The Application of Data Envelopment Analysis Based Malmquist Total Factor Productivity Index: Empirical Evidence in Turkish Banking Sector

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Abstract

In this study, the objective is to measure the total factor productivity and the changes in the components of the total factor productivity of the banks between 2004-2009 period. By the virtue of these measurements, we will be able to determine the production efficiency of the banks. Thereby; taking the total factor productivity as the starting point, both within the specified 3 groups and among the all deposit banks' performances comparisons are carried out.

In performance measurement, technical efficiency values, change in technical efficiency, technologic change, change in pure technical efficiency, change in scale efficiency and change in total factor productivity indexes are calculated. While calculating these indexes, Malmquist total factor productivity index method is used. Indexes provide us with the opportunity of performance comparison. Thus, it is aimed to assess which group and bank has comparatively the highest performance among banks and groups.

Detecting the performance change ratio in previous periods or forecasting the potential performance ratio in the following periods is of prime importance for the enduringly changing and developing banks. On that account, Malmquist total factor

productivity index apprises us of the changes in the total factor productivity over the years. In this study; which group is working efficiently or not is also revealed by the group analysis. Malmquist total factor productivity index requires the use of panel data and depicts efficiency changes by years; which is a crucial information for us.

Key words : Data Envelopment Analysis, Malmquist Total Factor Productivity Index, Banks.

1. Introduction

At the present day, banks are obliged to use their resources in the most efficient and fruitful way to operate long lastingly and cope with protean competition conditions.

The more accurate efficiency level measurements renders in the more effective applicability of anticipatory planning activities. Through lack of standardized, secure and valid measurement techniques, substantiation of performance measurements become troublesome, however.

One of the important criteria for performance measurement of banks is the changes in the total factor productivity. When it comes to productivity, the total factor productivity consisting of all the factors partaking in production process should be borne in mind. When partial productivity measures; labor and soil productivity are considered separately, it might lead to misinformation over the total factor productivity. Hence, taking the total factor productivity into consideration and trying to measure the change in it yields much more consistent results. Because the change in the total factor productivity is subdivided into two as change in technical efficiency and technologic change. Improvements in these areas constitute the basis of reaching high economical performance levels and thereby it forms the basis of having very high level of competitiveness, too. The change in efficiency, thereof, is

regarded as the indicator of national economy's internalization of global technology by adaptation and transferring it into the total factor productivity (Deliktas, 2002: 248).

2. Literature Review

The application of data envelopment analysis based on Malmquist total factor productivity index is widely used in the comparison of countries and business' productivity, agriculture, health and banking field. This method is used in Fare (et. al 1994) , Zachariadis (2004) for the comparison of OECD countries' productivity , Mahmood and Afza (2008) for the comparison of East Asia countries' productivity, Kesbic (et. al. 2004) in industry enterprises, Keskin Benli (2006) for the efficiency measurement of industrial enterprises in Istanbul Stock Exchange. Coelli (1996 b) in the field of Australia agriculture, Avci and Kaya (2008) in Turkish agriculture, Fare (et. al. 1989) in the productivity change of Sweden hospitals, and Fare (et. al. 1992) in Sweden pharmacies' productivity used the total factor productivity index.

Berg et. al. (1992) used the Malmquist total factor productivity index in the deregulation of Norwegian Banking. Sathye (2002) Measuring *Productivity Changes in Australian Banking*, Oncu and Aktas (2007) used the same index in their analyses.

3. Data

The 31 deposit bank; member of the Banks Association of Turkey; consist of the research area. Banks are dived into three. In the distribution of banks, the classification of the Banks Association of Turkey is remained[1.] . The table below shows the bank distribution. The 31 banks' data covering the 6 term between 2004-2009 used in the analysis are gathered from the Banks Association of Turkey's official website.

Table 1 marks the deposit banks that are included in the analysis and their distribution in terms of the groups.

