The Effect of Scale on Productivity of Turkish Banks in the Post-Crises Period: An Application of Data Envelopment Analysis

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The Effect of Scale on Productivity of Turkish Banks in the Post-Crises Period: An Application of Data Envelopment Analysis

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Abstract

The purpose of this paper is to investigate the productivity of Turkish Banks according to the effect of scale in the Post-Crises Period. The data used in this study covers the period from 2002:1 to 2004:3. We applied Data Envelopment Analysis (DEA), which is a non-parametric linear programming-based technique for measuring relative performance of decision-making units (DMUs). We calculated DEA as constant & variable return-to-scale based on output oriented Malmquist Index. Although the scale effect can be measured with DEA scale efficiency measurement, we used scale indicators as input variables in order to find out not only scale efficiency but also scale affect directly. We applied DEA by using financial ratios (Athanassopoulos and Ballantine, 1995; Yeh, 1996) and branch & personel number indicators. This study uses five input variables as i) branch numbers, ii) personnel number per branch, iii) share in total assets, iv) share in total loans, v) share in total deposits; and five output variables as i) net profit-losses/total assets (ROA), ii) net profit-losses/total shareholders' equity (ROE), iii) net interest income/total assets, iv) net interest income/ total operating income, and v) non-interest income/total assets. We find that difference in efficiency is mainly from technical efficiency rather than scale efficiency in the post-crises period. The other finding reveals that efficiency approximate between selected banks and supporting that advantage of scale economies can be lost in Turkish banking. Overall, the results confirm that Turkish banking has "U shaped Scale Efficiency" on selected profitability ratios. The application of this paper based on other financial ratios with decreasing and increasing return-to-scale DEA is left to future research.

Key Words: *Turkish Banks, Return to Scale, Scale Efficiency, Profit Efficiency, Data Envelopment Analysis*

JEL Codes: *C23, G2, G21, D2*

I. Introduction

After the 1990s Turkish banks widened their balance sheets and branch sizes following an increase in the budget deficit of the Turkish government. Most of the small-scale banks passed to medium-scale in this period until 2000-2001 banking crises. And most of these banks were subject to regulatory control by the government in the crisis. Uncontrolled scale growth was one of the most important reasons behind this crisis. The purpose of this paper to determine the effect of scale efficiency on the productivity of Turkish banks in the post crisis and investigate the relationship between scale effect and profitability.

The layout of this paper is as follows. Section II briefly reviews the literature survey on DEA and introduces constant&variable return-to-scale models and Malmquist Index. Section III expresses the models and results of other DEA applications in Turkish banking. Section IV describes the data and methodology used in this paper. Section V presents the empirical findings. Finally, section V concludes with a brief discussion of the empirical findings.

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II. Literature Overview

DEA in its present form was introduced by Charles, Cooper, and Rhodes (1978) as a "mathematical programming model applied to observational that provides a new way of obtaining empirical estimates of relations-such as the production functions and/or efficient production possibility surfaces-that are cornerstones of modern economics." DEA methodology is concerned with frontiers rather than central tendency like linear models. Therefore different decision making units (DMUs) can be compared based on productivity and efficiency. The efficiency score in the presence of multiple input and output factors is defined as:

$$Efficiency = \frac{\sum_{k=1}^{n} outputs_k}{\sum_{j=1}^{m} inputs_j} \tag{1}$$

Assuming there are *n* DMUs, each with *n* inputs and *s* outputs, the relative efficiency score of a test DMU *p* is obtained by solving the following model (Charnes et all, 1978):

$$\text{Max} \quad \frac{\sum_{k=1}^{n} v_k y_{kp}}{\sum_{j=1}^{m} u_j x_{jp}}; \qquad \text{s.t} \quad \frac{\sum_{k=1}^{n} v_k y_{kp}}{\sum_{j=1}^{m} u_j x_{jp}} \le 1 \ldots\ldots\ldots \forall i \qquad v_k u_j \ge 0 \ldots\ldots \forall k, j \tag{2}$$

Where k=1 to s; j=1 to m; i=1 to n; y_{ki}=amount of output k produced by DMU$_i$; x_{ij}=amount of input j utilized by DMU$_i$; v_k=weight given to output k; u_j=weight given to input j.

