APPLICATION OF DATA ENVELOPMENT ANALYSIS [DEA] TO STUDY THE PERFORMANCE EFFICIENCY OF THE SCHEDULED COMMERCIAL BANKS OF INDIA

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Abstract

The aim of this research work is to evaluate the performance of the seven scheduled Commercial banks of India. For this study the researcher collected the data from 2008 to 2012 and evaluated using Data Envelopment Analysis (DEA). DEA, mainly, takes into account the input and output gears of a Decision Making Unit (DMU) to evaluate their performance. The measure of performance lies in the range 0 to 1. The outcome of this analysis reveals that:

- The Punjab National Bank and Andhra Bank are relatively efficient based on the output oriented technical efficiency [CRS]
- The Punjab National Bank, UCO Bank and Dena Bank are relatively efficient based on the input oriented technical efficiency [CRS]
- Excepting Indian bank all the other banks are relatively efficient based on the output oriented technical efficiency [VRS]

Key Words: Data Envelopment Analysis, Decision Making Unit, Performance, Efficiency, Constant Return to Scale, Variable Return to Scale

JEL Classification: C14, C61, G21

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1.0 Introduction

It is one of the main activities for any firm to monitor its efficiency. In the current scenario there are a number of methods based either on the traditional approach or using IT to evaluate the efficiency. Efficiency measurement methods can be divided into three main categories: ratio indicators, parametric and nonparametric methods. In selecting indicators to measure efficiency one can focus primarily on a firm's inputs and outputs.

The evaluation of efficiency in production units and determining the sources of their inefficiency is a precondition to effectively improve the performance of any productive unit in a competitive environment. In general, the term productive unit refers to a unit producing certain outputs by spending certain inputs.

Banks, or bank branches, can be considered as production units too. In general, they are homogeneous units performing the same or similar activities. All inputs and outputs have an impact on efficient operation of such units, even though some are considered more or less important.

Scheduled Banks in India are those banks which have been included in the Second Schedule of Reserve Bank of India (RBI) Act, 1934. RBI in turn includes only those banks in this schedule which satisfy the criteria laid down vide section 42 (6) (a) of the Act.

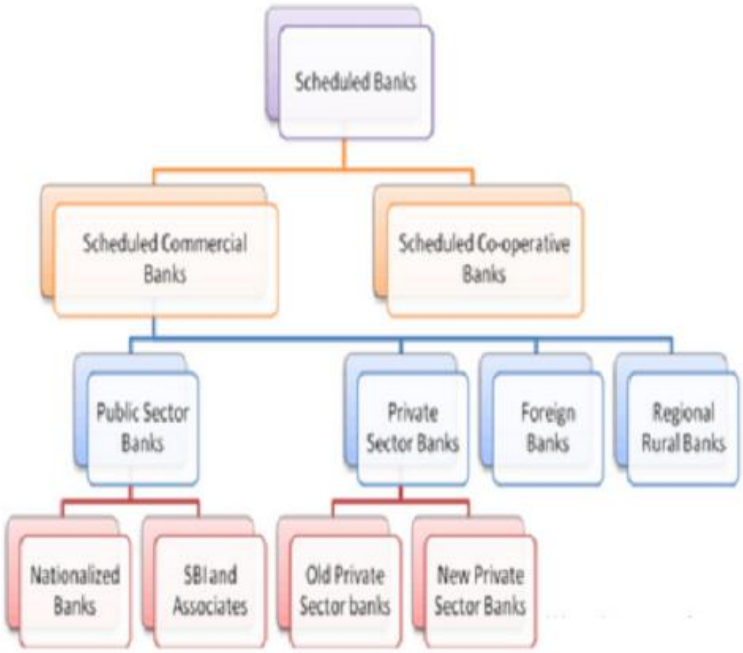


Figure 1: Kinds of Banks available in India

Performance is normally referred as the bank's ability to generate transaction by effectively utilizing their resources. Based on the Economical term, the efficiency refers to the ratio of outputs to inputs. Inputs which refers to the scarce resource and outputs in terms of goods and services offered to the consumers. One can understand the notion of efficiency in terms of banking operation is more consequential as banking sector is deemed to have vital role in the financial division of a country. Banking sector of a country is one of the most important sectors of the country's economy. Because of this, it is highly essential to measure its performance using proper tool. Usually the performance is measured with the help of Financial Management tools like; Return on Assets [ROA], Return on Investments [ROI], Return on Equity [ROE], Equity to Assets [ETA] and Internal Growth of Equity [IGE], etc. These measures are lacking in the sense that they are not total productivity measures but they are partial productivity measures. As a blessing in disguise Data Envelopment Analysis (DEA) came for rescue. It is considered as a tool for measuring total productivity. That is one can mix all the inputs and outputs to study the effectiveness of any type of organization.

