2011 International Conference on Economics and Finance Research
IPEDR vol.4 (2011) © (2011) IACSIT Press, Singapore

Iranian Bank Branches Performance by Two Stage DEA Model

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Abstract— **This paper seeks to measure and evaluate the overall performance of Finance organizations (Iranian Bank) using a Data Envelopment Analysis (DEA) methodology. DEA is a special linear programming model for deriving the comparative efficiency of multiple-input multiple-output Decision-Making Units (DMUs). DEA provides management with information regarding the relatively best practice branch in the observation set and locates the relatively inefficient branches by comparison with the best practice ones. In addition, it indicates the magnitude of these inefficiencies. The paper selects a set of inputs and outputs for Iranian bank branches for March 2009. Performance determined by product efficiency and effectiveness. We used two stage DEA model for calculate efficiency and effectiveness. In stage 1 we applied BCC model to efficiency evaluation, and in stage 2 we used BCC model to effectiveness evaluation too. Then overall performance calculated by product efficiency score and effectiveness score.**

Keywords-DEA, Data envelopment analysis, efficiency, effectiveness, peoductivity, performance.

I. INTRODUCTION

To maintain viability and to improve competitiveness, commercial banks in Iran are currently restructuring the operation of branch networks. Branches are a major delivery vehicle of business volume in banking and the performance of the branch network is bound to have a significant impact on the bank performance as a whole.

The banks are forced to re-evaluate their branch networks in order to identify the business drivers and improve the performance of their branches. The availability of performance analysis tools of bank networks can contribute positively in this effort. Among them a linear programming-based benchmarking technique, called data envelopment analysis (DEA), has been gaining increasing popularity as a viable technique for the analysis of branch performance. The employment of such a technique can assist in restructuring branch networks by gaining insight into the operation of the branches so that managerial actions can be taken to improve their performance (Berger and Humphrey, 1997; Oral and Yolalan, 1990; Sherman and Gold, 1985; see also Manandhar and Tang, 2002).

This paper aims to provide a framework for evaluating the overall performance of bank branches in terms of both profitability efficiency and effectiveness. The case study presented here concerns a sample of branches of a large commercial Iran bank. We focus on the branch network, since “The Bank” that provided the data set used in this study was interested in gaining insights into the performance of its network of branches as a first step in comparing the results of a DEA assessment with the results of an in-house performance measurement model.

The current study deviates from previous studies in several respects. First, we focus separately on both profitability efficiency and effectiveness, as components of a new overall performance metric concept. This is the overall performance (profitability-effectiveness measure) extracted from the DEA-profitability efficiency and DEA-effectiveness measures. Our findings provide direct guidance for the optimal deployment of cost input categories and the scale of outcomes produced in terms of income categories and net income.

II. SURVEY OF BRANCH EFFICIENCY EVALUATION

A. Efficiency, Effectiveness and Performance

Efficiency and effectiveness are the central terms used in assessing and measuring the performance of organizations (Mouzas, 2006). Performance, in both profit and non-profit organizations, can be defined as an appropriate combination of efficiency and effectiveness. However, there seems to be some inconsistency in the use of these termsin the existing literature on the subject matter. For the managers, these terms might be synonymous but each of these has their own distinct meaning. Drucker (1977) distinguished efficiency and effectiveness by associating efficiency to “doing things right” and effectiveness to “doing the right things.” In his terminology, a measure of efficiency assesses the ability of an organization to attain the output(s) with the minimum level of inputs. It is not a measure of a success in the marketplace but a measure of operational excellence in the resource utilization process. More precisely, efficiency is primarily concerned with minimizing the costs and deals with the allocation of resources across alternative uses (Achabal et al., 1984).While commenting on effectiveness, Keh et al. (2006) observed that ameasure of effectiveness assesses the ability of an organization to attain its pre-determined goals and objectives. Simply, an organization is effective to the degree to which it achieves its goals (Asmild et al., 2007). In sum, effectiveness is the extent towhich the policy objectives of an organization are achieved.

It is significant to note that though efficiency and effectiveness are two mutually exclusive components of overall performance measure yet they may influence each other. More specifically, effectiveness can be affected by efficiency or can influence efficiency as well as have an impact on the overall performance (Ozcan, 2008). Figure 1 puts the argument in proper scenario. Nevertheless, it is possible that an organization can be efficient in utilizing the inputs, but not effective; it can also be effective, but not efficient.

