CHAPTER- 3

RESEARCH METHODOLOGY

This chapter explains the sample, time period, data source, methodology and various tools and techniques used for analyses of efficiency scores. It also defines various variables and their hypotheses.

3.1. Sample of the study

The study is based on all Scheduled Commercial Banks (SCBs) operating in the Indian Banking Sector. However some filters have been applied over the years as:

- Banks that merged with other banks are not taken after merger.
- Banks closed during the time period of the study are excluded after their closure.
- Banks for which data was not available are dropped from the sample of the study.

Thus the effective sample of the study varies across years for estimating the efficiency scores of the banks. The same is given as follows in Table: 3.1:

Table: 3.1 Effective Sample of Scheduled Commercial Banks (SCBs)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Public Sector Banks</th>
<th>Private Sector Banks</th>
<th>Foreign sector Banks</th>
<th>Indian Scheduled Commercial Banks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-92</td>
<td>28</td>
<td>23</td>
<td>23</td>
<td>74</td>
</tr>
<tr>
<td>1992-93</td>
<td>28</td>
<td>22</td>
<td>21</td>
<td>71</td>
</tr>
<tr>
<td>1993-94</td>
<td>27</td>
<td>22</td>
<td>21</td>
<td>70</td>
</tr>
<tr>
<td>1994-95</td>
<td>27</td>
<td>29</td>
<td>20</td>
<td>76</td>
</tr>
<tr>
<td>1995-96</td>
<td>27</td>
<td>34</td>
<td>27</td>
<td>88</td>
</tr>
<tr>
<td>1996-97</td>
<td>27</td>
<td>33</td>
<td>32</td>
<td>92</td>
</tr>
<tr>
<td>1997-98</td>
<td>27</td>
<td>34</td>
<td>35</td>
<td>96</td>
</tr>
<tr>
<td>1998-99</td>
<td>27</td>
<td>33</td>
<td>34</td>
<td>94</td>
</tr>
<tr>
<td>1999-2000</td>
<td>27</td>
<td>32</td>
<td>37</td>
<td>96</td>
</tr>
<tr>
<td>2000-01</td>
<td>27</td>
<td>31</td>
<td>37</td>
<td>95</td>
</tr>
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<td>2001-02</td>
<td>27</td>
<td>30</td>
<td>34</td>
<td>91</td>
</tr>
<tr>
<td>2002-03</td>
<td>27</td>
<td>28</td>
<td>27</td>
<td>82</td>
</tr>
<tr>
<td>2003-04</td>
<td>27</td>
<td>30</td>
<td>27</td>
<td>84</td>
</tr>
<tr>
<td>2004-05</td>
<td>28</td>
<td>29</td>
<td>26</td>
<td>83</td>
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<td>2005-06</td>
<td>28</td>
<td>28</td>
<td>26</td>
<td>82</td>
</tr>
<tr>
<td>2006-07</td>
<td>28</td>
<td>25</td>
<td>24</td>
<td>77</td>
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<td>2007-08</td>
<td>28</td>
<td>23</td>
<td>23</td>
<td>74</td>
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<td>2008-09</td>
<td>27</td>
<td>20</td>
<td>21</td>
<td>68</td>
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<tr>
<td>2009-10</td>
<td>27</td>
<td>22</td>
<td>24</td>
<td>73</td>
</tr>
<tr>
<td>2010-11</td>
<td>26</td>
<td>20</td>
<td>26</td>
<td>72</td>
</tr>
<tr>
<td>2011-12</td>
<td>26</td>
<td>20</td>
<td>30</td>
<td>76</td>
</tr>
<tr>
<td>2012-13</td>
<td>26</td>
<td>20</td>
<td>30</td>
<td>76</td>
</tr>
</tbody>
</table>
3.2. Time Period

The study covers a time period of 22 years from 1991-92 to 2012-13. During these last 22 years banking industry in India witnessed many challenges. The year 1991 brought in liberalisation, privatisation and globalisation of financial services. Major reforms took place in the financial sector in the decade of 1991-2002. After 2000, expansion, enhancement and innovation in communication and information technology brought opportunities as well as challenges for the Indian Banking Sector. In late 2000s, Indian Banking Sector faced repercussion of Global US recession. These upheavals and alterations over years affected the performance of Indian Banks. This long time period of 22 years permits to account for various changes that took place in the Indian Banking Sector and Indian Economy.

In order to develop better understanding and inferences, the entire period of 22 years has been divided into two parts i.e. 1991-92 till 2001-02 and 2002-03 till 2012-13. The first period i.e. 1991-92 till 2001-02 is termed as Reformatory Era as all the major reforms were undertaken during this time period. The second time period from 2002-03 till 2012-13 represents the period termed as Post Reformatory Era.

During 1991-92 till 2001-02 (Reformatory Era), many reforms were introduced in Indian Banking Sector. Narasimham Committee gave its first report in 1991. The report included various recommendations regarding phased reduction in Statutory Liquidity Ratio (SLR) and Cash Reserve Ratio (CRR), proper asset classification, income recognition, provisioning and other safety norms to ensure sound banking system. Further, Reserve Bank of India accepted Basel norms to strengthen the soundness and stability of the Banking System and laid down instructions to banks to accomplish 8% Capital Adequacy Ratio (CAR) in a phased manner. Afterwards, Narasimham Committee gave its second report in 1998. This report included suggestions to open new areas for bank financing like insurance, asset management, leasing, gold banking, investment banking etc. They also advised Indian Banks to bring down their NPAs and adopt the global banking standards. In the early 2000s, reforms with respect to electronic banking as Real Time Gross Settlement System (RTGS), National Electronic Funds Transfers (NEFT), Clearing Mechanism, Online Bill
Payments, and Telephone Banking were introduced. Further, Anti-Money Laundering (AML) and Know Your Customer (KYC) norms in 2002 filtered the unethical and illegal issues from the banking business.

However, the period from 2002-03 to 2012-13 (Post Reformatory Era) focused on the implementation of these reforms. During this time period, it is assumed that a decade of gestation period is over and banks considered as adjusted to the reforms introduced. The latter period is of prime significance as the Indian Economy suffered from the ripplary effects of global recession from 2007-08 onwards.

3.3. Data Source

The present study is based on secondary data. It gathered data from annual reports of banks and Reports on Trend and Progress of Banking in India from 1991-92 to 2012-13. The source of financial data is website of Reserve Bank of India (RBI) which is considered as the most comprehensive database for research in banking. Statistical Tables related to Banks in India for various years published by RBI have also been used. Data relating to various macro variables has also been gathered from the website of Reserve Bank of India (RBI).