The large number of commercial banks in India, the high branch density, the quick technological change and increased competition has added more pressure to improve its performance. Instead of studying the banks partial Productivity with the available Financial Management Tool like Ratio Analysis, it is the order of the hour to study the total productivity. In this context the author introduced the concept of DEA model in this research paper. This system has the benefit of developing a data-driven technological frontier that necessitates no specification of any scrupulous functional shape or error structure. This study fills the gape in the literature by leaving from the traditional method of evaluating the efficiency.

1.1 Structural framework

The main aim of this research study is to validate the implication of DEA in investigating and examining the efficiency of some of the Scheduled Commercial Banks of India.

DEA was first introduced by Charnes et al. (1978) as a Mathematical Programming Model with the help of the theoretical frame work given by Farrell [1957], for computing the relative efficiencies of multiple Decision Making Units (DMUs) and it falls under the special category of Fractional Programming. DEA is a special technique which offers a comparative ratio for each unit in terms of output and input. The ratio is stated as efficiency score for each unit. The measure of performance lies in the range 0 to 1. If the performance measure is 1 then the organization is considered to be highly efficient and if the measure is tending towards 0, the efficiency is otherwise. One of the significant roles of DEA is that the efficiency scores indicate the gap for potential improvements and developments for inefficient DMUs. One more positive point of DEA is that this technique does not have any rigid or predetermined structure in defining the efficient units (Banker, 1984; Al- Faraj et al., 1993; Burley, 1995; Mester, 1996).

DEA firstly applied by Sherman and Gold (1985) for assessing the efficiency of bank branches, is a tool for evaluating relative efficiency since it first identifies banks efficiency frontier and then compares with other banks. It allows ranks to the banks according to their technical

efficiency scores and to single out driving forces for inefficiencies. In banking industry, DEA model is preferable to econometric approach of efficient measurement because it has a number of advantages i.e.,

- ✓ It can simultaneously analyze several inputs and outputs, which is an alternative characteristic because production in the banking industry often involves multiple inputs and outputs.
- ✓ It does not require any assumptions about the functional form of technology, and
- ✓ It calculates a maximal performance measure for each production unit relative to all other production units in the observed population with the sole condition that each production unit lies on or below the external.

1.2 Objectives

The researcher's main intention is to classify the Scheduled Commercial Banks of India in terms their efficiency using BCC and CCR models of Data Envelopment Analysis (DEA) and the measures to improvise the efficiency of the Banks.

2.0 Review of Literature

The Financial Management Tool known as Ratio Analysis Technique [RAT] was used many years to evaluate the performance of the Banks. The financial statements are examined to find different ratios and then compare them with the defined Benchmark. In this research paper, the traditional parametric technique is replaced with non – parametric method DEA to investigate the performance of the Banks.

Seiford and Zhu (1999) examined the profitability and marketability of the top 55 U.S. commercial banks by applying DEA model. According to this study it was concluded that large banks performed better with respect to profitability than small size banks, while small size banks have better characteristic of marketability as compare to large size banks.

Maudos et al. (2002) studied the cost and profit efficiency of 832 European banks based on ten European Union Countries (period 1993 – 1996). The return on assets (ROE) and return on

equity (ROA) were acquired as performance measures to check profit efficiency of banks using DEA. This study was made based on the four dimensions namely the market characteristics, differences in size, other bank characteristics and specialization. Variations in profit terms were found to be greater than the variations in cost terms

Park and Weber (2006) tested the profitability of all Korean banks by testing with (traditional hypothesis approach) market structure hypothesis against efficient structure hypothesis applied after examination of the panel data (for the period of 1992-2002); with the help of (DEA) model. The outcome of this study shows that the performance measures significantly affects the profitability of banks. Pastor, Lovell, and Tulkens (2006) discussed the financial performance of branch offices. They studied 573 branch offices for six month accounting period of large European savings banks. Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) programming mathematical models were used to estimate financial performance with respect to their safeguard against expenses in giving customer services and building customer bases. They concluded that the financial performance evaluation factors can be reduced without statistical loss of significant information to bank management.

