CHAPTER III: METHODOLOGY OF RESEARCH
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Introduction

In this chapter, the methodological details are discussed. To fulfil the analysis of objectives, which are given in the introduction chapter and hypothesizes the secondary data has been used with Data Envelopment Analysis (DEA) method. The objectives of study have been discussed in various chapters mainly in chapter five and six. General information of the country has been discussed in introduction chapter and chapter four. The past studies and their literature have been discussed and reviewed in chapter two.

1- Approach to data collection

For this study, mostly secondary data are used for the analysis and to fulfil the objectives of thesis. The secondary data have been collected from the various sources. The following are the sources:

a. Official documents (for example, reports) produced by the banking system of Iran for operational purposes. They include official letters, orders, bills, by law and circulars. In addition to these, literature and data are also collected from individual banks, banking experts, bankers and officials that also include annual financial statements, balance sheets and profit& loss statements, annual reports etc.

b. Published data also collected from statistical centre of I.R.Iran, Central Bank of I.R.Iran, Deputy Governance on banking - Ministry of Finance- Govt. of I.R.Iran, IMF, World Bank data base, etc.

c. Literature, Official documents and data are also collected from governmental organizations such as State auditing organization and Ministry of Finance

d. Materials produced by private organizations, universities, reference services, etc.

After collecting the various data from different sources, data are classified for the analysis. The following steps are followed for the analysis of data on the banking system operation in I.R.Iran.
Step I:
General information and data have been collected, analysed and discussed about banking system in chapter five and six, general overview of Iran in chapter one, and economy of Iran in chapter four.

Step II:
The literatures, which are collected from various text books, reference books, journal articles and conference papers and also websites, on banking efficiency are reviewed and discussed in chapter two. In this chapter, the literatures are discussed with the help of theoretical as well as empirical evidences, which are given by several authors, who developed particularly “frontier” methods including “parametric” and “non-parametric” approaches of efficiency studies and empirical studies on bank efficiency measurement such by DEA and SFA methods have been reviewed.

Step III:
After data collecting, data have been classified into pre-Islamic Revolution (1976-1979) and transition period of Islamic Banking (1979-1983), period of partial Islamic banking (1984-1989) and full-fledged period of Islamic banking (1990-onward). Particularly, the secondary data are collected on aggregate data of assets and liability side of banks balance sheets, including various type of deposits, loans (based on Islamic banking finance modes such as mudarabah, musharaka, legal partnership, civil partnership, direct investment, mark-up, Jualah, leasing, purchase with deferred delivery and qard al-hassanah).

Step IV:
The last step for the data analysis and discussion is based on the Data Envelopment Analysis (DEA) method. The DEA method is discussed in details in chapter six and used for the analysis, interpretation and discussion, which has given in the following paragraph:

2. Data Envelopment Analysis:
Data Envelopment Analysis (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. The definition of a DMU is generic and flexible. Recent years have seen a great variety of applications of DEA for use in evaluating the performances of many different kinds of entities engaged in many different activities in many different contexts in many different countries. These DEA applications have used DMUs of various forms to evaluate the performance of entities, such as hospitals, US Air Force wings, universities, cities, courts, business firms, and others, including the performance of countries, regions, etc. Because it requires very few assumptions, DEA has also opened up possibilities for use in cases which have been resistant to other approaches because of the complex (often unknown) nature of the relations between the multiple inputs and multiple outputs involved in DMUs.

Whereas for the estimation of efficiency in financial institutions there are two main approaches i.e.: parametric method (such as the stochastic frontier analysis, the thick frontier approach, and the distribution free approach) & nonparametric techniques (such as data envelopment analysis and free disposable hull analysis). However major drawback has been found in the non-parametric methods which do not allow for measurement error and other external variables that may temporarily affect outcomes, assuming that random error is equal to zero. By review of the previous studies in developed and developing countries, the Data Envelopment Analysis (DEA) method selected and utilized to analysis the banks performance and efficiency in Iran. The present research work, based on empirical analysis, suggests that Data Envelopment Analysis (DEA) could be a suitable approach towards measuring the relative efficiency of banks in the Iranian context. DEA method by several softwares solving the mathematical programme to optimization problem, DEAP2 software utilized for measuring the technical efficiency of Iranian banks.