Charles et all. (1978) Proposed constant returns to scale (CRS) DEA models. Table 1 presents the CCR (Charles, Cooper, Rhodes, 1978) models (Cooper et all. 2004).

Table 1: CCR DEA Model

Input-oriented	
Envelopment Model	**Multiple Model**
$\min \theta - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{y} s_r^+)$	$\max z = \sum_{r=1}^{s} \mu_r y_{r0}$
subject to	subject to
$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0}$ i=1,2,…,m;	$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0$
$\sum_{r=1}^{m} y_{rj}\lambda_j + s_i^+ = \theta y_{i0}$ r=1,2,…,s;	$\sum_{i=1}^{m} v_i x_{i0} = 1$
$\lambda_j \ge 0$ j=1,2,…,n.	$\mu_r, v_i \ge \varepsilon > 0$
Output-oriented	
Envelopment Model	**Multiple Model**
$\max \theta + \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+)$	$\min q = \sum_{i=1}^{m} v_i x_{r0}$
subject to	subject to
$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{i0}$ i=1,2,…,m;	$\sum_{r=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \ge 0$

$$\sum_{j=1}^{n} y_{rj}\lambda_j + s_i^+ = \phi y_{r0} \quad r=1,2,\ldots,s; \qquad \sum_{i=1}^{m} \mu_r y_{ro} = 1$$

$$\lambda_j \geq 0 \qquad j=1,2,\ldots,n. \qquad \mu_r, v_i \geq \varepsilon > 0$$

If the constraint $\sum_{j\_1}^{n} \lambda_j = 1$ is adjoined, they are known as BCC (Banker, Charnes and Cooper, 1984) or variable return-to-scale DEA models. The BCC model of DEA in "envelopment form" as follows (Banker et all, 2004),

$$\text{Min } \theta_0 - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_i^-\right)$$

Subject to

$$\theta_0 x_{i0} = \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- \quad \text{i=1,2,3,….,m;}$$

$$y_{r0} = \sum_{r=1}^{m} y_{rj}\lambda_j + s_i^+ \quad \text{r=1,2,3,…,s;} \qquad (3)$$

$$1 = \sum_{j=1}^{n} \lambda_j \quad ; \quad 0 \leq \lambda_j, s_i^-, s_i^+ \quad \forall i, r, j.$$

The malmqusit productivity index was first introduced by Malmquist (1953) and developed by Caves, Christensen, Diewert (1982), Fare, Grosskopf, Lingren, Pross (1989) and Fare, Grosskopf and Norris, Zhang (1994). While one has panel data, DEA-like linear programs and a (input-or output based) Malmquist Total Factor Productivity (TFP) index can be used to measure productivity change, and to decompose this productivity change into technical change and technical efficiency change (Coelli, 1996:26). Fare et all (1994) specifies an output-based Malmquist productivity change index can be represented as,

$$m_0(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^t(x_t, y_t)} \times \frac{d_0^{t+1}(x_{t+1}, y_{t+1})}{d_0^{t+1}(x_t, y_t)}\right]^{1/2} \qquad (4)$$

This equation represents the productivity point (x_{t+1}, y_{t+1}) relative to the production point (x_t, y_t).