Table 1 Banks and distributional groups

Publicly owned deposit banks	1.Ziraat Bank 2.Halk Bank 3.Vakiflar Bank		
Private owned deposit banks	4.Adabank 5.Akbank 6.Alternatif Bank 7.Anadolubank	8.Sekerbank 9.Tekstil Bank 10.Turkish Bank 11.Turk Ekonomi Bank	12.Garanti Bank 13.Is Bank 14.Yapi and Kredi Bank
Foreign owned deposit banks	15.Arap Turk Bank 16.Citibank 17.Denizbank 18.Deutsche Bank 19.Eurobank Tekfen 20.Finans Bank	21.Fortis Bank 22.HSBC Bank 23.ING Bank 24.Millennium Bank 25.Turkland Bank	26.Bank Mellat 27.Habib Bank Limited 28.JPMorgan Chase Bank N.A. 29.Société Générale (SA) 30.The Royal Bank of Scotland N.V. 31.WestLB AG

Intermediation approach; which is considered as better reflecting the production process of the banks, is adopted. It is assumed that an enormous part of banks' operations are formed by the conversion of the funds that are borrowed from financial and other deposit corporations into credits and other security investments (Oncu and Aktas; 2007:257). By this way, i) deposit and ii) interest expenses form the inputs, on the other side, i) credits and ii) interest incomes form the outputs.

4. Method

Malmquist Total Factor Productivity is a technique depending on The Data Envelopment Analysis (DEA). It measures the productivity change of a specific value (increase/decrease rate) between two timeframe (Berg et.al., 1992:213).

Change indexes in total factor productivity for the banks are calculated separately for both banks and bank groups via applying panel data for the period 2004-2009. Temporal development of banks' productivity and its sources are presented by Malmquist total factor productivity index. DEAP 2.1 program produced by Coelli (1996 b) is employed for the measurement of indexes.

Constant returns to scale hypothesis is applied over technology in order to estimate the distance functions that are used in the measurement of Malmquist total factor productivity index. For that reason, constant returns to scale hypothesis is deemed.

This index that is defined in terms of distance functions developed by Malmquist (1953) measures the change in the total factor productivity between two variable by calculating each variable's relative distance rate to common technology. Distance functions might be seen as both input and output based distance functions (Deliktas, 2002:252). In input based approach, the least input amount used for the production of output (input minimization); as for output based approach, the maximum production of output with a definite input (output maximization) should be predicated on. The solution of the two optimization problem is able to give effective edge; notwithstanding, differences occasionally would emanate in nonimpact units. Our study seize upon input based approach.

By means of Malmquist total productivity change index the change in the bank's productivity from the (t) period to (t+1) is measured. Malmquist total productivity change index which belongs to the input between (t) period and the following (t+1) period is measured via the below formula (Worthington, 2000:179., Oncu and Aktas, 2007:253).

$$M_1^{t+1}(y^{t+1},x^{t+1}, y^t, x^t) = \left[\frac{D_I^t\left(y^{t+1},x^{t+1}\right)}{D_I^t\left(y^t,x^t\right)} x \frac{D_1^{t+1}\left(y^{t+1},x^{t+1}\right)}{D_1^{t+1}\left(y^t,x^t\right)} \right]^{1/2} \quad (1)$$

Equation can be formulized as;

$$M_1^{t+1}(y^{t+1},x^{t+1}, y^t, x^t) = \frac{D_I^{t+1}\left(y^{t+1},x^{t+1}\right)}{D_I^t\left(y^t,x^t\right)} x \left[\frac{D_I^t\left(y^{t+1},x^{t+1}\right)}{D_I^{t+1}\left(y^{t+1},x^{t+1}\right)} x \frac{D_I^t\left(y^t,x^t\right)}{D_I^{t+1}\left(y^t,x^t\right)} \right]^{1/2} \quad (2)$$

The ratio written outside of the square brackets in the second formula measures the change in the input-based technical efficiency between (t) and (t+1) years. The efficiency change is the ratio of efficiency in (t+1) period in proportion to efficiency in (t) period. Geometric average of the two ratios in square brackets delineates the change in technology between two periods. That is to say; the changes in total factor productivity and components are measured as the geometrical average of Malmquist productivity indexes (Fare et. al., 1994: 253).

Malmquist total productivity index might be divided into two as the change in technical efficiency and technological change. When we split the equation (2) into two by this way, we can measure the change in efficiency and technological change asunder.

$$\text{Change in efficiency} = \frac{D_I^{t+1}\left(y^{t+1},x^{t+1}\right)}{D_I^t\left(y^t,x^t\right)} \quad (3)$$

$$\text{Technological change} = \left[\frac{D_I^t\left(y^{t+1},x^{t+1}\right)}{D_I^{t+1}\left(y^{t+1},x^{t+1}\right)} x \frac{D_I^t\left(y^t,x^t\right)}{D_I^{t+1}\left(y^t,x^t\right)} \right]^{1/2} \quad (4)$$

The change in technical efficiency is described as the efficiency in reaching to the production limit and technological change as the curve shift in productivity limit (Mahadevan, 2002: 590).

