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Yasemin Keskin Benli

Department of Business Education,
Gazi University,
Turkey
ykeskin@gazi.edu.tr

Suleyman Degirmen

Department of Economics,
Mersin University,
Turkey
suleymandegirmen@gmail.com

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

Summary: The objective of this study is to measure the total factor productivity and the changes in components of the total factor productivity generated by the banks in Turkish Banking Sector (TBS) during the period of 2004-2009. Based on these measurements, we quantify the production efficiency of the banks. To that end, the total factor productivity is taken as an initial point, and various performance comparisons are made both within the specified three sub-groups and among all deposit banks in TBS. Within the context of performance measurement, we use input and output variables to test technical efficiency index, which represents a combination of change in technical efficiency and in technology, and to test a change in total factor productivity index which comprises a change in pure technical efficiency and scale efficiency. In the calculation of these indexes, Malmquist total factor productivity index method is employed. Computed indexes provide us with the opportunity to make performance comparisons in order to assess which group and bank have comparatively highest performance among the groups and banks included in this study. When we consider the effects of 2007-2008 global crises on Turkish economy, notably on TBS, calculating the performance change ratio for previous periods or estimating the same for the following periods becomes vital in terms of enduringly changing and developing banks. The growing competition in TBS forces banks to attach more importance to productivity factor for sustainable growth purposes. In this regard, Malmquist total factor productivity index gives us the opportunity to quantify the changes in total factor productivity over the years. Accordingly, this study applies group analysis to determine which group is working efficiently. To do this, Malmquist total factor productivity index requires the use of panel data and depicts efficiency changes by years, representing crucial information for us to produce policy implications. In brief, the test results obtained by this study indicate that the foreign banks, thanks to positive changes in their technology, technical efficiency and total factor productivity, are more effective than other private and state banking groups.

Key words: Data envelopment analysis, Malmquist total factor productivity index, Banks.

JEL: G21, C40, C58.

The financial system in Turkey, especially banking sector, had a strong growth trend and fundamental financial deepening indicators improved significantly during the first decade of this millennium. However, according to detailed information presented in the report of Banking Regulation and Supervision Agency (BRSA), the sector was characterized by large number of small banks as well as structural problems in an unstable macroeconomic environment before 2000. As a result of devastating effects 2000 and 2001 crises, many banks had to leave the market. In the course of simultaneously-applied restructuring process (namely Banking Restructuring Program in 2001) market structure of the sector was considerably changed. Banks displayed a high-performance growth and the sector continued to develop during 2002-2007 with strengthened financial stability and general market structure within TBS. The foregoing program created a very attractive environment for foreign banks, in turn, the number of them in TBS has incrementally increased.

Finally, global financial crisis in 2008-2009 gave rise to new developments in the sector in terms of market structure. The global developments have also affected TBS to relatively limited extent in comparison with many other developed and developing countries. The reasons behind relatively limited negative effects on TBS include a high capital adequacy ratio, a high asset quality, low currency and liquidity risk thanks to successful risk management and effective supervision of Central Bank of Republic of Turkey (CBRT) and BRSA (BAT 2009).

Therefore, banks have been recently forced to use their resources in the most efficient and fruitful way to operate long lastingly, and to cope with the conditions of competition in TBS, which has been experiencing a change for two reasons.

First, participation of foreign banks into TBS has recently increased especially after the New Economic Stability Program, which was applied immediately after the 2001 financial crisis for the purpose of restructuring the economy and which maintained the economy at a robust growth performance until the recent global crisis. There is an assertion that the participation of foreign banks in emerging markets is often thought to improve overall bank soundness. Therefore, as the share of foreign banks in a national banking system increases, the system will quickly overcome both financial or currency crises, and quickly recover itself thanks to foreign banks' ability to overcome any crisis safely by means of their best management policies. The test results obtained by this study confirmed that foreign banks have more positive effects on TBS by increasing the overall capital structure (Suleyman Degirmen 2011).

Second, every economic and/or financial crisis has been followed by regulatory reforms in financial sector, particularly in TBS, which, in turn, has mitigated the devastating impacts of recent global crisis on TBS. Therefore, in consideration of the recent changes in TBS, it is clear that more accurate efficiency level measurements lead to more effective applicability of prospective planning activities. However, the substantiation of performance measurements becomes troublesome due to lack of standardized, secure and valid measurement techniques. In a nutshell, the objective of this study is to measure the total factor productivity and the changes in the components of the total factor productivity generated by the banks in Turkish Banking Sector during the period of 2004-2009.

