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# Efficiency Analysis of Indian Private Sector Banks: Data Envelopment Technique

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***Abstract:*** ***The Indian financial sector reforms of 1991 has greatly changed the face of Indian Banking system. In the face of this increased competition, efficiency of the banking system is one of the most imperative issue in order to sustain and perform better. Data Envelopment Analysis is one such tool developed by Charnes et. al (1978) and further extended by Banker et. al (1984) that uses the principles of linear programming theory to examine how a particular Decision-Making Unit (DMU) like a bank – operates relative to other DMUs in the sample. The focus of this paper is using Data Envelopment Analysis (DEA) approach to evaluate the efficiency of Indian Private Sector banks for the year 2019. In this study, 20 private sector banks each with 5 inputs namely deposits, employees, fixed assets, interest & non-interest expenses and 4 outputs namely advances, investments, non interest & net interest income, using intermediation approach are considered. For each bank, efficiency scores have been calculated for the year 2019 under the VRS- input oriented method. The most & least efficient and inefficient banks are then evaluated based on ranking of banks on the basis of efficiency scores. The reasons for the inefficiency of banks is also identified. Benchmarking, an advantage of DEA, is used for further analysis. Moreover, targets for suggested changes in inputs & outputs for inefficient banks have also been found using sensitivity analysis to make them efficient for year 2020. In addition, the returns to scale data with the efficiency score for the year 2019 was been analysed. It was concluded that the Indian private sector banks are dominated by increasing returns to scale and thus need to increase their size to increase their efficiency.***

***Keywords: Data Envelopment Analysis (DEA), Efficiency Analysis, Intermediation Approach, VRS- Input Oriented model, Sensitivity Analysis & Target Setting***

## I. INTRODUCTION

The Indian financial sector reforms of 1991 have greatly changed the face of Indian Banking system. In addition to nationalized banks, India has also seen the entry of private sector as well as foreign banks since the beginning of financial reforms. In the face of this increased competition, efficiency of the banking system is one of the most imperative issue in order to sustain and perform better. Investigating the efficiency of the financial system and in particular banks has gained a lot of popularity in recent times for several reasons. First, the efficiency of banks is directly linked to the productivity of the economy. Banking system assets constitute a substantial proportion of total output. Banks provide liquidity, payments and safekeeping for depositors and channel these funds into investment and working capital requirements. In addition, banks are supposed to play a special role in funding small businesses that often have very limited access to other sources of external finance. Banks also play a major role in ensuring a smoothly functioning payment system, which allows financial and real resources to flow freely to their highest-returns uses. A basic benefit of enhanced efficiency is a reduction in spreads between lending and deposit rates. This is likely to stimulate both greater loan demands for industrial investment (and thus contribute to higher economic growth) and greater mobilization of savings through the banking system. Thus, the focus of this paper is to measure the efficiency of private sector banks though Data Envelopment Analysis using intermediation approach.

### *A. Data Envelopment Analysis*

Data Envelopment Analysis was developed by Charnes et. al (1978) and further extended by Banker et. al (1984). DEA uses the principles of linear programming theory to examine how a particular Decision-Making Unit (DMU) like a bank – operates relative to other DMUs in the sample. The method constructs a frontier based on actual data. Firms on the frontier are efficient, while firms off the efficiency frontier are inefficient. Efficiency is measured as the ratio of weighted outputs (virtual output) to weighted inputs (virtual input) and considers the values between zero and one. An efficient firm does not necessarily produce the maximum level of output given the set of inputs. Further, efficiency means that the firm is a “best practice” firm in the taken sample. DEA selects the weights that maximize each bank's efficiency score under the conditions that no weight is negative, that any bank should be able to use the same set of weights to evaluate its own efficiency ratio, and that the resulting efficiency ratio must not exceed one.

That is, for each bank, DEA will choose those weights that would maximise the efficiency score in relation to other banks. In general, a bank will have higher weights on those inputs that it uses least and on those outputs that it produces most. As explained above, DMUs on the frontier having efficiency scores equal to 1 are efficient and DMUs off the frontier having scores less than 1 are inefficient. This technique has now become most popular for efficiency evaluation of those organizations which are providing services using multiple inputs to produce multiple outputs. Several different mathematical programming DEA models have been proposed in the literature. Essentially, these models seek to establish which of n DMUs determine the envelopment surface or best practice frontier or efficient frontier.

*B. Advantages of Efficiency Analysis Through Dea*

The DEA model has certain specific advantages such as, it is a methodology directed to frontier rather than central tendencies. This model is able to identify any apparent slack in input used or output produced and provides insight on possibilities for increasing output and/or conserving input in order for an inefficient decision-making unit to become efficient. And it also takes care of uncovering relationships, which remain hidden for other methodologies, and allows to rank decision-making units (DMUs) according to their technical efficiency scores and to single out the driving forces for inefficiencies.

The ability of the DEA to identify possible peers or role models as well as simple efficiency scores gives it an edge over other methods. DEA modelling allows the analyst to select inputs and outputs in accordance with a managerial focus. This opens the door to what-if analysis. Knowing which efficient banks are most comparable to the inefficient bank enables the analyst to develop an understanding of the nature of inefficiencies and reallocate scarce resources to improve productivity. This feature of DEA is clearly a useful decision-making tool in benchmarking. As a matter of sound managerial practice, profitability measures should be compared with DEA results and significant disagreements investigated. Furthermore, the technique works with variables of different units without the need for standardisation (e.g. dollars, number of transactions, or number of staff).

