Chapter - IV

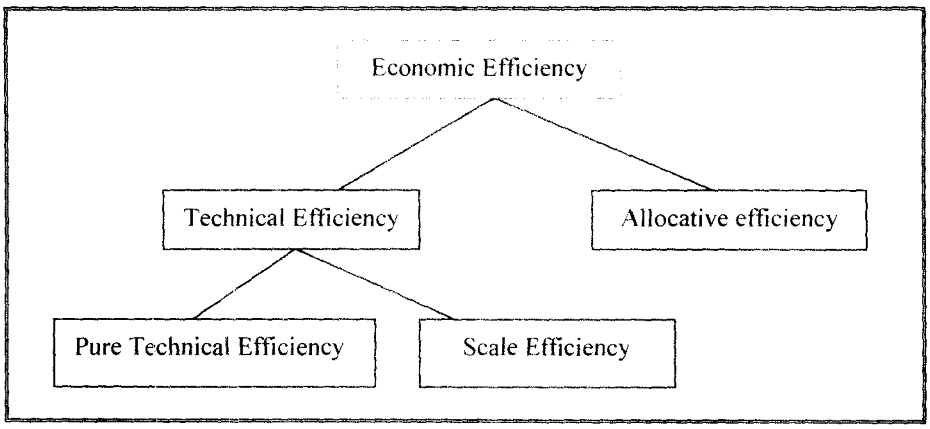
Research Methodology

4.1: Introduction

The main focus of this research is to measure and examine the efficiency of Indian domestic banks. The concept of efficiency is primarily an engineering concept, commonly used to describe the level of performance of a production unit in terms of its utilization of resources in generating outputs. Modern approach towards efficiency measurement is starting from the concept of efficiency of Farrell's[1] (1957). Michael J. Farrell, greatly influenced by Koopman's[2] (1951) formal definition and Debreu's[3] (1951) measure of technical efficiency has introduced a method to decompose the overall efficiency of a production unit into its technical and allocative components. However the different efficiency concepts are:

Box No: 4.1

Different Concepts of Efficiency



Economic efficiency or Overall efficiency means producing the "right" (Allocative efficiency) amount in the "right" way (Technical efficiency). Technical efficiency and allocative efficiency together form economic efficiency also called as X-efficiency. Overall efficiency i.e., economic efficiency refers to situation in which (with the given state of technology) it is impossible to generate a larger welfare total from the available resources . It means when more output cannot be obtained without increasing the amount of inputs. Production proceeds at the lowest possible per-unit cost. Profit maximization requires a firm to produce the maximum output by using given level of the inputs employed (i.e. be technically efficient), use the right mix of inputs in light of the relative price of each input (i.e. be input allocative efficient) and produce the right mix of outputs given the set of prices (i.e. be output allocative efficient) [4]. However, an organization will only be economic efficient if it is both technically and allocatively efficient.

Allocative efficiency refers to whether inputs, for a given level of output and set of input prices, are chosen to minimize the cost of production. It refers to ability to combine inputs and outputs in the optimal proportion in the light of prevailing prices[5]. It refers to allocation of resource that allows maximum possible benefit or utility from the available resource.

Technical Efficiency - The most common efficiency concept is technical efficiency: the conversion of inputs into outputs. Technical efficiency considers technological aspect of production. It is therefore, a measure of how well the transformation process (from input to output) is performing. In other words, it refers to ability to avoid waste by producing as much output as input usage allows or by using as little input as output allows.

Koopmans defined technical efficiency as a feasible input/output vector where it is technologically impossible to increase any output without simultaneously reducing another output. This analogy holds for a reduction in any input or both a reduction in any input and an increase in any output. Farrell measured technical inefficiency as the maximum equi-proportional reduction in all inputs consistent with equivalent production of observed output.

Thus, technical efficiency measurement can have output orientation and input orientation. Input oriented efficiency means minimization of inputs with producing al least the given level of outputs. Output oriented efficiency means maximization of outputs with using given level of inputs. Managerial practices and the scale or size of operations affect technical efficiency, which is based on engineering relationships but not on prices and costs. Technical efficiency therefore consists of pure technical efficiency and scale efficiency. Present study deals with technical efficiency which is based on input-output configuration.

4.2: Efficiency Measurement Techniques

There are basically two efficiency measurement techniques: Accounting Measures and Economic Measures.

4.2.1: Accounting Measures of Efficiency

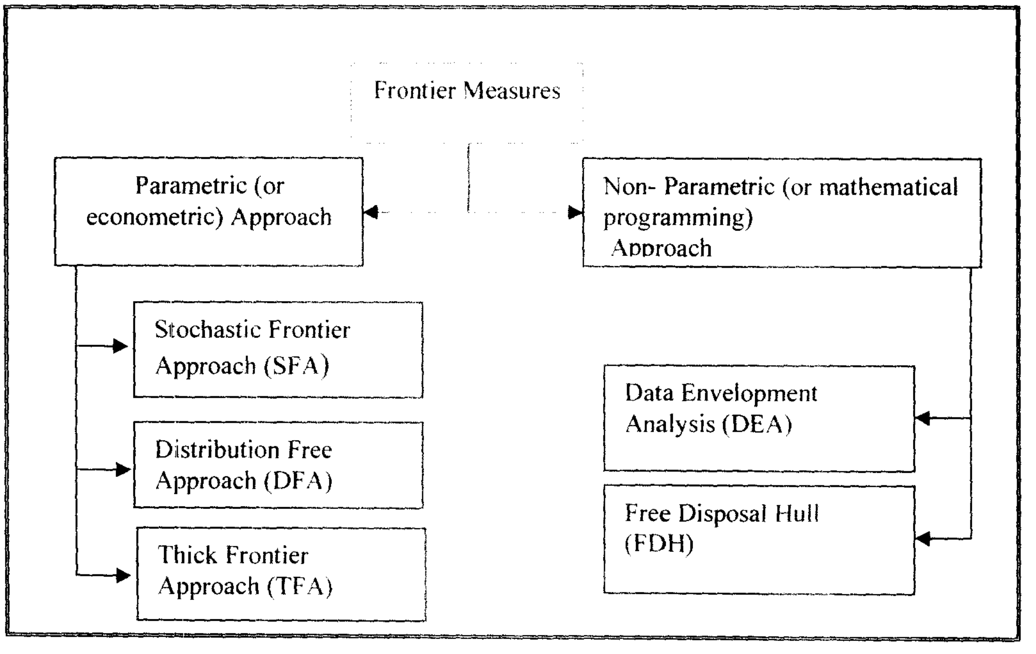
The earliest technique to assess the performances of business units is ratio analysis which examines the financial statements of individual firms and comparing them with a benchmark. These ratios are popular in financial analysis and even in economic literature only because of easy understanding. But analysis based on ratios is suffering from accounting biases. That is, accounting practices and norms in different environment differ significantly and hence ratios computed from two business units operating in differing economic environment may not be suitable for drawing economic conclusions. Besides, this technique fails to take into account the fact that banks produce multiple outputs from multiple inputs and consistent aggregation is not possible (See, for example, Barnes[6], 1987; Smith[7], 1990). The short comings of such a descriptive and static analysis of the data are overcome by later researchers with the use of parametric and non-parametric techniques.