3.4. Methodology

3.4.1. Efficiency Measurement Methods

Several approaches have been developed over time for measuring banks' performance ranging from simple financial ratios to complex econometric models. The estimates of efficiency are sensitive to the choice of technique (Jaforullah and Premachandra, 2003 and Jacobs et al., 2006). Two approaches of Complex Econometric Models are available namely Parametric (Econometric Approach) and Non-Parametric (Linear Programming Approach). Both Approaches construct efficient production frontier to measure the efficiency performance of firms. Number of studies has adopted both these approaches, but none is rigorously preferred as both have their own merits and demerits. Parametric Approach covers Stochastic Frontier Approach (SFA), Thick Frontier Approach (TFA) and Distribution Free Approach (DFA), while Non-Parametric Approach includes Data Envelopment Analysis (DEA) and Free Disposal
Hull (FDH). Parametric Approach requires specific functional form, for instance ‘The Tranlog Production Function’ or ‘Cobb Douglas Production Function’ which has close similarity to the actual production process (Coelli et al., 1998); whereas Non-Parametric Approach does not assume a particular functional form and has properties like convexity and homogeneity where chances of measurement errors are less (Avkiran, 1999 and Rebelo and Mendes, 2000). The Parametric Approach includes production, cost, profit and the revenue function as alternative approach for estimating efficiency (Ajibefun, 2008). Econometric Approach tries to discriminate efficiency, noise effects and inefficiency effects, but has disadvantage of requiring strong assumptions to form the frontier (Jacobs, 2001), while Non-Parametric Approach completely ignores any noise in the data and considers left behind effect as inefficiency (Murillo-Zamorano, 2004). Parametric Approach cannot deal with multiple outputs while Non-Parametric Approach can handle multiple inputs and multiple outputs to calculate the efficiency scores. Parametric Approach is mainly restricted to micro economic issues (Liu and Zhuang, 1998) whereas Non-Parametric Approach is relevant to social science studies (Hammad, 2007). The Parametric Approach uses specific functional form which may not be applied to all firms unanimously because all firms are distinctive and have unique features in reality (Avkiran, 1999). Econometric approach may provide misleading information if adequate numbers of firms are not taken in the sample while Non-Parametric Approach may give biased results if heterogeneous firms are treated as homogenous. The advantage of Non-Parametric Approach is that it requires a small amount of assumptions about underlying technology (Jacobs, 2001). It follows Linear Programming Technique for calculating the efficiency scores (Ajibefun, 2008).

3.4.2. Data Envelopment Analysis (DEA)

The review of literature provides mixed viewpoint relating to usage of techniques to measure the efficiency scores. Berger and Mester (1997) found that the choice of the measurement technique did not make any significant difference. However, Jaforullah and Premachandra (2003) and Jacobs et al. (2006) stressed that estimates of efficiency are sensitive to the choice of technique. Among various frontier efficiency measurement techniques, DEA has emerged as a foremost tool owing to its advantages and flexibility (Colwell and Davis, 1992). Data Envelopment Analysis is a
benchmarking technique which permits to measure firm’s efficiency based on inputs used and outputs produced by them. Banker et al. (1996) reported that DEA gives superior results at almost all sample sizes. DEA approach is comparatively robust (Seiford and Thrall, 1990). Fethi and Pasiouras (2010) and Sharma et al. (2013) in their review based study found that majority of studies adopted DEA to calculate the efficiency scores. Data Envelopment Analysis (DEA) is often used in various studies as it permits to identify the causes of inefficiencies. Moreover, some of the studies mentioned that DEA provides better and superior results than parametric approaches (Banker et al., 1988 and Banker et al., 1993). Data Envelopment Analysis (DEA) has also been used frequently in banking studies to measure the efficiency as Parkan (1987), Rangan et al. (1988), Yue (1992), Bhattacharyya et al. (1997), Saha and Ravishankar (2000), Ram Mohan and Ray (2004), Das et al. (2005), Ataullah and Le (2006), Varadi et al. (2006), Sahoo et al. (2007), Chansarn (2008), Ketkar and Ketkar (2008), Sanusi et al. (2011), Karimzadeh (2012), Karimzadeh (2012), Zeitun and Benjelloun (2013), Kamarudin et al. (2014), Jayaraman and Srinivasan (2014) and Okorie and Agu (2015).

Farrell (1957) extended the work initiated by Koopmans (1951) and Debreu (1951) who defined the measure of productive efficiency. Farrell (1957) used the economic concept of Production Frontier and Production Possibility Set to define the efficiency. Farrell's approach was based on single input that produces two separate outputs or two inputs that produce a single output. Later on, Farrell’s idea of single input and output was generalised to the multiple inputs and outputs by Charnes, Cooper and Rhodes (CCR) in 1978 who in the first instance reformulated Farrell’s (1957) idea into a mathematical problem. Charnes, Cooper and Rhodes (1978) developed Data Envelopment Analysis (DEA) which applies linear programming based technique to assess an empirical production technology frontier. It is employed for assessing the relative performance of a set of firms against the best observed firms which forms “The Efficiency Frontier” (Seiford and Thrall, 1990). It computes the efficiency of a firm in transforming inputs into outputs in relation to its peer group. The best practice firm defines an envelopment surface which is referred as an empirical Production Efficient Frontier. Firms that lie on envelopment surface are deemed to be efficient in DEA while those units that lie in the interior of the surface are termed inefficient firms. In other
words, DEA endeavours to construct the frontier from the most efficient firms and then measures how far the inefficient firms are from the frontiers. The distance between the actual performance of the firm and the observed best performance firm provides a base to estimate the degree of inefficiency. Firms in DEA are known as Decision Making Units (DMUs). The main endeavor of DEA is to calculate how efficiently DMUs uses available resources to generate outputs (Charnes et al., 1978). It differentiates the least efficient and best efficient DMUs from the set of all DMUs. DEA can identify inefficiencies in the process of converting inputs to outputs which can then be corrected for raising profitability (Avkiran, 2006). An inefficient firm can reach the efficiency frontier in order to become efficient by:

- Reducing the inputs while maintaining the outputs at its present level (input oriented approach)
- Increasing the production of outputs from the available inputs (output orientated approach)
- Increasing outputs as well as reducing the inputs simultaneously (non-oriented approach)

DEA takes the actual data of firm’s operations for calculating the efficiency scores along with efficient frontier created as the piecewise linear combination of the “most efficient firms”. Thus efficiency is in relation to the “best observed value”, rather than an “absolute value” (Rajput and Gupta, 2011). DEA has the capability to consider multiple inputs and outputs so that performance can be best modelled. As multiple inputs and outputs are used to calculate efficiency for this DEA tries to determine the weight using linear programming technique so as to maximize the ratio weighted output to weighted input. In DEA, the weights for inputs and outputs are derived from the data instead of being fixed in advance. The optimal weights generally vary from one DMU to another DMU. Accordingly, each DMU is assigned a best set of weights that may vary from one DMU to another. Thus DEA constructs the efficiency frontier from weighted sum of outputs (Virtual output) to weighted sum of inputs (Virtual input). DMUs having an efficiency score of one are rated as most efficient firms while less efficient DMUs have efficiency score between zero and one.
The original CCR (1978) formulation determines the relative efficiency for firms by maximizing the ratio of weighted output to weighted input based on the condition that similar ratios for all firms are less than or equal to one. The CCR model is based on Constant Return to Scale (CRS) when enveloping the actual data to determine the shape of the production frontier. Constant Return to Scale implies that a change in the amount of the inputs leads to a similar change in the amounts of the outputs. CCR Model was further extended by Banker, Charnes and Cooper (BCC) in 1984. The BCC model allows for the efficiency measurement of DMUs with Variable Return to Scale (VRS) assumption. VRS includes both increasing and decreasing returns to Scale.