Sufian (2009) studied the efficiency of Malaysian banking sector during Asian Crisis of 1997 for the period of 1995-1999. Efficiency of individual banks was computed by DEA technique. They considered the Profitability as the major ingredient which was used to evaluate the efficiency with other explanatory variables, like bank size and ownership. The outcome of this study indicated that as there is a positive association between the Efficiency of banks and loans intensity and the relationship is otherwise for the economic conditions and expense preference behavior. Izah Mohd Tahir, Nor Mazlina Abu Bakar, Sudin Haron [2009] evaluated the overall, pure technical and scale efficiencies for Malaysian commercial banks during the period 2000-2006. The results suggest that domestic banks were relatively more efficient than foreign banks. They suggested that domestic banks' inefficiency were attributed to pure technical inefficiency rather than scale inefficiency. In contrast, foreign banks inefficiency is attributed to scale inefficiency rather than pure technical inefficiency.

Nigmonov (2010) studied the banks performance and efficiency in Uzbekistan for the period of 2004-2006. The basic two DEA models were applied to analyse the data under the assumption of constant and variable return to scale. The results have revealed that the inefficiency occurs due to technical efficiency and overall banks average efficiency level decreased. Sufian and Habibullah (2010) analyzed the efficiency of the Thailand banking sector covering the duration 1999-2008 with the help of DEA approach. The results have shown that inefficiency offset during formulation of technical efficiency with respect to pure technical efficiency in banking sector. The efficiency level of banks in data envelopment analysis is measured using ratio of weighted sum of outputs to weighted sum of inputs. Joseph Magnus Frimpong [2010] examined the relative efficiency of the banks in Ghana during the year 2007 based on the dataset provided by Ghana Banking Survey 2008 and adopting input oriented intermediation-based approach. The study highlights the average efficiencies of Ghana banks during 2007, both overall and by group, as determined by ownership and size, only four (out of 22) banks were efficient. The remaining banks had their efficiencies ranging from 33% to 89%. The average technical efficiency for the banking sector was 74%. Khalid AlKhathlan, Syed Abdul Malik [2010] analyzed the relative efficiency of Saudi Banks using annual data from 2003 through 2008 using DEA. The results show that, on a relative scale, Saudi banks were efficient in the management of their financial resources. In addition, the results would provide crucial information about Saudi banks' financial conditions and management performance for the benefit of bank regulators, managers and bank stock investors.

Mehmet Hasan Eken, Suleyman Kale [2011] studied the performance model for measuring the relative efficiency and potential improvement capabilities of bank branches by identifying their strengths and weaknesses, production and profitability aspects of branches. Under both production and profitability approaches, efficiency characteristics of branches, which are grouped according to different sizes and regions, have similar tendencies. In both analyses, it is apparent that branch size and scale efficiency are related to each other. As branch size increases scale efficiency increases too and after the most productive scale size, however, as size increases efficiency decreases. Too small and too large branches need special attention. Putting production and profit efficiency scores on two scales reveals the performing characteristics of

branches. Each region needs different handling. Branches with low production-low profit efficiency should be evolved towards high production-high profit efficiency region.

Anastasios D. Varias and Stella Sofianopoulou [2012] evaluated the efficiency of the biggest commercial banks that operated in Greece at the financial year 2009 by using DEA with multiple inputs and outputs. The innovation of the paper refers to the choice of data and the use of a combination of the intermediation approach and the Sealey and Lindley (1977) approach. The results indicate several inefficiencies that may not have direct relation to the profitability of such institutions. But, these inefficiencies indicate the vulnerability of the Greek banking system and its potential to ask for help from the FSF (Financial Stability Fund).

Saâd Benbachir, Mohamed Abouch, Yassine El Haddad, Anas Benbachir (2013) evaluated the relative efficiency for the bank branches of a Moroccan regional bank during the period 2007-2010 using DEA. As a result they identified the inefficient bank branches with the help of identifying their strengths and weaknesses. Karan S. Thagunna, Shashank Poudel [2013], studied the relative efficiency and potential improvement capabilities of Nepali banks by scrutinizing intermediation aspects with the help of DEA. The outcome of this study reveals that efficiency level is relatively stable and has increased on overall. Additionally, it also breaks down the overall efficiency of banks into technical and scale efficiency.