1) *DEA and Benchmarking:* Data Envelopment Analysis (DEA) has been recognized as an excellent method for analyzing performance and modeling organizations and operational processes, particularly when market prices are unavailable. DEA has been applied to various areas of efficiency evaluation. In DEA, the ratio of weighted outputs and inputs produces a single measure of productivity called relative efficiency. The DMUs on the efficiency frontier are the best performing peers that need to be emulated. Hence, the first step in benchmarking is achieved by using the DMUs on the frontier.

A DMU that is not efficient and is inside the frontier can choose efficient DMUs on the frontier and selected efficient DMUs is named its reference set. Hence, depending on the size and scope of a DMU, each DMU will have a different set of reference set. The distance between a DMU and the frontier provide the goals for benchmarking. A unit can become efficient by moving towards the frontier by reduce inputs or increase outputs produced or a combination of both. Since efficiency is the ratio of output to input, a DMU can become efficient by increasing output or decreasing input. Such measurable and actionable goals satisfy the requirements of step 2 of the benchmarking process. In other words, a DMU becomes efficient by moving towards the frontier. Having identified the reference set and the areas for needed improvement, step 3 of the benchmarking process, implementing benchmarking, can be done. Management can evaluate the operations of the peer group units or reference set to determine what changes in inefficient unit can be made.

## II. LITERATURE REVIEW

(Afzal, Shelah , & Ahmad, 2019) This study evaluated the efficiency of domestic and foreign banks operating in Pakistan for the period 2010-2016. DEA was used to explore the scale, technical, pure technical and scale efficiency of the sample banks (six domestic and two foreign). Studies have supported the entry of foreign bank for bringing many benefits. The least efficient banks were found to be Bank Alfalah, National Bank, Askari Bank and Standard chartered in terms of scale efficiency. Technicall efficiency scores demonstrate that Allied Bank, Askari bank, Nationall Bank, Standard Chartered Bank and Bank Alfalah did not perform efficiently whereas other banks of the sample did well. Pure technicall efficiency scores under both orientations reveal that in 2010 and 2015, all banks showed a perfect pure technicall efficiency score of 1.00. Both domestic and foreign banks performance were mixed according to this study. Domestic banks are not less efficient in terms of all efficiencies than foreign banks. Both banks needed attention to managerial aspects and efficient utilization of technology in their operations.

(Kamarudina, Sufianb, Mohamad , Loonga , & Aina, 2017) The objective of this study was to examine the technical efficiency (TE) and the decomposition of pure technical efficiency (PTE) and scale efficiency (SE) of domestic and foreign Islamic banks from the selected Southeast Asian Countries. The sample comprised of 29 domestic and foreign Islamic banks from Malaysia, Indonesia and Brunei over the period of 2006–2014.

This study employs the Data Envelopment Analysis (DEA) method to measure banks' efficiency. The results indicate that the domestic Islamic banks have exhibited higher efficiency levels compared to their foreign bank peers. In addition, the empirical findings from this study seem to suggest that the domestic Islamic banks have exhibited a higher efficiency levels for all three efficiency measures and consistent with home field advantage theory. The findings of this study are expected to contribute significantly to the regulators or policy makers, Islamic banking itself, investors and existing knowledge on the operating performance of the Islamic banking sector.

(E.Saravanan & V.Prakash, 2015) This paper implements a Data Envelopment Analysis (DEA) approach to measure the relative performance of public sector banks in India for the period of 2013. In this study 20 Banks, each with 4 inputs and 3 outputs are considered. Each bank is identified as Decision making Unit (DMU). Bankers, Charnes, Cooper method, which admits VRS has applied in this study to compute efficiency score for each bank. Efficient banks whose Technical Efficiency (TE) scores is unity and inefficient banks whose Technical Efficiency scores less than unity has identified. The researcher also suggested the target for inefficient banks to attain efficiency. The results of this study revealed that 7 banks are Efficient whose teta value equal to 1. It is identified that the remaining 13 banks of the set of 20 banks are Inefficient relatively. The reference DMU i.e. the set of peers for the Inefficient banks is constructed to fix the input and output target for inefficient banks in this research. The Corporation Bank stood first rank, Union Bank of India and Canara Bank gets second and third ranks respectively, Punjab National Bank and IDBI Ltd both receives fourth rank. Indian Bank and United Bank of India secured Fifth rank in terms of efficiency according to this research.

(Kumar & Singh, 2014) In this paper an attempt has been made to review research conducted on the efficiency measurement and performance of the Indian banking sector. Many researches have been performed over the past decade in the area of measuring efficiency of firms, companies, banks, and other decision-making units. Studies in the past used conventional ratios such as return on assets to evaluate the efficiency. Most of these studies which look at the efficiency concentrate on cost, profit, income or revenue efficiencies. Later research in the area used various measure of performance which include financial index, a non-parametric approach-Data Envelopment Approach (DEA) and parametric approach Stochastic Production Approach (SPA) In this paper, efficiency measurement models-BCC and CCR have been discussed and literature review has been done in the area of efficiency analysis in banking sector. Most of the studies have used DEA to measure the efficiency of banking sector in India. The DEA is Capable of handling multiple inputs and outputs and is useful in uncovering relationships that remain hidden for other methodologies. The advantage of DEA is also that the sources of inefficiency can be analysed and quantified for every evaluated unit.