DEA was originally developed for measuring Technical Efficiency, Pure Technical Efficiency and Scale Efficiency where prices of inputs and outputs are not required. Afterwards, DEA was modified to measure economic efficiency i.e. Cost Efficiency, Revenue Efficiency and Profit Efficiency which require different input-output combinations as well as their prices (Fried, Lovell and Schmidt, 2008). The objective of this measure is to assess whether the firm has achieved the specified objective of cost minimization, revenue maximization and profit maximization or not. Farrell (1957) introduced a method to decompose the overall productive efficiency into product of two factors i.e. Technical and Allocative Efficiency. Further, Färe, Grosskopf and Lovell (1983) decomposed the Technical Efficiency into product of Scale Efficiency and Pure Technical Efficiency. Cost Efficiency model is an input oriented model as it minimizes inputs at a given level of output quantities and input prices. Cost Efficiency measures a bank’s ability to control the costs. On the other hand, Revenue Efficiency model is an output oriented model that maximizes revenue for a given set of input quantities and output prices. It is evaluating the bank’s ability to increase the revenues. Profit Efficiency measures how close a bank comes to producing maximum profit given the input, output quantities as well as their prices. It is used to maximize the bank’s profit as it takes into account cost as well as revenues. Data Envelopment Analysis (DEA) permits to verify whether the economic inefficiency in performance of the firm is due to Technical or Allocative inefficiency. Furthermore, DEA helps to analyze that Technical inefficiency is associated with the size (Scale inefficiency) or managerial inefficiency.
3.4.3. Mathematical Formulations of DEA

The simple method to measure the efficiency ratio is to calculate the ratio or make graphical presentation. The efficiency ratio is calculated as follows:

\[ \text{Efficiency} = \frac{\text{Output}}{\text{Input}} \]

This ratio is useful only in case of single output and single input. Nevertheless, firms normally use multiple inputs to produce multiple outputs. So, the simple efficiency ratio can be inadequate. DEA is used to compute the efficiency in case of multiple inputs and outputs. In DEA, multiple inputs and multiple outputs are linearly aggregated using weights. As a result, the efficiency is calculated as:

\[ \text{Efficiency} = \frac{\text{Weighted sum of outputs}}{\text{Weighted sum of Inputs}} \]

The weighted sum of inputs and outputs are known as virtual inputs and virtual outputs. The equation form of virtual inputs and outputs is written as follows:

Virtual input = \( v_1x_{1o} + v_2x_{2o} + v_3x_{3o} + \ldots + v_mx_{mo} \)

\[ = \sum_{i=1}^{m} v_i x_{io} \]

Virtual output = \( u_1y_{1o} + u_2y_{2o} + u_3y_{3o} + \ldots + u_ry_{ro} \)

\[ = \sum_{r=1}^{s} u_r y_{ro} \]

Hence, the efficiency scores in DEA can be calculated as follows:

\[ \text{Max } \theta = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \]
where,

\( \theta = \) Efficiency rating of the firm being evaluated by DEA

\( i = \) number of inputs used by the firm

\( r = \) number of outputs generated by the firm

\( u_r = \) coefficient or weight assigned by DEA to output \( r \)

\( v_i = \) coefficient or weight assigned by DEA to input \( i \)

\( y_{ro} = \) amount of output \( r \) produced by the firm \( o \)

\( x_{io} = \) amount of input \( i \) used by the firm \( o \)

Thus the data required to apply DEA are the actual observed outputs produced \( y_{ro} \) and the actual inputs used \( x_{ij} \) during one time period for each DMU. Hence, \( x_{ij} \) is the observed amount of the \( i^{th} \) input used by the \( j^{th} \) firm and \( y_{ro} \) is the amount of \( r^{th} \) output produced by the \( o^{th} \) firm. The coefficients of weights in DEA are derived from the data. The linear programming technique is used to find the set of coefficient (u’s and v’s) i.e. weights that will give the highest possible efficiency ratio of outputs to inputs for the firm being evaluated. The weights generally assigned to each firm will vary from one DMU to another DMU. Thus to maximize the efficiency of unit \( o \) is subject to the efficiency of all units being less than or equal to 1. This can be measured as:

\[
\begin{align*}
\text{Max } \theta &= \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \\
\text{Subject to,} \quad & \sum_{r=1}^{s} u_r y_{ro} \\ & 0 \leq \sum_{i=1}^{m} v_i x_{io} \leq 1; \ j=1, 2, 3, N \\
& u_r, v_i \geq 0
\end{align*}
\]
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where,

\( \theta \) = Efficiency of the DMU,

\( x_{ij} \) and \( y_{ij} \) are the inputs and outputs of the \( j^{th} \) DMU,

\( v_i \) and \( u_r \) are the input and output weights,

\( m \) and \( s \) are the number of inputs and outputs respectively.

Using mathematical programming technique, the weights for a DMU are determined subject to the condition that the efficiencies of DMUs are restricted to values between 0 and 1. The DMU for which the efficiency is maximized is termed as Reference DMU. In other words, the objective is to maximize the efficiency of DMU \( o \) subject to the constraints that the efficiency of none of the DMUs should exceed one. The above mathematical program when solved will give the values of weights \( u \) and \( v \) that will maximize the efficiency of the \( o^{th} \) DMU. These mathematical programs are fractional programs and are not linear. It is generally difficult to solve the fractional programs. The linear programs could be used to solve fractional models by converting to the linear forms. To achieve it, the denominator has to be set equal to constant and the numerator has to be maximized. If the denominator of the objective function is normalized, the above program can be transformed to a linear programming problem:

\[
\text{Max } h_o = \sum_{r=1}^{s} u_r y_{ro} \\
\text{Subject to } \sum_{i=1}^{m} v_i x_{io} = 1 \\
\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \quad j = 1, 2, \ldots, n \\
v_i, u_r \geq 0 \quad r = 1, 2, \ldots, s; \quad i = 1, 2, \ldots m
\]

The weighted sum of inputs is constrained to be unity in this linear program as the objective function is the weighted sum of outputs that has to be maximized. This formulation is termed as Output Maximization DEA program. A similar LP formulation is possible by minimizing the weighted sum of inputs by setting the weighted sum of outputs equal to unity. It is known as Input Minimization DEA program. The following is the input minimization DEA program:
Min $Z' = \sum_{i=1}^{m} v_i x_{io}$

Subject to $\sum_{r=1}^{m} u_r y_{ro} = 1$

$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} \geq 0$ $j = 1, 2, \ldots, n$

$u_r, v_i \geq E; i = 1, 2, \ldots, m; r = 1, 2, \ldots, s$

Both these above models developed so far are called the Charnes, Cooper and Rhodes (CCR) models in the DEA literature. The CCR model estimates the gross efficiency of a DMU. CCR DEA model assumes that the operations follow constant return to Scale. This represented one of the most limiting factors for the applicability of DEA.