III. DEA Applications in Turkish Banking

A number of studies have applied DEA in Turkish Banking. Oral and Yolalan (1990) measure operating efficiency and profitability of bank branches. The results show service-efficient bank branches are the most profitable ones and this evidence suggests that there exists significant effect of service-efficiency and profitability for Turkish bank branches. Zaim (1995) measures the effects of liberalization policies on the efficiency of Turkish commercial banks in the post-1980s. In the study, the years of 1981 and 1990 are selected as pre and post liberalization area respectively. This study uses four inputs as i) total number of employees, ii) total interest expenditure, iii) depreciation expenditure, iv) expenditure on materials, and four outputs as i) total balance of demand deposits ii) total balance of time deposits iii) total balance of short-term loans, and iv) total balance of long-term loans. The results indicate that financial liberalization has a positive effect on both technical and allocative efficiencies, and state owner banks appear more efficient than private banks.

Yolalan (1996) uses financial ratios to analyze the efficiency of Turkish commercial banks over the period 1988-1995. This study uses two inputs as i) non-performing loans/total assets, ii) non-interest expenditure/total assets and three outputs as i) (shareholders' equity+net income)/total assets ii) net fees and commission/total assets, and iii) liquid assets/total assets. The results show that foreign-owner banks are the most efficient group, followed by the private banks, and that state-owned banks are the least efficient. Yolalan also states that the olipolistic environment of banking sector and interest rate spread prevented a careful analysis of bank performance.

Jackson, Fethi, and Inal (1998) evaluate efficiency and productivity growth in Turkish commercial banking using DEA based Malmquist index between 1992 and 1996 period. They use two inputs as i) the number of employees, and ii) total non-labor operating expenses and three outputs as I) total loans, ii) total demand deposits, and iii) total time deposits. The results show that except for the financial crises period of 1993-1994, foreign and private banks are more efficient.

Jackson and Fethi (2000) used DEA and tobit analysis to determine Turkish Banks technical efficiency for the year of 1998 and they found evidence that larger and profitable banks are more likely to operate at higher levels of technical efficiency and the capital adequacy ratio has a statistically significant adverse impact on the performance of Turkish banks.

Denizer, Dinc, and Tarimcilar (2000) examine the banking efficiency pre and post-liberalization environment and investigate the scale effects on efficiency by ownership between the 1970 and 1994 period. This study utilizes the production and intermediation approaches and assumes that the banking operations in Turkey occur in a two-stage framework. They use three inputs for the production stage as i) total own resources of the bank, ii) total personnel expenses and iii) the interest and frees paid by the bank. At this stage a DMU produces two outputs i) total deposits, and ii) income from charges and commission collected. Next, the intermediation process comes into play and uses the previous stage's outputs as inputs. The other input is non-labor operating expenditure. The outputs at this stage are i) total loans and ii) banking related income (interest and commission collected, and charges and commission for banking). The study finds that liberalization programs were followed by an observable decline in efficiency. Another finding of the study is that Turkish banking system had a serious scale problem due to macroeconomic instability.

Cingi and Tarim (2000) examine the efficiency and productivity change in Turkish commercial banking using the DEA-Malmquist Total Factor Productivity Index for the period of 1986-1996. They use two inputs as I) total assets and ii) total expenses and four outputs as i) total income, ii) total loans, iii) total deposits, and iv) total non-performing loans/total loans. They find evidence that the four state banks are not efficient where three private banks are highly efficient. The other finding is that difference in efficiency is mainly due to scale economics.

Yildirim (2002) analyses the efficiency performance of Turkish banking between 1988 and 1999, a period characterized by increasing macroeconomic instability. The empirical results suggest that over the sample period both pure technical and scale efficiency measures show a great variation and the sector did not achieve sustained efficiency gains and the trend in the performance levels over the period suggests that macroeconomic conditions had a profound influence on the efficiency measures. The study also examines that the sector suffers mainly from scale inefficiency and scale inefficiency, in turn, is due to decreasing return to scale.

Isik and Hassan (2002) investigate input and output efficiency in Turkish banking with a non-parametric approach along with a parametric approach. They estimate the efficiency of Turkish banks over the 1988-1006 period. Their results suggest that the heterogeneous characteristics of banks have significant impact on efficiency. The study also indicates that the dominant source of inefficiency in Turkish banking due to technical inefficiency rather than allocative inefficiency, which is mainly attributed to diseconomies on scale.

