Available online at www.elixirpublishers.com (Elixir International Journal)

Finance Management

Elixir Fin. Mgmt. 58A (2013) 15105-15109

ISSN: 2229-712X

Bank productivity analysis: an empirical evidence from Iranian banking industry

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ARTICLE INFO

Article history:

Received: 27 November 2012;

Received in revised form:

15 May 2013;

Accepted: 22 May 2013;

Keywords

Bank Productivity,

Data Envelopment Analysis,

Slack Based Model,

Malmquist Productivity Index,

Decision Making Unit.

ABSTRACT

This paper explains the process of measuring and analyzing Bank Total Productivity (BTP) and the productivity changes in bank braches using Data Envelopment Analysis (DEA), Slack Based Measure (SBM) and Malmquiest Productivity Index (MPI) in Export Development Bank of Iran (EDBI). For this purpose, we have measured and analyzed the productivity growth in EDBI branches using MPI in the period of 1994-2005. The trend of efficiency scores' moving averages confirms improvement in BTP over the period of study. Moreover, the results show %1 and %2 on average improvement in the productivity of EDBI branches in period 2004 and 2005, respectively.

Introduction

Managerial accounting systems provide beneficial information to support managers' decision making and organizational performance evaluation process. One of the most important information that managerial accounting systems provide is about organizational productivity. In reality, measuring the productivity regards as one of the most important and difficult steps in productivity analysis process. In order to measure productivity, several methods have been introduced in literature.

One of the most famous non-parametric techniques in measuring the productivity of similar Decision Making Units (DMUs) is Data Envelopment Analysis (DEA). DEA is a mathematical programming that generates production function or efficient frontier using observed or available data. In addition to DEA, one can apply Malmquist Productivity Index (MPI) to measure firms' productivity growth.

This paper explains the process and the results of an empirical study that was conducted in one of the most leading Iranian banks named Export Development Bank of Iran (EDBI). The paper explains how to measure and analyze Bank Total Productivity (BTP) and productivity growth using DEA, Slack Based Measure (SBM) and Malmquiest Productivity Index (MPI). For this purpose, rest of the paper is organized as following. In the next section, we explain some related literature. Section 3 introduces two main research hypotheses. Research methodology is explained in section 4. Section 5 provides the results of empirical analysis. Finally, the paper ends with conclusions and final remarks.

Literature Review

Several researchers have focused on bank efficiency analysis. For example, Berger and Humphrey (1992) measure the efficiency in commercial banking. Berger and Humphrey (1997) investigate measuring efficiency of financial institutions. Berger and Mester (1997) in their paper titled "Inside the black box: What explains differences in the efficiencies of financial institutions?" profound the literature on financial institution efficiency. Rogers (1998) focuses on the nontraditional activities and the efficiency of US commercial banks. Altunbas et al. (2000) measures the efficiency and risk in Japanese banking. Laeven and Majnoni (2003) study on the loan loss provisioning and economic slowdowns.

Some researchers have applied DEA as a non-parametric technique in their productivity analysis. For example, Golany and Storbeck (1999) apply a multiperiod DEA to measure the efficiencies of selected branches of a large US bank over second quarter of 1992 to the third quarter of 1993. They develop budgeting and target-setting modules, within a DEA framework. Mukherjee et al. (2001) measure the productivity growth for 201 large US commercial banks in the period of 1984 to 1990 using DEA and MPI. They attempt to distinct the contributions of technical change, technical efficiency change, and scale change to productivity growth. Isik and Hassan (2003) study total factor productivity change in Turkish commercial bank. They utilize a DEA-type Malmquist total factor productivity change index and examine productivity growth, efficiency change, and technical progress in Turkish commercial banks during the deregulation of financial markets in Turkey. Halkos and Salamouris (2004) apply DEA in measuring the performance of the Greek banking sector. They study the efficiency of Greek banks and use a number of financial efficiency ratios for the time period 1997–1999. The ratios are return difference of interest bearing assets, return on average equity, profit or loss per employee, efficiency ratio, and net interest margin. Their model helps bank to compare the inefficient banks with the efficient ones. They suggest DEA as either an alternative or complement to ratio analysis for the evaluation of an organization's performance and find a positive relation between the size of total assets and the

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efficiency. They also argue that reducing the number of small banks due to mergers and acquisitions leads to increasing in efficiency and can not find systematic significant relationship between transfer of ownership and last period's performance.