Banker, Charnes and Cooper (BCC) (1984) came up with the modification to CCR DEA model in order to handle the variable return to Scale. Banker, Charnes and Cooper (1984) adjoined a convexity condition to DEA Model which ensures that an inefficient DMU is only compared with similar sized DMUs. The BCC model takes into account the variations of efficiency with respect to the Scale of operations and hence measures the Pure Technical Efficiency. The BCC model evaluates the efficiency of the DMUs by solving the following linear program:

Max $ho = \sum_{r=1}^{s} u_r y_{ro} + u_o$

Subject to $\sum_{i=1}^{m} v_i x_{io} = 1$

$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + u_o \leq 0$ $j = 1, 2, \ldots, n$

$v_i, u_r \geq E; r = 1, 2, \ldots, s; i = 1, 2, \ldots, m; u_o$ is free
The following is the input minimization BCC DEA program:

\[
\text{Min } Z' = \sum_{i=1}^{m} v_i x_{io} + v_o
\]

Subject to \(\sum_{r=1}^{m} u_r y_{ro} = 1\)

\[
\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} + v_o \geq 0 \quad j = 1, 2, \ldots, n
\]

\(u_i, v_r \geq E ; i = 1, 2, \ldots, m; r = 1, 2, \ldots, s ; v_o \text{ is free}\)

Thus Technical Efficiency scores calculated using CCR model are greater than or equal to those in the BBC model. If there is difference in the efficiency score of CCR Model and BCC Model, there exists Scale inefficiency. Scale Efficiency score can be derived by calculating the ratio of Technical Efficiency Score (CCR Model) to Pure Technical Efficiency Score (BCC Model). Hence, Overall Efficiency comprises Pure Technical Efficiency and Scale Efficiency. Pure Technical Efficiency describes the efficiency in converting the inputs to outputs, while Scale Efficiency recognizes that there is one most productive Scale size, where the Scale Efficiency is maximum i.e. 100%.

The above DEA models use quantitative data to capture Technical Efficiency score of DMUs while these models cannot be taken into account for Allocative Efficiency. But, if input and output prices data is available then DEA Models can be extended to measure Cost, Revenue and Profit Efficiency. The main purpose of these extended DEA models is to minimize cost or maximize revenue or profit. The following is the Mathematical programming equations used to calculate Cost, Revenue and Profit Efficiency:
Table: 3.2 Data Envelopment Analysis Mathematical Formulation of Efficiency

<table>
<thead>
<tr>
<th>Cost Efficiency</th>
<th>Revenue Efficiency</th>
<th>Profit Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min $= \sum_{r=1}^{m} p_i^o \bar{x}_{io}$</td>
<td>Max $= \sum_{r=1}^{s} q_r^o \bar{y}_{ro}$</td>
<td>Max $= \sum_{r=1}^{s} q_r^o \bar{y}<em>{ro} - \sum</em>{r=1}^{m} p_i^o \bar{x}_{io}$</td>
</tr>
<tr>
<td>Subject to $\sum_{j=1}^{n} \lambda_j x_{ij} \leq \bar{x}_{io}$</td>
<td>$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \bar{x}_{io}$</td>
<td>$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \bar{x}_{io}$</td>
</tr>
<tr>
<td>$i = 1,2, ..., m$</td>
<td>$\lambda_j \geq 0$</td>
<td>$\lambda_j \geq 0$</td>
</tr>
<tr>
<td>$\sum_{i=1}^{n} \lambda_j y_{rj} \geq y_{ro}$</td>
<td>$\sum_{i=1}^{n} \lambda_j y_{rj} \geq \bar{y}_{ro}$</td>
<td>$\sum_{i=1}^{n} \lambda_j y_{rj} \geq \bar{y}_{ro}$</td>
</tr>
<tr>
<td>$r = 1,2, ..., s$</td>
<td>$\lambda_j \geq 0$</td>
<td>$\lambda_j \geq 0$</td>
</tr>
<tr>
<td>$\sum_{j=1}^{n} \lambda_j = 1$</td>
<td>$\lambda_j \geq 0$</td>
<td>$\lambda_j \geq 0$</td>
</tr>
<tr>
<td>Source: Zhu (2009)</td>
<td>where</td>
<td></td>
</tr>
</tbody>
</table>

where

- $n =$ Number of DMUs
- $j =$ $n^{th}$ DMU
- $s =$ output observation
- $m =$ input observation
- $r =$ $s^{th}$ output
- $i =$ $m^{th}$ input
- $q_r^o =$ unit price of the output $r$ of DMU$_o$
- $p_i^o =$ unit price of the input $i$ of DMU$_o$
- $\bar{y}_{ro} =$ $r^{th}$ output that maximise revenue for DMU$_o$
- $\bar{x}_{io} =$ $i^{th}$ input that minimise cost for DMU$_o$
- $y_{ro} =$ $r^{th}$ output for DMU$_o$
- $x_{io} =$ $i^{th}$ input for DMU$_o$
- $y_{s} =$ $s^{th}$ output for $n^{th}$ DMU
- $x_{j} =$ $m^{th}$ input for $n^{th}$ DMU
- $\lambda_j =$ non-negative scalars
3.4.4. Return to Scale

In economic terms, firm’s objective is to operate on the most productive Scale size, i.e. Constant Returns to Scale (CRS) in order to minimize the cost and maximize the revenue. DEA helps to determine whether a DMU is operating at a wrong scale, i.e. either operating at Decreasing Returns to Scale (DRS) or Increasing Returns to Scale (IRS). DRS indicates that DMU is operating at a Scale that is too large which portrays that a percentage increase in inputs of that DMU produces a less than proportional increase in outputs. DMU with DRS lies above the optimum Scale and would improve their operations by compressing their Scale of operations which is resulting into diseconomies of Scale. On the other side, IRS depicts that DMU is operating at a Scale that is too small, which averages that the percentage increase in inputs of DMU produces a more than proportional increase in outputs. DMU with IRS lies below the optimum Scale and would improve their operations by mounting their Scale of operations. Return to Scale in DEA can be identified by comparing the efficiency scores obtained from the CCR model which assumes Constant Return to Scale (CRS) with the efficiency scores calculated from BCC model by assuming Variable Return to Scale (VRS). If VRS scores are equal to CRS scores then it is supposed that a bank is operating at Constant Returns to Scale (CRS). If the scores are not equal then it is desirable to ascertain whether a bank is operating at Increasing Returns to Scale (IRS) or Decreasing Returns to Scale (DRS). To recognize whether bank is operating on IRS or DRS, DEA model is applied under the assumptions of Non-Increasing Returns to Scale (NIRS). If VRS efficiency scores are equivalent to NIRS score then the bank is said to be operating at DRS while if VRS scores are different from NIRS score then the bank is said to be operating at IRS (Coelli et al., 1998). The nature of Return to Scale is very significant as the information obtained from the efficiency scores about the nature of RTS may be utilized by management to achieve the most productive Scale size by either downsizing or expanding the Scale of operations.

