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An empirical study to measure the relative efficiency and productivity of different units of an Iranian bank using DEA and Malmquist index

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ABSTRACT

In this paper, we propose a method to measure the relative efficiency of different units of a publicly traded bank using data envelopment analysis. The study also measures the productivity of different banks using Malmquist index and the results are compared with relative efficiency of banks. The proposed model uses nine financial factors reported by the bank officials for both studies where five items are used for efficiency measurement and the other four items are used for productivity measurement. The results indicate that different banks perform inefficient in terms of efficiency but they have attempted to increase their productivity. We also analyze the results and give guidelines on how inefficient units could increase their efficiency by reducing their inputs or increasing their outputs.

1. Introduction

One of the most important issues in banks is to measure the relative efficiency of different units of a bank. Measuing efficiency has been one of the most controversial issues among researchers for the past few decades. In fact, there are many cases where we face with more than one single input and output and we cannot simply measure the efficiency by dividing the output by input. Charnes (1978) are believed to be the first who introduced the idea of measuring relative efficiency by introducing a mathematical model called Data envelopment analysis (DEA). During the past two decades, there have been significant numbers of applications based on the implementation of DEA methods for measuring the performance of non-financial industries (Banker, 1984; Berger, 1997; Berger & Humphrey, 1997; Camanho & Dyson, 1999; Golany, 1999; Hartman et al., 2001; Camanho & Dyson, 2003; Canhoto & Dermine, 2005; Manthos & Papanikolaou, 2009). Cook and Hababou (2000) implemented DEA for performance measurement of bank industry. They measured the sales' performance in their other work (Cook & Hababou, 2001).

Banking industry is one of the important economic factors of each country, and it is important to monitor its performance. Drake and Howcroft (1994) measured the relative efficiency of UK banks

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using DEA method. Dekker and Post (2000) proposed a quasi-concave method for measuring the relative efficiency of UK banks. Webb (2003) implemented DEA for some UK banks in an attempt to measure the performance of the banks. Drake (2001) investigated the relative efficiency of different UK banks using DEA method. Drake et al. (2006) studied the impact of macroeconomic factors on the performance of banking industry. Fiordelisi (2007) investigated the impact of the European banks on their shareholders' value. Giokas (2008) performed an assessment on the efficiency in operations of a large Greek bank branch network under different economic conditions. Gregoriou and Zhu (2005) evaluated the performance of hedge funds using DEA methods. Haag and Jaska (1995) presented a method to Interpret the inefficiency ratings of bank industry. Athanassopoulos (1997) believes that one of the essential ways at regulating the productivity and efficiency improvement programs at level of a bank is existence of an efficient net of branches. Assessing the banks productivity and efficiency is a reliable way for increasing their power and more profitability and removing the deficiencies and obstacles. Halkos and Salamouris (2004) performed an empirical analysis based on DEA method for measuring the relative efficiency of Greek commercial banks with the use of financial ratios. Ioannis (2010) presented a mathematical modeling of bank branch profitability and effectiveness by means of DEA. Isik and Hassan (2003) investigated the effects of financial deregulation and total factor productivity change for Turkish commercial banks. Lovell and Pastor (1997) used DEA method for target setting for some bank branch network. Paradi and Schaffnit (2004) used DEA technique for measuring the performance of some commercial Canadian banks. Pasiouras (2008) estimated the technical and scale efficiency of Greek commercial banks by investigating the impact of credit risk, off-balance sheet activities, and international operations. Portela et al (2004) studied the impact of negative data in DEA models and applied their model for some banks. Portela and Thanassoulis (2005, 2007) investigated DEA model for some Portuguese banks. Sturm and Williams (2008) examined the characteristics determining the relative efficiency of Australian banks. Siriopoulos and Tziogkidis (2009) explained how Greek banking institutions react after significant events based on DEA approach. Sufian (2010) in his thesis studied the relative efficiency of Korean banks using DEA method.

In this paper we present an empirical analysis to study the relative efficiency as well as the productivity of different banks in a province of Iran called Semnan. The study of this paper uses nine formal indexes released formally in an annual reports of the banks for measuring both efficiency and productivity of different units of banks. The organization of this paper first introduces the mathematical models used for measuring the relative efficiency as well as productivity in section 2. Section 3 is devoted to the implementation of our case study and finally concluding remarks are given in the last section to summarize the contribution of the paper.