4.2.2: Economic Measures of Efficiency

Economic measures estimate various efficiencies with broadly two types of approaches- parametric and non-parametric. Parametric and non-parametric technique is actually frontier technique which is highly accepted and widely used in the field of efficiency studies. The frontier techniques have the advantage to convey the information of many operational ratios in a single index, thus permitting ranking of decision-making units (DMUs) and summarizing of multiple possibly qualitative characteristics in a quantitative way. Various types of these modern efficiency measurement techniques are presented in Box No: 4.2.

Box No: 4.2

Frontier Approaches for Measuring of Efficiency



The parametric and non-parametric techniques differ mainly in how they handle random error and their assumptions regarding the shape of the efficient frontier. The parametric Stochastic Frontier Approach (SFA) and the non-parametric Data Envelopment Analysis (DEA) are the most used tools to measure efficiency, taking into account that the literature considers both techniques as equally satisfactory. As stated by Berger and Humphrey[8] (1997), there is no consensus on the preferred method for determining the best-practice frontier against which relative efficiencies are measured. Berger and Mester[9] (1997) find that in general the choice of measurement technique and functional form does not make a substantial difference in determining the average efficiency for the banking sector or raking of individual banks. We prefer to the DEA approach as we consider it to be a more appropriate tool in our analysis since it does not require an assumption of a functional form for the frontier relating to given specification of inputs and outputs of the sample composed of banks of different sizes, types and ages. Thus, DEA is an appropriate technique for this study as it fulfils the objectives of estimating and examining technical efficiency of the Indian banks and ranking them. It also enables to give an insight into efficiency of the banks.

4.3: Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a non-parametric performance assessment methodology originally designed by Charnes, Cooper and Rhodes[10] (1978) to measure the relative efficiencies of organizational units or decision making units (DMUs). This technique aims to measure how efficiently a DMU uses the resources available to generate a set of outputs. The DEA approach applies linear programming techniques to observe inputs consumed and outputs produced by decision-making units and constructs an efficient production frontier based on best practices. Each DMU's efficiency is then measured relative to this frontier.

DEA is defined by Giokas[11] (1997) as follows:

"DEA measures relative efficiency [of DMUs] by estimating an empirical production function which represents the highest values of outputs/benefits that could be generated by inputs/resources as given by a range of observed input/output measures during a common time period."

DEA is a non-parametric linear programming based data analytic technique for measuring and evaluating relative efficiency of a homogeneous set of units termed as decision making units (DMUs) which use variety of identical inputs to produce variety of identical outputs. DEA is a relatively new "data oriented" approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs[12]. DEA is an optimization method of mathematical programming to generalize the Farrell's (1957) single-output single-input technical-efficiency measure to multiple-output and multiple-input case by constructing a frontier of the best practice DMUs established mathematically by the ratio of weighted sum of outputs to weighted sum of inputs from the identical input output data set available from the DMUs under evaluation and to estimate efficiency of a DMU relative to the constructed frontier. Thus, DEA is a mathematical linear programming approach to frontier analysis. The estimated frontier of the best practice DMUs is also referred to as efficient frontier or envelopment surface. In DEA literature, DMUs lie on the frontier are technically efficient having efficiency score equal to 1 and the DMUs lie off the frontier are technically inefficient having efficiency score between 1 and 0.

Box No. 4.3

DEA in summery

- DEA constructs an efficient frontier by yielding a piecewise linear production surface i.e., identifying best practice DMU(s) from the identical inputs and outputs data set available from the DMUs under evaluation.
- Frontier defines multiple inputs and multiple outputs productivity
- Frontier defines the (observed) efficient trade-off among inputs and outputs within a set of DMUs.
- Relative distance to the frontier defines efficiency.
- DMUs on the frontier are efficient and DMUs off the frontier are inefficient.
- Nearest point on frontier defines an efficient hypothetical DMU of the inefficient DMUs.
- Differences in inputs and outputs between DMU and hypothetical DMU define efficiency "gaps" (improvement potential)

Source: Author's compilation

4.3.1: Importance of DEA in Banking Efficiency Measurement

DEA with 30 years of journey since 1978 is now a very popular and well accepted methodology in the field of efficiency measurement and improvement of the units using multiple inputs to produce multiple outputs. DEA was firstly applied by Sherman and Gold[13] (1985) for assessing the efficiency of bank branches and, thereafter, it proved a very promising tool for monitoring the efficiency in banking industry. Of the 122 studies reviewed in the extensive survey carried out by Berger and Humphrey[14] (1997) on efficiency of depository financial institutions in 21 countries, 62 studies (i.e., just over 50%) employed DEA to examine the efficiency of the banking sector. The connotation of this reference is that over the years, DEA has emerged as a well accepted and popular technique for evaluating the efficiency of the banking system. Its popularity as an accepted method of efficiency analysis can also be realized from huge DEA bibliography database also[15].