One of the important criteria to measure the performance of banks is the changes in total factor productivity. When it comes to productivity, the total factor productivity consisting of the factors partaking in production process should be considered. Taking partial productivity measures, including labor and land productivity, into consideration separately may lead to misleading information about total factor productivity. Hence, taking total factor productivity as a whole and trying to measure the change in it yield much more consistent results. Since the change in total factor productivity is subdivided into two, (i.e. change in technical efficiency and technological change), improvements in these generate the basis of reaching high economical performance levels, and therefore of having very high level of competitiveness. A change in efficiency is regarded as the indicator of national economy's ability to internalize, adapt and transfer the global technology into total factor productivity (Ertuğrul Deliktas 2002, p. 248).

Following introductory motive, the structure of the paper is as follows. Section 1 surveys the literature on the application of Data Envelopment Analysis (DEA) based on Malmquist total factor productivity index. Section 2 presents the data used in our study and describes the related methodology. Section 3 discusses empirical results of the tests. Finally, Section 4 presents some concluding remarks including policy implications and further research.

1. Literature Review

The application of data envelopment analysis based on Malmquist total factor productivity index is widely used in the comparison of countries and for productivity calculations in different lines of business, e.g. in agriculture, health, banking sector, etc. In the study of Hasan M. Eken and Suleyman Kale (2011), Data Envelope Analysis (DEA) employs a non-parametric performance measurement tool that can be used for analysis and decision-making purposes in banking. This method sorts out banks individually and in groups according to their performances, and provides much more information that cannot be grasped by using other methods such as ratio analysis. The most common strengths of DEA can be listed as follow: it provides potential improvement capabilities; it indicates sources of inefficiency and it takes management preferences into account when measuring performances (see p. 889).

This method is used in the various studies: in Rolf Fare et al. (1989) to measure the productivity change in Swedish hospitals; in Fare et al. (1992) to measure Sweden pharmacies' productivity; in Fare et al. (1994) to compare productivity growth, technical progress and efficiency change in industrialized countries; in Tim Coelli (1996b) in the field of Australia agriculture; in Marios Zachariadis (2004) to compare OECD countries by productivity; in Surender Kumar (2006) for industry in India for 1982-2001; in Desheng Dash Wu and Chien-Ta Bruce Ho (2007) for integrated circuit system; in Ricardo Sellers-Rubio and Francisco Mas-Ruiz (2007) for 96 chain supermarkets in Spain for 1995-2003; in Mukesh Kumar and Partha Basu (2008) for Indian Food Sector for the period of 1988-2005; and in Ammara Mahmood and Talat Afza (2008) to compare East Asia countries by productivity. More recent one to be mentioned here is Patricio Ramírez-Correa, Jesús C. Peña-Vinces, and Jorge Alfaro-Pérez (2012), which estimates efficiency for a group of Chilean

universities based on the DEA technique and takes into account the reality of the Chilean university system. A DEA model with two input variables (operating expenses and academics full time equivalent - FTE) and three output variables (operating income, Institute for Scientific Information (ISI) publications and student enrollments) was developed to evaluate the performance of 34 Chilean universities. The empirical results indicate that 9 of 34 institutions are efficient in terms of financial performance level, and research and teaching levels. In addition, these do not reveal significant statistical differences between the efficiency of public and private institutions.

There are two studies applying Malmquist total factor productivity index in banking sector: Atle S. Berg, Finn R. Forsund, and Eilev S. Jansen (1992), which is dedicated to analyzing the deregulation of Norwegian Banking Sector; and Milind Sathye (2002) which is aimed at measuring productivity changes in Australian Banking Sector. To the best of our knowledge, there is no prior study doing analysis based on the calculation of total factor productivity (TFP) to make comparisons among groups and banks in TBS. Yet, studies on emerging markets have been done before, some of which also include Turkey. For instance, we count on related studies of Yenal C. Kesbic, İbrahim Tokatlioglu, and Serap Urut (2004) in industry enterprises in Turkish economy, Yasemin Keskin-Benli (2006) for the efficiency measurement of industrial enterprises in Istanbul Stock Exchange, and Ali Avci and Aysen Kaya (2008) in Turkish agriculture. Semra Oncu and Rabia Aktas (2007) use the same index in their analyses for TBS. Mehmet Candemir, Fatih Mumtaz Duran, and Nursel Koyubenbe (2009) examine the productivity performance of İzmir Agricultural Credit Cooperatives in the Aegean Region as well as the impacts of economic crises of 2001 and 2008 on the technical efficiency indexes of credit cooperative units, by evaluating 212 cooperative units. They use such relative measures of technical efficiency and the changes in total factor productivity as calculated by using DEA and Malmquist Productivity Index. Their findings suggest that there is a 1.6% decline in the cooperative unit's mean total factor productivity. The primary implication of it is that technical development is the factor behind this decline.