Isik and Hassan (2003) examine productivity growth, efficiency change, and technical progress in Turkish commercial banks with the DEA-Malmquist Total Productivity Change Index. The study finds that all forms of Turkish banks have recorded significant productivity gains driven mostly by efficiency increases rather than technical progress. On the other hand, efficiency increases are mostly owing to improved resource management practices rather than improved scales.

Mercan, Reisman, Yolalan, and Emel (2003) present a financial performance index which allows to observe the effects of scale and the mode of ownership on bank behavior. They apply the DEA to select fundamental financial ratios for the period of 1989-1999. The results show that the banks that were taken over by a regulatory government agency most recently in the analyzed period are observed to perform poorly with respect to their DEA performance index values.

IV. Data and Methodology

Our data set is compiled from the quarterly publications of the Banks Association of Turkey between 2002:4 and 2004:3 period where financial ratios and branches/personnel numbers are provided for each bank. According to the availability of data, we included three state banks and 15 private banks with three scale groups (Table 1).

Table 1: Selected Banks

No. of Branches	Government Banks (DMU_G)	No. of Branches	Private Banks-Big Scale (DMU_B)	No. of Branches	Private Banks-Medium Scale (DMU_M)	No. of Branches	Private Banks-Small Scale (DMU_S)
1146	Ziraat Bank	641	Akbank	199	Denizbank	88	TEB
707	Halk Bank	852	İsBank	197	Sekerbank	50	Anadolu Bank
296	VakiflBank	407	Yapi Kredi	171	DisBank	38	TekstilBank
		349	Garanti Bank	170	Finansbank	31	Tekfenbank
		293	Oyakbank	159	HSBC		
				159	Kocbank		

Although there have been considerable DEA applications in banking using physical units and monetary terms, few studies have been published using financial ratios (Fethi, Jackson, and Weyman-Jones, 2001). Athanassopoulos and Ballantine (1995) and Yeh (1996) are the first applications of DEA using financial ratios. As mentioned above Yildirim (1996) and Mercan et all. (2003) constitute other example where financial ratios in the Turkish banking industry were used.

In our study we use five inputs as i) branch numbers, ii) personnel numbers per branch, iii) share in total assets, iv) Share in total loans, and v) Share in total deposits. So we select scale indicators to measure directly the scale efficiency. We use five outputs as i) net profit-losses/total assets (ROA), ii) net profit-losses/total shareholders' equity (ROE), iii) net interest income/total assets, iv) net interest income/ total operating income, and v) non-interest income/total assets.

V. Empirical Results

Table 2 shows a summary of statistics pertaining to selected inputs and outputs. An important feature of the data is that there are enormous variations in standard deviations among banks in the sample.

Table 2: Summary of Statistics

	Variable	*Mean*	*Std.dev.*
Inputs			
Input 1	Branch numbers	311,52	286,71
Input 2	Personnel numbers per branch	20,66	3,92
Input 3	Share in total assets	5,01	5,00
Input 4	Share in total loans	4,81	4,11

Table 2 Continued

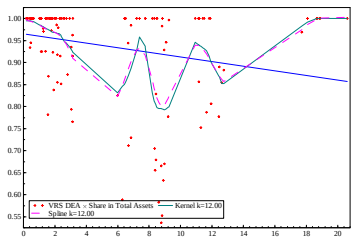
Input 5	Share in total deposits	5,27	5,46
Outputs			
Output 1	Net profit-losses/total assets (ROA)	1,07	1,12
Output 2	Net profit-losses/total shareholders' equity (ROE)	9,18	10,44
Output 3	Net interest income/total assets	3,22	2,30
Output 4	Net interest income/ total operating income	55,07	27,27
Output 5	Non-interest income/total assets	2,51	1,84

Table 3 shows CRS and VRS DEA scores from the Malmquist Index. Importantly, VRS DEA is higher than CRS DEA in selected sample due to large standard deviations in variables, such as branch numbers, and profitability ratios etc. Although scores change over time, small and big scale DMUs has higher scores than others in the sample. This shows that the Turkish Banking sector displays "U shaped Scale Efficiency" and this result will be discussed further in this study.