On the other hand, multiplication of the change in technical efficiency and technological change yields the change in the total factor productivity.

Total factor productivity index's being more than 1 shows that total factor productivity increased during the period between (t) and (t+1). Its being less than 1 asserts the contrary (Coelli , 1996a:28).

In order to measure Malmquist total factor productivity change index, a range of linear programming problem (LPP) should be measured. The LPP; which is used in Malmquist total factor productivity change index depended on the constant returns to scale hypothesis and input-based approach, is given (Worthington; 2000:180).

$[D^{t}{}_{I}(y_t, x_t)]^{-1} = \min_{\theta,\lambda} \theta$

st

$-y_{it} + Y_t\lambda \geq 0$ (1)

$\theta x_{it} - X_t\lambda \geq 0$

$\lambda \geq 0$

$D^{t+1}{}_{I}(y_{t+1}, x_{t+1})]^{-1} = \min_{\theta,\lambda} \theta$

st

$-y_{i,t+1} + Y_{t+1}\lambda \geq 0$ (2)

$\theta x_{i,t+1} - X_{t+1}\lambda \geq 0$

$\lambda \geq 0$

$D^{t+1}{}_{I}(y_t, x_t)]^{-1} = \min_{\theta,\lambda} \theta$

st

$-y_{it} + Y_{t+1}\lambda \geq 0$ (3)

$\theta x_{it} - X_{t+1}\lambda \geq 0$

$\lambda \geq 0$

$D^{t}{}_{I}(y_{t+1}, x_{t+1})]^{-1} = \min_{\theta,\lambda} \theta$

st

$- y_{i,t+1} + Y_t\lambda \geq 0$ (4)

$\theta x_{i,t+1} - X_t\lambda \geq 0$

$\lambda \geq 0$

The first two linear programming models are evaluated by using the efficient limit of the given period as the base. While Model (3) compares the datum of (t) period with the efficient limit of (t+1) period; model (4) compares the datum of (t+1) period with (t) period's efficient limit.

Each of the four linear programming models should be solved for each period and observation in the example so as to measure the Malmquist total factor productivity. Thus; Nx(3T-2) number of problem should be solved to depict the T period number and N observation number.

5. The Empirical Results

The change in total factor productivity index enables us to differentiate between productivity change and technological and technical efficiency change in it. Index value's being more than 1 indicates that it rises during the transition from (t) period to (t+1) period; on the other hand, being less than 1 indicates its decrease. The measurement of total factor productivity index is comprised of multiplication of change value in technical efficiency and technical change value (Angelidis and Lyroudi, 2005). The constituents of total factor productivity: technical efficiency change and technological change's being more than 1 once again represents the improvement in technology and technical efficiency, and its being less than 1 implies the retrogression. In other words; technical efficiency change index's being more than 1 depicts the capability of the organization in satisfying the production limit;

likewise, technologic change index's being more than 1 shows that the organization is successful in hoisting its efficiency level.

Technologic change index's having a negative change value means that there has been a reduction in the output amount produced by the similar amount of input (Karacabey, 2002:75).

On the other side; technical efficiency change is divided into two in itself as pure technical efficiency change and scale efficiency change. Multiplication of these divisions renders in technical efficiency change index. Managerial competence in pure technical efficiency questions whether the organizations work with the suitable scale and shows the achievement in producing within the appropriate scale. Decrease in pure technical efficiency signals the distortion in managerial competence. The observation of decay in scale efficiency is a glimpse of organizations' scale problem.

Malmquist total factor productivity index's being divided into abovementioned constituents plays a fundamental role in the detection of main sources in the rise of total factor productivity (Deliktas, 2002:263).

The measured change indexes in technical efficiency, technology, pure technical efficiency, scale efficiency and total factor productivity concerning all deposit banks and groups are demonstrated in the below tables.

5.1. All deposit banks

The measured change indexes during 2004-2009 in technical efficiency change, technological change, pure efficiency change, scale efficiency change and total factor productivity change concerning all deposit banks are demonstrated in Tablo 2.