2. Proposed methodology

2.1 Data envelopment analysis

In this section, we present the problem statement of the proposed DEA method used in this study. In a DEA method, there are normally some inputs and outputs associated with all decision-making units. Let x_{ij} be the inputs for one of decision-making unit with $i=1,\ldots,m$ and y_{rj} be the outputs of the same units with $r=1,\ldots,s$ and $j=1,\ldots,n$ and suppose u_i and v_j are the dual variables associated with x_i and y_j, respectively. The constant return to scale DEA model is formulated as follows,

$$\begin{aligned} \max \quad & z = \frac{\sum_{r=1}^{s} u_r y_{r.}}{\sum_{i=1}^{m} v_i x_{i.}} \\ \text{subject to} \quad & \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1. \\ & x_{ij}, y_{ij \ge 0} \end{aligned} \tag{1}$$

Model (1) is the basic DEA, which can be solved j times to measure the relative efficiencies of various units. However, since model (1) is nonlinear in structure, Charles et al. (1978) proposed a method to convert model (1) into a simple linear programming problem as follows,

$$\begin{aligned} \max \quad & z = \sum_{r=1}^{s} u_r y_{r.} \\ \text{subject to} \quad & \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1. \\ & \sum_{i=1}^{m} v_i x_{i.} = 1 \\ & u_r, v_i \ge 0, \qquad j = 1,...,n \end{aligned} \tag{2}$$

2.2 Malmquist productivity index and DEA

The Malmquist Index is a total factor productivity index based on distance functions,relative to the previous year (Caves, 1982). One of the prominent advantages of Malmquist index is that it does not involve the producer behavior optimization assumption and these units can be deficient (Tulkens, 1993). In addition, this index uses non-parametric DEA method (Rezitis, 2006). This index measures total factors productivity change at two time point by using interval function.To describe this index, we examine Fig. 1.

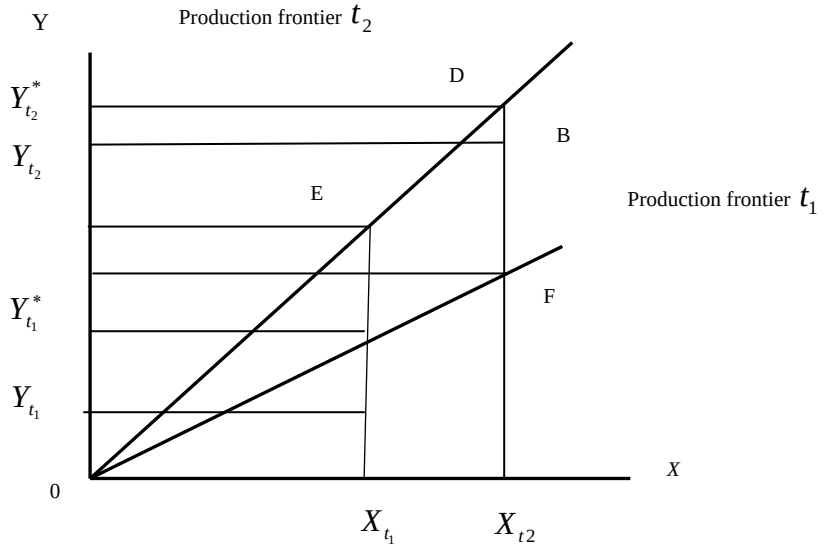

Fig. 1. Description of Malmquist index productivity

Fig. 1 examines a simple state, which includes a saving used for producing a production. Let (X_t^1, Y_t^1) and (X_t^2, Y_t^2) be the production in period t_1 and t_2, respectively. Malmquist index can be expressed as follows,

$$M_o^t = (X^{t+1}, Y^{t+1}, X^t, Y^t) = \frac{D_o^{t+1}(X^{t+1}, Y^{t+1})}{D_o^t(X^t, Y^t)} \times \left[\frac{D_o^t(X^{t+1}, Y^{t+1})}{D_o^{t+1}(X^{t+1}, Y^{t+1})} \times \frac{D_o^t(X^t, Y^t)}{D_o^{t+1}(X^t, Y^t)} \right]^{\frac{1}{2}}. \tag{6}$$

The first part represent the efficiency changes and the second part expresses the technology changes and the productivity is a result of multiplying efficiency by technology. Malmquist productivity index and its parts are calculated under the assumption of a fixed return to scale. When $M_o > 1$ we have improvement on productivity and once $M_o < 1$ we experience a decrease on productivity.