In the present study, number of banks operating on DRS, CRS and IRS as per DEA have been counted to check whether Indian Scheduled Commercial Banks are facing the problem of wrong scale or not.
3.4.5. Preliminaries to DEA

Prior to analysis of results of efficiency, there are two main issues which are required to be considered. The first issue is whether a Common Efficiency Frontier for the sample of all banks across time should be made or separate frontier should be constructed for all years. The second issue is whether Public, Private and Foreign Sector Banks share identical production technology or different. In other words, whether it would be feasible to pool the data of Public, Private and Foreign Sector Banks into one sample to construct same frontier or it would be feasible to construct different frontiers for banks according to their ownership.

A. Common Efficiency Frontier versus Separate Efficiency Frontier across Time

The literature based on efficiency performance of banks highlights that either a single grand frontier for all years or separate frontier for each year is to be constructed for benchmarking the firms. Bhattacharyya et al. (1997) and Ataullah and Le (2006) constructed a single grand frontier of all banks for all years by pooling data of inputs and outputs. They are of the view that grand frontier provides best practice benchmark across the whole time period and against that frontier the efficiency of each bank in each year is calculated. These researchers enlighten that the grand frontier approach provides variations in the efficiency scores over time and space. Moreover, it also demonstrates a trend in the efficiency scores.

Contrary to these researchers as Bauer et al. (1993), Bauer et al. (1998), Deyoung and Hasan (1998), Isik and Hassan (2002a), Andriş and Cocriş (2010), Ahmad and Noor (2011), Gulati (2011b), Tahir et al. (2011) and Lakew (2013) suggested that constructing separate frontier for each year offers more suppleness than a single multiyear frontier. Tahir et al. (2011) also proposed that making different frontier for every year is better as it implicitly incorporates the time as well as technological effects which are completely missing in the common frontier. Furthermore, Isik and Hassan (2002a) asserted that the problem related to lack of random error in DEA could be reduced, to some extent, by making separate frontier for each year, as enveloping different frontiers permit the most efficient bank in one year to be inefficient in another year. According to the researchers, the foremost benefit of constructing separate frontier
for each year is that it takes into consideration the different scenarios as well as captures the realistic changes that take place over the years in the environment in which the banks are operating.

Keeping in the view the fact that Indian Banking Industry has transformed drastically owing to several reforms and innovations that occurred during the past number of years, it is expected that the efficiency of Indian Scheduled Commercial Banks may not have consistent results over the time period. As a result, the study estimates the separate frontier for each year that helps to capture the changes in the performance of Indian Scheduled Commercial Banks.

B. Common Efficiency Frontier versus Separate Efficiency Frontier across Ownership

Analogous to former studies, it is assumed that all Scheduled Commercial Banks i.e. Public, Private and Foreign Sector Banks perform under identical legal framework and business environment as prevailing in the country. Public, Private or Foreign Sector Banks in India are governed and regulated by Reserve Bank of India. Moreover, banks belonging to different sectors have common norms of accepting deposits and lending loans and advances. Therefore, it may be viable to pool Public, Private and Foreign Sector Banks into one sample to estimate their efficiency scores.

However, banks in different sectors have distinct production technologies and varied customer base to deal with. Public Sector Banks have large network of branches and cover even the rural population, while majority of Private Sector Banks are operating in the urban areas whereas Foreign Sector Banks are operating only in the main metropolitan cities. Public Sector Banks have the obligation to fulfil social objective along with achieving commercial viability while Private Sector Banks and Foreign Sector Banks are completely profit centred. Consequently, it may be inappropriate to pool Public, Private and Foreign Sector Banks into one sample.

Studies available on bank efficiency as Byrnes (1985), Aly et al. (1990), Elyasiani and Mehdian (1992), Deyoung and Hasan (1998), Cummins et al. (1999), Isik and Hassan (2002a), Niazi (2003), Burki and Niazi (2010) and Gulati (2011a) have discussed the vital issue of taking up a common vs. a separate frontier across ownership.
These studies constructed pooled as well as separate frontier to calculate Efficiency Scores. Specifically, the data of Public, Private and Foreign Sector Banks were pooled into one sample and the efficiency scores were calculated by assuming that banks follow common technology and function alike. Further, year wise separate efficiency frontiers for banks in different sectors were constructed to measure the efficiency scores. The efficiency scores calculated by these studies depicted that the efficiency scores considered by making separate frontier for banks were higher as compared to common frontier. In other words, separate frontier either overlapped with or enclosed within that of pooled frontier. Then, various Parametric and Non Parametric Tests like Analysis of Variance (ANOVA), Kolmogrov-Smirnov Test, Median Test, Kruskal-Wallis Test, Mood’s Median Test, Wilcoxon Rank Test etc, were conducted to compare the efficiency scores across pooled and separate efficiency frontier. These studies failed to reject the null hypotheses. Hence it became convincing that banks in different sectors could be pooled to measure the efficiency scores year by year. Based on the above discussion, the present study assumes that since all banks belonging to different sectors have same production expertise and operate under similar environmental conditions, a common frontier could be constructed for computing their efficiency scores.

3.4.6. Selection of inputs and outputs

A critical issue in non-parametric programming technique is its sensitivity to selection and number of inputs and outputs along with number of DMUs to be used as they can affect the discriminating powers of DEA (Boussofiane et al., 1991). There is contradictory thought about the size of the data set. One of the viewpoints states that larger the number of DMUs taken for the purpose of analysis, better it is. This enables to capture the high performance firms as efficient frontier and further discriminates the efficient DMUs from inefficient ones. Golany and Roll (1989) contradicted this point and stated that the larger the data set the lesser will be homogeneity in DMUs as some exogenous factors may influence the results. Some academicians and researchers provide several rules of thumb on number of inputs and outputs in relation to number of DMUs. Boussofiane et al. (1991) specify that minimum number of DMUs should be multiple of the number of inputs and the number of outputs. Golany and Roll (1989) state that number of units should be at least twice the number of inputs and outputs.
considered while Bowlin (1998) mentions that in DEA for calculating efficiency scores, number of DMUs have to be three times as the number of input and output variables. Dyson *et al.* (2001) recommend that DMUs should be at least two times the product of the number of input and output variables. Thus according to the rule of thumb, the sample of our study is adequate and larger than various situations.