Table 2 Total Factor Productivity and its constituents' change for all deposit banks (2004-2009)

Banks	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity (TFP) Change
Ziraat	0.924	1.127	1.000	0.924	1.041
Halk	1.045	1.101	0.989	1.056	1.151
Vakiflar	1.040	1.029	1.034	1.006	1.070
Adabank	0.978	1.187	1.000	0.978	1.161
Akbank	0.950	1.014	1.000	0.950	0.963
Alternatif	1.041	1.021	0.966	1.077	1.063
Anadolubank	1.090	1.008	1.016	1.072	1.098
Sekerbank	0.998	1.064	0.967	1.032	1.062
Tekstilbank	1.072	0.942	0.990	1.083	1.010
Turkishbank	0.985	1.126	0.893	1.103	1.109
Turk Ekonomi	1.040	0.967	0.994	1.045	1.005
Garanti	1.020	0.997	1.029	0.991	1.017
Is Bank	0.983	1.036	1.032	0.953	1.018
Yapi and Kredi	1.066	1.032	1.000	1.066	1.100
Arap Turk	1.000	1.015	1.000	1.000	1.015
Citibank	0.935	1.091	0.972	0.962	1.020
Denizbank	1.095	0.993	1.043	1.050	1.088
Deutsche Bank	0.850	1.072	0.947	0.897	0.911
Eurobank	1.028	0.921	1.078	0.954	0.947
Finansbank	0.982	0.991	1.000	0.982	0.973

Fortisbank	1.078	0.949	1.000	1.078	1.023
HSBC	0.935	0.997	0.993	0.941	0.932
ING	1.095	0.974	1.016	1.078	1.067
Millennium	1.064	1.048	1.142	0.931	1.115
Turkland	1.034	0.998	1.004	1.030	1.032
Bank Mellat	0.986	0.942	0.987	0.999	0.928
Habib Bank	1.000	1.051	1.000	1.000	1.051
JPMorgan	1.000	1.114	1.000	1.000	1.114
Societe Generale	1.226	1.028	1.166	1.051	1.261
The Royal	1.064	1.129	1.077	0.988	1.201
WestLB	0.934	1.182	0.889	1.051	1.104
*Average	1.015	1.035	1.006	1.009	1.050

* All Malmquist index averages are geometric means

According to technical efficiency change index; % 52 of banks increased their average annual technical efficiency. Yet, as for the % 39 no change has been observed.

Among the banks which progressed in technical efficiency Societe Generale (SA) Bank (% 22.6) and ING bank (% 9.5) take the place on top; nevertheless, Deutsche Bank (% 15) Ziraat Bank (% 7.6) are the first two regressed banks. Ziraat Bank, due to decay in its scale efficiency; Deutsche Bank, due to both scale and pure technical efficiency showed diminution in technical efficiency. Arab Turkish, Habib and JPMorgan Chase Banks have no change in technical efficiency.

It also has been observed that there are average annual %3.5 improvements in technology. % 64.5 of the banks improved, but % 35.5 declined technologically during the period. Adabank (% 18.7), WestLB (% 18.2) and The Royal Bank (%

12.9) are the top three among the banks that improved technologically. As for the back warded banks; Eurobank (% 7.9), Bank Mellat (%5.8) and Tekstil Bank (%5.8) are the first three.

The annual average growth in total factor productivity for the relevant period is % 5. Improvement in % 81 and regression in %19 of the banks is observed. Having high increase in total factor productivity during 2000-2004, Societe Generale (% 26.1) and The Royal Bank (% 20.1) are the first two. These banks' factor productivity increase is not only based on the improvement in technical efficiency but also on innovation.

Deutsche Bank (% 8.9) and Bank Mellat (% 7.2) are the first two banks declined in total factor productivity. The decrease in technology, as well as technical efficiency regression of Bank Mellat and Deutsch Bank's contribute to total factor productivity reduce.

Table 3 Average Changes in All Deposit Banks' Total Factor Productivity and Its Components by Year

Years	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity (TFP) Change
2005	1.266	0.817	1.026	1.233	1.034
2006	0.907	1.035	1.016	0.893	0.939
2007	1.065	1.137	1.102	0.967	1.211
2008	0.788	1.208	0.944	0.835	0.952
2009	1.117	1.022	0.948	1.178	1.142
Average	1.015	1.035	1.006	1.009	1.050

As can be seen in Table 3, there occurred a rise in annual average technical efficiency between 2004-2009. In addition to this; while some banks' technical efficiency declined, some didn't show any change. Banks' average annual improvement technical efficiency index is 1.015. Besides; proceeding is observed both in pure technical efficiency and scale efficiency. As the increase in scale efficiency is %0.9 and % 0.6 in pure technical efficiency, average annual technical efficiency level improved.

2008 is the year when the technical efficiency level hit the bottom, and 2005 is the peak year. Nonetheless, 2008 is the year of technical progress, and 2005 is of decline. In parallel with these two parameters, 2007 is observed as the year to have highest increase level in total factor productivity. There appeared a decline in TFP in 2006. Concerning the period average, it is concluded that banks' total factor productivity, depending on the improvement in both technology and technical efficiency, rose % 5.