Drakea et al. (2006) evaluates the relative technical efficiency of institutions operating in a market that have been significantly affected by environmental and market factors in recent years. They incorporate environmental factors into the efficiency analysis using SBM, incorporate the operating environment into a nonparametric measure of technical efficiency, and employ SBM in DEA.

As mentioned earlier, this paper aims to explain the process of measuring and analyzing BTP in one of Iranian leading banks and the productivity changes in its branches using DEA, SBM and MPI. Next section of the pape, introduces research hypotheses.

Research Hypotheses

This research aims to assess BTP over period 1994-2005 and bank branches' productivity growth over 2003-2005 using DEA model. To compare bank total productivity in 1994-2005, SBM is applied. Also, in order to compare bank branches efficiency scores and analyze their efficiency growth over the period of study, DEA model is applied.

In this research, two main hypotheses are defined as follows:

H1: BTP has improved over the periods of study (1994-2005).

H2: The average productivity growth of the branches has improved over the periods of study (2003-2005).

Research Methodology

Statistical population of this research includes EDBI and its all 28 branches over the country. Each branch of bank provides foreign currency services as well as regular banking activities.

BTP was calculated over 1994-2005. In order to measure branches productivity, we selected all branches that were active in period 2003-2005. Since two branches were established in the middle of 2004, then, 26 of 28 branches were empirically examined. The data and information for BTP are based on bank's audited financial statement. But, in order to analyze bank branches productivity growth, we have used bank documents, bank statistical reports and bank's branches' monthly balance reports over the period of 2003-2005.

To measure and assess BTP, assuming variable rate of return to scale, SBM full ranking model of super-efficiency was applied. SBM is a DEA model that directly uses slack variables (input surplus and output slack variables) and focuses on both inputs and outputs at the same time so that provides a Scalar for efficiency score. (Tone, 2001) We used SBM and assumed variable rate of return to scale because it was not possible for the bank to increase its productivity just by decreasing its inputs or by increasing outputs. Accordingly, we find SBM and variable rate of return suitable for this case.

Suppose $X = (x_{ij}) \in R^{m\times n}$ and $Y = (y_{rj}) \in R^{s\times n}$ denote input and output matrix for n DMUs, respectively. In this case, the Production Possibility Set (PPS) for these DMUs can be defined as $P = \{(x, y)|\ x \geq X\lambda,\ y \leq Y\lambda,\ \lambda \geq 0\}$ where λ is a non-negative vector in R^n and for each $DMU(x_o, y_o)$ we will have $x_o = X\lambda + s^-$, $y_o = Y\lambda - s^+$, and $s^+ \geq 0$ ، $s^- \geq 0$ ، $\lambda \geq 0$ where s^- and s^+ are slack variables imply to output shortfall and input surplus vectors, respectively. Using slack variable vectors and assuming $\Lambda = t\lambda$, $S^- = ts^-$, $S^+ = ts^+$, a linear programming SBM under variable rate of return to scale assumption can be formulated as following:

$$\begin{aligned} &Minimize: \quad \rho = t - (1/m)\textstyle\sum_{i=1}^{m} S_i^- / x_{io} \qquad (1)\\ &subject\ to: \quad 1 = t + (1/s)\textstyle\sum_{r=1}^{s} S_r^+ / y_{ro}\\ &t\,x_o = X\Lambda + S^-\\ &t\,y_o = Y\Lambda - S^+\\ &\textstyle\sum_{j=1}^{n} \Lambda_j = 1\\ &\Lambda \geq 0,\ S^- \geq 0,\quad S^+ \geq 0,\quad t > 0 \end{aligned}$$

