MEASURING EFFICIENCY OF COMMERCIAL BANKS IN A DEVELOPING ECONOMY: THE CASE OF TURKEY

Selcuk Percin, Tuba Yakici Ayan

Abstract

The objective of this study is to measure and evaluate the efficiency of commercial banks in Turkey using a Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI) methodologies. For this purpose, two outputs representing total loans and non-interest income, and four inputs representing the number of employees, physical capital, non-deposit funds and total deposits are selected for a two-year (2003-2004) period in the analysis. Using data for the year 2004, 11 of the 31 banks are found to be efficient under CRS, while 16 of them efficient under VRS assumption. Also, for the year 2003, 16 of the 31 banks have been calculated efficient under CRS while 23 of them efficient under VRS assumption. In addition to efficiencies of banks, it has been found that there is an increase of bank's efficiency changes over the time period of 2003-2004. In this paper, the DEA models are solved using a modeling system called LINDO (linear, interactive, discrete optimizer) 6.1 software package.

Key words: Turkish commercial banks, DEA, Efficiency.
JEL Classification: C61, G21, D24.

1. Introduction

In this study, Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI) methodologies are used to measure and evaluate the efficiency of commercial banks in Turkey. In the literature, there are so many similar studies that have evaluated the performance of banking sector in the US, Europe or other developed countries. However, there have been very few empirical researches aimed at measuring efficiencies of commercial banks in developing countries, especially in Turkey. For example, Oral and Yolalan (1990), Zaim (1995), Ozkan-Gunay (1996, 1998), Yildirim (1999), Isik and Hassan (2002) and Emel *et al.* (2003), have examined various issues relating the performance of Turkish banks, none of these studies have evaluated the efficiency of banks with the diversity of bank ownership forms after the crisis emerged in Turkey in 2001. An exception of this is Isik and Hassan's (2002) study in which they initially examined size, ownership, control and governance variables on allocative, technical and scale efficiencies of Turkish commercial banks. However, they only studied the top commercial banks that have operated in Turkey between 1988 and 1996, which limits the generalizability of their results.

Turkish banks can be classified into three ownership forms; state owned, privately owned, and foreign banks. It will probably be performance variation across classified banks. Additionally, this study compares the measured relative efficiency of Turkish banks in 2003-2004 period. This is a critical issue in a continuously changing business environment because the bank that is most efficient in one period may not be the most efficient in another (Isik and Hassan, 2002: 724). Also, using a panel data with the Malmquist productivity index approach (MPI) will provide with healthier results than focusing on a one year period of time. This enables us to draw some conclusions over the efficiency of changes in the banking sector in the short run. For this reason, this study can be seen as the first attempt to understand the extent and importance of efficiencies of commercial banks in Turkey after crisis emerged in the banking sector in Turkey in 2001.

The paper is organized as follows. The evolution of the Turkish banking system is described in section 2. Specification of the DEA methodology is discussed in section 3. Empirical results of the sensivity analysis and MPI approach are summarized and discussed in section 4 and section 5 respectively. Section 6 offers a summary of the main findings and suggestions for future researches.

2. The Turkish Banking System[1]

The financial sector in Turkey is in the stage of development. Compared to the developed countries, the size of financial sector is small and shallow. On the other hand, Turkish banking system, within the financial sector characterized by many financial institutions and instruments, has begun to develop and grow after the banking restructuring reforms were launched in 2001. These efforts include auditing the assets of the banks, strengthening the financial structure and shareholder's equity of the banks, and taking corrective measures to increase efficiency of the banks. Besides, in accordance with the EU's directives, several amendments, mainly concentrated on improving risk-oriented supervision, reducing operational costs, increasing the quality of financial services and increasing the effectiveness of supervision in the banking system, were applied. Turkey has already accepted EU practices on capital adequacy and adjusted its customs and tariffs according to a mutual agreement with the EU (Isik and Hassan, 2002: 721).

The Turkish banking system has traditionally occupied an important position in the financial system. In the period of 1999-2003 in which the banking system underwent the restructuring, 20 banks were transferred to the Savings Deposit Insurance Fund (SDIF) due to their weakened financial structure. All liabilities of these banks were taken over by the SDIF. On the other hand, the banking licences of 8 banks were terminated and liquidated. In the same period, 11 bank mergers took place in the banking sector including the buying of some of the banks under the SDIF management. Thus, the structure of the banking system has become healthier since the economic crisis emerged in Turkey in 2001. Then, with the aim of reinforcing the financial system, some important steps for strengthening the regulatory and supervisory institutions have been taken. Apart from the Undersecretariet of Treasury, Central Bank of the Republic of Turkey, and Capital Market Board, an independent agency was formed for increasing the effectiveness of banking supervision and control – the Banking Regulation and Supervision Agency (BRSA). Since then, The Banking Act and other banking regulations have been considerably harmonized with international best practices such as accounting standards, reporting and public disclosure by means of the BRSA (BAT, 2005).

Banks in Turkey can be classified under two main groups as those collecting deposits (commercial banks) and those not accepting deposits (nondepository banks). Furthermore, each group can be divided into three subgroups as state owned, privately owned, and foreign banks according to the source of their respective capitals. Commercial banks perform the more traditional banking operations such as deposit taking, payment services, foreign exchange operations and marketing of securities and other financial products. They may be privately owned or state owned, but there is no difference between them in terms of their activities (BAT, 2005).

As of 2004, although smaller in number, the state owned commercial banks occupy a substantial share in the banking system with 45% of total banking assets. On the other hand, many of the privately owned commercial banks are almost small-sized. Foreign banks operate either with a branch or founding in Turkey. They are large in number but small in size in the market with an assets share of 5%. They face same regulation with domestic banks (Keskin, 2001). The number of commercial banks operating in Turkey in 2004 was 35; of which 3 were state owned banks, 18 were privately owned banks, and 13 were foreign banks. Also, one bank was operating under the SDIF (BAT, 2005).