5.2. Publicly Owned Deposit Banks

The measured change indexes during 2004-2009 in technical efficiency, technology, pure technical efficiency, scale efficiency and total factor productivity concerning publicly owned deposit banks are demonstrated in the below table.

Table 4 Average Changes in Publicly Owned Deposit Banks' Total Factor Productivity and Its Components (2004-2009)

Banks	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity (TFP) Change
Ziraat	0.988	0.985	1.000	0.988	0.973
Halk	1.000	0.991	1.000	1.000	0.991
Vakif	1.000	1.084	1.000	1.000	1.084
Average	0.996	1.019	1.000	0.996	1.015

In respect of technical efficiency change index; % 33 of publicly owned deposit banks declined in their average annual technical efficiency, and % 67 of them recorded no change. Ziraat Bank (%1.2) is the bank that declined in its technical efficiency. It can be said that this bank recorded decline in its technical efficiency on the ground of regression in its scale efficiency. The banks that didn't show any change in their technical efficiency are Halk and Vakif Bank.

The average annual technological progress is measured as %1.9 with respect to technological change index. It is seen that % 33 of banks showed progress, %67 of them declined in their technology during the period. Vakifbank (% 8.4) showed technological progress. Ziraat (%1.5) and Halk Bank (% 0.9) showed technological regression.

The average annual growth rate in total factor productivity for the concerned period is % 1.5. During 2000-2004 Vakifbank (% 8.4) improved its total factor productivity; which is subject to its technologic progress.

The banks which lived regression it their total factor productivity are Ziraat (% 2.7) and Halk bank (% 0.9). Ziraat bank, because of its decline in both technology

and technical efficiency level, Halk Bank, because of its decline in technology retreated in their total factor productivity.

Table 5 Average Changes in Publicly Owned Deposit Banks' Total Factor Productivity and Its Components by Year

Years	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity (TFP) Change
2005	0.997	0.943	1.000	0.997	0.940
2006	0.985	1.072	0.984	1.001	1.056
2007	1.019	0.991	1.016	1.003	1.009
2008	0.997	0.981	1.000	0.997	0.978
2009	0.983	1.119	1.000	0.983	1.100
Average	0.996	1.019	1.000	0.996	1.015

As can be seen from the table; there has been regression in average annual technical efficiency in 2004-2009 period. As this regression includes the % 33 of the publicly owned deposit banks; the average annual technical efficiency index turned out to be 0.996. Then again, the regression in the scale efficiency; which is one of the important constituent of technical efficiency index eventuated in the technical efficiency average regression. It might be put forward that this regression takes its source from the regression in scale efficiency.

2007 is the year when the improvement and 2009 is the year when the regression in technical efficiency is at most. Besides, 2009 is the year when technological improvement is at most, and 2005 is the year when it is at the least. Dependently; the highest rate in total factor productivity is reached in 2009. Its

lowest rate is recorded in 2005. In spite of the regression in technical efficiency, total factor productivity of the publicly owned deposit banks, owing to progress in technology, rose %1.5.

5.3. Private Owned Deposit Bank

The measured change indexes during the period in 2004-2009 for technical efficiency, technological change, pure technical efficiency, scale efficiency and total factor productivity concerning private deposit banks are demonstrated in the below table.

Table 6 Average Changes in Private Owned Deposit Banks' Total Factor Productivity and Its Components (2004-2009)

Banks	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity (TFP) Change
Adabank	1.000	1.118	1.000	1.000	1.118
Akbank	0.938	1.042	1.000	0.938	0.977
Alternatif	1.000	1.049	1.000	1.000	1.049
Anadolu	1.056	1.035	1.046	1.010	1.093
Sekerbank	0.993	1.047	1.000	0.993	1.040
Tekstil	1.000	1.031	1.000	1.000	1.031
Turkish	1.074	1.087	1.010	1.063	1.167
Türk Ekonomi	0.995	1.023	1.011	0.984	1.018
Garanti	0.990	1.041	1.020	0.970	1.031
Is Bank	0.988	1.048	0.996	0.993	1.036
Yapi and Kredi	1.031	1.038	1.000	1.031	1.070
Average	1.005	1.050	1.007	0.998	1.056

It is discovered that % 27 of the private owned deposit banks advanced, % 46 of them regressed, and % 27 of them recorded no change in their average annual technical efficiency. Turkish bank (% 7.4) and Anadolu bank (% 5.6) are first two banks that advanced their technical efficiency. Akbank (% 6.2) and T.İş bank (% 1.2) are top two to decline in their technical efficiency. The banks which didn't advance their technical efficiency are Adabank, Alternatif Bank and Tekstil Bank. Akbank, due to its decline in scale efficiency; Is Bank, due to its decline in both pure technical and scale efficiency, retreated in their technical efficiency.