In our analysis, we came across two recent studies for the Turkish Banking System. First, recent study by Eken and Kale (2011) aims to develop a performance model for measuring the relative efficiency and potential improvement capabilities of bank branches in TBS by identifying their strengths and weaknesses. It also investigates the production and profitability aspects of bank branches in TBS. Under both production and profitability approaches, efficiency characteristics of branches, which are grouped according to different sizes and regions, have similar tendencies. In both analyses, it is clear that branch size and scale efficiency are related to each other. As branch size increases, the scale efficiency increases as well; however after the scale size maximizing productivity, any expansion decreases efficiency. Too small and too large branches require special attention. Lastly, Saadet Kasman and Adnan Kasman (2011) investigates the link between stock performance of the listed commercial banks in the Turkish stock exchange and three measures of bank performance in regard of technical efficiency, scale efficiency and productivity for the period 1998-2008. They use DEA method to measure relative efficiency and use also the Malm-

quist index approach to measure TFP change in the banking firms. They found a positive and statistically significant causal relationship between changes in the three factors and stock returns.

2. Method and Data Analysis

The study consists of 31 deposit banks, all of which are members of both the TBS and the Banks Association of Turkey (BAT). Banks are divided into three subgroups based on the classification made by BAT (Table 1). The data for 31 banks between the years 2004 and 2009 as employed in the analysis has been obtained from the BAT's official website. Table 1 indicates 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 (or public banks)	1. Ziraat Bank 2. Halk Bank 3. Vakiflar Bank		
Privately owned deposit banks (or private 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 (or foreign 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

Source: BAT Report (2009).[1]

To build our model for the case of paper and then test it, we decide for input and output parameters under the guidance of Eken and Kale (2011). They provide a comprehensive literature review including 39 articles, all of which were published after 2000 and more than 49 studies/approaches, which were analyzed (for details see Table 1 on page 891-894). Production/operation approaches are used in 33 studies and profitability approaches are used in 7 studies. In 27 studies CCR (Charnes, Cooper, Rhodes) and in 29 BCC (Banker, Charnes, Cooper) models are employed. 36 studies are based on input-oriented approaches while 12 studies are based on output-oriented approaches. In addition, Duygun M. Fethi and Fotios Pasiouras (2010) analyze 136 studies using DEA-like techniques to predict bank efficiency. Of the 29 studies, 17 adopt production and 12 adopt intermediation approach. Therefore, the

[1] **Banks Association of Turkey - BAT**. 2009. The Financial System and Banking Sector in Turkey. http://www.tbb.org.tr (accessed February 27, 2011).

most widely-used inputs are related to employee, other operating expenses, rental area (lands for rent) or expenses and other equipments. On the other hand, the most widely-used outputs are value/number of deposits, loans, non-interest income and commissions, and number of accounts/transactions.

We adopt intermediation approach in order to reflect better the production process of the banks. It is assumed that an enormous part of banking operations are formed by the conversion of the funds borrowed from financial and other depository institutions into credits and other security investments (Oncu and Aktas 2007, p. 257). Although there are many inputs, outputs and methods, separating out inputs and outputs as well as deciding the model and orientation should depend on the purpose of research. For this reason, we choose deposit and interest expenses as inputs, and credits/loans and interest incomes as outputs.

Malmquist total factor productivity is a technique depending on the DEA. It measures the change in productivity of a specific value (increase/decrease rate) between two timeframes (Berg, Forsund, and Jansen 1992, p. 213). Change indexes in total factor productivity for the banks are calculated separately for both banks and banking groups via panel data application for the period of 2004-2009. Temporary development of banks' productivity and its sources are presented by Malmquist total factor productivity index. To that end, DEAP 2.1 program produced by Coelli (1996b) is employed for the measurement of the indexes.