As at the end of September 2004, there were 6106 branches in the banking system including those abroad. Of which, 2149 were state owned commercial banks, 3729 were privately owned commercial banks and 209 were foreign banks. The number of branches and employees in the banking system began to rise in 2004, notably in privately owned banks. In the same period, the number of people employed in the banking system was 127163; 39467 (31%) of which work for state owned commercial banks, 76880 (60%) for privately owned commercial banks, and 5880 (9%) for foreign banks (BRSA, 2004).

The banking industry that dominates the entire financial system has recorded phenomenal earnings in recent years (Isik and Hassan, 2002: 721). Mentioned above that the majority of financial flows go through the banking sector, total assets of the banking sector amounted to YTL 306

[1] For detailed information, please visit www. tbb.org.tr and www.bddk.org.tr

billion (USD 229 billion) by the end of 2004. However, the ratio of total assets to GNP remained the same at 71% as compared to the previous year. Per capita bank assets amounted to USD 3212. Within total assets, the share of commercial banks was 96%, and that of the non-deposit banks was 4% (BRSA, 2004).

In total loans, the share of commercial banks group was 95%. While developed country's banks lent average 60% of their total assets to borrowers, Turkey's commercial banks averaged a loans-total assets ratio below 40% for the period of 2001-2004. Since then, the ratio of loans to total assets has increased to 21% for state owned banks, 40% for privately owned banks, and 46% for foreign banks. The main reason for the increase in total loans was the rapid growth in consumer loans and loans extended via credit cards.

Turkish banks have not fared better on the deposits-generation side of financial intermediation by the end of 2004. However, since 2004, according to the data of the Central Bank, total deposits of the commercial banks increased by 22% in current prices, and 7% in constant prices. While the insurance coverage on saving deposits was limited to 50 YTL, the share of the total deposits of commercial banks in 2004 was 100% (BRSA, 2004).

The major reason behind these developments in the Turkish banking system can be connected with the banking restructuring reforms supported by legislative changes. Reforms also increased competition in the financial system. Increased competition in the financial system has also resulted in the development of new products and services. Major banks with a nationwide presence have completely automated their branches and have started providing improved levels of customer service through their POS and ATM terminals as well as through home banking services. In particular, payment services have improved substantially with the introduction of new technology. More recently, many of the major banks have started offering internet banking services. These services include a variety of technology-intensive applications such as online credit transfers, online investment accounts, trading of government bonds, mutual funds and equities (Keskin, 2001). In line with these developments, a research study on the assessment of efficiency of commercial banks in Turkey is presented in this paper.

3. The DEA Methodology

DEA, which is a nonparametric, multifactor, productivity analysis tool, considers multiple input and output measurements in evaluating relative efficiencies of decision making units (DMUs) such as banks (Barros, 2005).

The major advantage of the DEA approach is that DEA does not require any assumptions about the function form. That means that DEA does not need any priori information on the underlying functional forms and weights among various input and output factors (Zhu, 2000; Guan *et al*., 2006). For this reason, DEA is more robust and comprehensive than any of the typical productivity ratios commonly used in financial analysis. It also allows for the identification of appropriate benchmarks, which are potentially important for the commercial banks and above all, for those that are performing poorly (Barros, 2004).

Charnes *et al.* (1978) first proposed the CCR model that had an input orientation and assumed constant returns-to-scale (CRS). Later studies have considered alternative set of assumptions. Banker *et al.* (1984) introduced the assumption of variable returns-to-scale (VRS) known in the literature as the BCC model. Since CCR and BCC models are well established, a number of different DEA studies have appeared in the literature. For example, Zhu (2000) employed DEA to explore the multi-dimensional financial performance of Fortune 500 companies. Joro *et al*. (1998) studied the relationship between DEA and multiple criteria decision-making. Apart from industrial organizations, DEA has also been applied to evaluate comparative performance of university departments (Tomkins and Green, 1988; Wong and Beasley, 1990), restaurants (Banker and Morey, 1986a), pharmacies (Banker and Morey, 1986b), hospitals (Banker *et al*., 1986c), non-profit organizations (Nunamaker, 1985) and nations (Golany and Thore, 1997).

An efficiency score for a particular DMU can be obtained by maximizing the ratio of total weighted output over total weighted input for all units. Hence, the objective of the DEA is to identify the DMU that produces the largest amounts of outputs by consuming the least amounts of inputs. This is done subject to the constraint on all such ratios of the other DMUs in the sample being less than, or equal to, one (Barros, 2005; Al-Shammari, 1999). The performance of each DMU is then measured relative to the performance of all other DMUs.

Assume that there are N DMU (or DMUs) that are using m inputs to produce s outputs. Let the *m*th DMU produces outputs Y_{rk} using X_{ik} inputs. Where the subscript *i* stands for inputs, *r* stands for outputs and *j* stands for the DMUs. Y_{rj} defines the value of the *r* th output for the *j* th DMU and X_{ij} defines the value of the *i* th input for *j* th DMU. The variables u_{rk} and v_{ik} are the weights to be determined by the mathematical program. Also, h_k is the relative efficiency of the DMUs that is under evaluation. A DMU is considered to be efficient if the ratio of weighted sum of outputs to the weighted sum of inputs is the highest. In this model, DMU is efficient if and only if h_k =1, otherwise its DEA is inefficient. The efficiencies of other inefficient DMUs are obtained relative to the efficient DMUs, and are assigned efficiency scores between zero and one. For inefficient units, DEA also provides those efficient units (peers), which the inefficient units can emulate to register performances that could improve their efficiency scores (Ramanathan, 2006).