3. Case study

The proposed study of this paper is implemented for a case study of banking industry called Tejarat located in one of Iranian provinces called Semnan. The bank maintain 43 branches in this province and we choose 36 ones for the study of this paper. The study is held for two fiscal years of 2009 and

2010. In our study, the relative efficiency is measured using DEA and the productivity is computed by Malquist method.

3.1 DEA/Mamquist input/output parameters

Perhaps, one of the most important efficiency assessing issues of a decision making units is the selection of the input and the output parameters. In DEA, total inputs and outputs should not be over than one-third of DMUs numbers. Meanwhile, production, intermediary, added value and operational trends are addressed for determining the input and output indexes (Berger & Hamphery, 1997). We have used the annual productivity report published by the bank industry of this case study where there are nine factors for measuring the productivity where five factors are selected for measuring the relative efficiency and the remaining are chosen for assessing the productivity. Table 1 summarizes the inputs and the outputs used for two methods.

Table 1

The input and the output parameters used for DEA and Malquist methods

DEA	input	personal number, personal record, real branch value
	output	effective branches deposit balance, total income
Malquist	input	personal number, active accounts number, education
	output	paid facilities number, total cost

Fig. 1 shows the results of the implementation of the DEA method (2) for 36 units of our case study.

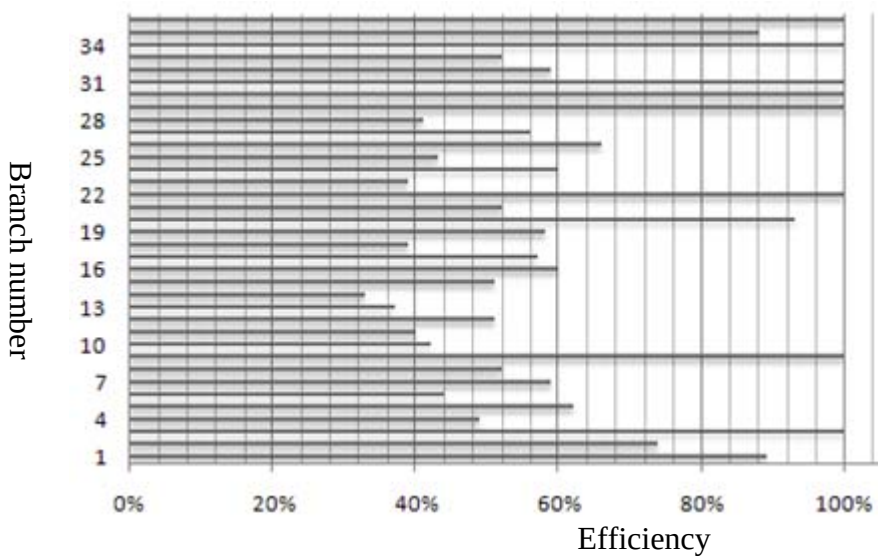

Fig. 2. The relative efficiency of different units

As we can observe from Fig. 2 there are eight efficient units, three units, which are relatively efficient and the other seem to be inefficient. One of the primary concerns is to know how to setup different targets for inefficient units to become efficient units. Table 2 shows how to change an inefficient unit into a an efficient one by either reducing the inputs or increasing the outputs. According to the results, the first branch needs to reduce the number of its employee from 20 people to ten people or reduce its real state value by selling off some unnecessary assets. Alternatively, this unit could increase its total income from 584 to 1372.

Note that the information of eight efficient units are not reported in this table since we there was no need to make any change either on the inputs or on the outputs of these units.