In SBM, $DMU(x_o, y_o)$ is efficient if $\rho^* = 1$. Also, for full ranking of all DMUs in SBM, we have to include DMUs that their efficiency score value are equal to 1 (Tone, 2002). Accordingly, full ranking linear programming model under variable rate of return to scale can be defined as following:

$$\begin{aligned} &\tau^* = \min \tau = 1/m \textstyle\sum_{i=1}^{m} \tilde{x}_i / x_{io} \qquad (2)\\ &subject\ to \quad 1 = 1/s \textstyle\sum_{r=1}^{s} \tilde{y}_r / y_{ro}\\ &\tilde{x} \geq \sum_{j=1,\neq o}^{n} \Lambda_j x_j\\ &\tilde{y} \leq \sum_{j=1,\neq o}^{n} \Lambda_j y_j\\ &\textstyle\sum \Lambda_j = 1\\ &\tilde{x} \geq t\,x_o,\ \tilde{y} \leq t y_o,\ \tilde{y} \geq 0,\ \lambda \geq 0 \end{aligned}$$

where $\tau^* \geq 1$.

In order to assess BTP using SBM, we have considered yearly performance of bank in period 1994-2005 as a distinct DMU. We have solved SBM for each DMU in each financial period by Lindo software. Then, a full ranking linear programming model has been formulated and solved for DMUs with efficiency score value 1. We also measured scale inefficiency and compared SBM results under both variable and constant rate of return to scale assumptions. To test H1 (first research hypothesis), we used the results of SBM under variable rate of return to scale.

In order to measure banks branches' efficiency scores, we measured MPI. This index measures DMUs efficiency changes over the periods and calculates a yearly efficiency of a DMU based on the data of that year respect to previous year production technology. MPI does not assume that a DMU behavior is an optimized behavior. Moreover, it uses non-parametric method of DEA (Rezitis and Anthony 2006).

If a DMU in period t (where t:=،1، ... T) can produce M of y^t outputs using x^t inputs, in each period t, production technology and distance functions can be defined as $S^t = \left(x^t, y^t\right)$ and $D_O^t(x^t, y^t) = \inf\{\theta : (y^t/\theta) \in S^t\}, t = 1,...,T$ ، respectively. This equations show the maximum outputs that can be obtained with the technology of period t. If outputs vector locates on the technology frontier, the value of distance function for outputs, θ, will be one. MPI, using distance function for outputs, measures the changes in productivity between t and $t+1$ as follows:

$$\begin{aligned} &M_O(x^{t+1}, y^{t+1} x^t, y^t) = \qquad (3)\\ &[M_O^t(x^{t+1}, y^{t+1} x^t, y^t) \times M_O^{t+1}(x^{t+1}, y^{t+1} x^t, y^t)]^{1/2} =\\ &\left[(D_O^t(x^{t+1}, y^{t+1}) / D_O^t(x^t, y^t)) \times (D_O^{t+1}(x^{t+1}, y^{t+1}) / D_O^{t+1}(x^t, y^t))\right]^{1/2} \end{aligned}$$

When $M_0 > 1$, it means that the productivity is increased. MPI uses DEA to estimate the function. Solving four linear programming problems, we can generate the functions as $D_O^t(x^{t+1}, y^{t+1})$ ‘ $D_O^{t+1}(x^{t+1}, y^{t+1})$ ‘ $D_O^t(x^{t+1}, y^{t+1})$ and $D_O^{t+1}(x^t, y^t)$. For example, distance function for the *kth* DMUs (k:1, 2, K) under constant rate of return to scale assumption can be calculated as following:

$$Max\,\theta^p = \left(D_O^t(x^{p,t}, y^{p,t})\right)^{-1} \quad (4)$$

subject to

$$\theta^p y_m^{p,t} \le \sum_{k=1}^{K} z^{k,t} y_m^{k,t} \quad m = 1, ..., M$$

$$\sum_{k=1}^{K} z^{k,t} x_n^{k,t} \le x_n^{p,t} \quad n = 1, ..., N$$

$$z^{k,t} \ge 0 \quad k = 1, ..., K$$

In order to measure MPI for our case of study, first we have solved $D_O^t(x^{t+1}, y^{t+1})$, $D_O^{t+1}(x^{t+1}, y^{t+1})$ ‘ $D_O^t(x^{t+1}, y^{t+1})$ and $D_O^{t+1}(x^t, y^t)$ using EMS software and then the index was calculated for each period.