Model I:

max

$$h_k = \frac{\sum_{r=1}^{s} u_{rk} Y_{rk}}{\sum_{i=1}^{m} v_{ik} X_{ik}} \tag{1}$$

s.t.

$$\frac{\sum_{r=1}^{s} u_{rk} Y_{rj}}{\sum_{i=1}^{m} v_{ik} X_{ij}} \le 1; \qquad j = 1, \ldots, N$$

$$u_{rk} \ge 0, v_{ik} \ge 0 \quad r = 1, \ldots, s; \quad i = 1, \ldots, m$$

Equation (1) is a fractional programming model that has an infinite number of solutions. To simplify computation equation (1) is to be reformulated as a linear programming model. The multiplier form of the linear programming model can be presented in equation (2) (Charnes *et al.*, 1978):

Model II:

max

$$\phi_k = \sum_{r=1}^{s} u_{rk} Y_{rk} \tag{2}$$

$$\sum_{r=1}^{m} v_{ik} X_{ik} = 1$$

$$\sum_{r=1}^{s} u_{rk} Y_{rj} - \sum_{i=1}^{m} v_{ik} X_{ij} \le 0; j = 1, \ldots, N$$

$$u_{rk} \ge 0, v_{ik} \ge 0 \quad r = 1, \ldots, s; \quad i = 1, \ldots, m\,,$$

where ϕ is a scalar variable, measuring the level of efficiency under the terms of input-oriented constant-return to scale (CRS). Also, the linear programming problem, which may be either constant (CRS) or variable (VRS), must be solved N times, once for each DMU in the sample. A value of ϕ is then obtained for each DMU.

The assumption of CRS is said to prevail at a point on the frontier if an increase of all inputs 1% leads to an increase of all outputs by 1%. Similarly, the assumption of VRS is said to prevail when the CRS assumption is not satisfied. VRS includes increasing returns to scale (IRS) and decreasing returns to scale (DRS). DRS reveal if outputs increase by less than 1%, while IRS exist if they increase by more than 1% (Golany and Thore, 1997). Besides, VRS efficiency of a DMU measures its pure technical efficiency, while CRS efficiency accounts for both technical efficiency and efficiency loss when the DMU does not operate in its most productive scale size (Ramanathan, 2005: 44).

3.1. Inputs and Outputs

Substantial studies have been conducted around the issues of banking efficiency. Besides, inputs and outputs used by these studies published in the literature vary widely. Elyasiani and Mehdian (1995) evaluated the relationship between size and productive performance of 150 randomly chosen US commercial banks in 1986. They employed four inputs (labor, capital, time and saving deposits and demand deposits) and four outputs (investment, commercial and industrial loans, real estate loans and other loans). Their results indicate that small banks achieve higher levels of technical efficiency than the large banks. Moreover, in the pre-deregulation environment small banks were more efficient then the large banks while in the deregulated environment small and large banks were equally efficient.

Miller and Noulas (1996) examined the technical efficiency of 201 large banks from 1984 to 1990. In their DEA analyses, commercial and industrial loans, consumer loans, real estate loans, investment, total interest income, and total non-interest income are considered as outputs. Inputs considered by them include, total transactions deposits, total non-transactions deposits, total interest expense, and total non-interest expense. Their results indicate that the mean bank technical inefficiency averages at the 5% level. Also, larger and more profitable banks seem to have higher levels of technical efficiency.

Wheelock and Wilson (1999) used the Malmquist decomposition to examine U.S. banks from 1984 to 1993. They used three inputs (labor, physical capital, and purchased funds) and five outputs (real estate loans, commercial and industrial loans, consumer loans, all other loans, and total demand deposits). The major finding of their results indicates that the US commercial banks experienced large decreases in both efficiency and productivity ratios between 1984 and 1993. They also concluded that the inefficiency increased in the same period due to the failure of banks to adopt technological improvements made by a few banks. Thus, it can be seen that a variety of inputs and outputs have been considered by the studies in the literature.

While there is no consensus amongst researchers about the inputs and outputs of a bank, there are mainly two different approaches in defining inputs and outputs. One of these is production approach where banks are treated as producers of services that use capital and labor to generate deposit and loan accounts. The other is the intermediation approach where banks are viewed as intermediators of financial services rather than producers of loans and deposit account services. In this approach, the value of loans and investments is used as output measures; labor, and capital are inputs to this process (Luo, 2003; Miller and Noulas, 1996; Seiford and Zhu, 1999).

This study adopts inter-mediation approach of choosing inputs and outputs. Based on this approach four inputs are considered in evaluating a bank's performance: total labor (the number of full-time employees), physical capital (the net book value of premises and fixed assets), non-deposit funds (borrowed funds from Interbank, Central bank, domestic banks, abroad and others as well as funds raised by issuing marketable securities), and total deposits (checking accounts and time deposits). These inputs represent the costs of labor, administration, equipment and funds purchased for bank operations, and the source of loanable funds for investment (Yeh, 1996; Kao and Liu, 2004). There are also two factors representing the outputs in assessing bank performance: total loans (short-term, medium and long-term loans), and non-interest income (commissions, and other operating income). These outputs represent bank revenue and the major profit making business activities (Yeh, 1996; Kao and Liu, 2004).

3.2. Data and Empirical Results

There are 35 commercial banks in banking sector in Turkey in 2004. Of the 35 banks, the first three banks are public or state banks, the second eighteen are their private counterparts, the last thirteen are the foreign banks, and one is operating under the SDIF management. Both the categories of banks are operated under the Banking Regulation and Supervision Agency (BRSA). In this study, two of the foreign banks (Deutche Bank and JP Morgan Chase Bank), have not been evaluated due to fact that they have no available data on some input and output measures for the years 2003 and 2004. Also, since DEA cannot deal with negative values (Luo, 2003), banks with negative profits and/or revenue (Bayindir Bank and Adabank) are dropped. As a result, a final sample of 31 commercial banks is utilized for analysis and is listed in Table 2 along with their inputs and outputs data. Data on input and output measures for the years 2003 and 2004 were collected mainly from the financial statements of these banks as given in the Banks in Turkey in 2004 published by Banks Association of Turkey (BAT) or web sites of this association (http://www.tbb.org.tr, accessed October 2005). The first step in the DEA analysis is the measurement of bank's performance for the year 2004. Data used for this analysis are presented in Table 1.