Box No. 4.4

Strength and Weakness of DEA

Strengths

⇒ DEA produces a single score for each unit rather than population average, which makes the comparison easy. DMUs are directly compared against a peer or combination of peers.

⇒ Its main strength lies in its ability to handle multiple inputs and outputs situation effectively i.e. to capture the multidimensional nature (of inputs/outputs) in the production process which is the prevalent characteristics of many units under evaluation.

⇒ It places no restrictions on the functional form of the production relationship. That is it doesn't require an assumption of a functional form relating inputs to outputs.

⇒ DEA modeling allows the analyst to select inputs and outputs in accordance with a managerial focus.

⇒ Furthermore, the technique works with variables of different units (unit's invariance) without the need for standardization. There is as such no limit to the number of inputs and outputs. This is not possible through traditional ratio analysis.

⇒ There is no requirement for any *a priori* views or information regarding the assessment of the efficiency of DMUs. The weights for outputs and inputs are obtained by calculating the DEA models, rather than being given artificially

⇒ Another advantage of DEA that attracts analysts and management is its ability to identify the potential improvement for inefficient units by providing both the sources and the amount of inefficiency such as pure technical and mix inefficiencies. Moreover, the reference set used to benchmark these inefficiencies are also indentified. A deficiency of the econometric approaches is their inability to identify sources and estimates the inefficiency amounts associated with these sources. Hence, no clue as to corrective action is provided even when the inefficiencies are present.

Limitations

➢ The lack of allowance for statistical noise is widely regarded as the most serious limitation of DEA because this puts a great deal of pressure on users of this technique to collect data on all relevant variables and to measure them accurately.

➢ DEA is good at estimating "relative" efficiency of a DMU but not "absolute" efficiency. In other words, it can tell you how well you are doing compared to your peers but not compared to a "theoretical maximum."

➢ Since DEA is a nonparametric technique, statistical hypothesis tests are difficult.

➢ Results are sensitive to the selection of inputs and outputs

Source: Author's compilation

4.3.2: DEA Models

There is variety types of DEA models developed in the DEA literature since1978. There are two approaches in DEA models: radial and non radial. Differences exist in the characterization of input or output items. In DEA literature, two models namely CCR model (named after Charnes, Cooper and Rhodes[16], 1978) and BCC model (named after Banker, Charnes and Cooper[17], 1984) are called basic DEA models. These models which are radial measure of efficiency are of two types- input oriented and output oriented.

Input oriented technical efficiency aims at reducing input amounts as much as possible while keeping at least the present output levels and output oriented technical maximizes the output level while using at least the present input levels.

4.3.2.1: CCR and BCC Models

The study has utilized two most popular and widely used basic DEA models- input oriented CCR model and input oriented BCC models to estimate the bank wise level of relative technical efficiency. CCR model measures the efficiency called overall technical efficiency (OTE) and BCC model measures efficiency called pure technical efficiency (PTE). OTE and PTE allow to measure scale efficiency (SE). SE = OTE/ PTE. So, using these CCR and BCC models the study has estimated three types of efficiencies: OTE, PTE and SE for individual banks.

Figure: 4.1

CCR and BCC Frontier

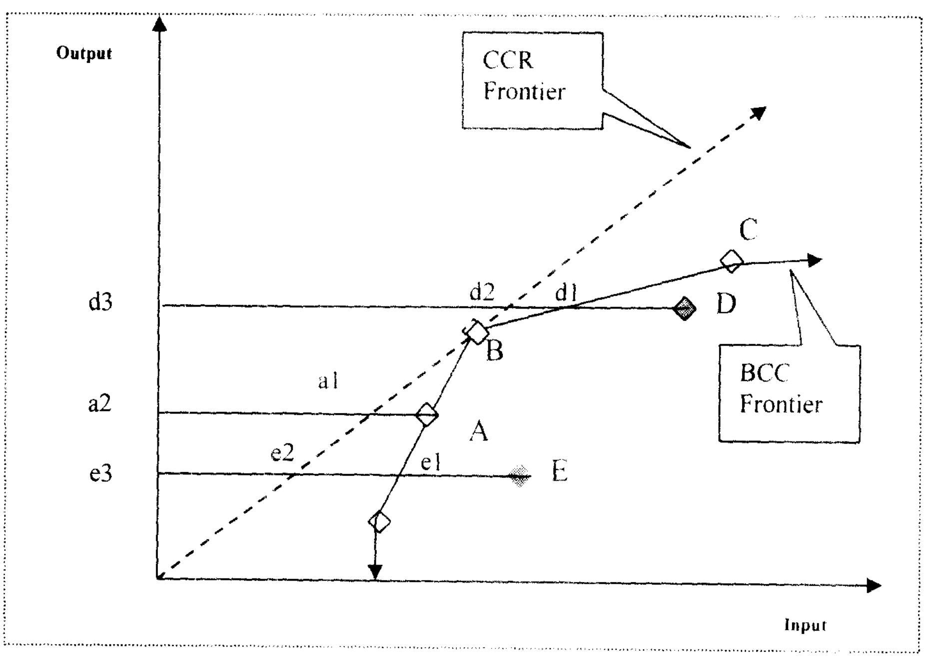


Figure 4.1 illustrates the CCR and BCC models in a simple single-input and singe-output along with the derivation of concept of OTE, PTE and SE. The CCR model assumes constant returns to scale so that all observed production combinations can be scaled up or down proportionally. This constant returns-to-scale DEA frontier is derived simply by the ray through the origin passing through point B. The DEA-BCC model, on the other hand,

allows for variable returns to scale and is graphically represented by the piecewise linear convex frontier. The areas to the right of the two frontiers represent production possibility set (PPS).CCR and BCC models define different production possibility sets and efficiency results. As an example, the input-oriented efficiency of unit 'E' in Figure 4.2 is given by e_3e_2/e_3e as yielded by the CCR model and e_3e_1/e_3e by the BCC model. The shape of the VRS frontier is piecewise boundary and closer to observed inefficient points which results in BCC efficiency score higher or equal to corresponding CCR score. The rational for this is that CCR efficiency incorporates scale efficiency while BCC do not.