(Karimzadeh, 2012) The study is aimed at examining the efficiency of Indian commercial banks during 2000 – 2010 by utilizing Data Envelopment Analysis (DEA). Based on the sample of 8 commercial banks, the findings of this study reveal that the mean of cost(economic) efficiency, technical efficiency, and allocative efficiency are 0.991, 0.995, and 0.991 in VRS model and 0.936, 0.969, and 0.958 in CRR model respectively using DEA approach. Inputs and outputs of this study were analyzed based on intermediation approach. In addition, the results suggest that Bank of India and ICICI bank are more efficient as compare to other banks in India and result confirmed that selected Public Sector Banks are more efficient than Private sectors during the study period in India. The technical efficiency averaged around 99% for the banks under study with insignificant differences among the banks under study. This suggests that the banks under study might increase one or more of their current outputs by around 1% without reduction in their other outputs or without a need for more inputs. Bank of India averaged the highest technical efficiency in both model while the Central bank of India along with Axis bank averaged the least under both constant and variable returns to scale.

### *A. Objectives of The Study*

1) To analyse the technical efficiency of various private sector banks in India using intermediation approach of DEA for the year 2019.
2) To find out the efficiency score for the various private sector banks.
3) To find the most efficient bank and least efficient bank in the sample using DEA analysis by ranking the banks on the basis of efficiency scores obtained.
4) To compare the relative efficiency of the banks in the sample with that of the most efficient bank found in the sample.
5) To identify the measures that can be taken by various inefficient banks in the terms of input and output for the year 2019 to become efficient using sensitivity analysis.
6) To identify the measures that can be undertaken by efficient banks to further enhance and improve their efficiency in comparison to other efficient banks in the sample and to become the benchmark for the other banks.

*B. Scope Of Study*

The study is based on the secondary data collected from the relevant sources, published annual reports of all banks in Indian Banking System. To analyse the efficiency of banks, the data for 20 private sector banks for 2019 was used. Intermediation approach under VRS assumption using input-oriented DEA is the scope of the study.

*C. DEA Specifications*

There are basically two types of DEA models: Charnes et al. (1978) introduced the constant returns to scale (CRS) and Banker et al. (1984) introduced the variable returns-to-scale (VRS) model. DEA models are also classified as input-oriented, output-oriented or additive (both inputs and outputs are optimized in the best interest of the evaluated unit) based on the direction of the projection of the inefficient unit onto the frontier surface. Experts point to the fact that CRS can be applied only for the companies which operate at an optimal scale (Coelli *et al.* 1998). In turn, in many industries (including banking sector) the factors such as imperfect competition or government regulations, may cause the deviation from an optimal scale. Besides, VRS is considered to be more appropriate assumption for measuring efficiency in developed banking sector). Therefore, in the current research DEA model is applied under VRS assumption.

Further, DEA model can be either input- or output-orientated. The choice of the orientation primarily is based on industry specifics. As for banking, some researchers measure efficiency with output-oriented models (Thagunna & Poudel, 2013; Casu & Girardone, 2005) or apply both in their studies (Beccalli, Casu, & Girardone, 2006). However, the input-orientated models are the most frequently used in measuring bank efficiency with DEA (Arshinova, 2011; Nigmonov, 2010; Yang, 2009; Zreika & Ekanj, 2011). The possible reason assumed by Fethy & Pasiouras is that bank managers have higher control over inputs rather than over outputs (Fethy & Pasiouras, 2010). Applying the input-oriented DEA model, it is possible to answer the question "By how much can input quantities be proportionally reduced without changing the output quantities produced?" The opposite question is "By how much can output quantities be proportionally expanded without altering the input quantities used?" is addressed to the output-orientated model. The term input- and output-oriented models relates to the way in which inefficient DMUs are projected onto the efficient frontier. Thus, input-oriented DEA is applied here.

*D. Determining Input-Output Variables*

The choice of input-output variables in bank efficiency studies have significant impact on the result. The bank specific variables e.g. loans, deposits etc. are such variables which are controllable by the bank itself. Such variables can be used in the study, so that the bank management is able to improve efficiency level by adjusting the variable that has relevance with the bank's efficiency. The choice of inputs and outputs in DEA is a matter of long-standing debate among researchers. Three main approaches for defining inputs and outputs in the analysis of the efficiency of a bank were developed, namely: the intermediation approach or the asset approach; the production approach and the user cost approach. Like most of the DEA studies, this study also uses the intermediation approach to define bank inputs and outputs. According to the intermediation approach, banks are considered the intermediaries that transfer the financial resources from surplus agents to the fund deficit ones. The intermediation approach is considered relevant for the banking sector, where the largest share of activity consists of transforming the attracted funds into loans or financial investments (Andrie and Cocris, 2010). Unlike the production approach, which focuses on operating cost and ignores interest expense, in the intermediation approach both operating and interest expenses are included in the analysis (Berger et al., 1987). Within the intermediation approach, the exact set of inputs and outputs used depends largely on data availability as well as choice of input-output variables. This is strength of the technique, since it reveals which of the input-output variables need to be closely monitored by bank management to improve efficiency. Chen *et al.* (2005) study demonstrated that for a branch appraisal the earlier approach (production approach) can be adapted while to analyze overall efficiency, the later approach (intermediation approach) is better to apply. In this paper, the following set of inputs and outputs were used to quantify the efficiency of banks in India:

Table 1: Variables used in the technical efficiency analysis

| INPUTS | OUTPUTS |
|---|---|
| Deposits | Advances |
| Employees | Investments |
| Fixed Assets | Non-interest income |
| Interest Expenses | Net interest income |
| Non-Interest Expenses | |

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## III. ANALYSIS & RESULTS

Table 2: Efficiency Scores for the year 2019

| DMU No. | Banks | 2019 |
|---|---|---|
| 1 | Axis | 1.0000 |
| 2 | ICICI | 1.0000 |
| 3 | HDFC | 1.0000 |
| 4 | Kotak Mahindra | 1.0000 |
| 5 | IndusInd | 1.0000 |
| 6 | Bandhan | 1.0000 |
| 7 | IDFC First Bank | 1.0000 |
| 8 | Federal | 1.0000 |
| 9 | RBL | 1.0000 |
| 10 | YES Bank | 1.0000 |
| 11 | Catholic Syrian Bank | 0.9866 |
| 12 | City Union Bank | 1.0000 |
| 13 | DCB Bank | 0.9554 |
| 14 | Jammu & Kashmir Bank | 0.9932 |
| 15 | Karnataka Bank | 1.0000 |
| 16 | Lakshmi Vilas Bank | 0.7970 |
| 17 | IDBI Bank | 1.0000 |
| 18 | Karur Vysya Bank | 0.9305 |
| 19 | South Indian Bank | 1.0000 |
| 20 | Dhanlaxmi Bank | 1.0000 |
| | Average | 0.9831 |
| | Minimum | 0.7970 |
| | Standard Deviation | 0.0473 |

(Source: Calculations based on data in Annexure I)

Table 2 determines the efficiency scores for various private sector banks for the year 2019. Out of the sample of 20 banks, 15 banks (75%) are found to be efficient whereas 5 banks are found to be inefficient. The bank with the lowest efficiency score is Lakshmi Vilas Bank, followed by Karur Vyasa and DCB Bank. These banks were not able to maintain their inputs like fixed assets, employees & non-interest expense as against outputs like non-interest income & net interest income.

The average efficiency score is found to be 0.9831, which means for the year 2019, private sector banks are found to be 98% efficient.

Table 3: Benchmarks and peer count for the banks in the year 2019

| | 2019 | | | | |
|---|---|---|---|---|---|
| | DMU'S | EFFICIENCY SCORE | PEER WEIGHTS | PEER GROUP (BENCHMARKS) | PEER COUNT |
| 1 | Axis | 1.0000 | 1 | Axis | 1 |
| 2 | ICICI | 1.0000 | 1 | ICICI | 2 |
| 3 | HDFC | 1.0000 | 1 | HDFC | 3 |
| 4 | Kotak Mahindra | 1.0000 | 1 | Kotak Mahindra | 1 |
| 5 | IndusInd | 1.0000 | 1 | IndusInd | 1 |
| 6 | Bandhan | 1.0000 | 1 | Bandhan | 5 |
| 7 | IDFC First Bank | 1.0000 | 1 | IDFC First Bank | 4 |
| 8 | Federal | 1.0000 | 1 | Federal | 1 |
| 9 | RBL | 1.0000 | 1 | RBL | 3 |
| 10 | YES Bank | 1.0000 | 1 | YES Bank | 4 |
| 11 | Catholic Syrian Bank | 0.9866 | 0.024,0.023,0.004,0.058,0.892 | Bandhan, RBL, YES, City Union, Dhanlaxmi | 0 |
| 12 | City Union Bank | 1.0000 | 1 | City Union Bank | 5 |
| 13 | DCB Bank | 0.9554 | 0.072,0.060,0.380,0.487 | Bandhan, IDFC, City Union, Dhanlaxmi | 0 |
| 14 | Jammu & Kashmir Bank | 0.9932 | 0.062,0.056,0.301,0.581 | HDFC, Bandhan, City Union, Dhanlaxmi | 0 |
| 15 | Karnataka Bank | 1.0000 | 1 | Karnataka Bank | 1 |
| 16 | Lakshmi Vilas Bank | 0.7970 | 0.001,0.058,0.941 | IDFC, YES, Dhanlaxmi | 0 |
| 17 | IDBI Bank | 1.0000 | 1 | IDBI Bank | 1 |
| 18 | Karur Vysya Bank | 0.9305 | 0.013,0.013,0.023,0.003,0.109,0.006,0.633,0.201 | ICICI, HDFC, Bandhan, IDFC, RBL, YES, City Union, Dhanlaxmi | 0 |
| 19 | South Indian Bank | 1.0000 | 1 | South Indian Bank | 1 |
| 20 | Dhanlaxmi Bank | 1.0000 | 1 | Dhanlaxmi Bank | 6 |

Table 3, over & above efficiency scores for 2019, also indicates weight of each of the peers or the benchmarking units in third column. The fourth column shows the peers or the benchmarking units for the corresponding DMUs. The last column shows the peer count of the DMUs, that is, the number of times a particular DMU is being referred by other DMUs for improvements.