Table 1

Data on performance of commercial banks in Turkey during the year 2004

Banks No.	TOTLOA	NONINCO	NUOFEMP	PHYCA	NONDEP	TOTDEP
I-State-owned						
1-ZIBNK	6789.79	500.62	21172.00	547.50	768.31	33961.09
2-HABNK	3216.29	211.19	11145.00	527.66	842.39	14557.58
3-VABNK	6033.11	444.88	7150.00	834.96	2421.91	13159.09
II-Privately-owned						
4-AKBNK	9682.86	607.23	10413.00	494.14	5382.45	14905.65
5-ALNTF	425.03	39.43	547.00	2.37	262.15	467.64
6-ANBNK	541.10	23.84	1036.00	12.90	366.73	927.16
7-DENIZ	1957.28	133.83	4344.00	85.68	1048.28	3113.16
8-FINBN	3884.40	223.82	5464.00	142.20	1224.14	3810.30
9-KBNK	2870.27	173.82	3611.00	94.89	1310.72	5288.06
10-MNG	120.42	7.52	226.00	6.01	62.80	144.43
11-OBNK	2587.48	107.90	4199.00	143.57	401.32	3472.46
12-SKBNK	973.61	112.69	3334.00	71.99	238.99	1716.41
13-TKBNK	172.36	10.92	578.00	23.64	62.50	293.21
14-TEKST	551.69	21.48	938.00	54.45	291.66	579.49
15-TURBNK	32.17	1.79	188.00	8.15	72.36	188.95
16-DISBA	2262.42	159.69	3843.00	122.80	1579.32	2594.60
17-TEBNK	1178.69	45.40	2131.00	30.17	553.08	1691.14
18-GARAN	7717.64	688.48	9128.00	946.15	3489.80	13179.86
19-ISBTR	9318.15	935.91	16055.00	1433.75	4716.19	18199.84
20-YKBNK	7392.25	549.29	10537.00	1797.30	3883.79	10696.13
III-Foreign banks						
21-ABN	64.09	22.83	128.00	17.20	69.50	137.70
22-AKUL	16.81	4.57	70.00	7.48	58.29	72.11
23-ARTRK	52.44	4.81	186.00	18.42	136.16	33.51
24-BDIROM	20.20	0.89	30.00	2.71	48.37	16.28
25-BMELLA	76.06	3.51	47.00	4.34	88.74	22.48
26-BEURO	67.65	1.54	215.00	16.09	23.93	134.57

Table 1 (continuous)

Banks No.	TOTLOA	NONINCO	NUOFEMP	PHYCA	NONDEP	TOTDEP
27-CBNK	588.44	53.80	1351.00	16.38	125.49	992.28
28-HBL	3.20	0.79	15.00	1.06	9.02	1.17
29-HSBC	2629.85	118.80	3652.00	59.03	186.43	2629.86
30-SA	28.07	2.44	54.00	3.84	40.92	191.25
31-WLBAG	0.93	4.37	60.00	8.99	22.23	120.31

Note: *Data on TOTLOA, NONINCO, PHYCA, NONDEP, and TOTDEP measures are presented in USD Million.

31 LP models, one for each bank, were solved for DEA analysis. The resulting efficiency scores of banks for the year 2004 are given in Table 2.

Table 2

Efficiency scores and peers for the year 2004

Banks No.	CRS efficiency	VRS efficiency	Scale efficiency	Returns to scale	Peers as per CRS efficiency
1	1.000	1.000	1.000	-	-
2	0.476	0.583	0.816	DRS	29, 21
3	1.000	1.000	1.000	-	-
4	1.000	1.000	1.000	-	-
5	1.000	1.000	1.000	-	-
6	0.666	0.670	0.993	DRS	29, 5, 25
7	0.635	0.839	0.758	DRS	21, 5, 25, 29
8	0.951	1.000	0.951	DRS	21, 5, 25, 29
9	0.952	1.000	0.952	DRS	5, 29, 25, 4
10	0.757	0.759	0.997	IRS	5, 21, 25, 29
11	0.831	0.832	0.998	DRS	29, 25
12	1.000	1.000	1.000	-	-
13	0.594	0.595	0.999	-	28, 21, 29
14	0.752	0.855	0.879	DRS	29, 25
15	0.196	0.256	0.764	IRS	3, 29, 25, 18, 4
16	0.767	1.000	0.767	DRS	21, 5, 25, 29
17	0.721	0.750	0.962	DRS	5, 29, 25
18	1.000	1.000	1.000	-	-
19	0.771	1.000	0.771	DRS	25, 21, 29, 18
20	0.841	1.000	0.841	DRS	21, 29, 18, 25
21	1.000	1.000	1.000	-	-
22	0.421	0.511	0.824	IRS	25, 5, 21
23	0.565	0.856	0.660	DRS	25, 29, 28
24	0.454	0.749	0.606	IRS	29, 25
25	1.000	1.000	1.000	-	-
26	0.472	0.559	0.844	IRS	29, 25
27	1.000	1.000	1.000	-	-
28	1.000	1.000	1.000	-	-
29	1.000	1.000	1.000	-	-
30	0.538	0.675	0.798	IRS	5, 21, 25, 4
31	0.572	0.814	0.703	IRS	29, 21
mean	0.772	0.848	0.900		

Calculations under DEA indicate that almost half of the commercial banks under the input-oriented VRS hypothesis operated at a high level of pure technical efficiency in 2004. More explicitly, 11 (35.5%) of the 31 banks are considered efficient under CRS while 16 (51.6%) of them efficient under VRS assumption. About 15 (49%) of the banks have CRS scores within the range of 0.50, 0.96, and only 5 (16%) of them have the CRS scores below 0.5. The mean efficiency level is slightly higher in the state owned banks than those in the privately owned and foreign banks (82.5% vs 79.0% and 72.9%, respectively). However, many of the banks were technically inefficient. For example bank 15 is rated as the least efficient of the banks considered in the analysis under both the CRS and VRS assumptions.