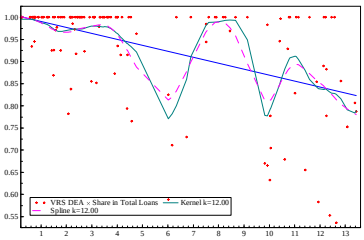
Table 3: CRS and VRS DEA Frontiers

	2002:4		***2003:1***		***2003:2***		***2003:4***		***2003:4***		***2004:1***		***2004:2***		***2004:3***	
	CRS	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**
dmu 1	0.927	0.969	0.860	1.000	1.000	1.000	0.994	1.000	0.939	1.000	0.935	1.000	1.000	1.000	1.000	1.000
dmu 2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.968	1.000	1.000	1.000	1.000	1.000
dmu 3	0.777	0.825	0.436	0.588	0.482	0.711	0.760	1.000	0.488	0.730	0.698	1.000	0.667	0.944	0.724	0.985
dmu 4	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
dmu 5	0.756	0.856	0.660	0.753	0.723	0.787	0.774	0.807	0.736	0.777	0.752	0.854	0.760	0.890	0.739	0.883
dmu 6	1.000	1.000	0.446	0.536	0.389	0.553	0.350	0.583	0.378	0.655	0.550	0.829	0.419	0.679	0.431	0.705
dmu 7	0.585	0.777	0.770	0.997	0.438	0.632	0.437	0.665	0.408	0.670	0.670	0.983	0.651	0.946	0.634	0.929
dmu 8	0.987	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
dmu 9	0.845	0.869	0.913	0.926	1.000	1.000	0.780	0.782	0.793	0.838	1.000	1.000	0.819	0.918	0.827	0.986
dmu 10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
dmu 11	1.000	1.000	1.000	1.000	0.943	0.973	0.891	0.923	1.000	1.000	0.730	0.855	0.816	0.979	0.665	0.852
dmu 12	1.000	1.000	1.000	1.000	0.955	1.000	0.823	1.000	0.927	1.000	0.752	0.915	0.737	1.000	0.842	1.000
dmu 13	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
dmu 14	0.720	0.915	0.769	0.963	0.637	0.765	0.669	0.794	0.782	0.935	0.688	0.873	0.849	1.000	0.833	1.000
dmu 15	0.798	0.925	1.000	1.000	0.953	1.000	0.858	1.000	0.885	1.000	0.787	0.925	0.856	0.971	0.827	0.977
dmu 16	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
dmu 17	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.803	0.945	1.000	1.000	0.890	0.934	1.000	1.000
dmu 18	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
mean	0.911	0.952	0.881	0.931	0.862	0.912	0.852	0.920	0.841	0.919	0.863	0.957	0.859	0.959	0.862	0.962

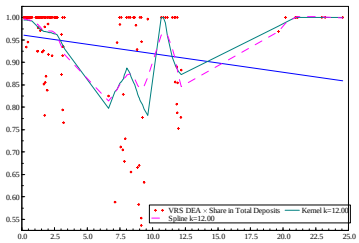
Figure 1(a), (b), (c), (d), and (e) shows VRS DEA scores versus input variables. Lines formed with kernel smoothing and cubic spline smoothing in order to determine variable effect of scale indicators on efficiency. Figure 1(b) shows that the increase in total loans (share of loans in the market) decreases the efficiency for selected DMUs. This evidence suggests that increase in loans reduce the efficiency or there is decreasing-return-to scale for this variable in the sample. Figure 1(a), (c), (d), and (e) shows that share in total assets, share in total deposits, branch numbers, and personnel numbers per branch affect efficiency with a "U Shape" character. In other words, efficiency is intensified small scale and big scale. Figure (f) also verifies this evidence with original input and output variables as an increase in branch numbers reduces ROA and ROE until a certain point and increases ROA and ROE after this point, or branch number.