DEA is a nonparametric mathematical programming model used to evaluate the relative efficiency of a group of entities or decision making units (DMUs) in their use

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1 In literature on productivity and efficiency analysis term, "Decision Making Unit" (DMU) is used to describe a productive entity in instances when the term "Firm" may not be entirely appropriate. For example, when comparing the performance of power plants in a multi-plant utility, or when comparing bank branches in a large banking organisation, the units under consideration are really parts of a firm rather than firms, themselves, therefore called DMUs instead of firm itself.
of multiple inputs to produce multiple outputs where the form of the production is not known or specified as is the case with the parametric approach. DMUs refer to the collection of firms, departments, divisions, or administrative units with the same goals and objectives which have common inputs and outputs. Examples of DMUs include hospitals, schools, courts, banks, and so on.

DEA is based on the pioneering work of Farrell (1957). However, it was the work of Charnes et al. (1978) which developed this technique. They generalized Farrell’s framework to include multiple incommensurate inputs and multiple incommensurable outputs and reformulated as a mathematical programming model to assess the comparative efficiency of DMUs. The original DEA model developed by Charnes et al. (1978) is a fractional and non-linear model. The objective function in that model was to maximize the ratio of weighted outputs to weighted inputs for a particular DMU. This is done subject to the constraints (one for each DMU) that the ratio of weighted outputs to weighted inputs is equal to or less than 1. The decision variables are outputs weights (one for each type of output) and input weights (one for each type of input).

The DEA approach uses a linear programming (LP) model to construct a hypothetical composite unit based on all units in the reference group. That is, the performance of each DMU is measured relative to the performance of all other DMUs. The unit being evaluated can be judged relatively inefficient if the composite unit requires less input to obtain the output achieved by the unit being evaluated, or judged relatively efficient if the composite unit requires as much input as the unit being evaluated does. A composite unit is a hypothetical best-practice unit made up of a subset of units that should be emulated by a given inefficient unit in order to improve the efficiency of its operation. DEA results help in identifying the relatively inefficient DMUs and providing insights into ways to improve productivity of these relatively inefficient units without reducing quality of service and while maintaining or even increasing the volume of services provided by DMUs. DEA has been used in a number of bank studies. Sherman and Gold (1985) used DEA to evaluate bank branch operating efficiency.

efficiency for a saving bank in the USA with 14 branch offices. They located inefficient branches by explicitly considering the mix of services provided and the resources used to provide these bank services. Vassiloglou and Giokas\(^3\) (1990) used DEA to assess the relative efficiency of bank branches at the commercial bank of Greece. Drak and Howcroft\(^4\) (1994) used DEA to assess the relative efficiency of the branches of a UK bank.

This thesis, using originally collected micro-data on the Iran banking industry, estimate the cost structure of banks and examines how to advance banking sector reforms through operational specialization, portfolio diversification, divestiture and consolidation. Bank exerts a fundamental influence.

In this study, the working papers, books and other materials of CEPA\(^5\) (centre for efficiency and productivity analysis) founded by Coelli, T.J. (1996) and a Guide to DEAP Version 2.1 "A Data Envelopment Analysis"\(^6\) is used. The academic and educational website of Data Envelopment Analysis founded by "Dr. Ali Emrooznejad"\(^7\), has been created in honour of A. Charnes, W. W. Cooper, E. Rhodes and Rajiv D. Banker who originally developed DEA at Warwick University, UK was also very much helpful in providing original references, sample projects and guidelines regarding using the method.

In this study, non-parametric Data Envelopment Analysis (DEA) has been used to examine bank specific technical efficiencies. Among other efficiency measurement methods, the DEA technique provides particular advantage where firms (e.g. banks and other service sector firms) are known to produce multiple outputs. Also, under the variable returns to scale (VRS) technologies, as assumed in this study, the DEA allows decomposing technical efficiency (TE) into pure technical efficiency (PTE) and scale efficiency (SE). This provides an insight into the sources of inefficiencies