Table 2
Improve inefficient branches to efficient branches

Unit #	Personal number	Personal record	Real branches value	Effective branches deposit balance	Total income
1	20 to 10.228	128 to 114.267	134 to 119.623	-	584 to 1372.08
2	7 to 5.162	75 to 55.308	122 to 64.354	-	205 to 619.207
4	5 to 2.454	43 to 21.108	90 to 39.351	-	112 to 133.369
5	6 to 3.712	54 to 33.406	107 to 57.006	-	175 to 247.771
6	4 to 1.762	40 to 17.616	81 to 24.083	-	82 to 172.255
7	5 to 2.454	35 to 20.608	93 to 40.174	-	118 to 118
8	5 to 2.063	33 to 17.319	76 to 33.785	-	-
10	4 to 1.659	46 to 19.487	42 to 17.793	-	81 to 252.146
11	7 to 2.809	97 to 38.928	98 to 20.13	-	113 to 610.965
12	7 to 2.283	56 to 28.821	41 to 21.101	-	126 to 409.201
13	6 to 1.834	46 to 17.11	73 to 27.152	-	91 to 141.131
14	8 to 1.973	68 to 20.83	82 to 25.118	-	109 to 227.065
15	17 to 6.788	152 to 80.926	133 to 70.81	-	412 to 1068.54
16	-	74 to 58.878	-	-	151 to 276.451
17	-	56 to 56	69 to 58.25	821 to 1434.25	105 to 270.875
18	-	81 to 62.195	-	410 to 1453.61	111 to 282.878
19	-	61 to 53	-	683 to 1215	138 to 238
20	8 to 7.333	-	74 to 58.667	1392 to 1745.3	302 to 326.333
21	6 to 5.667	-	66 to 45.333	701 to 1348.66	110 to 252.167
23	-	-	72 to 42.25	375 to 958.25	62 to 181.875
24	6 to 5.667	-	67 to 45.333	803 to 1348.66	145 to 252.167
25	-	-	82 to 48	612 to 1428	111 to 267
26	9 to 7.556	-	92 to 60.444	1085 to 1798.2	222 to 336.222
27	6 to 4.667	-	72 to 37.333	619 to 1110.66	75 to 207.667
28	-	-	69 to 45.125	484 to 1193.12	66 to 224.438
32	5 to 4.337	-	80 to 64.802	595 to 1013.73	116 to 197.636
33	5 to 4.838	-	-	605 to 1155.03	68 to 187.069
35	4 to 2.106	-	65 to 35.765	514 to 583.394	73 to 82.856

Next, we have measured the productivity of all 36-unit banks for the fiscal years of 2009 and 2010.

Table 3
The productivity of different branches using Malmquist index

Unit #	TC	EC		Unit #	TC	EC	
1	1	1	**1**	19	1.011	1.001	1.012
2	1.007	1.031	**1.038**	20	1.013	0.991	1.004
3	1.005	0.997	**1.002**	21	1.012	1.053	1.065
4	1.004	1.02	**1.024**	22	1	1	1
5	0.982	1.038	**1.02**	23	0.97	1.045	1.014
6	1.005	1.037	**1.042**	24	0.999	1.025	1.024
7	1.005	1.051	**1.056**	25	0.984	1.031	1.014
8	1.002	1.01	**1.012**	26	0.883	1.162	1.026
9	1	1	**1**	27	1.011	1.015	1.026
10	1.003	1.012	**1.015**	28	1.011	1.002	1.013
11	1.002	1.002	**1.004**	29	1	1	1
12	1.004	1.006	**1.01**	30	1.012	1.013	1.015
13	1	1	**1**	31	1	1	1
14	1	1	**1**	32	1	1	1
15	1.007	0.999	**1.006**	33	1	1	1
16	1.013	1.015	**1.028**	34	1	1	1
17	1.012	1.01	**1.022**	35	1	1	1
18	1.012	1.016	**1.029**	36	1.012	1.032	1.044

Table 3 summarizes the results of our implementation of Malquist method for the case study of this paper for two fiscal years of 2009 and 2010. In Table 3, TC represents the technology changes, EC

shows the efficiency changes and M_0 explains the Malmquist index for 36 units. The computations were based on two consecutive fiscal years of 2008 and 2009. This was coincident with the privatization of the bank. As we can observe from the table, all banks performed better in terms of productivity mainly because of the privatization, which could help managements of all 36-unit banks restructure their infrastructures.

4. Conclusion

In this paper, we have presented an empirical method for measuring the relative efficiency and productivity of selected units of a publicly traded bank located in one of the provinces of Iran. The proposed model of this paper used DEA method to measure the relative efficiency and Malmquist technique to study the productivity of the bank for two consecutive fiscal years. The results indicated that most branches were inefficient but they attempted to increase their efficiency and productivity over time. The results of productivity measurement indicated an improvement on productivity growth for two consecutive years of study.

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