DMUs 'A', 'B' and 'C' are BCC efficient, only 'B' is CCR efficient. DMUs 'D' and 'E' are both CCR and BCC inefficient and their input oriented projection individualizes reference points 'd_1' and 'e_1' on VRS frontier , 'd_2' and 'e_2' on CRS frontier. The difference between 'D1' and 'D2'', 'E1' and 'E2' are due to control for scale. The ratio of $e_3e_2/\ e_3e_1$ and $d_3d_2/\ d_3d_1$ represents the scale efficiency of DMUs 'E' and 'D'. Here it is to be pointed out that the DMUs 'D' and 'E' are characterized by opposite scale properties. DMU 'E' is radially projected on a increasing return to scale facet of the VRS frontier while DMU 'D' is radially projected on a VRS surface where variable return to scale hold. It is important to note that if a DMU is fully efficient under both CCR and BCC score the DMU is said to be operating in the most productive scale size i.e. scale efficiency is 100% i.e. region where constant returns-to-scale (CRS) prevails.

However three types of DEA efficiency measures of DMUs E, A and B are presented below-

Table: 4.1

Different Efficiency Measures

Efficiency Type	DMU-'E' (CCR and BCC inefficient)	DMU-'A' (CCR inefficient but BCC efficient)	DMU-'B' (CCR and BCC efficient)
OTE	$e_3e_2/\ e_3e < 1$	$a_2\ a_1/a_2\ a < 1$	$b_1b/b_1b = 1$
PTE	$e_3e_1/e_3e < 1$	$a_2a/a_2a = 1$	$b_1b/b_1b = 1$
SE	$e_3e_2/e_3e_1 < 1$	$a_2\ a_1/a_2\ a < 1$	$b_1b/b_1b = 1$

So, the important aspects of DEA methodology based on CCR & BCC models are

⇒ Reference set and improvement in efficiency i.e. projection of inefficient DMUs,

⇒ Returns-to-Scale and

⇒ Decomposition of technical efficiency

These important economic factors are again discussed at the time of analyzing them in the next chapter 'Empirical findings and analysis'.

4.3.2.2: Mathematical Formulation CCR and BCC Models

Graphical presentation cannot be used for frontier analysis in case of multiple inputs and multiple outputs. Hence a general mathematical formulation is needed to handle the multiple inputs outputs situation. The first mathematical linear programming based formulation of the frontier analysis was developed by Charnes et al. (1978) after 20 years of frontier analysis technique described by Farrel in 1957.The authors also coined the name Data Envelopment Analysis.

CCR Model

Assuming that there are n DMUs to be evaluated [DMUj (j = 1, 2... n)]. Each DMU consumes m different inputs of identical nature for all DMUs [x_{ij} (i = 1,2, ...,m)] to produces 's' different outputs of identical nature for all DMUS [y_{rj} (r = 1,2, ...,s)]. x_{ij} and y_{rj} are assumed to be positive ie $x_{ij} \geq 0$ and $y_{rj} \geq 0$ and further assumption is that each DMU has at least one positive input and one positive output value. Given the data, the efficiency of DMU_k can be measured by the following programming

$$\min_{(\theta, \lambda_j\, s_i^-, s_r^+)} \theta_k - \varepsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right) \qquad (1)$$

Subject to

$$\sum_{j=1}^{n} x_{ij} \lambda_j + s_i^- = \theta_k x_{ik} \qquad i = 1,2,\ldots,m.$$

$$\sum_{j=1}^{n} y_{rj} \lambda_j - s_r^+ = y_{rk} \qquad r = 1,2,\ldots,s$$

$$\lambda_j \geq 0 \qquad j = 1,2,\ldots,n$$

$s_i^-, s_r^+ \geq 0$ for all i and r.

x_{ij} = Amount of input of i utilized by the jth DMU

y_{rj} = Amount of output of r produced by the jth DMU

x_{ik} = Amount of input of i utilized by DMU_k

y_{rk} = Amount of output of r produced by DMU_k

θ_k= efficiency score of DMU 'k' being evaluated

λs represent the dual variables which identify benchmarks for inefficient units.

Slack variables - s_i^- (input slacks), s_r^+ (output slacks)

Here $\varepsilon > 0$ is non-Archimedean element defined to be smaller than any real number and to be accommodated without having to specify the value of ε.

Above mathematical formulation is the input oriented CCR model (envelopment form) used in this study to estimate OTE. Note that the above mathematical program yields an efficiency score (θ) of a particular DMU_k only. To get the efficiency score of other DMUs it is required to repeat this process for each DMU i.e., 'n' optimization one for each DMUj. DMUs for which $\theta < 1$ are inefficient, while DMUs for which $\theta = 1$ are on frontier line and efficient. Some frontier points or boundary points may be 'weekly efficient' because of presence of non zero slacks in inputs and/or outputs.

CCR efficient – a DMU is CCR efficient if the optimal solution of the above two-phase procedure satisfies both (i) $\theta = 1$ and (ii) all slacks are zero. So, DMUs which satisfy both the conditions are also called CCR efficient or strongly efficient or Pareto-Koopmans efficient.

CCR inefficient - a DMU is said to be CCR inefficient -

Case I: if and only if both (i) $\theta < 1$ and (ii) $s_i^- \neq 0$, $s_r^+ \neq 0$ for some i and r. or all slacks are non zero.

Case II: if and only if both (i) $\theta = 1$ and (ii) $s_i^- \neq 0$, $s_r^+ \neq 0$ for some i and r. This case is also termed as weakly efficient in DEA.

So there are two sources of inefficiencies: purely technical inefficiency represented by the radial measure (1- efficiency score obtained) and mix inefficiency represented by the input and output slack values.

BCC Model

The BCC (ratio) model is one of the most important extensions of CCR model. It measures technical efficiency rather pure technical efficiency. BCC model differs slightly yet remarkable from CCR model with an additional constraint

$$\sum_{j=1}^{n} \lambda_j = 1 \qquad (2)$$

in the above CCR envelopment model. This constraint is called convexity constraint in mathematics literature. It imposes of assessing the efficiency under VRS.