For selecting the inputs and outputs variables, the literature is reviewed. Some researchers suggested correlation technique. For this research, the following widely used inputs and outputs variables were selected:

- In SBM, number of employee, cost of doubtful liabilities, and main financing resources considered as input variables, and facilities amounts as output variable.
- In MPI, number of employees, administrative & salary costs, profit and fees paid considered as input variables, and fees received, facility donated, without cost deposits and cost consuming deposits as output variables.

The Results

Table 1 and 2 show the descriptive statistical results.

Using inputs and outputs data in Figure 1 and for each financial period, regular linear programming model of SBM and full ranking SBM for efficient DMUs under constant and variable rate of returns to scale assumptions were formulated. Table 3 presents the solutions over the period of study.

Figure 1: Comparing BTP trend under variable and constant return to scale (VRRS and CRRS) assumptions

Figure 1 shows BTP trends under variable and constant rate of return to scale (VRRS and CRRS) assumptions over the period of study.

As shown in Figure 1, there is a significant difference between two trends. This difference is called as scale inefficiency. Remind that first research hypothesis (H1) states that BTP has improved over the periods of study. The data on Figure 1 confirms H1. Moreover, to have a better conclusion, moving averages were calculated.

Table 4 provides results of calculations.

Remind that second research hypothesis (H2) indicates that the average productivity growth of the branches improved over the past three periods. To examine this research hypothesis, we have calculated MPI for the period 2003-2005. In other words, once we have measured this index and compared change in productivity between 2003 and 2004, and again it has been calculated for the years 2004 and 2005, respectively. Table 5 presents results of calculating MPI and rank of each branch in terms of its MPI values. According the data, average productivity growth of the branches in 2004 and 2005 are 1% and 2%, respectively.

Table 6 shows lower level and upper level of productivity growth in 2004 and 2005.

Since the bank uses a three level ranking system, in order to define the categories, we have divided the range of productivity growth to 3. Then, using this method of partitioning, we have positioned all branches in their proper groups in terms of their MPI value.

Conclusions and Final Remarks

This paper explained the process of measuring BTP and analyzing bank branches' productivity growth over the time using DEA, SBM and MPI. To explain the process more simply, empirical evidence of EDBI was provided. In this research, we have examined two main research hypotheses. These hypotheses stated that "BTP and its branches' average productivity have improved over the periods of study. Results of empirical examination show that both research hypotheses have been confirmed. The results show that in addition to increasing BTP, its branches productivity has improved on average %1 and %2 in 2004 and 2005, respectively. Moreover, in order to compare our reluts to the result obtained by current ranking system of the bank, we have provided a simple three level categorization framework.

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Table 1: Descriptive statistics of selected variables in SBM

Outputs	Inputs			
Facilities *Amounts	Cost of doubtful *Liabilities	Number of Employees	Main Financing *Resources	
10,128	175	895	11,888	Maximum
164	3	156	325	Minimum
2,823	40	578	3,655	Mean
3,294	51	234	3,827	Standard Deviation
* Numbers in million rials				

Table 2: Descriptive statistics of three years average of selected variables in SBM

Outputs				Inputs			
Cost Consuming Deposits *	Without Cost Deposits*	Facility *Donation	Fees *Received	Profit and *Fees paid	Administrative & *Salary Costs	Number of Employees	
352,503	1,726,815	3,484,583	38,479	27,584	6,783	85	Maximum
1,142	2,270	6,911	105	114	767	6	Minimum
27,420	99,589	239,892	3,070	2,140	1,513	14	Mean
68,073	333,355	684,385	7,648	5,334	1,167	15	Standard Deviation
* Numbers in million rials							