All technically efficient constant return-to-scale (CRS) banks are also technically efficient at variable return-to-scale (VRS), signifying the dominant source of efficiency is scale (Ramanathan, 2005). When the t-test is applied to the CRS-inefficient companies, the results of the test show that the mean of the paired differences between CRS and VRS scores are significantly greater than zero (t: 5.32, $p<0.01$). A scale efficiency is defined by the ratio of a CRS score to a VRS score. If the ratio is equal to one, then a bank is scale efficient; otherwise if the ratio is less than one, the bank is scale inefficient. This t-test indicates that the scale efficiency ratios are significantly less than one, i.e., serious scale inefficiencies were present for the commercial banks in Turkey. For example, the scale efficiency of bank 2 is 0.816, indicating that the bank is not considered efficient under the CRS assumption because it is not operating at the most productive scale size.

Another important issue of bank efficiency is to evaluate whether banks experience IRS, CRS, or DRS. From Table 2, it can be seen that 12 banks (38.7%) operate in DRS, only 7 banks (22.5%) operate in IRS, and 12 banks (38.7%) operate in CRS. The results reveal that although a majority of these banks try to improve their efficiency capability continually, their efficiencies are still unsatisfactory. For example, bank 2 (ZIBNK), which is not efficient, is operating under DRS. Hence, it may be concluded that a main reason for the inefficiency of this bank comes from its scale size. It is operating under DRS leading to the fact that any increase in inputs to this bank results in less than proportionate increase in its outputs. Table 2 also presents information about peer(s) (reference sets) for banks calculated inefficient in the analysis under the input-oriented CRS assumption. Although DEA identifies the inefficient banks in the country, it does not reveal the cause of the inefficiency. For example, bank 2 is considered inefficient and banks 29 and 21 are its peers, meaning that bank 2 can try to make an effort to emulate banks 29 and 21 (or a combination of them) in order to register the values of inputs and outputs to enable it to be considered best in the DEA study (Ramanathan, 2005: 47).

The input-oriented CRS DEA model is also employed to determine the best performing banks. However, as seen from Table 2, majority of the banks need to improve their efficiencies. For this reason sensivity analyses of the inefficient banks are to be employed to take corrective actions.

4. Sensitivity Analysis

Results on the sensitivity analysis for inefficient banks are given in Table 4. In DEA analysis, if the DMU's all input and output slacks are equal to zero, then DMU is defined to be CRS efficient, otherwise; some input and/or output slacks differ from zero, then DMU is defined to be CRS inefficient and could improve its efficiency by either reducing its input levels or increasing its output levels (Zhu, 2000). For example, in Table 3, the CRS efficiency score of bank 2 is 0.476, and in Table 4, its output slack (TOTLOA), is 546.404. This means that, if all the two outputs of this bank are increased by a factor of 2.100 (i.e. reciprocal of the CRS efficiency), and if the output in terms of TOTLOA is further increased by 546.404, then bank 2 will have a DEA efficiency score of 1. Alternatively, all the four inputs of this bank should be decreased by a factor of 2.100 and the output in terms of TOTLOA should be further increased by 546.404 to enable bank 2 get a DEA efficiency score of 1. Input slacks can also be interpreted similarly. For example, if all the two outputs of this bank are increased by a factor of 2.100, and if the input in terms of PHYCA and TOTDEP are further decreased by 134.157 and 3015.507 respectively, then bank 2 will have a DEA efficiency score of 1 (Ramanathan, 2005).

Table 3

Slack results for inefficient banks for the year 2004

	Outputs		Inputs			
Banks No.	TOTLOA	NONINCO	NUOFEMP	PHYCA	NONDEP	TOTDEP
2	546.404			134.157		3015.507
6		14.676				75.577
7			176.328			
8			208.547			
9						1774.456
10			21.616			
11		9.119		56.436		393.133
13			77.541	6.650		
14		3.602	66.108	22.874		
16			271.258			
17		28.374				49.315
19				145.982		
20				935.710		
22					8.490	0.204
23			21.243	4.263		
24		0.041		0.128		0.382
26		1.522	12.038	5.866		
30						68.248
31	18.910			1.954		36.205

In general, any DEA study considers performance analysis at a given point of time. However, in order to generalize the conclusions of DEA analysis a larger panel data set would be necessary. In this section, the change in the efficiencies of banks in Turkey during the period of 2003-2004 using the Malmquist Productive Index (MPI) approach is presented. The application of MPI approach to panel data allows to calculate total factor productivity (TFP) change, technological change, and technical efficiency change in a time series setting (Coelli, 1996: 2).

5. Malmquist Productivity Index Approach

To avoid many difficulties of cross-sectional models, MPI procedure is generally used by the researchers in the literature (Fare *et al.*, 1994; Wheelock and Wilson, 1999). However, the basic component of Malmquist index is related to measures of technical efficiency, firstly, efficiency scores and peers for the year 2003 are calculated under DEA analysis in Table 4.

Table 4

Efficiency scores and peers for the year 2003

Banks No.	CRS efficiency	VRS efficiency	Scale efficiency	Returns to scale	Peers as per CRS efficiency
1	0.551	1.000	0.551	DRS	29
2	1.000	1.000	1.000	-	-
3	0.906	0.934	0.970	DRS	8, 5, 9, 20
4	1.000	1.000	1.000	-	-
5	1.000	1.000	1.000	-	-
6	0.781	0.797	0.980	IRS	17, 5, 9

Table 4 (continuous)

Banks No.	CRS efficiency	VRS efficiency	Scale efficiency	Returns to scale	Peers as per CRS efficiency
7	0.691	0.736	0.939	DRS	30, 29, 5, 8
8	1.000	1.000	1.000	-	-
9	1.000	1.000	1.000	-	-
10	0.959	1.000	0.959	IRS	20, 29, 4, 30
11	1.000	1.000	1.000	-	-
12	0.861	0.865	0.995	IRS	29
13	0.645	0.692	0.931	IRS	29, 27, 2
14	0.818	0.862	0.948	DRS	29, 30, 4
15	0.527	1.000	0.527	IRS	29
16	0.799	0.955	0.837	DRS	21, 29, 30, 5, 8
17	1.000	1.000	1.000	-	-
18	0.993	1.000	0.993	DRS	21, 5, 30, 20
19	0.776	1.000	0.776	DRS	8, 21, 5, 20
20	1.000	1.000	1.000	-	-
21	1.000	1.000	1.000	-	-
22	0.738	0.750	0.983	IRS	21, 31, 30
23	0.695	1.000	0.695	DRS	28, 21, 29
24	1.000	1.000	1.000	-	-
25	1.000	1.000	1.000	-	-
26	0.163	1.000	0.163	IRS	29
27	1.000	1.000	1.000	-	-
28	1.000	1.000	1.000	-	-
29	1.000	1.000	1.000	-	-
30	1.000	1.000	1.000	-	-
31	1.000	1.000	1.000	-	-
Mean	0.868	0.955	0.911		