A DMU is BCC efficient if the optimal solution of the above two-phase procedure satisfies both (i) $\theta = 1$ and (ii) all slacks are zero. Otherwise, DMU is BCC inefficient.

Box No. 4.5

Summary of Models (CCR & BCC) Characteristics

- ⇒ CCR model considers the production possibility set based on constant return to scale assumption. Where BCC model based on variable return to scale assumption.
- ⇒ Optimal values of $\theta / \emptyset$ are independent of units in which inputs and outputs are measured provided these units are same for all DMUs under evaluation.
- ⇒ Note that the above mathematical program yields an efficiency score (θ) of a particular DMU_k only. To get the efficiency score of other DMUs it is required to repeat this process for each DMU i.e. 'n' optimization one for each DMUj.
- ⇒ DEA computes a unique set of input and output weights for each DMU using linear programming technique subject two condition i) no weights can be negative ii) weights must be universal i.e. resulting ratio must be ≤ 1 under the same input weights and output weights of the evaluated DMU i.e. DMUk.
- ⇒ All inputs and outputs data are assumed to be positive or semi positive and they can be varied at the discretion of management or other users i.e. 'discretionary variables'.
- ⇒ Both the BCC and CCR models are called ratio models because they define efficiency as the ratio of weighted outputs divided by weighted inputs.
- ⇒ Both the BCC and CCR ratio models use a radial or proportional measure to determine a unit's efficiency score. A unit's efficiency is defined by the ratio of the distance from the origin to the inefficient unit, divided by the distance from the origin to the composite unit on the efficient frontier.
- ⇒ The CCR models are *not* translation invariant but BCC are translation invariant.
- ⇒ CCR measure incorporates technical as well as scale inefficiency whereas BCC considers only technical inefficiency. That is why CCR efficiency score is called as overall technical efficiency or global technical efficiency and BCC score as pure technical efficiency or local technical efficiency.

Source: Author's compilation

4.3.2.3: Super-efficiency Model (SEM)

The study has also utilized input oriented super efficiency model under CRS assumption for ranking purpose as proposed by Andersen and Petersen[18] (1993). The basic DEA models- CCR & BCC mainly distinguish the DMUs into two groups – efficient DMUs (having score equal to one) and inefficient ones (having score less than one). But it is not possible by these conventional models for ranking efficient DMUs since efficiency score of all the efficient DMUs are equal to one. To overcome this limitation, Andersen and Petersen (1993) have introduced super-efficiency DEA model. This model was originally introduced with the objective of providing tie breaking procedure for ranking DMUs rated as efficient in conventional DEA model. This model allows effective ranking of efficient DMUs based on super-efficiency scores which are more than one or equal to one i.e. not same for efficient DMUs.

The super-efficiency model is almost identical to the basic DEA models with the exception that the efficient DMU being evaluated is excluded from the production possibility set (PPS). This exclusion or removal from the PPS is the main philosophy of this model. This exclusion modifies the efficient frontier developed by the basic DEA models and forms a new frontier above such frontier and thereby allowing the efficiency score of the efficient DMUs grater than or at least equal to the value of 1(one). An important consideration of SEM is that this exclusion does not influence the efficiency score of inefficient DMUs. This is the specialty of this model. Like CCR and BCC models SEM are of two approaches – input oriented and output oriented both under CRS and VRS assumption. In this study input oriented SEM under CRS assumption is followed for effective ranking of efficient DMUs as determined by input oriented CCR model.

Figure 4.2

Super-efficiency Model (Input Oriented)

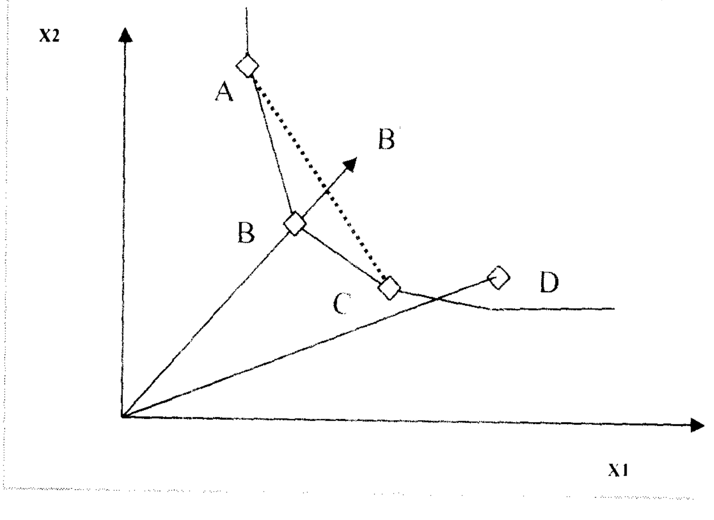


Figure: 4.2 provides input oriented radial supper efficiency model. The efficient frontier consisting line segment connecting efficient DMUs- A, B and C is developed by the standard DEA models. If DMU B is excluded from the reference set effect is to construct a new frontier consisting dotted line segment connecting DMUs A and C. Super-efficiency score of DMU B becomes OB' / OB ≥100% . This reflects that the maximum proportional increase in inputs by B preserving efficiency (100%) is 20% if super efficiency score of B is 120%. Efficiency score of inefficient DMU like 'D' remains unchanged.

Input oriented SEM provides a means of evaluating the extent to which an efficient DMU is able to increase its inputs level without violating its status as an efficient DMU. Super-efficiency score therefore provides a measure of stability of the 'efficient' status of the efficient DMUs. The study follows the following input oriented formulation of SEM under CRS assumption as described by Anderson and Petersen (1993).

$$\underset{(\theta\lambda)}{\text{Min}}\ \theta_k - \varepsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right) \qquad (3)$$

Subject to

$$\sum_{\substack{j=1 \\ j \neq k}}^{n} x_{ij} \lambda_j + s_i^- = \theta_k x_{ik} \qquad i = 1,2,\ldots\ldots,m.$$

$$\sum_{\substack{j=1 \\ j \neq k}}^{n} y_{rj} \lambda_j - s_r^+ = y_{rk} \qquad r = 1,2,\ldots\ldots,s$$

$$\lambda_j \geq 0 \qquad j = 1,2,\ldots\ldots,n$$

$$\lambda_k = 0$$

$s_i^-, s_r^+ \geq 0$ for all i and r.

