of 3 years. Thus, the time 2005 to 2017 is divided into 11 windows. The results depict that 59.9% of all private sector banks are currently operating at 0.9 efficiency score, which represents an appreciable performance of private sector banks. There are only three banks that are working with an efficiency score between 0.6 to 0.7. Further analysis the consistency in the efficiency scores of the banks, the standard deviation of the mean efficacy score of the bank in each window is analyzed, which indicate that PR010 (Karnataka Bank Ltd) is having the minimum standard deviation of 0.056, which represents consistency in the efficiency scores for the bank. The maximum standard deviation accounted for PR018 (Yes Bank Ltd), which is 0.174. It indicates a high risk of deviated expected efficiency score for Yes Bank Ltd.

The findings from the efficiency mapping matrix illustrate that South Indian Bank and Lakshmi Vilas Bank are having the lowest efficiency scores as well as standard deviation scores. It implies that these banks are operating

at deficient efficiency scores along with little variability in the results. Further on the same level of the efficiency RBL Bank, Jammu and Kashmir Bank & Catholic Syrian Banks are operating at higher standard deviation. These banks must take countermeasures to reduce variability in the results. Similarly, Federal Bank and Karnataka Bank were running on the same level of variability as of South Indian Bank and Lakshmi Vilas Bank, but are having more excellent efficiency position score. Thus, Federal Bank and Karnataka Bank must practice techniques for more excellent output maximization at the given level of input. On the central zone of the matrix, it observed that City Union Bank, IndusInd Bank, DCB Bank, Karur Vyasa Bank are having average efficiency scores and moderate variability. But even for these banks, there is a scope to maximize the efficiency and stable performance on efficiency scores.

As we move higher in the matrix, we can observe Nainital Bank, Tamil Nadu Mercantile Bank, ICICI Bank, and Yes bank is among the few banks that are showing the highest efficiency scores. Still, the efficiency results are highly variable also. There was no bank identified in the matrix that promises high-efficiency ratings with low variability. Thus, we conclude that the study of efficiency mapping matrix indicates that as a DMU move to a higher level of efficiency, the risk factor for the standard deviation also tends to rise. Considering the competence to be a key driver to the profitability of the firm, we can conclude that the findings of the study complement the concept of higher risk to higher return or greater efficiency. Such a matrix can help the banks in strategic planning and policy formations for their operations by analyzing their current position on the model and comparing it with the view of peers.

6. Limitations and Future Directions

We would like to acknowledge the following limitations of the study. Firstly, the scope of the present study is based on private sector banks and has not covered the public sector and foreign banks that are operating in the country. Secondly, the study is based on banks operating in India and has not contrasted with the efficiency scores for other developing nations. Thirdly, the period of the study is limited to 2005 to 2017. Thus, caution is required while interpreting and generalizing the results to the present year. Therefore, the study directs a scope of research to compare the efficiency scores of banks across a variety of ownership. Further, the results of the study can be applied to banks operating in other developing nations, and the results can thus provide a more comprehensive view of the concept and a better understanding of the idea. Empirical studies in the future can also expand the scope of the study to the current period.

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