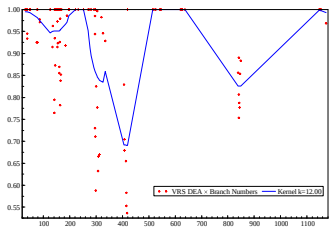
VRS DEA-Share in Total Assets
Figure (a)



VRS DEA-Share in Total Loans
Figure (b)

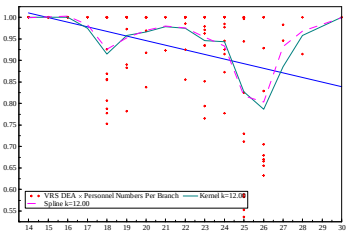


VRS DEA-Share in Total Deposits
Figure (c)

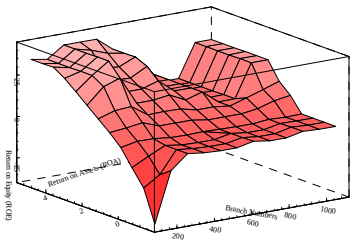


VRS DEA-Branch Numbers

Figure (d)



VRS DEA-Personnel Numbers Per Branch
Figure (e)



Branch Numbers versus ROA and ROE
Figure (f)

Figure 1: DEA Scores and Output Variables

Figure 2 summarized the result of the analysis above. The reason that efficiency intensified to small and big scale can be "Risk Adjusted Efficiency" and "Operating Income Efficiency". As a result of the regulatory framework, small-scale banks prefer to invest less risky assets, and their efficiency is higher than large-scale and medium-scale banks. This can be called as "Risk Adjusted Efficiency". On the other hand, since large-scale banks have the advantage of control and manage operating income and expenses more efficiently, their efficiency is higher than large-scale and medium-scale banks.

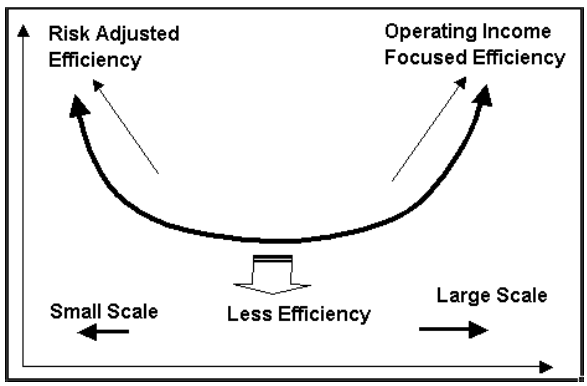


Figure 2: Scale and Efficiency

Figure 3 shows the Malmquist Index summary of quarterly means. Pure technical change and scale efficiency are near constant where technical and efficiency change vary over selected period.

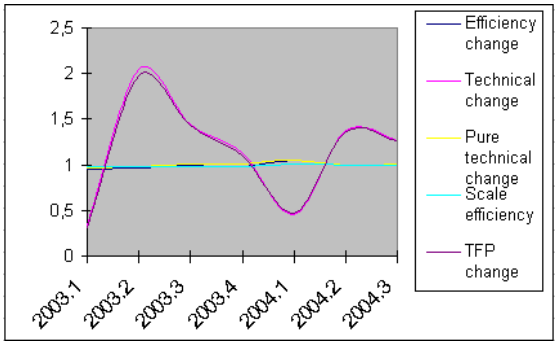


Figure 3: Malmquist Index Summary of Quarterly Means

Figure 4 shows the Malmquist index summary of bank means for the period of 2002:1 to 2004:3. The first evidence is that small-scale banks are less efficient, where middle-scale banks' efficiency varies depend on DMUs, and government banks have average efficiency.