Constant returns to scale hypothesis is applied over technology in order to estimate the distance functions used in the measurement of Malmquist total factor productivity index. Being defined in terms of distance functions developed by Sten Malmquist (1953), this index measures the change in total factor productivity between two variables by calculating each variable's relative distance rate to common technology. Distance functions may be seen as both input and output based distance functions (Deliktas 2002, p. 252). Input based approach is predicated on the minimum amount of inputs used for the production of output (input minimization) while output based approach is predicated on the maximum production of output with a given input (output maximization). Solution of the both optimization problems provides effective edge; notwithstanding, differences occasionally may arise from ineffective units. Therefore, this study adopts input based approach.

By means of Malmquist total productivity change index, the change in bank's productivity from the period of (t) to (t+1) is measured. Malmquist total productivity change index pertaining to the input between (t) and (t+1) is calculated using the following formula (Andrew Worthington 2000, p. 179; Oncu and Aktas 2007, p. 253):

$$M_1^{t+1}(y^{t+1},x^{t+1}, y^t, x^t) = \left[\frac{D_1^t\left(y^{t+1},x^{t+1}\right)}{D_1^t\left(y^t,x^t\right)} x \frac{D_1^{t+1}\left(y^{t+1},x^{t+1}\right)}{D_1^{t+1}\left(y^t,x^t\right)} \right]^{½}. \quad (1)$$

Equation can be formulized as:

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

The first term on the right side of Equation 2 measures the change in input based technical efficiency between the year (t) and the year (t+1). The change in efficiency is represented by the ratio of efficiency in period (t+1) in proportion to efficiency in period (t). Geometric means of these two ratios in square brackets represents the change in technology between two periods. That is to say; the changes in total factor productivity and components are measured as the geometric mean of Malmquist productivity indexes (Fare et al. 1994, p. 253).

Malmquist total productivity index may be divided into two as of 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 respectively.

$$\text{Technical change in efficiency} = \frac{D_1^{t+1}\left(y^{t+1},x^{t+1}\right)}{D_1^{t}\left(y^{t},x^{t}\right)}. \tag{3}$$

$$\text{Technological change} = \left[\ \frac{D_1^{t}\left(y^{t+1},x^{t+1}\right)}{D_1^{t+1}\left(y^{t+1},x^{t+1}\right)} x\ \frac{D_1^{t}\left(y^{t},x^{t}\right)}{D_1^{t+1}\left(y^{t},x^{t}\right)}\ \right]^{1/2}. \tag{4}$$

The change in technical efficiency is described as the efficiency in approximating to the production limit and the technological change is described as the curve shift in productivity limit (Renuka Mahadevan 2002, p. 590). On the other hand, multiplication of the change in technical efficiency and technological change yields the change in total factor productivity. Total factor productivity index's exceeding 1 indicates an increase in total factor productivity during the period between (t) and (t+1) whereas its being less than 1 means the contrary (Coelli 1996a, p. 28).

In order to build Malmquist total factor productivity change index, a range of Linear Programming Problem (LPP) should be measured. Given the constant returns to scale hypothesis and input-based approach, the LPP that is used in building Malmquist total factor productivity change index is as follows (Worthington 2000, p. 180).

$$\begin{aligned}
&[D^{t}{}_{I}\,(y_t, x_t)]^{-1} = \min{}_{\theta,\lambda}\,\theta \\
&\text{st} \\
&-y_{it} + Y_t\lambda \geq 0 \\
&\theta x_{it} - X_t\lambda \geq 0 \\
&\lambda \geq 0
\end{aligned} \tag{5}$$

$$\begin{aligned}
&D^{t+1}{}_{I}\,(y_{t+1}, x_{t+1})]^{-1} = \min{}_{\theta,\lambda}\,\theta \\
&\text{st} \\
&-y_{i,t+1} + Y_{t+1}\lambda \geq 0 \\
&\theta x_{i,t+1} - X_{t+1}\lambda \geq 0 \\
&\lambda \geq 0
\end{aligned} \tag{6}$$

$$D^{t+1}{}_I\,(y_t, x_t)]^{-1} = \min_{\theta,\lambda}\,\theta$$
$$\text{st}$$
$$-y_{it} + Y_{t+1}\lambda \geq 0 \qquad (7)$$
$$\theta x_{it} - X_{t+1}\lambda \geq 0$$
$$\lambda \geq 0$$

$$D^{t}{}_I\,(y_{t+1}, x_{t+1})]^{-1} = \min_{\theta,\lambda}\,\theta$$
$$\text{st}$$
$$-y_{i,t+1} + Y_t\lambda \geq 0 \qquad (8)$$
$$\theta x_{i,t+1} - X_t\lambda \geq 0$$
$$\lambda \geq 0$$

The first two linear programming models are evaluated by using the efficient limit of the given period as a base. Model (7) compares the data of period (t) with the efficient limit of period (t+1) while model (8) compares the datum of period (t+1) with period (t)'s efficient limit. Each of the four linear programming models should be solved for each period and observation in the example so as to quantify the Malmquist total factor productivity. Thus, given number of periods (T) and number of observations (N), Nx(3T-2) problems should be solved.