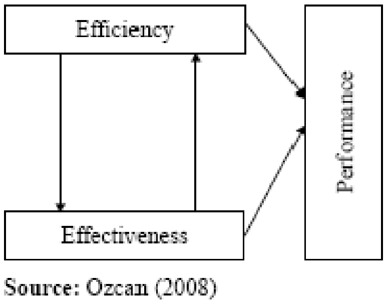

Figure 1. Relations between efficiency, effectiveness and performance

In the profitability approach it is examined how well different branches combine their resources (i.e. expenses) to produce revenues. Profitability efficiency evaluates the ability of branches to minimize the cost of resources for the level of revenue generated from different activities (e.g. Athanassopoulos, 1997; Oral et al., 1992; Oral and Yolalan, 1990; Soteriou and Zenios, 1999; Manandhar and Tang, 2002). In the profitability efficiency assessment the objective function of DEA models is the ratio of the weighted sum of revenues to the weighted sum of expenses, i.e. an indicator of profitability (Oral and Yolalan, 1990; Athanassopoulos, 1997; Giokas, 2008a). Published DEA studies of branch banking are numerous, see Paradi et al. (2004) for a recent survey, but Iranian studies are relatively few.

DEA studies that analyze bank branch efficiency in other countries are those of Sherman and Gold (1985), Tulkens (1993), Drake and Howcroft (1994), Haag and Jaska (1995), Sherman and Ladino (1995), Athanassopoulos (1998), Berger et al. (1997), Lovell and Pastor (1997), Camanho and Dyson (1999, 2005), Zenios et al. (1999), Schaffnit et al. (1997), Golany and Storbeck (1999), Avkiran (1999), Kantor and Maital (1999), Soteriou et al. (1999), Cook et al. (2000), Cook and Hababou (2001), Dekker and Post (2001), Hartman et al. (2001), Bala and Cook (2003), Portela et al. (2003, 2004), Paradi and Schaffnit (2004) and Portela and Thanassoulis (2005, 2007).

Our work differs from previous studies by focusing on a three-stage DEA model formulation, based on DEA-profitability efficiency, DEA-effectiveness and DEA-productivity measures, keeping each measure dependent from each another.

B. DEA Models

Performance evaluation is a critical part of the management process. It provides information necessary for decision-making, and also delivers a competitive advantage for continued operations (Phillips, 1999). Therefore, it is important to determine how to measure organizational performance in a multidimensional construct (Lewin and Minton, 1986).

Among the techniques of assessing organization performance, the method of data envelopment analysis (DEA) proposed by Charnes et al. (1978) may be the most representative of performance evaluation.

DEA is a non-parametric, linear programming technique to evaluate the relative efficiency of a homogenous set of decision making units (DMUs) with multiple inputs and outputs. The efficiency score of any DMU is determined by comparison with the DMU located on the efficient frontier as a benchmark representing the minimum resources necessary for a firm to achieve at a given level of output (input oriented), or the maximum output expansion at a given level of input resource (output oriented).

Two main DEA models have been developed according to the nature of returns to scale: the CCR model and the BCC model. The CCR model, named for Charnes et al. (1978), was developed under the assumption of constant returns to scale (CRS). The second model, the BCC model, introduced by Banker et al. (1984) as an extension of the CCR model, was developed under the assumption of variable returns to scale (VRS). VRS implies disproportionate variation in outputs when inputs are increased. This model is able to measure pure technical efficiency, while scale efficiency can be determined by overall performance efficiency divided by pure technical efficiency. This enables the decision makers to determine whether the inefficiency comes from a technical problem or from a scale problem.

DEA has been widely applied in a variety of fields, including airlines (Schefczyk, 1993), banking (Jemric and Vujcic, 2002), education (Thanassoulis and Dunstan, 1994), forest management (Kao et al., 1993), insurance (Mahajan, 1991), library management (Hammond, 2002), life insurance companies (Cummins et al., 1999), mutual funds (Basso and Funari, 2001), nursing (Nunamaker, 1983), telecommunications (Uri, 2001), hospitals (Chilingerian and Sherman, 1990), transportation companies (Kerstens, 1996), and textile companies (Chandra et al., 1998). However, very few papers have used DEA to examine the performance of the bank industry.

C. CCR and BCC Model

The concept of efficiency is derived from physical and engineering science and indicates the relationship between inputs and outputs. Charnes et al. (1978) introduced the ratio definition of efficiency, also known as the CCR ratio definition, which generalizes the single-output to single-input ratio definition used in classical science to multiple outputs and inputs not including requiring pre-assigned weights. The main strength of the DEA model as it is applied in this study lies in its ability to combine multiple inputs and outputs into a single summary measure to select the most efficient unit.