\(^5\) Center for Efficiency and Productivity Analysis, University of Queensland, Australia, Website: http://www.uq.edu.au/economics/cepa/ him
\(^6\) CEPA Working Papers, Department of Econometrics "University of New England, Armidale, Australia
\(^7\) www.DEAZONE.com
and helps determine whether banks have been operating at most productive scale size (MPSS). The estimates of pure technical and scale efficiency are also expected to provide opportunity to assess the impact of the substantial changes from consolidation, diversification and rationalization of the banking sector, on efficiency of Islamic banking operations.8

Also regarding to assessment of technical efficiency by these data, I had to get DEA software from different types or versions so I referred to so many search works in Internet to find out a related software specially from website of “The Center for Efficiency and productivity analysis” www.cepa.com and Dr. Ali Emroznejad web site as a centre for DEA.9

‘Reliable’ efficiency prediction requires appropriate definitions and certain assumptions regarding the measurement of input, output and input price variables. The exclusion of certain important bank inputs and/or outputs might bias the final efficiency measures by distorting construction of the frontier (the locus of the efficient combination of inputs and outputs). To determine what constitutes inputs and outputs of banks, one should first decide on the nature of banking technology10. In literature on the theory of banking, there are two main approaches competing with each other in this regard: the production and the intermediation approaches (Sealey and Lindley, 1977).

As pointed out in Cooper, Seiford and Tone (2000), DEA has also been used to supply new insights into activities (and entities) that have previously been evaluated by other methods. For instance, studies of benchmarking practices with DEA have identified numerous sources of inefficiency in some of the most profitable firms - firms that had served as benchmarks by reference to this (profitability) criterion – and this has provided a vehicle for identifying better benchmarks in many applied studies. Because of these possibilities, DEA studies of the efficiency of different legal organization forms such as "stock" vs. "mutual" insurance companies have shown

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8 Valli Boobal Batchelor, and I.K.M. Mokhtarul Wadud
9 www.cepa.com, “The Center for Efficiency and Productivity Analysis”,
that previous studies have fallen short in their attempts to evaluate the potentials of these different forms of organizations. Similarly, a use of DEA has suggested reconsideration of previous studies of the efficiency with which pre- and post-merger activities have been conducted in banks that were studied by DEA.

Since DEA in its present form was first introduced in 1978, researchers in a number of fields have quickly recognized that it is an excellent and easily used methodology for modelling operational processes for performance evaluations. This has been accompanied by other developments. For instance, Zhu (2002) provides a number of DEA spreadsheet models that can be used in performance evaluation and benchmarking. DEA’s empirical orientation and the absence of a need for the numerous a priori assumptions that accompany other approaches (such as standard forms of statistical regression analysis) have resulted in its use in a number of studies involving efficient frontier estimation in the governmental and non-profit sector, in the regulated sector, and in the private sector. See, for instance, the use of DEA to guide removal of the Diet and other government agencies from Tokyo to locate a new capital in Japan, as described in Takamura and Tone (2003).

3. Importance and Popularity of Data Envelopment Method

In their originating study, Charnes, Cooper, and Rhodes (1978) described DEA as a ‘mathematical programming model applied to observational data that provides a new way of obtaining empirical estimates of relations - such as the production functions and/or efficient production possibility surfaces - that are cornerstones of modern economics’.

Formally, DEA is a methodology directed to frontiers rather than central tendencies. Instead of trying to fit a regression plane through the centre of the data as in statistical regression, for example, one ‘floats’ a piecewise linear surface to rest on top of the observations. Because of this perspective, DEA proves particularly adept at uncovering relationships that remain hidden from other methodologies. For instance,
consider what one wants to mean by “efficiency”, or more generally, what one wants to mean by saying that one DMU is more efficient than another DMU. This is accomplished in a straightforward manner by DEA without requiring explicitly formulated assumptions and variations with various types of models such as in linear and nonlinear regression models.

Relative efficiency in DEA accords with the following definition, which has the advantage of avoiding the need for assigning a priori measures of relative importance to any input or output. Data Envelopment Analysis (DEA) is widely used for the measurement of the relative performance of the banks (Galagedera and Silvapulle, 2003) and it becomes an accepted approach for identifying the inefficient decision making units in the industry. In DEA, the frontier is estimated by using mathematical methods i.e. linear programming (Coelli et al., 2005) and this estimated frontier is used to measure the relative performance of the banks. As DEA is a non-parametric technique, it does not require any structural form of the production frontier.