Where θ represents efficiency score of DMU 'k' , an efficient one is excluded from the reference set by equating input and output weights to zero i.e. ($\lambda_k = 0$)

4.4: DEA Software: Estimation of Efficiency Scores

We solve input oriented CCR, BCC and Super-efficiency model by using DEA software '**DEA-Solver Learning Version 3**' designed on the basis of the textbook - "Data Envelopment Analysis : A Comprehensive Text with Models, Applications, References and DEA-Solver Software".[19]

4.5: Selection of Input and Output Variables

The most challenging task to the researchers for estimating efficiency of banks through DEA methodology is to select appropriate and relevant inputs and outputs. The choice of inputs and outputs largely affects the derived efficiency level. There is no consensus on what constitutes inputs and outputs of banks. Banks mostly provide services to customers and play an important role of intermediaries in directing fund between depositors and creditors and also perform non-monetary activities. So, these wide ranges of bank activities which are mainly non-tangible in nature make difficult to define its input and output. There is a theoretical gap in the literature on multi-input and multi-output production structure of banking. In spite of increasing trend of interest on banking efficiency measurement, there is no universally accepted approach in the literature of banking efficiency for selecting input and output variables. However, in the context of banking efficiency measurement, there are mainly two approaches to deal with this problem: **Production Approach** and **Intermediation Approach**. Both the approaches apply the traditional microeconomic theory of the firm to banking and differ only in the specification of the banking activities.

Production Approach (PA) – This approach as pioneered by Benston[20] (1965) treats banks as providers of services to customers by administering customers' financial transactions, keeping deposits, issuing loans and managing other financial assets. Outputs under this approach are the services provided to the customers and best measured by the numbers and type of transactions and inputs include physical variables like labor and capital or their associated cost. This approach focuses on only non interest expenses and ignores completely interest expenses since it considers deposit as an output. This approach is also known as service provision or value added approach.

Intermediation Approach (IA) - This approach as proposed by Sealey and Lindley[21] (1977) treats bank as financial intermediaries for channeling fund from savers to borrowers. According to this approach only bank assets are thought as outputs. It is distinguished from PA by adding deposits as an input and therefore considers both operating cost and interest cost in the input side. Banks performing two major role of mobilizing resources (saving) in order to make investment activities (lending) in the economy are taken into consideration in this approach.

IA vs. PA

The main difference between these two approaches is the use of deposit as input or output. Berger and Humphrey[22] (1997) pointed out that neither of these two approaches is perfect because they can not fully capture the dual roles of banks as intermediaries of financial services as well as service providers. Therefore none is universally accepted approach. Berger and Humphrey (1997) suggested that IA is best suited for analyzing bank level efficiency where PA for branch level efficiency. This is because at the bank level, management will aim to reduce total cost not just non-interest expenses while minimization of total cost is not the headache of the branch. Branches are basically concerned with providing large customers' based services. Grifell Tatje and Lovel[23] (1999) argued that when interest is in the analysis on bank productivity, then PA prefers to IA as PA essentially focuses on the bank productivity. On other side, IA may be superior for evaluating banking performance since it considers all expenses including interest expenses as input. As a result, it enables for better reflection of bank profitability. In the banking literature, it is found that the IA has the larger appeal than the PA. One reason for this could be the non availability of published data on the number of accounts and type of transactions serviced for different financial instruments[24]. Though, in a customers' oriented market economy particularly (after 1996), Indian banks play both the role as intermediaries as well as providers of services but still now Indian commercial banks primarily mediate funds between depositors and creditors i.e., they play intermediating role much more than the service providing role. Therefore, given this and as a majority of the empirical literature present study adopts IA for selecting input and output variables for estimating bank level efficiency of Indian commercial banks.

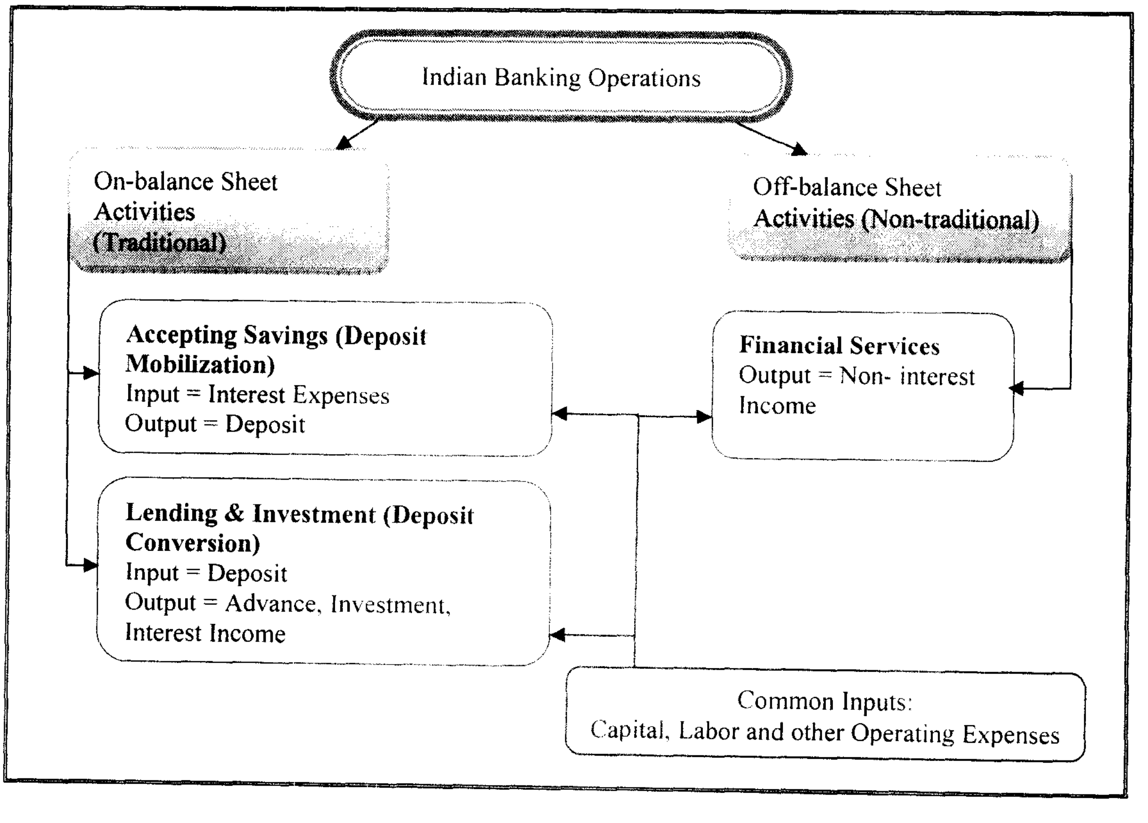
Summary of literature survey on inputs and outputs of some important and relevant studies on banking efficiency based on DEA methodology are listed in Annexure: 4 (A).