In Table 4, it has been shown whether an improvement in efficiency scores of banks from passing through 2003 to 2004 is presented. Based on the distribution of CRS efficiency scores, it can be seen that substantial input savings could be achieved in 2003. With one exception of DMU 26, about 42% DMUs have CRS scores within the range of (0.50, 0.96), and nearly 52% DMUs have CRS-efficient scores. However, some bank's efficiency scores are different from the efficiency scores recorded for the year 2004 (Table 2). For example bank 1 is CRS efficient in the year 2004, whereas it is not efficient in the year 2003. Panel data will probably make it possible to estimate the rate and direction of technical efficiency change. For this reason, a panel data of banks for the years 2003 to 2004 are used in estimating Malmquist productivity change index (MPI) after the banking crisis emerged in Turkey in 2001. MPI is a valuable tool since it allows for the decomposition of productivity change into technical efficiency change and technology change. The product of these two components of MPI yields a frontier version of productivity change. Fare *et al.* (1994: 70) specify an output-based Malmquist index of productivity change within the framework of distance function:

$$m_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{d_0^t(x^{t+1}, y^{t+1})}{d_0^t(x^t, y^t)} \times \frac{d_0^{t+1}(x^{t+1}, y^{t+1})}{d_0^{t+1}(x^t, y^t)} \right]^{1/2}.$$

This represents the productivity of the production point (x_{t+1}, y_{t+1}) relative to the production point (x_t, y_t). Where d_0^t is a distance function measuring the efficiency of conversion of inputs x_t to outputs y_t in the period t (Ramanathan, 2005). Also, the value of *m* greater than one will indicate positive TFP growth, where as lower than one will indicate decline from period t to t+1.

MPI is the geometric mean of the two output-based Malmquist index (Fare *et al*., 1994: 68). One index uses period t technology and the other uses period t+1 technology (Coelli, 1996). Mathematically this can be written as (Fare *et al.*, 1994: 71):

$$m_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{d_0^{t+1}(x^{t+1}, y^{t+1})}{d_0^t(x^t, y^t)}\right] \times \left[\frac{d_0^t(x^{t+1}, y^{t+1})}{d_0^{t+1}(x^{t+1}, y^{t+1})} \times \frac{d_0^t(x^t, y^t)}{d_0^{t+1}(x^t, y^t)}\right]^{1/2},$$

where, the first term of the right of the equality defines technical efficiency change, whereas the second term defines technology change. Technical efficiency change, the change in how far observed production is from maximum potential production, measures the change in the CRS technical efficiency of Period t+1 over the Period t (Ramanathan, 2005). If technical efficiency change >1, then there is an increase in the technical efficiency of converting inputs to outputs. Technology change represents the average technological change over the two periods (Fare *et al*., 1994). In addition to technical efficiency and technology change index, other indices such as the MPI, VRS technical efficiency changes (pure technical efficiency) and the index of scale efficiency changes for the period from 2003 to 2004 are presented in Table 5.

Table 5

Efficiency changes for the banks over the period of 2003-2004

Banks No.	Technical efficiency change	Technology change	Malmquist productivity index	VRS technical efficiency change	Scale efficiency change
1	1.814	0.975	1.769	1.000	1.814
2	0.476	1.254	0.597	0.680	0.700
3	1.104	1.380	1.523	1.058	1.043
4	1.000	1.332	1.332	1.000	1.000
5	1.000	1.521	1.521	1.000	1.000
6	0.852	1.525	1.299	0.876	0.972
7	0.920	1.439	1.323	1.102	0.834
8	0.951	1.296	1.232	1.000	0.951
9	0.952	1.347	1.283	1.000	0.952
10	0.789	1.136	0.897	0.758	1.041
11	0.831	1.674	1.390	0.869	0.956
12	1.162	0.867	1.008	1.159	1.003
13	0.924	1.044	0.964	0.885	1.044
14	0.920	1.346	1.238	1.001	0.919
15	0.372	1.123	0.417	0.201	1.845
16	0.961	1.193	1.147	1.046	0.919
17	0.721	1.591	1.147	0.782	0.922
18	1.010	1.384	1.398	1.000	1.010
19	0.995	1.369	1.363	1.000	0.995
20	0.841	1.325	1.115	1.000	0.841
21	1.000	1.308	1.308	1.000	1.000
22	0.574	1.354	0.777	0.608	0.944
23	0.815	1.386	1.130	0.870	0.936
24	0.454	1.825	0.828	0.541	0.839
25	1.000	1.696	1.696	1.000	1.000

Tabel 5 (continuous)

Banks No.	Technical efficiency change	Technology change	Malmquist productivity index	VRS technical efficiency change	Scale efficiency change
26	2.893	1.180	3.415	0.482	6.004
27	1.000	1.033	1.033	1.000	1.000
28	1.000	1.119	1.119	1.000	1.000
29	1.000	1.194	1.194	1.000	1.000
30	0.538	1.206	0.649	0.607	0.887
31	0.572	1.283	0.734	0.737	0.777
Mean	0.879	1.296	1.139	0.842	1.044

If the value of Malmquist index or any of its components is less than 1, that denotes regress or deterioration in performance, whereas values greater than one denote improvements in the relevant performance (Fare *et al*., 1994). In Table 5, it has been shown that there is decline in MPI indices for eight banks (25.8%), whereas there is an increase for twenty-three banks (74.2%) in the year 2004 compared to 2003. Bank 26 has registered the highest value of technical efficiency change while bank 15 has registered the lowest value. Combining these two changes, Bank 26 has registered the highest MPI while Bank 15 has registered the lowest MPI. During the period of 2003-2004, the (geometric) average MPI (1.139) and average technology change (1.296) of the banks have increased, while the average technical efficiency change (0.879) decreased. Thus, it can be concluded that the operational efficiencies of these banks have increased in the year 2004 compared to the year 2003. Finally, Table 5 shows that the banks have achieved varying levels of improvements in their VRS technical efficiencies and scale efficiencies.