The average annual technological improvement is measured as % 5 according to technological change index. It is observed that %100 banks made progress technologically during the whole period. Adabank (% 11.8) and Turkish Bank (% 8.7) are the top two.

Technologic change index's having a positive change value means that there has been a reduce in the output amount produced by the similar amount of input. In other words; they hoist their production efficiency level.

With respect to total factor productivity change index, The average annual growth rate for the concerned period is % 5.6. % 91 of private deposit banks' total factor productivity advanced, and % 9 declined. Turkish (% 16.7) and Adabank (% 11.8) which advanced their total factor productivity highly during 2000-2004 are the top two. Turkish Banks' total factor productivity advancement is subject to its progress in both technology and technical efficiency. Adabank witnessed improvement just because of its technological progress. The bank which regressed in total factor productivity is Akbank (% 2.3). Its regression is parallel with the regression in its technical efficiency.

Average changes in private deposit banks' total factor productivity indexes by year are depicted as follows.

Table 7 Average Changes in Private Owned Deposit Banks' Total Factor Productivity Indexes By Year

Years	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity (TFP) Change
2005	0.933	1.324	1.028	0.908	1.236
2006	1.017	0.975	1.013	1.004	0.991
2007	0.983	1.033	0.993	0.990	1.015
2008	1.181	0.839	1.022	1.156	0.991
2009	0.933	1.144	0.984	0.948	1.066
Average	1.005	1.050	1.007	0.998	1.056

As can be seen in the table, the average annual technical efficiency change index is 1.005. Furthermore, it is found that the components of technical efficiency index, scale efficiency regressed; pure technical efficiency advanced.

2008 is the top year for private deposit banks to advance their technical efficiency. 2005 and 2009 are the regression years. However, 2005 is the technological advance, 2009 is the technological decline years. Correspondingly, the highest rate of total factor productivity is captured in 2005. Despite the technical efficiency regression in this year, substantial advancement in technology leaded to a significant advancement in total factor productivity. TFP declined in 2006 and 2008; which is based on the technological backwardness. As of the period average, total

factor productivity of private deposit banks, depending on the progress not only in technology but also in technical efficiency, advanced % 5.6.

5.4. Foreign Owned Deposit Banks

The measured change indexes in 2004-2009 for in technology, technical efficiency, pure technical efficiency, scale efficiency and total factor productivity for foreign owned deposit banks are demonstrated in the below table.

Table 8 Average Changes in Foreign Owned Deposit Banks' Total Factor Productivity and Its Components (2004-2009)

Banks	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity (TFP) Change
Arap Türk	1.000	0.984	1.000	1.000	0.984
Citibank	0.935	1.104	0.958	0.976	1.032
Denizbank	1.095	0.981	1.032	1.061	1.074
Deutsche	0.850	1.159	0.947	0.897	0.985
Eurobank	1.028	0.939	1.074	0.957	0.965
Finans	0.982	0.995	1.000	0.982	0.977
Fortis	1.078	0.938	1.000	1.078	1.011
HSBC	0.935	1.001	0.993	0.941	0.935
ING	1.095	0.967	0.995	1.101	1.059
Millennium	1.064	1.044	1.142	0.931	1.111
Turkland	1.034	0.994	1.004	1.030	1.027
Bank Mellat	0.986	0.954	0.987	0.999	0.941
Habib	1.000	1.048	1.000	1.000	1.048
JPMorgan	1.000	1.157	1.000	1.000	1.157

Societe Generale	1.226	0.920	1.155	1.062	1.128
The Royal	1.063	1.138	1.064	0.999	1.209
WestLB	0.934	1.163	0.887	1.053	1.086
Average	1.015	1.025	1.012	1.003	1.040

It is discovered that % 47 of the private owned deposit banks advanced, % 35 regressed, and % 18 recorded no change in their average annual technical efficiency.