In the results for the year 2019, as 15 banks are found to be efficient, they build the efficient frontier. Every bank beneath this efficient frontier is inefficient. DEA allows us to take one step further and identify a smaller group of best performers specific to the characteristics of an individual bank (based on the weights given to the inputs and outputs). DEA does this in the form of benchmarks which are then set as the reference units for the inefficient banks. The efficient banks are considered as benchmarks with different weights for the inefficient banks. These benchmarks are called the peer group in the language of DEA. The inefficient banks can observe the benchmark banks that they need to catch up to become efficient. Obviously efficient banks may consider themselves to be their own benchmarks. So, for banks like Axis, ICICI, HDFC etc being efficient, the benchmark for them are these banks themselves. However, for inefficient banks, their benchmarks are one or many of the efficient banks. For example, for Catholic Syrian bank, the benchmark group includes Bandhan, RBL, YES, City Union & Dhanlaxmi, which are all efficient. This means to become efficient Catholic Syrian bank can use a combination from all these banks (a virtual bank) to become efficient. How much of these banks' weights are to be used by Catholic Syrian bank are given by the column of peer weights. When a DMU is efficient, the peer weight for them would be equal to 1. For inefficient banks, there is a different weight assigned to each benchmark or the reference unit which can be utilised by the inefficient bank to achieve the efficiency. And so, banks like DCB, Jammu & Kashmir, Laksmi Vilas can become efficient by making desired changes in the input & output with the given peer weights for the reference groups.

Table 4: Rankings based on peer counts

| BANKS | PEER COUNT | RANK |
|---|---|---|
| Dhanlaxmi Bank | 6 | 1 |
| Bandhan | 5 | 2 |
| City Union Bank | 5 | 2 |
| IDFC First Bank | 4 | 3 |
| YES Bank | 4 | 3 |
| HDFC | 3 | 4 |
| RBL | 3 | 4 |
| ICICI | 2 | 5 |

The ranking of the banks based on the peer count is showed in table 4. The peer count shows the frequency by which a particular DMU is being referred by other DMUs for improvements. The bank which is considered as the reference unit for the other banks for the highest number of times is given the first rank and the bank which is considered as the reference unit for the lowest number of times is given the last rank.

The number of efficient banks in the year 2019 were 15 but the banks used as reference units are 8, which means 7 banks can be termed as 'efficient by default'. Dhanlaxmi bank in the year 2019 was considered as the reference unit for 6 banks securing the highest rank. This shows that if we consider the data for the year 2019, Dhanlaxmi bank can be said to be the bank with high robustness and is an example of "well rounded performer" for the year 2019. While, ICICI bank is the one with the lowest rank with the peer count of 2, which means that it is considered to be marginally efficient bank and a small increase or decrease in the output or input of this bank might result in the dropping of this bank from the efficient frontier.

*A. Suggestions for Efficiency Improvement: Slacks and Target Setting Analysis for the Year 2020 On the Basis of Year 2019*

The optimum solution of linear programming provides non-zero input and output slacks corresponding to input and output constraints. It is important to note that, slacks exist only for those DMUs that are identified as inefficient in a particular DEA run. These slacks provide vital information pertaining to the areas which an inefficient bank needs to improve upon in its drive towards attaining the status of efficient one, therefore existing for inefficient banks. The slacks should be interpreted along with the efficiency values. However, slacks represent only the leftover portions of inefficiencies; after proportional reductions in inputs or outputs. If a DMU cannot reach the efficiency frontier (to its efficient target), slacks are needed to push the DMU to the frontier (target).

Table 5.1 & 5.2 provides the input and output slacks for 5 inefficient banks identified in the year 2019. It can be observed that DCB Bank, in order to become efficient bank is required to reduce its number of employees by approximately 181 and fixed assets by 227.7. However, despite this reduction it would not achieve efficiency. No other input can be reduced. Thus, DCB bank should augment its investments, non- interest income and net-interest income by approximately 1314, 4.7 and 151 respectively to achieve efficiency. Similarly, other banks can also become efficient with the change in input & output variables as stated in table 5.1 & 5.2. It is interesting to note that for Karur Vyasa bank to become efficient it should reduce its fixed asset by approximate 128, which will lead it to the efficient frontier.

The analysis for all the non-efficient banks delineates that among the input variable, 4 out of 5 banks have non-zero slacks for fixed assets, while only 1 bank has non-zero slack for deposits and interest expenses. With regard to non-zero slacks for output variable, 4 out of 5 banks have non-zero slacks for non-interest income and net interest income. Further no non-zero slack has been observed for advances. This suggests that the inefficient private sector banks in India need to reduce their fixed assets while augment the level of non-interest income and net interest income, for projecting themselves on efficient frontier.

Table 5.1 Input slacks for the inefficient private sector banks

| YEAR 2019 | | | | | | |
|---|---|---|---|---|---|---|
| DMU NAME | INPUT SLACKS | | | | | |
| | Efficiency | Deposits | Employees | Fixed Assets | Interest expenses | Non- Interest Expenses |
| Catholic Syrian Bank | 0.9866 | 0 | 0 | 0 | 0 | 118.3981454 |
| DCB Bank | 0.9554 | 0 | 180.764581 | 227.700777 | 0 | 0 |
| Jammu & Kashmir Bank | 0.9931 | 11907.70724 | 0 | 1203.2959 | 0 | 304.5616637 |
| Lakshmi Vilas Bank | 0.7969 | 0 | 841.503313 | 135.900086 | 63.656831 | 0 |
| Karur Vysya Bank | 0.9305 | 0 | 0 | 128.384604 | 0 | 0 |

Table 5. 2 Output slacks for the inefficient private sector banks

| YEAR 2019 | | | | |
|---|---|---|---|---|
| DMU NAME | OUTPUT SLACKS | | | |
| | Advances | Investments | Non-Interest Income | Net Interest income |
| Catholic Syrian Bank | 0 | 986.9220208 | 16.7203498 | 134.97818 |
| DCB Bank | 0 | 1313.7584 | 4.72646962 | 150.98021 |
| Jammu & Kashmir Bank | 0 | 0 | 520.177806 | 532.542136 |
| Lakshmi Vilas Bank | 0 | 650.4875231 | 68.2879119 | 342.023211 |
| Karur Vysya Bank | 0 | 0 | 0 | 0 |

For getting more focused diagnostic information about the sources of inefficiency for each bank with respect to the input and output variables, target values of these variables at bank level were calculated using the efficiency scores, optimum values of slacks and actual values. Further, the above findings have been validated by examining the "Target" sheet.