3. 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 exceeding 1 indicates that it rises during the transition from period (t) to period (t+1); on the other hand, being less than 1 evidences its decline. The measurement of total factor productivity index is comprised of multiplication of change value in technical efficiency and technical change value (Dimitrios Angelidis and Katerina Lyroudi 2005). In other words, the constituents of total factor productivity, technical efficiency change and technological change's being more than 1 once again, represents an improvement in technology and technical efficiency, and its being less than 1 implies the retrogression. Therefore, technical efficiency change index's being more than 1 depicts the organization's being able to satisfy its production limit; likewise, technological change index's being more than 1 shows that the organization manages to leverage its efficiency level.

A negative change value of technological change index means that there has been a reduction in output amount produced by the similar amount of input (Argun A. Karacabey 2002, p. 75). On the other side; technical efficiency change is divided into two in itself as pure technical and scale efficiencies 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 detection of main sources triggering total factor productivity (Deliktas 2002, p. 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 tables below.

3.1 All Deposit Banks

The indexes of change built for technical efficiency change, technological change, pure efficiency change, scale efficiency change and total factor productivity change concerning all deposit banks for the period of 2004-2009 are demonstrated in Table 2.

Table 2 Total Factor Productivity and Its Constituents' Change for all Deposit Banks, 2004-2009 (Malmquist Index Summary of Firms Means)

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
Vakifbank	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
Şekerbank	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
Mean	1.015	1.035	1.006	1.009	1.050

Source: Authors' calculation.

According to technical efficiency change index; 52% of banks increased their mean annual technical efficiency. Yet, the same for 39% of the banks remained unchanged. Among the banks which made progress in technical efficiency, Societe Generale (SA) Bank (22.6%) and ING bank (9.5%) take the place on top; nevertheless, the first two of those who regressed are Deutsche Bank (15%) and Ziraat Bank (7.6%). Ziraat Bank, due to decay in its scale efficiency and Deutsche Bank, due to both scale and pure technical efficiency, experienced a decline in technical efficiency. Technical efficiency of Arab Turkish, Habib and JPMorgan Chase Banks remained unchanged.

It was also observed that 3.5% average annual technological progress was made. 64.5% of the banks made progress; however remaining 35.5% experienced technological decline during the period. Adabank (18.7%), WestLB (18.2%) and The Royal Bank (12.9%) are the top three among the banks that made technological progress. As for the banks suffering from retrogression; Eurobank (7.9%), Bank Mellat (5.8%) and Tekstil Bank (5.8%) are the first three.

The average annual growth in total factor productivity for the relevant period is 5%. 81% of the banks were observed to have made progress while 19% experienced a decline. In terms of increase in total factor productivity during 2004-2009, Societe Generale (26.1%) and The Royal Bank (20.1%) are the first two. An increase in these banks' factor productivity is driven by not only the improvement in technical efficiency but also innovation.

Deutsche Bank (8.9%) and Bank Mellat (7.2%) are the first two banks who experienced the highest decline in total factor productivity. The decrease in technology and technical efficiency decline of Bank Mellat and Deutsch Bank contributed to decrease in total factor productivity.

Table 3 Changes in all Deposit Banks' Total Factor Productivity and Its Components by Year (Malmquist Index Summary of Annual Means)

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
* Mean	1.015	1.035	1.006	1.009	1.050

Note: * All Malmquist indexes represent geometric means (Coelli 1996a, p. 45).

Source: Authors' calculation.

Table 3 shows that annual technical efficiency improved during the period of 2004-2009. In addition, while some banks' technical efficiency declined, some did not show any change. The index of annual technical progress made by banks is 1.015. Moreover, banks are observed to have made progress both in pure technical efficiency and scale efficiency. As a result of the increase in scale efficiency and in pure technical efficiency by 0.9% and 0.6% respectively, annual technical efficiency level improved.