6. Summary and Conclusions

Developments in the Turkish economy and the banking system in 2002-2004 period took place in accordance with the targets of the banking restructuring reforms. With the aim of restructuring financial system and particularly the banking system, some important steps have been taken. Accordingly, banks with weak financial structures were left out of the banking system, and the effectiveness of banking supervision has increased, and banking rules and regulations have been harmonized considerably with the international standards. Further, banks have also shown in great importance in their efficiencies as well as financial structures (BRSA, 2004).

Majority of the studies on banking efficiency focus on the banks of developed countries in general. On the other hand, the economic and political environments surrounding financial institutions or banks differ substantially across countries (Isik and Hassan, 2002). In this paper, the comparative performance of 31 commercial banks has been assessed using Data Envelopment Analysis. For this purpose, two outputs and four inputs have been used in the analysis. According to findings, for the year 2004, 11 (35.5%) of the 31 banks have been calculated efficient under CRS while 16 (51.6%) of them efficient under VRS assumption. Also, for the year 2003, 16 (51.6%) of the 31 banks have been calculated efficient under CRS while 23 (74.2%) of them efficient under VRS assumption. Our findings also show that the state owned banks are more efficient than the privately owned and foreign banks in the commercial banking industry in Turkey. The use of input sources seems to enhance technical efficiency of public banks than the private and foreign banks. These findings are in accordance with the Zaim (1995) and Isik and Hassan's (2002) study results. Inefficiency is more prevalent among the privately owned banks (76.4%) than among the foreign (54.5%) and state owned banks (33.3 %). Therefore, majority of the privately owned and foreign banks need to improve their efficiencies.

Furthermore, sensivity analysis of the inefficient banks for the year 2004 and changes in efficiencies of the banks over the period of 2003-2004 have been analyzed using the MPI approach. Sensivity analysis explains how to adjust input and output variables of banks to eliminate inefficiencies in the commercial banking industry in Turkey. For this purpose, reducing input or increasing output is generally used to improve inefficient banks. From Table 3, it can be seen that

29 (93.5%) of the banks have total loans slacks, and 25 (80.7%) of them have non-interest income slacks, are equal to zero. This indicates that banks can acquire and sustain considerable benefits from their inputs. At the same time, the other five inputs namely, number of employees, physical capital, non-deposit funds and total deposits, hold a median position. About 50% of the banks have zero input slacks in these four aspects. This information is useful when a bank considers its future policy against other banks (Zhu, 2000).

MPI analysis is applied to a sample of 31 commercial banks over the period of 2003-2004. In MPI process, technical efficiency change, technology change, MPI change, VRS technical efficiency change and scale efficiency changes are analyzed. MPI analysis has indicated that, for all the 31 banks, there has been an increase in the efficiencies of banks over the period of 2003-2004. For this purpose, each bank is compared only to itself in previous period, not to a common benchmark. However, results for individual commercial banks vary. Looked first at the bottom of the Table 5, seen that, on average, efficiency increased slightly over the 2003-2004 period for the commercial banks in our sample. On average, that growth was due to technology change rather than improvements in technical efficiency change. Such an approach would allow a dynamic view of the multidimensional performance within the Turkish commercial banking sector (Zhu, 2000).

This empirical study, a number of limitations that may constrain the generalization of the results, can be improved by several ways. Firstly, in order for the conclusions to be generalized, and to examine productivity changes in detail, we would need to have a larger panel data set. For this purpose, more years could be included in the MPI analysis. Secondly, the inputs and outputs selected for assessing efficiencies are not impeccable. For instance, one may argue that total loans may be good candidate for inputs of banks (Mlima and Hjalmarsson, 2002). In addition, other variables such as various types of inputs and outputs may be included in efficiency analysis. Thirdly, it is worthy to note that a bank may have branches in multiple regions and, thus, may confound the empirical results. Therefore, further research efforts using consistent data with different time periods may be highly valuable to track the efficiency changes over a certain period of time and across different geographical locations. Finally, other DEA techniques may be employed to measure the relative efficiency of banks.

References

1. Al-Shammari M., 1999, 'A multi-criteria data envelopment analysis model for measuring the productive efficiency of hospitals', *International Journal of Operations & Production Management*, Vol. 19 (9), pp. 879-890.
2. Banker R.D. and R.C. Morey, 1986a, 'Efficiency analysis for exogenously fixed inputs and outputs', *Operations Research*, Vol. 34 (4), pp. 513-521.
3. Banker R.D. and R.C. Morey, 1986b, 'The Use of Categorical Variables in Data Envelopment Analysis', *Management Science*, Vol. 32 (12), pp. 1613-1627.
4. Banker R.D., A. Charnes and W.W. Cooper, 1984, 'Some Models For Estimating Technical and Scale Inefficiencies In Data Envelopment Analysis', *Management Science*, Vol. 30 (9), pp. 1078-1092.
5. Banker R.D., R.F. Conrad and R.P. Strauss, 1986c, 'A Comparative Application of Data Envelopment Analysis and Translog Methods: An Illustrative Study of Hospital Production', *Management Science*, Vol. 32 (1), pp. 30-44.
6. Barros C.P., 2004, 'Measuring performance in defense-sector companies in a small NATO member country', *Journal of Economic Studies*, Vol. 31(2), pp. 112-128.
7. Barros C.P., 2005, 'Measuring The Efficiency In The Hotel Sector', *Annals of Tourism Research*, Vol. 32 (2), pp. 456-477.
8. BAT, 2005, 'Financial Sector and Banking System in Turkey', The Banks Association of Turkey.
9. BRSA, 2004, 'Turkish Economy and Turkish Banking System', Banking Regulation and Supervision Agency, Banks in Turkey 2004.
10. Charnes A., W.W. Cooper, and E. Rhodes, 1978, 'Measuring the efficiency of decision making units', *European Journal of Operational Research*, Vol. 2 (6), pp. 429-444.