Here, for each inefficient bank, target input and output levels are prescribed. These targets are the results of respective slack values added to outputs. To calculate the target values for inputs, the input value is multiplied with an optimal efficiency score, and then slack amounts are subtracted from this amount. The table 6.1 & 6.2 below displays theses target values for inefficient banks for the year 2019. The target for input variables comprises proportional reduction in the input variables by the given efficiency score of the inefficient banks minus the slack value, if any.

For example, the target calculation for DCB bank's employees' input is calculated as follows:

=0.9554*6134-180.76

=5679.85

Whereas the target calculation for DCB bank's deposits is calculated as follows:

=0.9554*28435.11-0 (as no slacks value are there for deposits of DCB bank)

=27167.83

Similarly, the target calculation for DCB bank's investments output can be calculated just by adding the output slack values to the output variables:

=7844.09+1313.76

=9157.85

In the same way the target values are calculated for all the inefficient banks and similar conclusions can be drawn for other inefficient banks.

Table 6. 1 Input Target for the inefficient private sector banks

| YEAR 2019 | | | | | |
|---|---|---|---|---|---|
| DMU NAME | EFFICIENT INPUT TARGET | | | | |
| | Deposits | Employees | Fixed Assets | Interest expenses | Non- Interest Expenses |
| Catholic Syrian Bank | 14921.43536 | 2960.83129 | 214.81566 | 895.412211 | 436.582597 |
| DCB Bank | 27167.83248 | 5679.859289 | 274.837688 | 1807.86966 | 814.840735 |
| Jammu & Kashmir Bank | 77118.04838 | 10003.10591 | 459.93895 | 4262.27457 | 2157.14391 |
| Lakshmi Vilas Bank | 23335.3502 | 2842.970297 | 238.64423 | 1753.27562 | 655.4665 |
| Karur Vysya Bank | 55709.75916 | 7403.407731 | 414.113218 | 3213.16829 | 1502.64238 |

Table 6. 2 Output Target for the inefficient private sector banks

| YEAR 2019 | | | | |
|---|---|---|---|---|
| DMU NAME | EFFICIENT OUTPUT TARGET | | | |
| | Advances | Investments | Non-Interest Income | Net Interest income |
| Catholic Syrian Bank | 10615.24 | 5014.532021 | 152.64035 | 574.92818 |
| DCB Bank | 23568 | 9157.8484 | 354.88647 | 1300.27021 |
| Jammu & Kashmir Bank | 66271.51 | 23160.5 | 1332.80781 | 3916.47214 |
| Lakshmi Vilas Bank | 20103.26 | 9080.657523 | 318.607912 | 902.163211 |
| Karur Vysya Bank | 48580.81 | 14881.59 | 962.77 | 2362.82 |

Thus, the inefficient banks can follow the above targets for their inputs and outputs for the next year in order to become efficient.

Table 7 Returns to scale for the banks in the year 2019

| DMU NO. | DMU NAME | EFFICIENCY | RETURNS TO SCALE |
|---|---|---|---|
| 1 | Axis | 1 | Constant |
| 2 | ICICI | 1 | Constant |
| 3 | HDFC | 1 | Increasing |
| 4 | Kotak Mahindra | 1 | Increasing |
| 5 | IndusInd | 1 | Constant |
| 6 | Bandhan | 1 | Constant |
| 7 | IDFC First Bank | 1 | Decreasing |
| 8 | Federal | 1 | Constant |
| 9 | RBL | 1 | Increasing |
| 10 | YES Bank | 1 | Constant |
| 11 | Catholic Syrian Bank | 0.986614892 | Increasing |
| 12 | City Union Bank | 1 | Constant |
| 13 | DCB Bank | 0.955432649 | Increasing |
| 14 | Jammu & Kashmir Bank | 0.99315984 | Increasing |
| 15 | Karnataka Bank | 1 | Increasing |
| 16 | Lakshmi Vilas Bank | 0.796987586 | Increasing |
| 17 | IDBI Bank | 1 | Constant |
| 18 | Karur Vysya Bank | 0.930543958 | Increasing |
| 19 | South Indian Bank | 1 | Constant |
| 20 | Dhanlaxmi Bank | 1 | Increasing |

The table 7 shows the returns to scale data with the efficiency score for the year 2019, out of 20 banks, 9 banks showed the constant returns to scale (output increases by that same proportional change with input), 10 banks showed increasing returns to scale (output increases by more than that proportion) and only one bank was found to be operating at decreasing returns to scale (output increases by less than that proportional change). On the whole, IRS is observed to be the predominant form of scale inefficiency in Indian private sector banking industry.