Being non-parametric, DEA has no danger regarding the misspecification of the frontier. Similarly, DEA can capture multiple outputs while parametric approach captures only a single output (Galagedera and Silvapulle, 2003). According to Oral and Yolalan (1990), DEA seems the most meaningful method to measure relative efficiency when units or organizations provide similar services by using similar resources. So it is appropriate to use DEA model when banks under considerations belong to the same category.

DEA technique was introduced by Charens et al (1978) to measure the efficiency of decision making units under input orientation and constant returns to scale (CRS) while this was extended by banker et al (1984) to allow variable return to scale (VRS). Basically, Charnes et al. (1978) developed this multi output and multi input linear programming model on the basis of single output and single input idea of efficiency given by Farrell (1957). After Charnes et al. (1978) article, around 2000 articles appeared in literature (Cooper et al, 2000 and Tavares, 2002), which shows

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the acceptance of DEA methodology and its applicability strengths. DEA measure the efficiency of a decision making unit on the basis of its position relative to the frontier estimated by linear programming technique. DEA model can be analysed in input orientation or output orientation. In input orientation, DEA model focuses on the output enhancement with given set of inputs to achieve the efficiency. A DEA efficient decision making unit will always have 100 percent efficiency in both orientations.

DEA methodology does not base on the assumption of pre-specified functional form of the production function (Al-Faraj et al, 1993). In DEA, data under consideration should be free from statistical noise. In the presence of statistical noise in the data, DEA estimate of technical efficiency captures the impact of inefficiency and may also be influenced by the statistical noise of the data (Charnes et al., 1984; Charnes and Neralie 1990; Charnes et al., 1992; Charnes et al., 1996; Zhu, 1996; Seiford and Zhu 1998b).

4. Method of Analysis

DEA technique was first applied in the banking sector by Sherman an Gold (1985) to evaluate the operating efficiency of bank branches. Berger and Humphry (1997) reviewed 122 frontier studies of financial institutions and among these studies, 69 used non-parametric techniques for the frontier estimation. Further out of these non-parametric studies, 62 used DEA.

Following Coelli et al (2005) DEA methodology under input oriented model, it is assumed that there are C commercial banks each having I inputs to produce O outputs. For all C commercial banks, X represents input matrix of all banks inputs having order I*C (each column represents the inputs of different banks under consideration) and Y represents output matrix containing output data of all banks having order O*C (each column represents the outputs of different banks under consideration). DEA methodology was introduced by Charnes et al. in 1978. It measures the efficiency of a bank by maximizing the ratio of observed weighted outputs to weighted inputs subject to the constraint that the similar ratios for all banks in the sample is less than or equal to one. For example for a particular pth bank, \( X_p \) is
a column vector representing measured inputs of the $p^{th}$ bank and $Y_p$ is column vector representing measured outputs of the $P^{th}$ bank. The $P^{th}$ bank’s efficiency is measured by maximizing the ratio of weighted outputs to weighted inputs (i.e. $U'Y_p/V'X_p$ where $U$ is $O*1$ vector of outputs weights (column matrix) and $V$ is $1*1$ vector of input weights (column matrix) while $U'$ represents the transpose of the output weights matrix and $V'$ represents the transpose of inputs weights matrix) subject to the constraint that all the banks in the sample have similar ratios less than or equal to one. The optimal weights are obtained by solving the following problem by linear programming technique for $P^{th}$ bank.

$$\text{Max}_{u,v} \ (U'Y_p/V'X_p)$$
Subject to: $U'Y_r/V'X_r \leq 1 \quad r = 1, 2, \ldots, C$
$U, V \geq 0$

Our aim in this problem is to find the efficiency of $P^{th}$ bank by finding the values of $U$ and $V$ subject to the constraint that the efficiency of all banks in the sample is less than or equal to one. But in this ratio formulation, objective function is nonlinear and gives us infinite number of solution for $U$ and $V$. But if $V'X_p$ is set equal to one, the problem of nonlinear function and infinite solution of $U$ and $V$ can be tackled and in this case the problem under study takes the following form.

$$\text{Max}_{u,v} \ (U'Y_p)$$
Subject to: $V'X_p = 1$
$U'Y_r - V'X_r \leq 0 \quad r = 1, 2, \ldots, C$
$U, V \geq 0$

This is multiplier form of DEA linear programming problem and variables defined in this problem are the same as defined in problem (1).