Literature on inputs and outputs specification for measuring bank efficiency summarizes that most of the studies rely on three inputs a) Fixed assets as a proxy of physical capital b) labor (No. of Employees) and c) Deposit and two outputs namely a) Interest Income b) Non-interest Income. In place of interest income some studies choose advance and investment in the output vectors.

With these existing theoretical strands, extant literature, the study selects finally four input and four output variables following the three stage procedures illustrated below. The choice of input and output variables is mainly guided by operational pattern, objectives of the Indian banking system in the post reform period and the availability of data.

Figure: 4.3

Banking Operation Patterns & Related Inputs and outputs



In the above diagram, banking operations pattern of the Indian commercial banks along with inputs and outputs in that specific area of operation are presented.

From the above diagram combining the traditional and non traditional activities of Indian banking, following input and output variables are specified based on the intermediation approach.

Stage-I: selection of Inputs and Outputs –

Input Variables	Output Variables
➢ Interest Expenses ➢ Deposit ➢ Operating expenses ➢ Fixed assets ➢ No. of Branches ➢ No. of employees	➢ Advance ➢ Investment ➢ Interest income ➢ Non-interest income

Number of Input & Output Variables

Selection of input and output items is the most important task for estimating efficiency level under DEA technique and the number of such items is also crucial for successful application of DEA. Inclusion of many variables is not a viable option in DEA as the number of inputs and outputs ($m + s$) increases in the model, more and more DMUs become efficient and efficiency discrimination among DMUs is questionable due to an inadequate number of degree of freedoms. A rough rule of thumb in the envelopment model is to choose n (number of DMUs) equal to or greater than max $\{m \times s, 3 \times (m + s)\}$ [25]

Therefore, some variables are excluded from the above mentioned inputs and outputs of stage-I to make the DEA models viable. This exclusion is based on the theoretical concepts and existing inputs and outputs in the literature. First 'interest expenses' and 'interest income' two variables are converted to single variable known as 'net interest income' or spread which is placed in output variables set. Now, three output variables-'advance', 'investment' and 'net interest income' are related to traditional banking activities. Therefore, as majority studies, we chose only 'net interest income' to represent the on-balance sheet activities of banking.

Fixed assets is then excluded from the inputs set of Stage-I. Most of the prior research used fixed assets as a proxy of physical capital. But they ignored the fact that in many cases, items of physical capital will be leased rather than owned. Even if they were owned, there might be problems with their valuation. In the sample banks, some are too old and some new. Some are rural and semi urban oriented and some are metropolitan based. Some are highly technology based and some are not. Therefore, there is a major difference among the banks so far as valuation of fixed assets are concerned. Besides fixed assets are partially represented through 'operating expenses (an input variable) since depreciation charge on fixed assets is included in operating expenses. Instead of fixed asset, the study considers 'No. of Branches' and 'No. of Employees' as proxy of physical capital. Actually both the variables provide the infrastructure to banks. Use of No. of Branches and No. of Employees as proxy of physical capital in the inputs vector is not universal in the prior literature, but it can be justified. Correlation between these two variables with Fixed Assets and Net worth are highly significant (at .01 level) over all the years. Therefore, this is reasonable justification to use 'No. of Branches' and 'No. of Employees' as proxy of physical capital as well as financial capital. They are highly positively correlated with the size (Total Assets) of banks also.

Table: 4.2

Correlation Results for Inputs Consideration

	2005		2006		2007		2008	
	No of Branches	No of Employees	No of Branches	No of Employees	No of Branches	No of Employees	No of Branches	No of Employees
Fixed Assets	0.481	0.564	0.524	0.647	0.483	0.575	0.561	0.605
Net Worth	0.799	0.886	0.736	0.839	0.753	0.847	0.701	0.784
Total Assets	0.874	0.952	0.864	0.943	0.839	0.917	0.876	0.928

Note: *All are significant at .01 levels*

In the prior research 'No. of employees' were used as a proxy of labour but they ignored non labour operating expenses which have been heavily incurring by the banks for technology upgradation. So the study uses 'operating expenses' as one of the inputs, which includes both labour and non-labour expenses. So, input-output variables of Stage-I are modified as follows -

Stage-II: Inputs and Outputs

Input Variables	Output Variables
➢ No. of Branches ➢ No. of Employees ➢ Operating expenses ➢ Deposit	➢ Net Interest income ➢ Non-interest income

Inputs and output variables of stage-II except 'No of Branches' and 'No of Employees' are basically based on the monetary flows taken from both the Profit and Loss account and the Balance Sheet of the each banks considering three basic banking functions. Now, variables of Stage-II are again modified in order to accommodate the objectives of the Indian banking system in the post reform era into the input output vector.