The top three to advance their technical efficiency are Societe Generale (% 22.6), Denizbank (% 9.5) and ING Bank (% 9.5). Deutsche bank (% 15) and WestLB AG (% 6.6) are top two to decline in their technical efficiency. WestLB AG, due to its decline in pure technical efficiency; Deutsche bank, due to its decline in both pure technical and scale efficiency, retreated in their technical efficiency. Arab Turkish, Habib and JPMorgan Chase Bank are the banks which showed no change in their technical efficiency.

According to technological change index, the average annual technological improvement is measured as % 2.5. % 47 of the banks improved, but % 53 declined technologically during the period. WestLB AG (% 16.3) and Deutsche bank (% 15.9) are the top two among the banks that improved technologically. As for the back warded banks; Societe Generale (% 8) and Fortis bank (% 6.2) are the first two.

With respect to total factor productivity change index, the average annual growth rate for the concerned period is % 4. % 65 of foreign owned deposit banks' total factor productivity advanced, and % 35 declined. The Royal Bank (% 20.9) and JPMorgan Chase (% 15.7) are the top two to advance their total factor productivity highly during 2000-2004. The Royal Banks' total factor productivity advancement is subject to its progress in both technology and technical efficiency. Adabank's

advancement is subject to its technological progress. The first two banks which regressed in total factor productivity are HSBC (% 6.5) and Bank Mellat (% 5.9).

Average changes in foreign owned deposit banks' total factor productivity indexes by year are depicted as follows.

Tablo 9 Average Changes in Foreign Owned Deposit Banks' Total Factor Productivity and Its Components by Year

Years	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity (TFP) Change
2005	1.377	0.675	0.988	1.393	0.929
2006	1.108	0.810	1.067	1.039	0.898
2007	0.826	1.665	1.161	0.711	1.375
2008	0.799	1.155	0.930	0.859	0.923
2009	1.067	1.077	0.932	1.145	1.150
Average	1.015	1.025	1.012	1.003	1.040

As can be seen in the table, the average annual technical efficiency change index increased as 1.005 in 2004-2009. The constituents of technical efficiency index, scale and pure technical efficiency advanced. The improvement in scale efficiency is %0.3 and % 1.2 in pure technical efficiency. As a consequent of these two improvements the average annual technical efficiency advanced, too. 2005 is the top year for foreign owned deposit banks in terms of highest technical efficiency rate. Yet, 2008 is the top year of regression. Technological advancement reached its peak in 2007 and regression in 2005. Dependently; the highest rate in total factor productivity is reached in 2007. There occurred a regression in 2006. As of the

period average, total factor productivity of foreign owned deposit banks, depending on the progress not only in technology but also in technical efficiency, advanced % 4.

Average changes in foreign owned deposit banks' total factor productivity indexes values by year are as follows.

Table 10 Total Factor Productivity Index Value by Year on Groups

	Years	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity (TFP) Change
	2004-2005	1.266	0.817	1.026	1.233	1.034
All Deposit	2005-2006	0.907	1.035	1.016	0.893	0.939
Banks	2006-2007	1.065	1.137	1.102	0.967	1.211
	2007-2008	0.788	1.208	0.944	0.835	0.952
	2008-2009	1.117	1.022	0.948	1.178	1.142
Average	**2004-2009**	**1.015**	**1.035**	**1.006**	**1.009**	**1.050**
	Years	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity (TFP) Change
State	2004-2005	0.997	0.943	1.000	0.997	0.940
owned	2005-2006	0.985	1.072	0.984	1.001	1.056
deposit	2006-2007	1.019	0.991	1.016	1.003	1.009
banks	2007-2008	0.997	0.981	1.000	0.997	0.978
	2008-2009	0.983	1.119	1.000	0.983	1.100
Average	**2004-2009**	**0.996**	**1.019**	**1.000**	**0.996**	**1.015**

Private	2004-2005	0.933	1.324	1.028	0.908	1.236
owned	2005-2006	1.017	0.975	1.013	1.004	0.991
deposit	2006-2007	0.983	1.033	0.993	0.990	1.015
banks	2007-2008	1.181	0.839	1.022	1.156	0.991
	2008-2009	0.933	1.144	0.984	0.948	1.066
Average	**2004-2009**	**1.005**	**1.050**	**1.007**	**0.998**	**1.056**
Foreign	2004-2005	1.377	0.675	0.988	1.393	0.929
owned	2005-2006	1.108	0.810	1.067	1.039	0.898
deposit	2006-2007	0.826	1.665	1.161	0.711	1.375
banks	2007-2008	0.799	1.155	0.930	0.859	0.923
	2008-2009	1.067	1.077	0.932	1.145	1.150
Average	**2004-2009**	**1.015**	**1.025**	**1.012**	**1.003**	**1.040**

The total factor productivity index's being more than 1 for both all deposit banks and groups (2000-2004) , the efficiency of banks advanced. If we examine the table for 2005, it is seen that with respect to 2004, all deposit banks and groups improved in terms of total factor productivity.