Let X_{ij} , $i = 1,2,\dots m$ and Y_{rj} $r = 1,2,\dots,s$ be the ith input and rth output, respectively, of the jth DMU, j = 1...n. The DEA model for measuring the relative efficiency of DMU_o under an assumption of constant returns to scale is the CCR model (Charness, Cooper and Rhodes, 1978).

$$\text{Max} \sum_{r=1}^{k} u_r y_{ro}$$

s.t

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

$$\sum_{r=1}^{k} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \qquad j = 1, \dots, n$$

$$u_r \geq 0 \quad r = 1, \dots, k$$

$$v_i \geq 0 \quad i = 1, \dots, m$$

We can say that the dual model is:

$$\text{Min } \theta$$

S.t

$$\sum_{j=1}^{n} \lambda_j X_{ij} \leq \theta X_{io} \quad i = 1, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j Y_{rj} \geq \theta Y_{ro} \quad r = 1, \dots, k$$

$$\lambda_j \geq 0$$

The following BCC input oriented value-based model (Banker, Charnes and Cooper, 1984) can be used to assess efficiencies.

$$\text{Max} \sum_{r=1}^{k} u_r y_{ro} + w$$

s.t

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

$$\sum_{r=1}^{k} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + w \leq 0 \qquad j = 1, \dots, n$$

$$u_r \geq 0 \quad r = 1, \dots, k$$

$$v_i \geq 0 \quad i = 1, \dots, m$$

The dual model is:

$$\text{Min } \theta$$

S.t

$$\sum_{j=1}^{n} \lambda_j X_{ij} \leq \theta X_{io} \quad i = 1, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j Y_{rj} \geq \theta Y_{ro} \quad r = 1, \dots, k$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \qquad j = 1, \dots, n$$

III. THE CONCEPTUAL FARAMEWORK

The proposed framework, which is referred to as the "overall performance" model, encompasses two performance dimensions as depicted in Figure 2. The model specifically incorporates a direct measure of profitability efficiency and its integration with an effectiveness model.

The performance metric Net income/Total cost ratio (overall performance) assesses the level of total cost to achieve the expected level of net income generation, and could be treated as overall performance in this study. It can be disaggregated into profitability and effectiveness as follows:

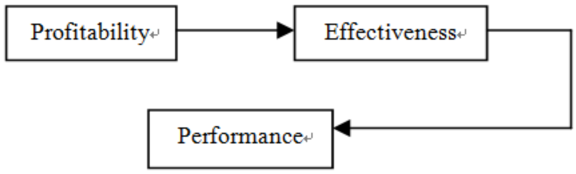

Figure 2. Relations between Efficiency, Effectiveness and performance

The overall efficiency model assesses performance of bank branches in terms of profitability and effectiveness. That is, we suppose an efficient and effective bank branch as using a minimum of resources (i.e. expenses) to generate total income and a minimum of total income to generate net income. The above analysis shows that overall performance is disaggregated into profitability efficiency and effectiveness. This approach accounts for the possible trade-off between profitability efficiency and effectiveness in bank branch operation.

The operationalization of overall performance model, i.e. the specification of inputs and outputs for each individual model, and their integration to reflect the causal relationship among the performance dimensions is shown in Table 3.

The causal relationships are operationalized by specifying the outputs of one model (stage 1) as inputs to another (stage 2). The output of profitability efficiency model, which is specified as the aggregate measure of total income to total cost ratio, is an input to the effectiveness model. The outputs of profitability efficiency model positively influence effectiveness and hence they are inputs to effectiveness model.

Our sample includes branches of various sizes, hence, the variable returns to scale (VRS) model, accounting for possible scale effects, is a natural choice (see also Paradi and Schaffnit, 2004). Since the branches typically have little or no direct control over the demand for services required by their customers, input-orientation was chosen for the first (profitability efficiency) model presented in this study. For the effectiveness approach we retain the same model orientation in order to investigate whether the branches use the efficient level of income (interest and non-interest) in generating profits.

For the identification of best-practice branches for each dimension the input minimization BCC (Banker et al., 1984) is used.

IV. PERFORMANCE EVALUATION IN IRANIAN BANKS BEANCHES

Now we apply this method to performance evaluation in Iranian bank branches.

Determination of inputs and outputs is an important part of performance evaluation. Since, we calculate performance in two stages, so we must determine inputs and outputs in two stages.

In stage 1, efficiency, we have physical capital, personal, value of deposits and operating expenses as inputs and number of transactions, advances, investment and commissions as outputs. These inputs and outputs are shown in below table. See Table 1.

Physical Capital Personal Value of deposits Operating expenses	Stage1 Efficiency	No of transactions Advances Investment Commissions

TABLE1. . INPUTS AND OUTPUTS FOR PROFITABILITY EFFICIENCY (STAGE 1)

In stage 2, effectiveness, we have number of transactions, advances, investment and commissions as inputs and net income as output. These inputs and outputs are shown in table 2. See Table 2.