3.0 Research Methodology

3.1 Data Collection

For this study, the required data of all the seven Scheduled Commercial Banks have been taken from the annual reports of the banks for the financial years 2008-2012 from their respective official websites.

3.2 Selection of inputs and outputs

Reviewing the literature on the application of data envelopment analysis (DEA), different studies have used different combination of inputs and outputs. This study has used operating expense, advances and capital as input and operating income and net-interest income as outputs for this

study. The selection of the inputs and outputs has been supported by literatures (Chen & Yeh, 1998; Sarkis & Talluri, 2002; Mukherjee, et al., 2002; Ong, et al., 2003; Pastor, et al., 2006; Singh, et al., 2008; Hassan, et al., 2009; Sufian, 2009; AlKhathlan & Malik, 2010).

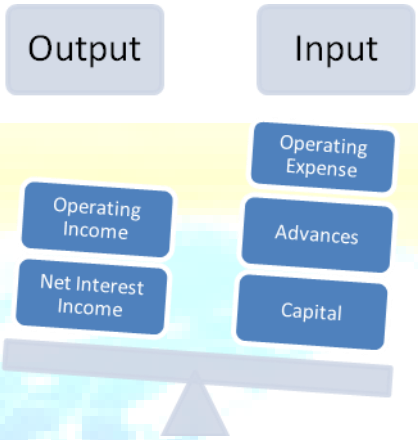


Figure 2: Inputs and Outputs for Data Envelopment Analysis (DEA)

3.3 CCR and BCC Model

The original CCR model was pertinent only to that expertise which is categorized by constant returns to scale. The major advancement was extended by Charnes, and Cooper (BCC) model to facilitate expertise that reveals variable returns to scale. This study has used input-oriented DEA model, which emphasizes on the minimization of inputs and the maximization of outputs held at their current levels. Also the BCC model with variable return to scale is considered.

3.3.1 General form of CCR Model:

The general form Output Maximization DEA [CCR] model can be represented in the form of Fractional Programming Model as follows:

Here the general model is constructed to maximize the efficiency of the q^{th} output variable:

v_{jq} - j^{th} output value of the q^{th} DMU

y_{jq} - j^{th} output variable of the q^{th} DMU

u_{iq} - i^{th} input value of the q^{th} DMU

x_{iq} - i^{th} input variable of the q^{th} DMU

E_q - Efficiency of the qth DMU

$$Max\ E_q = \frac{\sum_{j=1}^{m} v_{jq} y_{jq}}{\sum_{i=1}^{s} u_{iq} x_{iq}}$$

subject to the constraints

$\frac{\sum_{j=1}^{m} v_{jq} y_{jq}}{\sum_{i=1}^{s} u_{iq} x_{iq}} \leq 1;\ q = 1,2,\ldots,n$

$v_{jq}, y_{jq}, u_{iq}, x_{iq} \geq 0\ for\ all\ i = 1,2,..s; j = 1,2,..m, q = 1,2,...n$

Solving this fractional programming problem directly is so tedious; hence the fractional programming model is converted into regular linear programming model as described below:

$$Max\ E_q = \sum_{j=1}^{m} v_{jq} y_{jq}$$

subject to the constraints

$\sum_{i=1}^{s} u_{iq} x_{iq} = 1$

$\sum_{j=1}^{m} v_{jq} y_{jq} - \sum_{i=1}^{s} u_{iq} x_{iq} \leq 0;\ q = 1,2,...n$

$v_{jq}, y_{jq}, u_{iq}, x_{iq} \geq 0\ for\ all\ i = 1,2,..s; j = 1,2,..m, q = 1,2,...n$

The general form of input minimization DEA [CCR] linear programming model can be represented as follows:

$$Min\ E_q = \sum_{i=1}^{s} u_{iq} x_{iq}$$

subject to the constraints

$\sum_{j=1}^{m} v_{jq} y_{jq} = 1$

$\sum_{j=1}^{m} v_{jq} y_{jq} - \sum_{i=1}^{s} u_{iq} x_{iq} \leq 0;\ q = 1,2,...n$

$v_{jq}, y_{jq}, u_{iq}, x_{iq} \geq 0\ for\ all\ i = 1,2,..s; j = 1,2,..m, q = 1,2,...n$

3.3.2 **General form of BCC Model:**

The DEA envelopment program for considering variables return to scale is as follows:

$Min\ \theta_m$

Subject to the Constraints

$Y\lambda \geq Y_m$

$X\lambda \leq \theta X_m$

$$\sum_{n=1}^{N} \lambda_n = 1$$

$\lambda \geq 0$; θ_m *free variable*

4.0 EMPIRICAL RESULTS

4.1 Input-Oriented Technical Efficiency (Constant Return to Scale)

Table 4.1[a] communicates that the DEA efficiency score based input oriented technical efficiency [Constant return to scale] under the CCR Model. The Analysis report strongly communicates that the Punjab National Bank, UCO Bank and Dena Bank are the three banks which are very much consistent based on their maximum efficiency score 1 for the year 2008 – 2012.

It is observed that there is a varying trend in their mean of technical efficiency of commercial banks of India from 2008 to 2012, the score lies in the interval [0.994, 1.000]. In the financial year 2009-2010 the average efficiency is 1 and for the remaining three financial years the average efficiency is less than 1.

Table 4.1[a]: Input-Oriented Technical Efficiency (Constant Return to Scale)

Name of the Bank\ Year	2008-2009	2009-2010	2010-2011	2011-2012	**Mean efficiency of the individual banks**
Andhra Bank	.997	1	1	1	**0.99925**
Dena Bank	1	1	1	1	**1**
Syndicate Bank	1	0.999	1	1	**0.99975**

UCO Bank	1	1	1	1	**1**
Indian Bank	0.9591	1	0.86	0.896	**0.928775**
SBI	1	1	.973	.711	**0.921**
PNB	1	1	1	1	**1**
Mean Efficiency of over al banks	**0.994**	**1**	**0.976**	**0.944**	

Table 4.1[b]: Output -Oriented Technical Efficiency (Constant Return to Scale)

Name of the Bank\ Year	2008-2009	2009-2010	2010-2011	2011-2012	**Mean efficiency of the individual banks**
Andhra Bank	1	1	1	1	**1**
Dena Bank	1	0.9984	1	1	**0.9996**
Syndicate Bank	1	1	0.9583	0.9639	**0.98055**
UCO Bank	1	0.897	1	1	**0.97425**
Indian Bank	0.9591	1	0.7915	0.8506	**0.9003**
SBI	1	.869	.8751	.68436	**0.85712**
PNB	1	1	1	1	**1**
Mean Efficiency of over al banks	**0.944**	**0.966**	**0.946**	**0.928**	

Table 4.1[b] communicates that the DEA efficiency score based output oriented technical efficiency [Constant return to scale] under the CCR Model. The Analysis report strongly communicates that the Punjab National Bank and Andhra are the two banks which are very much consistent based on their maximum efficiency score 1 for the year 2008 – 2012.

It is observed that there is a varying trend in their mean of technical efficiency of commercial banks of India from 2008 to 2012, the score lies in the interval [0.994, 0.996]. Almost in all the financial years 2008-2012 the average efficiency is moderately efficient.

4.2 Input-Oriented Pure Technical Efficiency (Variable Return to Scale)

Table 4.2 communicates that the DEA efficiency score based input oriented technical efficiency [Variable Return to Scale] under the BCC Model. In BCC Model there is an increase in number of banks which shows the consistency in their performance. The Analysis report strongly communicates that except Indian bank all other banks attained maximum efficiency score 1 for the year 2008 – 2012.

It is observed that there is a varying trend in their mean of technical efficiency of commercial banks of India from 2008 to 2012, the score lies in the interval [0.993, 1.000]. In the year financial year 2009-2010 the average efficiency is 1 and for the remaining three financial years the average efficiency is less than 1.

Table 4.2: Input-Oriented Technical Efficiency (Variable Return to Scale)

Name of the Bank\ Year	2008-2009	2009-2010	2010-2011	2011-2012	**Mean efficiency of the individual banks**
Andhra Bank	1	1	1	1	**1**
Dena Bank	1	1	1	1	**1**
Syndicate Bank	1	1	1	1	**1**
UCO Bank	1	1	1	1	**1**
Indian Bank	.9480	1	.8161	.7826	**0.887**
SBI	1	1	1	1	**1**
PNB	1	1	1	1	**1**
Mean Efficiency of over all banks	**0.993**	**1**	**0.974**	**0.969**	

4.3 Input-Oriented Scale Efficiency

Table 4.3: Input-Oriented Scale Efficiency (Variable Return to Scale)