2008 is the year when the technical efficiency level hit rock bottom, and 2005 is the peak year. Nonetheless, 2008 is the year of technical progress, and 2005 is of decline. Regarding these two parameters, 2007 is observed to be the year with highest increase in total factor productivity. There appeared a decline in TFP in 2006. Concerning this period, it is concluded that banks' total factor productivity rose by 5% depending on the improvement in both technology and technical efficiency. The following subsections give more details about what we have covered so far in this section.

3.2 Public/State Banks

The indexes of change built for technical efficiency change, technological change, pure efficiency change, scale efficiency change and total factor productivity change concerning public banks for the period of 2004-2009 are demonstrated in Table 4 below.

Table 4 Changes in Public/State Banks' Total Factor Productivity and Its Components, 2004-2009 (Malmquist Index Summary of Firms Means)

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
Vakifbank	1.000	1.084	1.000	1.000	1.084
Mean	0.996	1.019	1.000	0.996	1.015

Source: Authors' calculation.

In respect of technical efficiency change index; 33% of public banks declined in terms of annual technical efficiency, and 67% of them underwent no change. Ziraat Bank (1.2%) is the bank whose technical efficiency declined. It can be interpreted that this bank suffered from a decline in its technical efficiency in consequence of retrogression in its scale efficiency. Halk and Vakif Bank did not undergo any change in terms of technical efficiency.

The annual technological progress is measured as 1.9% with respect to technological change index. It is seen that 33% of banks made progress while 67% of them declined during the period in terms of technology. Vakifbank (8.4%) made technological progress. Ziraat (1.5%) and Halk Bank (0.9%) experienced technological retrogression. The annual total factor productivity retrogression for the concerned period is 1.5%. During the period of 2004-2009, Vakifbank (8.4%) improved its total factor productivity which may be explained by its technologic progress.

The banks that experienced retrogression in terms of total factor productivity are Ziraat (2.7%), due to deterioration of both technology and technical efficiency level, and Halkbank (0.9%) due to retrogression in terms of total factor productivity as caused by its decline in technology.

Table 5 Changes in Public Banks' Total Factor Productivity and Its Components by Year (Malmquist Index Summary of Annual Means)

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
* Mean	0.996	1.019	1.000	0.996	1.015

Note: * All Malmquist indexes represent geometric means.

Source: Authors' calculation.

As can be seen in the figures above, annual technical efficiency declined during the period of 2004-2009. As this decline includes the 33% of public banks; the annual technical efficiency index turned out to be 0.996. Furthermore, the drop in the scale efficiency, which is one of the important components of technical efficiency index, gave rise to technical efficiency setback. This setback can be attributed to retrogression in scale efficiency.

In terms of technical efficiency, 2007 is the year when the highest progress was made while 2009 is the year when the heaviest retrogression was observed. In terms of technological progress, 2009 witnessed the highest increase while 2005 saw the lowest. Accordingly, the highest rate in total factor productivity is reached in 2009. Its lowest rate is recorded in 2005. In spite of retrogression in technical efficiency, total factor productivity of public banks rose by 1.5% thanks to technological progress.

3.3 Private Banks

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

Table 6 Changes in Private Banks' Total Factor Productivity and Its Components, 2004-2009 (Malmquist Index Summary of Firms Means)

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
Anadolubank	1.056	1.035	1.046	1.010	1.093
Şekerbank	0.993	1.047	1.000	0.993	1.040
Tekstilbank	1.000	1.031	1.000	1.000	1.031
Turkishbank	1.074	1.087	1.010	1.063	1.167
Turk 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
Mean	1.005	1.050	1.007	0.998	1.056

Source: Authors' calculation.

In terms of average annual technical efficiency, 27% of private banks made progress while 46% of them experienced retrogression; remaining 27% underwent no change. Turkish bank (7.4%) and Anadolu bank (5.6%) are the first two banks that advanced their technical efficiency. Akbank (6.2%) and Is bank (1.2%) are top two to experience a decline in terms of technical efficiency. Adabank, Alternatif Bank and Tekstil Bank did not advance their technical efficiency. Akbank, due to its decline in scale efficiency; Is Bank, due to its decline in both pure technical and scale efficiency, experienced their technical efficiency retrogression. The average annual technological improvement is measured as 5% according to technological change index. It is observed that 100% of private banks made progress technologically during the whole period. Adabank (11.8%) and Turkish Bank (8.7%) are the top two.