There is no consensus on what encompass the inputs and outputs of a bank (Casu and Girardone, 2002). The selection of inputs and outputs is an arbitrary process in DEA (Ariff and Can, 2008 and Berger and Humphrey, 1997). The results of efficiency scores may vary depending on the selection of variables for each of the bank’s efficiency (Forughi and De Zoysa, 2012 and Kamarudin *et al.*, 2014). The basic problem in relation to input and output specification in bank arises due to different treatment of deposits. Some studies consider deposits as outputs (Bhattacharyya *et al.*, 1997; Saha and Ravisankar, 2000; Ram Mohan and Ray, 2004; Chansarn, 2008 and Ketkar and Ketkar, 2008) as it is part of banking services offered by bank to the customers while some treat it as inputs (Yue, 1992; Avkiran, 1999a; Sathye, 2003; Drake and Hall, 2003; Kao and Liu, 2004; Das *et al.*, 2005; Ataullah and Le, 2006; Varadi *et al.*, 2006; Sahoo *et al.*, 2007; Sufian, 2007; Sanusi *et al.*, 2007; Chansarn, 2008; Ketkar and Ketkar, 2008 and Karimzadeh, 2012) considering that deposits are used to issue loans to customers. This different treatment of deposits gives rise to diverse approaches. Different approaches for selecting inputs and output of banks include Operating Approach, Intermediate Approach, Value Added Approach, Assets Approach and User Cost Approach. Production Approach is the contribution of Benston (1965) and Bell and Murphy (1968) which presumes that banks serve as the producer of services for account holders. This approach considers that banks use purchased inputs, i.e. operating cost and interest expenses to produce deposits and loans and advances (Avkiran, 2000). Intermediate Approach supposes that banks act as financial intermediaries and their main role is to obtain funds from the savers and further lend these funds to the borrowers for making profit. Under Intermediation Approach, banks employ labour, physical capital, and borrowed funds to produce earning assets (Sealey and Lindley, 1977). Value Added Approach identifies Inputs and outputs based on the share of value added by them. High value adding items in the balance sheet with a substantial share are regarded as outputs like deposits and loans while labour, physical
capital and purchased funds are regarded as inputs (Wheelock and Wilson, 1995). Assets Approach considers assets as outputs specifically loans and advances whereas liabilities are considered as inputs. User Cost Approach was elaborated by Hancock (1985) who developed production theory for financial institutions. Under this approach, bank assets are treated as outputs if interest rate (returns) from them is greater than the opportunity cost whereas if financial cost of liabilities is less than the opportunity costs then liabilities are regarded as output. When both conditions are not satisfactory, then both assets and liabilities are to be treated as inputs (Berger and Humphrey, 1992).

The banking literature suggested that mainly two approaches i.e. Production Approach (operating approach) and Intermediate Approach are constantly used for selection of inputs and outputs. Also, majority of papers on efficiency of banks follow either Production Approach (Bhattacharyya et al., 1997; Saha and Ravisankar, 2000; Ram Mohan and Ray, 2004; Chansarn, 2008 and Ketkar and Ketkar, 2008) or Intermediation Approach (Yue, 1992; Avkiran, 1999a; Drake and Hall, 2003; Kao and Liu, 2004; Das et al., 2005; Ataullah and Le, 2006; Varadi et al., 2006; Sahoo et al., 2007; Sanusi et al., 2007; Chansarn, 2008; Ketkar and Ketkar, 2008 and Karimzadeh, 2012). Among researchers, Intermediation Approach is mostly preferred to evaluate the efficiency of the banks for the reason that Intermediate Approach suits more to the nature of the banking industry while Production Approach suits to evaluate the bank branch efficiency (Benston, 1965 and Berger and Humphrey, 1997). Berger and Humphrey (1997) and Favero and Papi (1995) pointed out that the Intermediation Approach is most appropriate for banks as a whole because most activities consist of converting huge deposits and funds into loans and financial investments. However, the Intermediate Approach enlightens that deposits and funds along with other inputs assist to produce the income and loans and advances.

This study also follows the intermediation approach by treating bank deposits as input, as the funds collected are used for the production of loans and other assets. In order to calculate Revenue Efficiency, Cost Efficiency and Profit Efficiency, input-output prices are required. Thus sticking with the intermediation approach, this study uses four inputs and three outputs along with their prices. The description of inputs, outputs and the prices of outputs are presented in Table: 3.3.
Table: 3.3 Description of input and output variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Variables</strong></td>
<td></td>
</tr>
<tr>
<td>1. Deposits</td>
<td>Demand Deposits + Term Deposit + Savings Deposits</td>
</tr>
<tr>
<td>2. Borrowings</td>
<td>Borrowings from RBI and other Banks or Financial institutions</td>
</tr>
<tr>
<td>3. Fixed Assets</td>
<td>Premises + Fixed Assets under Construction + Other fixed Assets</td>
</tr>
<tr>
<td>4. Number of Employees</td>
<td>Number of Employees working in the banks</td>
</tr>
<tr>
<td><strong>Output Variables</strong></td>
<td></td>
</tr>
<tr>
<td>1. Investments</td>
<td>Investments in Approved Securities, Government Securities, other approved</td>
</tr>
<tr>
<td></td>
<td>securities, shares, debentures</td>
</tr>
<tr>
<td>2. Loans and Advances</td>
<td>Term Loans + Cash Credit, overdraft + Bills purchased and discounted etc</td>
</tr>
<tr>
<td>3. Non-Interest Income</td>
<td>Commission + Bill Discounted + Fee</td>
</tr>
<tr>
<td><strong>Input Prices</strong></td>
<td></td>
</tr>
<tr>
<td>1. Price of Deposits</td>
<td>Interest paid on deposits / deposits</td>
</tr>
<tr>
<td>2. Price of Borrowings</td>
<td>Interest paid on borrowings from RBI and other agencies / Borrowing</td>
</tr>
<tr>
<td>3. Price of Fixed Assets</td>
<td>Rent, taxes and Lighting + Depreciation on banks’ assets + Repair and</td>
</tr>
<tr>
<td></td>
<td>Maintenance + Insurance / Fixed Assets</td>
</tr>
<tr>
<td>4. Price of number of employees</td>
<td>Payment and provisions for employees / number of employees</td>
</tr>
<tr>
<td><strong>Output Prices</strong></td>
<td></td>
</tr>
<tr>
<td>1. Prices of Investments</td>
<td>Income (interest and dividend received) from Investments / Investments</td>
</tr>
<tr>
<td>2. Prices of Loan and Advances</td>
<td>Interest received from loans and advances / Loans and Advances</td>
</tr>
<tr>
<td>3. Prices of Non-interest Income</td>
<td>Assumes the Price of non-interest income as unity throughout the years for</td>
</tr>
<tr>
<td></td>
<td>all banks</td>
</tr>
</tbody>
</table>