In linear programming, original problem is called as primal problem and corresponding to this problem another linear problem exist which is called dual of the problem. If primal problem involves maximization (minimization) of the objective function then the dual problem involves minimization (maximization) (Chiang and
Wainwright, 2005). So by applying duality theorem to the above primal problem, the problem takes the following form:

\[
\begin{align*}
\text{Min}_{\lambda, \theta} (\theta) \\
\text{Subject to: } Y\lambda \geq Y_p \\
\theta X_p - X\lambda \geq 0 \\
\lambda \geq 0
\end{align*}
\]

in the above linear problem, \( \lambda \) is a column matrix having order \( C \times 1 \) and containing vector of constants only while \( \theta \) is a scalar. This problem has fewer constraints as compared to the original problem. So this form is preferred for analysis. \( \theta \) represents the efficiency score of the particular bank with respect to other banks in the sample and its value is less or equal to one. The one vale of \( \theta \) indicates that the bank under consideration is technically efficient and lies on the estimated frontier. This problem is solved \( C \) times to find out the value of \( \theta \) for each bank in the sample. This specification of DEA is appropriate when all the banks are operating under constant returns to scale. But this situation usually does not prevail in the banking sector and many studies estimated efficiency of commercial banks under variable return to scale (Miller and Noulas, 1996; Jackson and Fethi, 2000, Grigorian and Manolc, 2002; Isak and Hassan, 2002b; Ataullah et al., 2004; Maghyereh, 2004; Ataullah and I.e.2006; Burki and Niazi, 2006; Pasiouras, 2006).

So variable return to scale model of above specification is appropriate for the analysis of banking sector efficiency. Banker et al. (1984) proposed the extension of constant returns to scale to account for variable returns to scale in DEA model. The dual of original DEA linear programming model which is constant return to scale can be modified to variable return to scale model by adding a constraint in the problem. New specification of that model is given below.

\[
\begin{align*}
\text{Min}_{\lambda, \theta} (\theta) \\
\text{Subject to: } Y\lambda \geq Y_p \\
\theta X_p - X\lambda \geq 0 \\
K'\lambda = 1 \\
\lambda \geq 0
\end{align*}
\]
in this model, K denotes a matrix of order c*1 having ones and it envelops data more tightly than the constant return to scale specification of DEA.

To find the scale efficiency, one has to use both CRS and VRS model of DEA. If technical efficiency scores measured under CRS and VRS models of DEA are different then scale inefficiency is present. If technical efficiency score obtained by DEA under CRS and VRS are different, they are represented by \( TE_{CRS} \) and \( TE_{VRS} \) respectively. At that time, scale efficiency (SE) present in the banking unit understudy is measured as

\[
SE = \frac{TE_{CRS}}{TE_{VRS}}
\]

So technical efficiency score obtained under CRS can also be obtained by multiplying scale efficiency present in the banking unit with the technical efficiency obtained under VRS.

To find out whether bank is operating in an area of increasing return to scale or decreasing return to scale, one has to run an additional DEA problem. The specification of this DEA model is given below.

\[
\text{Min} x_e(z)
\]

Subject to: 
\[
Y \lambda \geq Y_p \\
\delta X_p - X \lambda \geq 0 \\
K^\lambda \lambda \leq 1 \\
\lambda \geq 0
\]

If \( TE_{CRS} \), \( TE_{VRS} \) and \( TE \) of this model are equal, then bank is under CRS. If \( TE_{CRS} \) and \( TE_{VRS} \) are not equal, one has to compare the technical efficiency scores obtained from this model with that of VRS model to find out return to scale. If these efficiency scores are equal then decreasing return to scale to the bank understudy while if they are unequal then bank is under increasing returns to scale (Fare et al., 1985b).