Name of the Bank\ Year	2008-2009	2009-2010	2010-2011	2011-2012	**Mean efficiency of the individual banks**
Andhra Bank	.997	1	1	1	**0.999**
Dena Bank	1	1	1	1	**1**
Syndicate Bank	1	.999	1	1	**1**
UCO Bank	1	1	1	1	**1**
Indian Bank	.999	1	.8161	.8734	**0.922**
SBI	1	1	.973	1	**0.993**
PNB	1	1	1	1	**1**
Mean Efficiency of over all banks	**0.999**	**1**	**0.970**	**0.982**	

Table 4.3 shows the mean efficiency each year by decomposing technical efficiency into pure technical efficiency and scale efficiency. Decomposing technical efficiency into pure technical efficiency and scale efficiency allows us to gain insight into the main sources of inefficiencies. The average index of technical efficiency during the study period varies in between 99.4% to 100%, pure technical efficiency varying at 99.3% to 100%, and of scale efficiency varying at 97% to 100%.

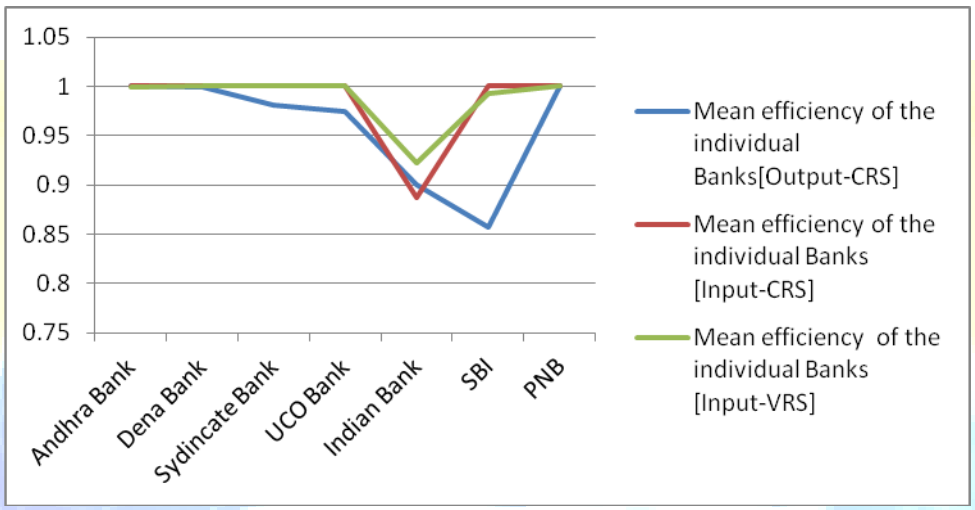
4.4 Over all mean efficiency

Table 4.4 Over all mean efficiency of all the measures put together

Name of the Bank	Mean efficiency of the individual Banks[Output-CRS]	Mean efficiency of the individual Banks [Input-CRS]	Mean efficiency of the individual Banks [Input-VRS]	Mean of Mean Efficiency	Rank based on efficiency
Andhra Bank	1	1	0.999	0.99967	**3**
Dena Bank	0.9996	1	1	0.99987	**2**
Syndicate Bank	0.98055	1	1	0.99352	**4**

UCO Bank	0.97425	1	1	0.99142	**5**
Indian Bank	0.9003	0.887	0.922	0.90310	**7**
SBI	0.85712	1	0.993	0.95004	**6**
PNB	1	1	1	1	**1**

Graph 4.4 Over all mean efficiency of all the measures put together



Among all the seven banks considered for the study the Punjab National Bank is highly consistent with the efficiency score of 1 and stands first, Dena Bank and Andra Banks are followed by PNB with the efficiency score almost nearly equal to 1.

The rank of all the seven banks is given in the Table 4.4.

5 Summary and concluding remarks

This research analysis is based on the application of DEA to compute the relative efficiency of seven scheduled commercial banks of India. The outcome of this research study reveals certain constructive managerial insights into evaluation and advancing of banking operations. The estimated result analysis shows that three banks are relatively efficient when their efficiency is measured in terms of 'constant return to scale' and six banks are relatively efficient when their efficiency is measured in terms of 'variable return to scale'. By improved handling of operating expenses, advances, capital and by boosting banking investment operations, the less efficient banks can successfully endorse resource utilization efficiency.

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