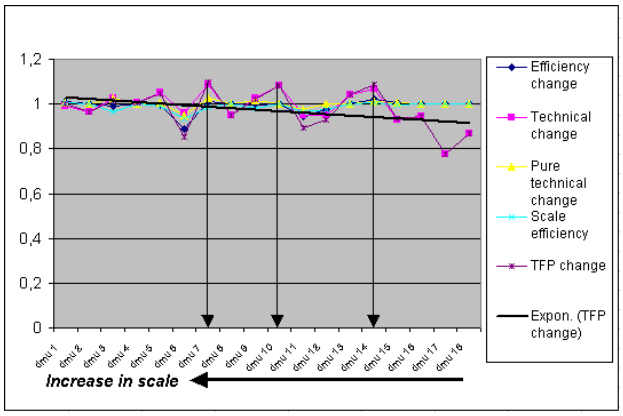


Figure 4: Malmqist Index Summary of Bank Means

Table 4 reveals Malmquist index summary of four groups of banks' means for selected time period. Government (DMU_G) banks' and small-scale (DMU_S) banks' efficiency change tend to be higher than big-scale (DMU_B) and middle-scale (DMU_M) banks' means. In contrast, DMU_B and DMU_M's technical change are higher than DMU_G and DMU_S's scores. As shown in Figure 4 although DMU_M's scale efficiency is lower than the other groups' scale efficiency, the total factor productivity of DMU_M is the highest one among the others. This evidence suggests that difference in efficiency is mainly due to technical efficiency rather than scale efficiency.

The other finding is that scale efficiency is too close in each group and this also supports the opinion that scale efficiency is not mandatory in determining productivity.

Table 4: Malmquist Index Summary of Group Means*

Group	*Efficiency Change*	*Technical Change*	*Pure technical change*	*Scale efficiency*	*Total factor productivity change*
DMU_G	1,0003	0,9943	1,0103	0,9903	0,9943
DMU_B	0,9796	1,0108	0,9964	0,9824	0,9914
DMU_M	0,9895	1,0201	1,0013	0,9880	1,0105
DMU_S	1,0012	0,8795	1,0020	0,9992	0,8805
Mean	0,9910	0,9790	1,0010	0,9890	0,9700

** All Malmquist index averages are geometric means.*

Figure 5 shows the total factor productivity change for DMUs. The efficiency scores approximate between selected banks shows that advantage of scale economies can be lost in Turkish banking or would be less important than in the present.

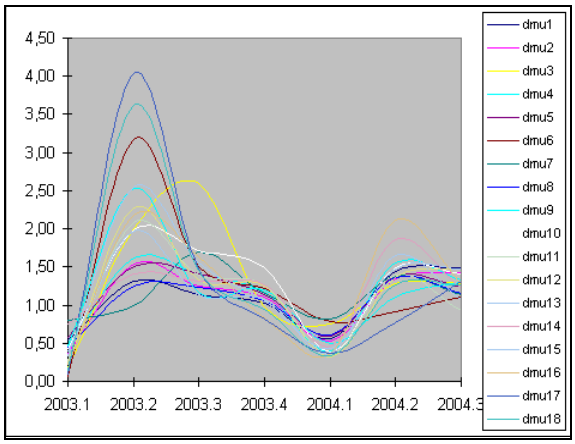


Figure 5: Total Factor Productivity Change

V. Conclusion

The objective of this paper is to investigate the productivity of Turkish Banks according to the effect of scale in the Post-Crises Period. Our study uses constant & variable return-to-scale DEA based on the output oriented Malmquist Index for three state banks and 15 private banks with three scale groups. We applied DEA by using financial ratios and branch & personnel number indicators. We find that difference in efficiency is mainly from technical efficiency rather than scale efficiency in the post-crises period. Overall, the results confirm that Turkish banking system has "U shaped Scale Efficiency" on selected profitability ratios. The application of this paper based on other financial ratios with decreasing and increasing return-to-scale DEA is left to future research.

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