5. Input/Output variable selection for bank efficiency measurement

From various survey studies on banking efficiency measurement revealed that there are two main approaches in input/output variable selection which is named production approach and intermediate approach.
H. Ahmad Mokhtar and others (2006) in a survey on bank efficiency studies summarized decision on input and output variables. Specifically, they demonstrate the decision, that a service provider has to undertake before measuring the bank's efficiency. Any decision made, however, will essentially be subject to banks' treatment of the money they received from the depositors as well as the money they extended to the creditors. In relation to this, two main approaches can be found in the literature. They are: the intermediation approach; and, the production approach.

Table 3-1: Input and Output Variables, its Approaches, and Techniques used:

<table>
<thead>
<tr>
<th>Inputs variables</th>
<th>Frequency</th>
<th>Outputs Variables</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>39</td>
<td>Investment Securities</td>
<td>15</td>
</tr>
<tr>
<td>(Physical) Capital</td>
<td>32</td>
<td>Net/ total loans</td>
<td>14</td>
</tr>
<tr>
<td>(core) deposits</td>
<td>15</td>
<td>Commercial Loans</td>
<td>13</td>
</tr>
<tr>
<td>Interest expense</td>
<td>10</td>
<td>Real Estate Loans</td>
<td>13</td>
</tr>
<tr>
<td>Non-interest expense</td>
<td>8</td>
<td>Consumer Loans or Loans</td>
<td></td>
</tr>
<tr>
<td>Purchased Funds</td>
<td>6</td>
<td>to individuals</td>
<td>13</td>
</tr>
<tr>
<td>Time and Savings</td>
<td>6</td>
<td>Non-interest Income</td>
<td>12</td>
</tr>
<tr>
<td>Deposits</td>
<td>6</td>
<td>Other Loans</td>
<td>10</td>
</tr>
<tr>
<td>Borrowed Funds/Money</td>
<td>6</td>
<td>Interest Income</td>
<td>7</td>
</tr>
<tr>
<td>Operating Expense</td>
<td>5</td>
<td>Demand/savings Deposits</td>
<td>7</td>
</tr>
<tr>
<td>Demand Deposits</td>
<td>3</td>
<td>Time Deposits</td>
<td>7</td>
</tr>
<tr>
<td>Customer Funds</td>
<td>3</td>
<td>Earning Assets</td>
<td>5</td>
</tr>
<tr>
<td>Expenditure on Materials</td>
<td>3</td>
<td>Deposits Placements</td>
<td>5</td>
</tr>
<tr>
<td>Financial Capital</td>
<td>3</td>
<td>Securities in Trading</td>
<td>4</td>
</tr>
<tr>
<td>Transactions Deposits</td>
<td>2</td>
<td>Commitment &amp; Contingencies</td>
<td>4</td>
</tr>
<tr>
<td>Non-transactions</td>
<td>2</td>
<td>Short Term Loans</td>
<td>3</td>
</tr>
<tr>
<td>Deposits</td>
<td>2</td>
<td>Long Term Loans</td>
<td>3</td>
</tr>
<tr>
<td>Occupancy Costs</td>
<td>2</td>
<td>Instalment Loans</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>145</td>
<td>Total</td>
<td>137</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inputs and Outputs Approaches</th>
<th>Frequency</th>
<th>Estimation Techniques</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediation</td>
<td>34</td>
<td>DEA</td>
<td>32</td>
</tr>
<tr>
<td>Production</td>
<td>5</td>
<td>SFA</td>
<td>23</td>
</tr>
<tr>
<td>Value-Added</td>
<td>5</td>
<td>DFA</td>
<td>5</td>
</tr>
<tr>
<td>User Cost</td>
<td>3</td>
<td>TFA</td>
<td>2</td>
</tr>
<tr>
<td>Asset</td>
<td>2</td>
<td>FDH</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>Total</td>
<td>63</td>
</tr>
</tbody>
</table>

Sources: (H.S. Ahmad Mokhtar, et al. -2006)

Note: These results were found to be used in a review of 47 bank efficiency studies. Take note that the total number of techniques used in the previous studies are more than 47 studies since there are studies which used more than one technique. The same goes to the other findings.

Based on the analysis in Table 3-1, one can safely conclude that labour, physical capital, various kinds of deposits (core deposits, time and savings deposits, demand deposits, purchased funds, borrowed funds) and interest expenses are the most widely used input variables. Likewise, the most commonly used outputs are investment securities, different kinds of loans (such as real estate loans, commercial loans, consumer loans or loans to individuals, total or net loans and other loans), interest income and non-interest income. It is also obvious from the table that the intermediation approach, the frequency of which is 34 as opposed to value-added (5) and production (5), is the most frequently employed technique to define the banks’ inputs and outputs.