Technological change index's having a positive value indicates a decline in the quantity of output produced by the similar quantity of input. In other words, they increase their production efficiency level. With respect to total factor productivity change index, the mean annual growth rate for the concerned period is 5.6%. In terms of total factor productivity, 91% of private banks advanced while 9% retrogressed. The top two banks, Turkish (16.7%) and Adabank (11.8%) advanced their total factor productivity significantly during 2004-2009. Turkish Banks' total factor productivity advancement was caused by its progress in both technology and technical efficiency. Adabank's progress is just because of its technological progress. Akbank retrogressed in total factor productivity by 2.3%. Its retrogression was a result of a setback in technical efficiency. Average changes in private banks' total factor productivity indexes by year are depicted as follows.

Table 7 Average Changes in Private Banks' Total Factor Productivity Indexes by Year (Malmquist Index Summary of Annual Means)

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
* Mean	1.005	1.050	1.007	0.998	1.056

Note: * All Malmquist indexes represent geometric means.

Source: Authors' calculation.

As can be seen in the table, the average annual technical efficiency change index is 1.005. Furthermore, it is found that out of the components of technical efficiency index, pure technical efficiency increased while scale efficiency declined.

2008 is the top year for private banks to advance their technical efficiency. 2005 and 2009 are the retrogression years. However, 2005 is the year of technological progress while 2009 is the year of technological setback. Correspondingly, the highest rate of total factor productivity was achieved in 2005. Despite the technical efficiency retrogression in this year, substantial progress in technology gave rise to a significant advancement in total factor productivity. TFP declined in 2006 and 2008, for which technological setback can be blamed. As of the period average, total factor

productivity of private banks increased by 5.6% thanks to progress in both technology and technical efficiency.

3.4 Foreign Banks

The indexes of change built for technical efficiency change, technological change, pure efficiency change, scale efficiency change and total factor productivity change concerning foreign banks for the period of 2004-2009 are demonstrated in the table below.

Table 8 Average Changes in Foreign Banks' Total Factor Productivity and Its Components, 2004-2009 (Malmquist Index Summary of Firms Means)

Banks	Technical efficiency change	Technological change	Pure technical efficiency change	Scale efficiency change	Total factor productivity (TFP) change
Arap Turk	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 Bank	0.850	1.159	0.947	0.897	0.985
Eurobank	1.028	0.939	1.074	0.957	0.965
Finansbank	0.982	0.995	1.000	0.982	0.977
Fortisbank	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 Bank	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
Mean	1.105	1.025	1.012	1.003	1.040

Source: Authors' calculation.

In terms of average annual technical efficiency, 47% of foreign banks made progress while 35% experienced retrogression; remaining 18% underwent no change. 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 West LB AG (6.6%) are top two to retrogress in terms of technical efficiency. West LB AG, due to its decline in pure technical efficiency; Deutsche bank, due to its decline in both pure technical and scale efficiency, experienced retrogression in terms of technical efficiency. Arab Turkish, Habib and JPMorgan Chase Bank are the banks that underwent no change in terms of technical efficiency.

According to technological change index, the average annual technological progress is measured as 2.5%. 47% of the banks made technological progress while 53% of them declined technologically during the period. West LB AG (16.3%) and Deutsche bank (15.9%) are the top two among the banks that improved technologically. With respect to backwardly operated 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 banks made progress in their total factor productivity while 35% experienced retrogression. The Royal Bank (20.9%) and JPMorgan Chase (15.7%) are the top two to advance their total factor productivity highly during 2004-2009. The Royal Banks' total factor productivity progress may be attributed to its progress in both technology and technical efficiency. Adabank's progress was generated by its technological progress. The first two banks that experienced retrogression in terms of total factor productivity are HSBC (6.5%) and Bank Mellat (5.9%). Average changes in foreign banks' total factor productivity indexes by year are depicted as follows.

Table 9 Changes in Foreign Banks' Total Factor Productivity and Its Components by Year (Malmquist Index Summary of Annual Means)

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
* Mean	1.015	1.025	1.012	1.003	1.040

Note: * All Malmquist indexes represent geometric means.

Source: Authors' calculation.