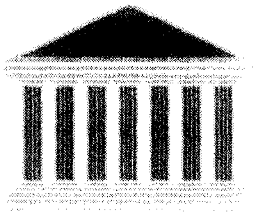
In 1992, the RBI launched banking sector reform to create a more profitable, efficient and sound banking system. The reform opened the banking sector for private players. The emergence of new private banks exposed the inefficiency of public banks which are lager in size, large number of employees and branches with socio-economic obligation. But there is a debate among the authors and researchers that the profitability should not be the criteria for comparison of performance evaluation between public and private banks. They argue that PSBs are more social than economic. But profits are required to fulfill this socio-economic objective. That is why policy makers rightly laid emphasis on profitability as a criterion for performance evaluation of PSBs. Some public banks already are gone to partial privatization and most of the banks are listed in stock market. They are easily approachable to capital market to mobilize additional fund. In this back ground, after 18 years of reform process going on, profitability aspect should be considered for estimating and analyzing efficiency of the banks. Further, Indian banks have to invest in the priority sector. So, priority sector advance is also taken into consideration as an output variable for social objectives of the banks.

Therefore, two output variables namely 'Priority Sector Advance' and 'Net profit' are taken into consideration as output variables in order to have an effect on the socio economic objectives of the Indian commercial banks.

Stage 3: Final Input Variables and Output Variables

Inputs (Resources)

- No. of Branches
- No. of Employees
- Operating expenses
- Deposit



Outputs (Desired Outcomes)

- Net Interest income
- Non-interest income
- Priority Sector Advance
- Net Profit

Finally, the study specifies four inputs and four outputs. All the inputs and outputs are measured by monetary terms of rupees in lakhs except 'No. of branches' and 'No. of employees' which are in terms of physical numbers.

'Number of Branches' and *'Number of Employees'* are considered as inputs by Saha & Ravisankar[26] (2000), Ketkar, et al.[27] (2005). Many studies considers 'No of employees' as a proxy of labour [e.g. Das et al.[28] (2004), Kumar and Gulati[29] (2008)]. But, present study includes them into the input vector as proxy of physical and financial capital.

'Operating Expenses include all labor and non-labor cost which includes rent, printing charges, depreciation on banks properties, insurance and so on. [Sathye[30] (2003), Mohan & Ray[31] (2004), Chakrabarty & Chwala[32] (2005)]

'Deposit' includes all types of deposit: demand, savings and time deposit and it is used as a loanable fund. Most of the studies in India use it as an input.

'Net Interest Income' is also called spread computed by subtracting interest expenses from interest income. This variable represents the performance of the traditional activities of banking. [Das[33] (1997), Kumar[34] (2008)]

The output variable *'Non-interest Income'* accounts for income from off-balance sheet activities such as commission, brokerage and so on. The inclusion of this variable enables the capturing of recent changes in banking services. Most of the studies in India use it as an output.

'Priority Sector Advance' variable as output is considered to accommodate the social aspect of the Indian banking. Present study uses this variable as output probably for the first time for measuring efficiency of the Indian banking.

'Net Profit' computed by subtracting total expenditure including provision and contingencies from total income is considered for economic objective of the banking operation, which is very important for existence in the competitive market. [Debasish [35] (2006)]

However, the study tries to select input and output variables that minimize the problem of differences among the banks and bank groups under study.

4.6: Sampling and Data

Sample Banks

Oral and Yololan[36] (1990) suggests to use DEA models for firms employing similar resources and providing the same services. Quey-Jen Yeh [37] (1996) states that it is important to take into account the homogeneity condition during the choice of DMUs to make the DEA result more realistic. Regional Rural Banks are local banks with their domain of operations restricted to one or two contiguous districts and mostly provide credit to farmers and small enterprises whereas foreign banks with limited branches in the metropolitan cities only are operating mainly to serve their clients of their parent banks abroad. Based on the criteria of homogeneity condition, the study relies on selection of 36 Indian scheduled commercial domestic banks which have already been listed in the stock exchanges. Stock behavior pattern of the banks have not been taken into consideration in this study. The main objective of the study is to estimate and examine the technical efficiency (DEA) of the selected banks. Sample banks consist of both public and private banks. The banks which have been operating continuously in all the years of the study period are only included in the sample. Industrial Development Bank of India (IDBI) has been included in the list of public sector banks. Yes Bank has been excluded from the list due to unavailability of some important data and very recent entrance into the industry in 2004-05. UTI bank has been renamed as AXIS bank in 2007. Sample banks with their codes have been listed in the Annexure: 4 (B).

Data sources

All the data are annual and secondary in nature. Annual bank level data are obtained from the published annual accounts (Balance Sheet and P&L Account) in Annual Reports of the individual banks, collected mainly from the 'Statistical Tables relating to Banks in India' and 'Report on Trend and Progress of banks in India' for the various years under study, available on the official website of RBI[38]. Other sources of the data are annual reports of the respective banks, websites of the respective banks, Report on currency on finance, RBI; Handbook of statistics on Indian Economy, RBI.

Study period

The study covers a period of four years: beginning 2004-05 and ending in 2007-08. The period taken under analysis was one of great changes in the Indian banking system. During this period, most of the Indian banks have already been listed in stock market. They can easily approach capital market to mobilize additional fund. During this period, Indian economy has gathered more strength as indicated by the various economic factors.

Table: 4.3

Macroeconomic indicators in India

Indicator	*1996-2003*	*2003-08*
GDP growth	5.6	8.8
Inflation	4.6	5.3
Fiscal Deficit-GDP Ratio	5.7	3.8
Forex Reserves-GDP Ratio	9.5	20.7

Source - Samantaraya and Verrie3[39] (2009)

Banking performance is heavily depended on economic performance of the country as well as global. So, from the above factors it is clear that Indian economy during the period of evaluation was very stable and strong. During this period also, Indian capital market has witnessed a tremendous growth as indicated by the upward movement of BSE-Sensex from 5839 (as 31/12/03) to 21078 (08/01/08)[40]. Capital expenditure by the government and private industry, demographic profile, regulatory and technological advancement and investment opportunity across all segments are expected to enable Indian banks leading to higher growth. Healthy growth of the assets of commercial banks driven primarily by credit growth and sharp rise in credit-GDP. deposit-GDP and M3-GDP ratios are reflective of significant financial deepening in India. So the period, we choose for efficiency evaluation, is favorable for better performance of the Indian banks.

However, with this sample and data. the study estimates the relative technical efficiency of a sample of 36 Indian banks during the period from 2004/05 to 2007/08 using DEA methodology.

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