Table 3-2- Input—Output Variables, estimation methods used in several studies:

<table>
<thead>
<tr>
<th>Name of Author (Date)</th>
<th>Country</th>
<th>Estimation method/ variables</th>
<th>Input variables</th>
<th>Output variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valli Boobal Batchelora and I.K.M. Mokhtarul Wadud (2004)</td>
<td>Malaysia</td>
<td>DEA method, intermediary approach</td>
<td>income attributable to depositors (interest expense) expenses not related to income-attributable to depositors (non-interest expense)</td>
<td>Income from financing (net interest income), Non-financing related income (non-interest income)</td>
</tr>
<tr>
<td>Laurent Weill (2003)</td>
<td>Poland &amp; Czech</td>
<td>SFA method</td>
<td>Personal expenses, Other non-interest expenses, Interest paid</td>
<td>Loans, Investment assets</td>
</tr>
<tr>
<td>Atsushi limi (2004)</td>
<td>Pakistan</td>
<td>SFA method, intermediary approach</td>
<td>Labour, Capital, Interest Paid</td>
<td>Four type of loans (commercial and industrial loans, agricultural loans, Public-sector loans), Non-lending accounts (including guarantees and mortgage lending)</td>
</tr>
<tr>
<td>Authors</td>
<td>Country</td>
<td>Methodology</td>
<td>Data Source</td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----------</td>
<td>---------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Asish Saha &amp; T.S. Ravisankar</td>
<td>India</td>
<td>DEA method / intermediation</td>
<td>Number of Branches, Number of employees, Establishment expenditure, Non-establishment expenditure (excluding interest expenditures)</td>
<td></td>
</tr>
<tr>
<td>Hamim A. Mokhtar and others</td>
<td>Malaysia</td>
<td>SFA method / Intermediation</td>
<td>Total deposits, Total overhead expenses</td>
<td></td>
</tr>
<tr>
<td>Fadzlan Sufian</td>
<td>Malaysia</td>
<td>DEA method / intermediation</td>
<td>Total deposits, Total assets, Labor</td>
<td></td>
</tr>
<tr>
<td>Donsyah Yudistira</td>
<td>18 banks from Islamic countries</td>
<td>DEA method / intermediation</td>
<td>Staff costs, Fixed assets, Total deposits</td>
<td></td>
</tr>
<tr>
<td>Shamshur Mohammad &amp; others</td>
<td>21 Organization of Islamic countries</td>
<td>DEA method / intermediation (with reference to Isik &amp; Hassan selection of variables)</td>
<td>Labor, Fixed assets, Total funds</td>
<td></td>
</tr>
<tr>
<td>UN, economic and social</td>
<td>Egypt, Oman, U.A.E., Lebanon</td>
<td>SFA method / intermediation</td>
<td>Labor, Capital, Deposits and borrowed funds</td>
<td></td>
</tr>
<tr>
<td>commission for west Asia</td>
<td></td>
<td></td>
<td>Various categories of Interest-bearing assets</td>
<td></td>
</tr>
<tr>
<td>David Grigorian and Vlad</td>
<td>Bahrain, Kuwait, Qatar, U.A.E., Singapore</td>
<td>DEA method /</td>
<td>Personnel expenditures, Fixed assets, Interest expenditures</td>
<td></td>
</tr>
<tr>
<td>Manole, IMF working paper</td>
<td></td>
<td>Fixed assets</td>
<td>Revenues (interest and non-interest income), Net loans (loans net of loan loss provisions), Liquid assets (cash &amp; treasury bill holding)</td>
<td></td>
</tr>
<tr>
<td>(2005)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors' own survey studies