No of transactions Advances Investment Commissions	Stage1 Effectiveness	Net income

TABLE2. INPUTS AND OUTPUTS FOR EFFECTIVENESS (STAGE 2)

As you seen in above, outputs in stage1 then become inputs in stage 2. So we have two stages model for overall performance. Inputs and outputs of two stage model are shown in table 3. See Table 3.

Physical Capital, Personal, Value of deposits, And Operating expenses	**stage1**	No of transactions, Advances, Investment, And Commissions	**stage2**	Net incom e

TABLE3. INPUTS AND OUTPUTS FOR OVERALL PERFORMANCE

In fact, each DMU evaluate in two stages. See Figure 1.

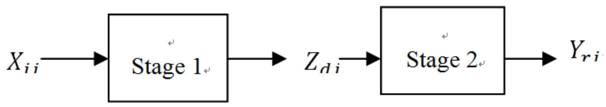

Figure 3. . Relations between stage1 and stage 2

Now we apply two BCC model in stage 1 and stage 2. BCC was introduced Banker Charnes and Cooper (1978): BCC model is:

$$\text{Min } \theta$$

$$\text{S.t}$$

$$\sum_{j=1}^{n} \lambda_j X_{ij} \le \theta X_{io} \qquad i = 1, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j Y_{rj} \ge \theta Y_{ro} \qquad r = 1, \dots, k$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \ge 0 \qquad j = 1, \dots, n$$

We calculate the profitability efficiency From stage 1, and the effectiveness from stage 2. Then we determine performance by product efficiency score and effectiveness score.

V. RESULTS

Now, we apply the first BCC model in stage 1. In this stage, capital, personal, value of deposits and operating expenses are inputs and number of transactions, advances, investment and commissions are outputs. We used the data from March 2009 in Iranian banks. The results of the profitability efficiency are shown in below table. See Table 4.

DMUs	*Efficiency*	*DMUs*	*Efficiency*
Branch (1)	**0.5805**	Branch (11)	**1.0000**
Branch (2)	**0.5278**	Branch (12)	**1.0000**
Branch (3)	**0.7119**	Branch (13)	**1.0000**
Branch (4)	**0.3772**	Branch (14)	**0.298**
Branch (5)	**0.5669**	Branch (15)	**0.5506**
Branch (6)	**1.0000**	Branch (16)	**0.3401**

Branch (7)	**0.8012**	Branch (17)	**0.4473**
Branch (8)	**0.8808**	Branch (18)	**1.0000**
Branch (9)	**0.304**	Branch (19)	**0.5113**
Branch (10)	**0.5531**	Branch (20)	**0.3684**

Figure 4. Efficiency Score (stage 1)

And then we apply the second BCC model in stage 2. In this stage number of transactions, advances, investment and commissions are inputs and net income is outputs. The results of the effectiveness are shown in below table. See Table 5.

DMUs	***Effectiveness***	***DMUs***	***Effectiveness***
Branch (1)	**0.986**	Branch (11)	**0.6628**
Branch (2)	**1.0000**	Branch (12)	**1.0000**
Branch (3)	**1.0000**	Branch (13)	**1.0000**
Branch (4)	**0.773**	Branch (14)	**1.0000**
Branch (5)	**0.5526**	Branch (15)	**0.8078**
Branch (6)	**1.0000**	Branch (16)	**1.0000**
Branch (7)	**0.7422**	Branch (17)	**1.0000**
Branch (8)	**1.0000**	Branch (18)	**0.6619**
Branch (9)	**0.8452**	Branch (19)	**0.4611**
Branch (10)	**0.6505**	Branch (20)	**1.0000**

Figure 5. Effectiveness Score (stage2)

And overall performances are shown in Table 6.

DMUs	***Overall***	***DMUs***	***Overall***
Branch (1)	**0.572373**	Branch (11)	**0.6628**
Branch (2)	**0.5278**	Branch (12)	**1.00000**
Branch (3)	**0.7119**	Branch (13)	**1.00000**
Branch (4)	**0.291576**	Branch (14)	**0.298**
Branch (5)	**0.313269**	Branch (15)	**0.444775**
Branch (6)	**1.00000**	Branch (16)	**0.3401**
Branch (7)	**0.594651**	Branch (17)	**0.4473**
Branch (8)	**0.8808**	Branch (18)	**0.6619**
Branch (9)	**0.256941**	Branch (19)	**0.23576**
Branch (10)	**0.359792**	Branch (20)	**0.3684**

Figure 6. Performance

VI. CONCULTION

In this study, we calculated efficiency and effeteness and productivity of 20 branches of Iranian banks. This productivity determine by product efficiency and effectiveness. We can see raking of branches in Table 6.

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