Various input and output variables are deflated taking 2004-05 as base year for neutralizing the effect of rise in the prices considering the fact that rise in prices means fall in value of money and a fall in the prices means rise in the value of the money. Moreover, specifying the inputs and outputs for calculating the efficiency scores for banks is often a controversial issue in banking. To ensure the soundness of DEA model, correlation among inputs and output variables is to be verified (Avkiran, 1999 and Mostafa, 2009). The degree of correlation between inputs and outputs is an important issue that has great impact on the robustness of the DEA model (Yang, 2009). The correlation between inputs and outputs is calculated for identifying whether increasing amounts of inputs generate greater outputs or not. To meet the requirements of DEA, there is need to have positive and statistically significant correlation between inputs and outputs. If an input variable has very low correlation with all the output variables, it may indicate that this variable is not fit for the model (Yang, 2009). Thus a correlation analysis is necessary to establish appropriate inputs and outputs (Pedraja-Chaparro et al., 1999). Table 3.4 provides the Pearson correlation matrix:
Table: 3.4 Pearson Correlation Matrix of inputs and outputs

<table>
<thead>
<tr>
<th>Outputs</th>
<th>Inputs</th>
<th>Number of Employees</th>
<th>Deposits</th>
<th>Borrowings</th>
<th>Fixed Assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investments</td>
<td>.833*</td>
<td>.964*</td>
<td>.751*</td>
<td>.830*</td>
<td></td>
</tr>
<tr>
<td>Loan and Advances</td>
<td>.718*</td>
<td>.983*</td>
<td>.805*</td>
<td>.797*</td>
<td></td>
</tr>
<tr>
<td>Non-Interest Income</td>
<td>.774*</td>
<td>.914*</td>
<td>.802*</td>
<td>.823*</td>
<td></td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.01 level of significance

As can be seen from Table 3.4, the correlation test is satisfied since there is a positive and significant correlation between inputs and outputs which is significant at 1% level of significance. Hence, the collection of the inputs and outputs is reasonable.

3.5. Statistical Tools and Technique used

3.5.1. Descriptive Statistics

Various descriptive tools like minimum, maximum, mean and standard deviation are calculated to analyse and compare the efficiency performance of banks.

3.5.2. Panel Data Tobit Regression Model

In the first stage of analysis, efficiency scores are calculated which can be further used in second stage for checking the consistency of DEA results and for identifying impact of the explanatory variables. However, the efficiency scores calculated from the first stage of analysis with the help of DEA falls between 0 and 1 thus making the variable a limited dependent variable. Due to this limited nature of dependent variable, Ordinary Least Squares Method (OLS) cannot be applied. As the expected errors will not be equal to zero in OLS thus it will provide biased estimates (Saxonhouse, 1976 and Resende, 2000). In other words, when the sample size increases, the coefficients from OLS method will not necessarily approach the true population parameters. Therefore, to generate consistent estimates of regression coefficients, a censored Tobit Model is preferred. Tobit model is applied due to the censored nature of the dependent variable as well as the extreme values of the independent variables which deviate from a normal distribution and are highly skewed in nature. Moreover, the work of previous researchers as Niazi (2003), Khanam and Nghiem (2006), Burki and Niazi,
Research Methodology

(2006), Gupta et al. (2008), Ahmed (2008), Gulati (2011a and b), Sharma et al. (2012) and Raphael (2013) also suggest that Tobit Model is the best model as it has the ability to handle equations with restricted threshold.

The present study is based on 1790 bank year observations for a period of 22 years thus suggesting that Panel Tobit Regression Model is to be used. Fixed-effect Tobit model cannot be used as there is no command for a parametric conditional fixed-effects model that allows the fixed-effect to be conditioned out of the likelihood (Stata Press Publications, 2009). Unconditional fixed-effect Tobit models may be fit using the Tobit model with an individual indicator, but these estimates are biased (Stata Press Publications, 2009).

Thus to estimate factors affecting Revenue, Cost and Profit Efficiency score, Random-effect Panel Tobit model is used. The Random-effects Panel Tobit model for $i^{th}$ bank can be specified as:

$$y_{it}^* = \beta' x_{it} + u_{it} \quad i = 1,2,3 \ldots N, t = 1,2,3, \ldots , T$$

$$u_{it} = v_i + \epsilon_{it}$$

where, $x_{it}$ is a vector of explanatory variables and the common error term $u_{it}$ could be freely correlated over time. The error term $u_{it}$ can be split into a time-invariant individual Random-Effect (RE) $v_i$ and a time-varying idiosyncratic random error $\epsilon_{it}$. Thus the Random-effects Panel Tobit model can be considered in the following form:

$$y_{it}^* = \beta' x_{it} + v_i + \epsilon_{it}$$

The observed variable for left-censored and right-censored observations is:

$$y_{it} = \begin{cases} y_{it}^* & \text{if } y_{it}^* > 0 \\ 0 & \text{otherwise} \end{cases}$$

$$y_{it} = \begin{cases} y_{it}^* & \text{if } y_{it}^* < 1 \\ 0 & \text{otherwise} \end{cases}$$

In this study, second stage of analysis is done by employing Random-Effect Panel Tobit Regression Model to determine the effects of bank specific, industry specific and economy specific factors on various banks’ efficiency parameters.
3.6. Independent Variables of the Study

In order to identify the factors affecting the Revenue, Cost and Profit Efficiency of Scheduled Commercial Banks (SCBs) operating in India, the following bank specific, industry specific and economy specific variables have been taken:

A. Banks Specific Variables

To take into consideration the entire aspect of banks, the study selects bank specific variables as per CAMEL framework along with bank specific control variables. These parameters are explained as follows:

I. Bank Specific Variables as per CAMEL Framework

1) Capital Adequacy: In order to determine the capital adequacy of a bank, Capital Adequacy Ratio (CAR) and Equity to Total Assets (ETA) have been taken. These are explained as follows:

(i) Capital Adequacy Ratio (CAR): This is defined as the ratio of capital to risk weighted assets. It is formulated as:

\[
\text{Capital Adequacy Ratio (CAR)} = \frac{\text{Capital} (\text{Tier I + Tier II + Tier III})}{\text{Risk weighted assets}}
\]

(ii) Equity to Total Assets (ETA): It refers to the proportion of equity to total assets. It can be written as:

\[
\text{Equity to Total Assets (ETA)} = \frac{\text{Equity} (\text{Capital + Reserves and Surplus})}{\text{Total Assets}}
\]

2) Asset Quality: In order to measure the asset quality of a bank three ratios are taken namely, Net Non-Performing Assets (NPA) to Net Advances, Total Investments to Total Assets (TITA) and Total Loan and Advances to Total Deposits (TATD). These are explained as follows:

(i) Net Non-Performing Assets to Net Advances (NPANA): This is defined as the ratio of Net Non-Performing Assets to Net Advances. It is formulated as:

\[
\text{Net Non-Performing Assets to Net Advances (NPANA)} = \frac{\text{Net Non - Performing Assets (NPA)}}{\text{Net advances}}
\]
(ii) **Total Investments to Total Assets (TITA):** It indicates the extent of deployment of assets in investment other than loans and advances. It is calculated as:

\[
\frac{\text{Total Investments (Investment in India + Investment outside India)}}{\text{Total Assets}}
\]

(iii) **Total Loan and Advances to Total Deposits (TATD):** This ratio indicates the quantum of loans and advances lent by banks out of their deposits. It is estimated as:

\[
\frac{\text{Loan and advances (Advances in India + Advances outside India)}}{\text{Total Deposits (Demand Deposits + Saving Bank Deposits + Term Deposits)}}
\]

3) **Management Soundness:** Management Soundness is another vital parameter of the CAMEL framework. It is analyzed by the following three ratios:

(i) **Total Expenses to Total Income (TETI):** It refers to the proportion of total expenses to total income. It is written as:

\[
\frac{\text{Total Expenses (Interest Expended + Operating Expenses)}}{\text{Total Income (Interest earned + Other Income)}}
\]

(ii) **Operating Expenses to Total Expenses (OETE):** It depicts the amount of operating expenses in relation to total expenses. It is calculated as:

\[
\frac{\text{Operating Expenses (Payments to and Provisions For Employees + Rent, TaxesAnd Lighting + Printing And Stationery + Advertisement and Publicity + Depreciation on Bank’S Property + Other Expenses)}}{\text{Total Expenses (interest Expenses + other Expenses)}}
\]

(iii) **Business per employee (BPE):** The ratio is calculated by dividing the total business i.e. deposits plus loan and advances by total number of employees working in a bank. The same is presented as follows:

\[
\frac{\text{Total Business (Deposits + Loan and Advances)}}{\text{Number of Employees}}
\]
4) **Earning Quality**: In order to measure the earning quality of a bank three ratios namely, Return on Assets (ROA), Spread to total assets (STA) and non-interest income to total income (NIITI) are used. These are explained as follows:

(i) **Return on Assets (ROA)**: Return on Assets is calculated by dividing the net profit generated by the bank with the total assets. It is formulated as:

\[
\text{Net profit generated by the bank} \left( \text{Total Income generated} - \text{Total expenses} - \text{Provisions} \right) \\
\text{Total Assets}
\]

(ii) **Spread to Total assets (STA)**: The ratio shows the competence of bank in managing its interest expenditure with interest income in relation to total assets. It is formulated as follows:

\[
\text{Spread} \left( \text{Interest Received} - \text{Interest Paid} \right) \\
\text{Total Assets}
\]

(iii) **Non-Interest Income to Total Income (NIITI)**: It refers to the proportion of Non-Interest Income to Total Income. It can be written as:

\[
\text{Non - Interest Income} \left( \text{Commission, Exchange and Brokerage} + \text{Net profit and loss on sale of Asset, investment} + \text{Miscellaneous Income} \right) \\
\text{Total Income} \left( \text{Interest earned} + \text{Other Income} \right)
\]

5) **Liquidity Management**: Liquidity is analyzed by the following two ratios:

(i) **Cash Deposit Ratio (CDR)**: It is calculated by dividing the cash with deposits. It can be written as:

\[
\text{Cash in hand} + \text{Balances with RBI} \\
\text{Total Deposits} \left( \text{Demand Deposits} + \text{Saving Bank Deposits} + \text{Term Deposits} \right)
\]

(ii) **Liquid Assets to Total Assets (LATA)**: The ratio of Liquid Assets to total assets indicates the overall liquidity position of the bank in relation to total assets. It can be calculated as follows:

\[
\text{Liquid Assets} \left( \text{Cash + balance with the RBI and other banks + money at call and short notice} \right) \\
\text{Total Asset}
\]
II. Control Variables

1) **Size**: Bank Size is captured by taking natural Logarithm of total assets.

2) **Time Dummy (TD)**: Time Dummy is used to incorporate the effect of introduction of reforms on the efficiency of the banks. For dummy value, 1 for the Reformatory Era and 0 for Post Reformatory Era is taken.

B. Industry Specific Variables

Two industry specific variables are taken namely Ownership and Market Share in terms of Total Assets. These are discussed as follows:

I. **Ownership Dummy**: To capture the impact of ownership, two dummies are considered as independent variables. One dummy for Public Sector Banks (PUBD) with a value of 1 for Public Sector Banks and 0 for other banks is taken. Similarly, another dummy of Private Sector Banks (PVTD) is created, while Foreign Sector Banks are considered as the reference sector.

II. **Market Share in terms of Total Assets (MSTA)**: It is calculated by dividing particular bank’s assets by banking sector’s total assets. The same can be written as:

\[
\text{Particular bank's assets in each year} \quad \text{over} \quad \text{Banking sector’s total assets in each year}
\]

C. Economy Specific Variables

Two important macro variables namely, Inflation and Gross Domestic Product are used. These are explained as follows:

I. **Inflation (INF)**: Wholesale Price Index is considered for computing the inflation by taking 2004-05 as base year.

II. **Gross Domestic Product (LNGDP)**: GDP is used by taking natural Logarithm of Gross Domestic Product.

3.7. **Hypotheses of the variables**

Taking into consideration theoretical as well as empirical results of previous research, following hypotheses are framed and tested:
H1- There is a positive relationship between Capital Adequacy Ratio and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H2- There is a positive relationship between Equity to Total Assets Ratio and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H3- There is a negative relationship between Non Performing Assets (NPA) to Net Advances and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H4- There is a positive/negative relationship between Total Investments to Total Assets and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H5- There is a positive/negative relationship between Total Loan and Advances to Total Deposits and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H6- There is a negative relationship between Total Expenses to Total Income and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H7- There is a negative relationship between Operating Expenses to Total Expenses and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H8- There is a positive relationship between Business per Employee and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H9- There is a positive relationship between Return on Assets and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H10- There is a positive relationship between Spread to Total Assets and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H11- There is a positive relationship between Non-Interest Income to Total Income and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H12- There is a positive/negative relationship between Cash Deposit Ratio and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H13- There is a positive/negative relationship between Liquid Assets to Total Assets and Revenue Efficiency, Cost Efficiency and Profit Efficiency.
H₁₄- There is a positive/negative relationship between Size and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H₁₅- There is a positive/negative relationship between Time Dummy and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H₁₆- There is a positive/negative relationship between Public Dummy and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H₁₇- There is a positive/negative relationship between Private Dummy and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H₁₈- There is a positive relationship between Market Share in terms of Total Assets and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H₁₉- There is a negative relationship between Inflation and Revenue Efficiency, Cost Efficiency and Profit Efficiency.

H₂₀- There is a positive relationship between Gross Domestic Product and Revenue Efficiency, Cost Efficiency and Profit Efficiency.