Table 3: Solution of SBM using linear programming

Years	Variable Return to Scale		Constant Return to Scale	
	τ^*	ρ^*	τ^*	ρ^*
1994		0.40	1.42	1.00
1995		0.28		0.75
1996		0.38		0.63
1997		0.38		0.59
1998		0.53	1.05	1.00
1999		0.47		0.56
2000		0.52		0.60
2001	1.21	1.00	1.21	1.00
2002		0.65		0.69
2003	1.04	1.00	1.04	1.00
2004	1.15	1.00	1.23	1.00
2005	1.08	1.00	1.10	1.00

Table 4: Moving average of efficiency scores for different durations

Periods / Duration of Moving Averages	1	2	3	4	5	6	7	8	9	10	11
2 Years	1.08	0.69	0.61	0.82	0.81	0.58	0.90	0.93	0.85	1.14	1.17
3 Years	0.93	0.66	0.76	0.74	0.74	0.79	0.82	0.97	0.97	1.13	
4 Years	0.85	0.76	0.71	0.70	0.86	0.75	0.87	1.03	1.01		
5 Years	0.89	0.72	0.69	0.80	0.81	0.81	0.95	1.05			
6 Years	0.83	0.70	0.77	0.78	0.85	0.88	0.97				
7 Years	0.80	0.77	0.76	0.81	0.91	0.91					
8 Years	0.83	0.79	0.84	0.89	0.93						
9 Years	0.83	0.79	0.84	0.89							
10 Years	0.85	0.83	0.87								
11 Year	0.88	0.86									

Table 5: Results of MPI moving and grouping branches in terms of their productivity growth

2005 Comparing to 2004			2004 Comparing to 2003			Branches
Rank of Branch in Terms of Its Productivity Growth	Productivity Situation	MPI	Rank of Branch in Terms of Its Productivity Growth	Productivity Situation	MPI	
2	Stable	1.00	2	Stable	1.00	DMU1
1	Increased	2.30	3	Decreased	0.35	DMU2
2	Decreased	0.85	2	Decreased	0.97	DMU3
2	Increased	1.01	3	Decreased	0.77	DMU4
2	Decreased	0.92	2	Increased	1.16	DMU5
3	Decreased	0.79	2	Decreased	0.88	DMU6
2	Stable	1.00	2	Decreased	0.91	DMU7
2	Decreased	0.91	2	Decreased	0.96	DMU8
2	Stable	1.00	2	Stable	1.00	DMU9
2	Decreased	0.94	2	Decreased	0.86	DMU10
2	Increased	1.20	2	Increased	1.04	DMU11
3	Decreased	0.61	2	Increased	1.12	DMU12
2	Decreased	0.96	2	Increased	1.03	DMU13
1	Increased	1.46	2	Decreased	0.91	DMU14
2	Stable	1.00	2	Stable	1.00	DMU15
2	Decreased	0.94	2	Increased	1.06	DMU16
2	Increased	1.10	2	Increased	1.02	DMU17
2	Stable	1.00	2	Stable	1.00	DMU18
3	Decreased	0.89	1	Increased	1.75	DMU19
2	Decreased	0.97	2	Increased	1.03	DMU20
2	Decreased	0.84	2	Decreased	0.98	DMU21
2	Decreased	0.83	2	Decreased	0.87	DMU22
2	Stable	1.00	2	Increased	1.13	DMU23
2	Increased	1.07	2	Stable	1.00	DMU24
3	Decreased	0.61	2	Decreased	0.87	DMU25
1	Increased	1.32	2	Decreased	0.88	DMU26
-	Increased	1.02	-	Increased	1.01	Average

Table 6: Basic data for grouping branches based on MPI

Group Rank	2005		2004	
	Upper Level	Lower Level	Upper Level	Lower Level
Group 1	2.30	1.73	1.75	1.28
Group 2	1.73	1.17	1.28	0.82
Group 3	1.17	0.61	0.82	0.35

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