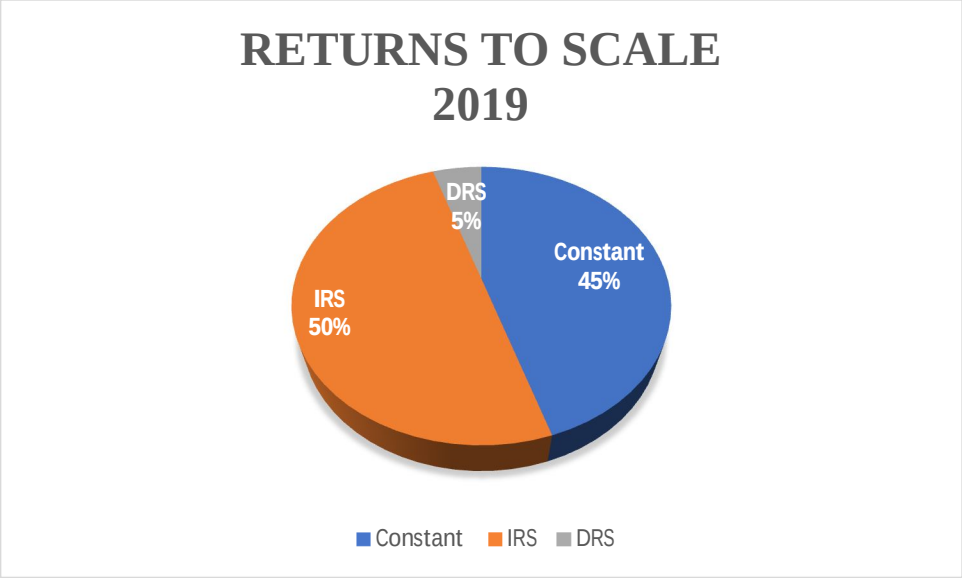


Figure 1: Percentage of returns to scale of the Indian Private Sector Banks in the year 2019

However, all the inefficient banks are operating at IRS, which means they are operating at sub-optimal size and to improve their efficiency and to become efficient, all these banks can increase their size of operations so that they can increase their returns and effectively utilize their inputs. Thereby it can be interpreted that for these banks the output variables have increased by the larger proportion of the given input variables, thus they need to increase or decrease the input variables to become efficient.

## IV. CONCLUSION

Data Envelopment Analysis (DEA) technique is an effective technique to analyse the efficiency of the given units in the sample based on observed performances. Further, it also helps to identify a set of units which can be considered as benchmarks for the inefficient units.

In this paper where efficiency of various private sector banks were analysed, there were mainly three suggestions. Firstly, Indian private sector banks should concentrate more on reduction of fixed assets as an input and increase of non-interest income and net-interest income as output. Secondly, through returns to scale analysis, it is suggested that private sector banks in India should concentrate on increasing their operations in order to enhance efficiency. Lastly, the banks which were efficient but were not found to be as benchmarks for any of the inefficient banks, need to work towards enhancing their efficiency by either increasing their scale of operations or changing their input-output ratio.

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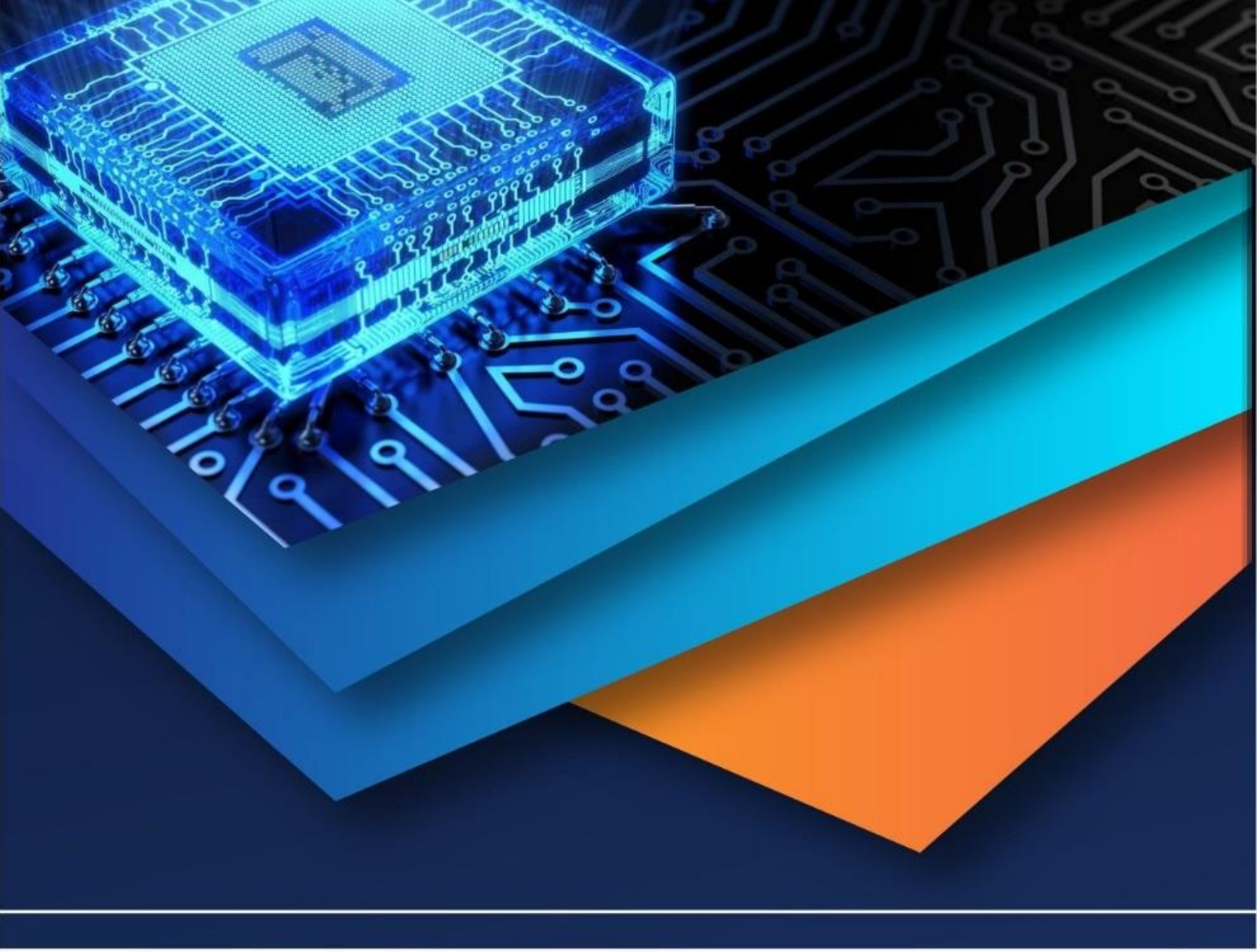
## ANNEXURE