11. Coelli T., 1996, ‘A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program’, CEPA Working Paper No. 96/08, University of New England, Armidale, Australia (www.une.edu.au/econometrics/cepa.htm, accessed July 2005).
12. Elyasiani E. and S. Mehdian, 1995, ‘The comparative efficiency performance of small and large US commercial banks in the pre- and post deregulation eras’, *Applied Economics*, Vol. 27, pp. 1069-1079.
13. Emel A.B., M. Oral, A. Reisman and R. Yolalan, 2003, ‘A credit scoring approach for the commercial banking sector’, *Socio-Economic Planning Sciences*, Vol. 37, pp.103-123.
14. Fare R., S. Grosskopf, M. Norris and Z. Zhang, 1994, ‘Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries’, *The American Economic Review*, Vol. 84 (1), pp. 66-83.
15. Golany B. and S. Thore, 1997, ‘The economic and social performance of nations: efficiency and returns to scale’, *Socio-Economic Planning Sciences*, Vol. 31 (3), pp. 191-204.
16. Guan J.C., R.C.M. Yam, C.K. Mok and N. Ma, 2006, ‘A study of the relationship between competitiveness and technological innovation capability based on DEA models’, *European Journal of Operational Research*, Vol. 170 (3), pp. 971-986.
17. Isik I. and K. Hassan, 2002, ‘Technical, scale and allocative efficiencies of Turkish banking industry’, *Journal of Banking & Finance*, Vol. 26, pp.719–766.
18. Joro, T., P. Korhonen and J. Wallenius, 1998, ‘Structural comparison of DEA and multiple objective linear programming’, *Management Science,* 44 (7), pp. 962-970.
19. Kao C. and S.L. Liu, 2004, ‘Predicting bank performance with financial forecasts: A case of Taiwan commercial banks’, *Journal of Banking & Finance*, Vol. 28, pp. 2353-2368.
20. Keskin E., 2001, ‘2000 Yılında Türkiye Ekonomisi ve Türk Bankacılık Sistemi’, *Bankacılar Dergisi*, Vol. 37, pp. 1-43.
21. Luo X., 2003, ‘Evaluating the profitability and marketability efficiency of large banks: An application of data envelopment analysis’, *Journal of Business Research*, Vol. 56, pp. 627-635.
22. Miller S. and A. Noulas, 1996, ‘The technical efficiency of large bank production’, *Journal of Banking Finance*, Vol. 20 (3), pp. 495-509.
23. Mlima, A.Z. and L. Hjalmarsson, 2002, ‘Measurement of Inputs and Outputs in the Banking Industry’, *Tanzanet Journal*, Vol. 3 (1), pp. 12-22.
24. Nunamaker T.R., 1985, ‘Using Data Envelopment Analysis to Measure the Efficiency of Non-Profit Organizations: A Critical Evaluation’, *Managerial and Decision Economics*, Vol. 6 (1), pp. 50-58.
25. Oral M. and R. Yolalan, 1990, ‘An empirical study on measuring operating efficiency and profitability of bank branches’, *European Journal of Operational Research*, Vol. 46 (3), pp. 282-294.
26. Ozkan-Gunay E.N., 1996, ‘The effect of the financial liberalization program on the economies of scale and scope of Turkish Commercial Banking’, *Yapi Kredi Economic Review*, Vol. 7 (2), pp. 47-66.
27. Ozkan-Gunay E.N., 1998, ‘Economies of Scale and Scope in the Turkish Banking Industry: The Effect of the Financial Liberalization Program’*, The Journal of Economics*, Vol. XXIV (1), pp. 67-84.
28. Ramanathan R., 2005, ‘Operations assessment of hospitals in the Sultanate of Oman’, *International Journal of Operations & Production Management*, Vol. 25 (1), pp. 39-54.
29. Ramanathan R., 2006, ‘Data envelopment analysis for weight derivation and aggregation in the analytic hierarchy process’, *Computers & Operations Research,* Vol. 33, pp. 1289-1307.
30. Seiford L. and J. Zhu, 1999, ‘Profitability and marketability of the top 55 U.S. commercial banks’, *Management Science*, Vol. 45 (9), pp. 1270-1288.
31. Tomkins C., and R. Green, 1988, ‘An experiment in the use of data envelopment analysis for evaluating the efficiency of UK University Departments of Accounting’, *Financial Accountability and Management*, Vol. 4 (2), pp. 147-164.

32. Wheelock D. and P.W. Wilson, 1999, 'Technical progress, inefficiency, and productivity change in US banking, 1984-1993', *Journal of Money, Credit and Banking*, Vol. 31 (2), pp. 212-234.
33. Wong Y.H.B. and J.E. Beasley, 1990, 'Restricting weight flexibility in data envelopment analyses, *Journal of the Operational Research Society*, Vol. 41 (9), pp. 829-835.
34. Yeh Q.J., 1996, 'The Application of Data Envelopment Analysis in Conjunction with Financial Ratios for Bank Performance Evaluation', *The Journal of the Operational Research Society*, Vol. 47 (8) pp. 980-988.
35. Yildirim C., 1999, 'Evaluation of the performance of Turkish commercial Banks: A non-parametric approach in conjunction with financial ratio analyses", International Conferences in Economics III, ERC/METU.
36. Zaim O., 1995, 'The effect of financial liberalization on the efficiency of Turkish commercial banks', *Applied Financial Economics*, Vol. 5, pp. 257-264.
37. Zhu J., 2000, 'Theory and Methodology: Multi-factor performance measure model with an application to Fortune 500 companies', *European Journal of Operational Research*, Vol. 123, pp. 105-124.