6. Variables Selected for this thesis

This study analysis is based on originally collected data with detailed items, secondary data from financial statements (balance sheet and profit/loss statement) of 10 government owned banks which is including the 4 specialized banks (Keshavarzi bank, San’at o Ma’adan bank, Maskan bank, and Tosaeh Saderat Bank) and 6 commercial banks (Saderat bank, Sepah bank, Terjarat bank, Melli bank of Iran, Mellat Bank, Refah Bank) the more than 75% of the banking business in the country.
except to newly established private banks, Qard-al hassanah funds, post bank of Iran and representatives of foreign banks. The data collected covers the period from 1995 to 2005. The aggregate data for liability side and asset side of the banking sector along with their components has been collected from central bank data base and finance ministry of Govt. of Iran (secondary sources), but micro level data for efficiency analysis has been collected from the individual banks financial statement and annual reports (primary sources) and international research institutes. For economic indices and general picture of the country wide source of data including national and international used such as WDI data base and IMF data base and central bank “balance sheet and economic reports” (secondary sources).

The input/ output variables are used in this thesis in chapter six for data interpretation and analysis. The input/ output variables are selected based on the intermediary approach. ‘Reliable’ efficiency prediction requires appropriate definitions and certain assumptions regarding the measurement of input, output. The exclusion of certain important bank inputs and/or outputs might bias the final efficiency measures by distorting construction of the frontier (the locus of the efficient combination of inputs and outputs). To determine what constitutes inputs and outputs of banks, one should first decide on the nature of banking technology. In literature on the theory of banking, there are two main approaches competing with each other in this regard: the production and the intermediation approaches (Sealey and Lindley, 1977). Like many studies on banking efficiency (e.g., Aly et al., 1990; Zaim, 1995; DeYoung and Nolle, 1998; Berger and Mester, 1997; Resti, 1997; DeYoung and Hasan, 1998), we adopt the intermediation approach in this paper. Accordingly, we model commercial banks as multi-product firms, producing 3 outputs and employing 4 inputs. All variables except for the input factor labor are measured in millions of Rials.

In this study, the inputs and outputs have been defined following the intermediation approach, which is appropriate for measuring the entire bank level efficiency since it is inclusive of the variable equivalent to interest expense, which often accounts for one-half to two-third of total costs (Berger and Humphry, 1997). Since Islamic banking is based on interest free principles, the variables adopted are based on the
banking system operation whereas four input variables and three output variables which followed by review of many studies on banking efficiency and their variable selection.\textsuperscript{15}

The input vector includes:

1. labour \texttt{[LABOR]}, the number of full-time employees;
2. physical capital \texttt{[PHYCAPIT]} the book value of premises and fixed assets;
3. total deposits \texttt{[TOTALDEP]}, the sum of demand deposits and term-investment deposits, and
4. number of Branches \texttt{[BRANCHES]}.

The output vector includes:

1. total loans \texttt{[loans]} including all type of loans and mode of financing which outstanding based on Islamic modes
2. Investment securities \texttt{[INVSECUR]}, including investment on government securities and central bank securities,
3. Gross profit \texttt{[PROFIT]} the bank profit before tax reduction.

While our definition of bank inputs and outputs is not free from short-comings, we believe that it might be a reasonable challenge to improve the way to present bank production in I.R.Iran.

Data have been collected for ten years period (1995-2005) for analyzing Iranian banking efficiency. Both the liability and asset side data have been analysed and discussed by using DEA method, under which technical efficiency with constant return to scale and technical efficiency with variable return to scale and scale efficiency. The indices of each efficiency are calculated for each bank (10 state banks) and for every year from 1995.

7. Limitation of Data

While Collecting data for the study, the researcher found that it was extremely difficult to get reliable data on performance of the banking sector due to poor data base and macroeconomic performance of the economy as well. It happened because of some sanctions on Iran banking sector by U.S. government, therefore it is very difficult to access to detail financial statements of Iranian banks and imposed ratios

\textsuperscript{15} The table of input/output variables of bank efficiency studies has been derived and designed in chapter three as methodology of research
restrictions to access database. So, with these limitations, data have been collected on
general financial statements of banks from library of the central bank of Iran as
secondary data from 1990 till 2005, but annual managerial financial reports and
inspector reports, audit organization reports were strictly limited access. However,
aggregate data base of whole banking system and monetary data in the central bank of
Iran website is: http://www.cbi.ir which data for recent couple of year's annual
statement of public and private banks is available and accessible from their internet
websites. These data have been used for the assessment of the banking in Iran.