*A. Input & Output data for the year 2019*

| Year 2019(in Rs. Cr) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Banks | INPUTS | | | | | OUTPUTS | | | |
| | Deposits | Employees | Fixed Assets | Interest expenses | Non-Interest Expenses | Advances | Investments | Non-Interest Income | Net Interest income |
| Axis | 5,48,471.34 | 59,614.00 | 4,036.64 | 33,277.60 | 15,833.40 | 4,94,797.97 | 1,74,969.28 | 13,130.34 | 21708.17 |
| ICICI | 6,52,919.67 | 81,548.00 | 7,931.43 | 36,386.40 | 18,089.06 | 5,86,646.58 | 2,07,732.68 | 14,512.17 | 27014.79 |
| HDFC | 9,23,140.93 | 88,253.00 | 4,030.01 | 50,728.83 | 26,119.37 | 8,19,401.22 | 2,90,587.88 | 17,625.87 | 48243.22 |
| Kotak Mahindra | 2,25,880.36 | 50,000.00 | 1,651.55 | 12,684.25 | 7,514.81 | 2,05,694.81 | 71,189.09 | 4,604.03 | 11259 |
| IndusInd | 194867.91 | 25,284.00 | 1,710.01 | 13414.97 | 6404.68 | 1,86,393.50 | 59,266.16 | 5646.72 | 8846.18 |
| Bandhan | 43,231.62 | 33,000 | 331.2 | 2,147.95 | 1,810.96 | 39,643.39 | 10,037.48 | 1,063.05 | 4496.1 |
| IDFC First Bank | 70,479.01 | 5,814.00 | 950.21 | 8,749.08 | 3,287.39 | 86,302.29 | 58,475.39 | 938.56 | 3199.09 |
| Federal | 1,34,954.34 | 12,112.00 | 472.04 | 7,242.68 | 2,764.27 | 1,10,222.95 | 31,824.47 | 1,351.02 | 4176.35 |
| RBL | 58,394.42 | 5,330.00 | 402.48 | 3,761.23 | 2,042.02 | 54,308.24 | 16,840.36 | 1,442.37 | 1221.34 |
| YES Bank | 2,27,610.18 | 18,238.00 | 817 | 19,815.72 | 6,264.28 | 2,41,499.60 | 89,522.03 | 4,590.15 | 9809.03 |
| Catholic Syrian Bank | 15123.87 | 3001 | 217.73 | 907.56 | 562.51 | 10615.24 | 4027.61 | 135.92 | 439.95 |
| City Union Bank | 38,447.95 | 5,319.00 | 250.03 | 2,155.68 | 885.89 | 32,673.34 | 7,712.20 | 514.39 | 1611.49 |
| DCB Bank | 28,435.11 | 6,134.00 | 525.98 | 1,892.20 | 852.85 | 23,568.00 | 7,844.09 | 350.16 | 1149.29 |
| Jammu & Kashmir Bank | 89,638.90 | 10,072.00 | 1,674.69 | 4,291.63 | 2,478.66 | 66,271.51 | 23,160.50 | 812.63 | 3383.93 |
| Karnataka Bank | 68,452.12 | 8,185.00 | 775 | 4,000.84 | 1,457.27 | 54,828.20 | 16,184.99 | 1,001.96 | 1905.12 |
| Lakshmi Vilas Bank | 29279.44 | 4,623.00 | 469.95 | 2279.75 | 822.43 | 20103.26 | 8430.17 | 250.32 | 560.14 |
| IDBI Bank | 2,27,371.72 | 17,475.00 | 8,230.98 | 16165.62 | 5153.79 | 1,46,790.44 | 93072.63 | 1057.75 | 5905.61 |
| Karur Vysya Bank | 59,867.95 | 7,956.00 | 582.99 | 3,453.00 | 1,614.80 | 48,580.81 | 14,881.59 | 962.77 | 2362.82 |
| South Indian Bank | 80,420.12 | 7,946.00 | 708.66 | 4,856.82 | 1,506.93 | 62,693.74 | 19,081.38 | 726.21 | 2019.7 |
| Dhanlaxmi Bank | 10,603.32 | 1,884.00 | 202.03 | 624.71 | 304.57 | 6,289.28 | 4,036.70 | 52.73 | 346.78 |



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