When the groups are compared with each other for 2005 it is concluded that the highest advancement, with 1.236 ratio, belongs to private deposit banks, and the lowest advancement rate, with 0.929, belongs to foreign owned deposit banks.

Analyzing 2006, regression, 0.939 in all deposit banks, 0.898 in foreign owned deposit banks, 0.991 in private deposit banks, is seen in terms of total factor productivity. Nevertheless, publicly owned deposit banks improved their TFP by 1.056.

Analyzing 2007, all deposit banks and groups improved are found to improve their TFP. The highest level, 1.375, belongs to foreign owned deposit banks.

Analyzing 2008, total factor productivity regression is recognized in all deposit banks and groups. The highest decline ratio, 0.923, belongs to foreign owned deposit banks. This state is relatable to global financial crisis of 2008.

Analyzing 2009, total factor productivity improvement holds true for all deposit banks and groups. Foreign owned deposit banks, 1.150, have the highest ratio.

6. Conclusions

This study carries out the performance measurement of the banks during the period in 2004 - 2009. Groups are designated contingent with classification of The Banks Association of Turkey. On behalf of performance measurement, technical efficiency values, technical efficiency change, technological change, pure technical efficiency change, scale efficiency change and total factor productivity change indexes of all deposit banks and groups are measured. Malmquist total factor productivity index method is used for the measurement of these indexes. both intergroup and banks comparisons are made available by means of group index measurement ; so that, it is aimed to ascertain which bank group or bank relatively has the highest level of performance. On account of analysis' findings;

By taking all measured performance criteria (technical efficiency change, technological change and total factor productivity change) into consideration, the banks with the highest and lowest level of performance are given in the below table.

Table 11 The Banks With The Highest And Lowest Level of Performance on the basis of Groups

	Technical Efficiency Change		Technological Change		Total Factor Productivity (TFP) Change	
Groups	Bank that provides the most progress	Bank showing the biggest decline	Bank that provides the most progress	Bank showing the biggest decline	Bank that provides the most progress	Bank showing the biggest decline
State owned deposit banks	-	Ziraat (%1.2)	Vakıf (%8.4)	Ziraat (%1.5)	Vakıf (%8.4)	Ziraat (%2.7)
Private owned deposit banks	Turkish (%7.4)	Akbank (%6.2)	Adabank (%11.8)	-	Adabank (%11.8)	Akbank (%2.3)
Foreign owned deposit banks	Societe Generale (%22.6)	Deutsche (%15)	WestLB AG (%16.3)	Societe Generale (%8)	The Royal Bank (%20.9)	HSBC (%6.5)

Turkish and Societe Generale are encountered to be the banks with highest level of technical efficiency improvement. Ziraat, Akbank and Deutsche bank are the banks with highest level of technical efficiency regression. Besides, the banks with highest level of technological advancement are Vakıf, Adabank and WestLB AG. Ziraat ve Societe Generale are turned out to be the banks with lowest technological advancement.

It is concluded that the banks with the highest total factor productivity growth rate are Vakıf, Adabank and The Royal Bank. The highest regression rate in terms of this criterion belongs to Ziraat, Akbank and HSBC. In the face of the wholly measured performances; the banks with highest and lowest performance among the all deposit banks are listed as follows.

Table 12 The Banks with Highest and Lowest Performance among the all Deposit Banks

	Technical Efficiency Change		Technological Change		Total Factor Productivity (TFP) Change	
Groups	Bank that provides the most progress	Bank showing the biggest decline	Bank that provides the most progress	Bank showing the biggest decline	Bank that provides the most progress	Bank showing the biggest decline
	ING (%9.5)	Deutsche (%15)	Adabank (%18.7)	Eurobank (%7.9)	Societe Generale (% 26.1)	Deutsche (%8.9)

ING bank is observed to improve technical efficiency at optimum level, and Deutch bank is to regress at the highest ratio. The bank with the highest level of technological advancement is Adabank. The bank with the highest level of technological backward is Eurobank Tekfen. While Societe Generale is discovered to have the highest level of total factor productivity growth rate, Deutsche is seen to be just vice versa.

As the tables suggest, the foreign owned deposit banks, thanks to positive changes in their technology, technical efficiency and total factor productivity are found to be more effective.

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