The table shows that the annual technical efficiency change index increased to 1.015 in 2004-2009. The two components of technical efficiency index, i.e., scale and pure technical efficiency parameters advanced. The improvement in scale efficiency is 0.3% and 1.2% in pure technical efficiency. In consequence of these two improvements, the annual technical efficiency advanced as well. 2005 is the top year for foreign banks in terms of highest technical efficiency rate. Yet, 2008 is the top year of retrogression. Technological advancement reached its peak in 2007 and retrogression in 2005. Correspondingly, the highest rate in total factor productivity is reached in 2007. There occurred retrogression in 2006. As of the period, total factor productivity of foreign banks increased by 4% depending on the progress in both technology and technical efficiency. Changes in foreign banks' total factor productivity index values by year are as follows.

Table 10 Total Factor Productivity Index Value by Years on the Basis of Groups

	Years	Technical efficiency change	Technological change	Pure technical efficiency change	Scale efficiency change	Total factor productivity (TFP) change
All deposit banks	2004-2005	1.266	0.817	1.026	1.233	1.034
	2005-2006	0.907	1.035	1.016	0.893	0.939
	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
Mean	**2004-2009**	**1.015**	**1.035**	**1.006**	**1.009**	**1.050**
Public/ State banks	2004-2005	0.997	0.943	1.000	0.997	0.940
	2005-2006	0.985	1.072	0.984	1.001	1.056
	2006-2007	1.019	0.991	1.016	1.003	1.009
	2007-2008	0.997	0.981	1.000	0.997	0.978
	2008-2009	0.983	1.119	1.000	0.983	1.100
Mean	**2004-2009**	**0.996**	**1.019**	**1.000**	**0.996**	**1.015**
Private banks	2004-2005	0.933	1.324	1.028	0.908	1.236
	2005-2006	1.017	0.975	1.013	1.004	0.991
	2006-2007	0.983	1.033	0.993	0.990	1.015
	2007-2008	1.181	0.839	1.022	1.156	0.991
	2008-2009	0.933	1.144	0.984	0.948	1.066
Mean	**2004-2009**	**1.005**	**1.050**	**1.007**	**0.998**	**1.056**
Foreign banks	2004-2005	1.377	0.675	0.988	1.393	0.929
	2005-2006	1.108	0.810	1.067	1.039	0.898
	2006-2007	0.826	1.665	1.161	0.711	1.375
	2007-2008	0.799	1.155	0.930	0.859	0.923
	2008-2009	1.067	1.077	0.932	1.145	1.150
Mean	**2004-2009**	**1.015**	**1.025**	**1.012**	**1.003**	**1.040**

Source: Authors' calculation.

Total factor productivity index's being more than 1 for both all deposit banks and groups (2004-2009) show an efficiency growth. If we examine the Table 10 for 2005, all deposit banks and groups are observed to have made progress in terms of total factor productivity as compared to 2004. When the groups are compared with each other for 2005 it is concluded that the highest progress was made by private banks (1.236) and the lowest progress was made by foreign banks (0.929).

In 2006, retrogression was experienced by all deposit banks (0.939), foreign banks (0.898) and private banks (0.991) in terms of total factor productivity. Nevertheless, public banks improved their TFP by 1.056. In 2007, all deposit banks and groups improved are found to improve their TFP. The highest level, 1.375, belongs to foreign banks. Analyzing 2008, total factor productivity regression is recognized in all deposit banks and groups. The highest decline ratio, 0.923, belongs to foreign banks. This situation is relatable to global financial crisis of 2007-2008. Last one, in 2009, total factor productivity improvement holds true for all deposit banks and groups. Foreign banks, 1.150, have the highest ratio.

4. Conclusions

This study carries out the performance measurement of the banks during the period of 2004-2009. To evaluate the performance comparison of individual banks and of the subgroups in TBS, total factor productivity change indexes of all deposit banks and groups are measured by Malmquist total factor productivity index which is useful to see differentiation between technical efficiency and technical changes. Both intra-group and bank-to-bank comparisons were made available by these measurements that are aimed at determining which bank group or bank relatively has the highest level of performance under the influence of the Global financial crisis and of recent financial regulatory framework, which escalated the competition in TBS and forced banks to attach more importance to productivity factor for sustainable growth.

The table below indicates the banks with the highest and lowest level of performance measured by considering all of the performance criteria.

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	The highest progress	The greatest decline	The highest progress	The greatest decline	The highest progress	The greatest decline
State/Public banks	-	Ziraat (%1.2)	Vakıf (%8.4)	Ziraat (%1.5)	Vakıf (%8.4)	Ziraat (%2.7)
Private banks	Turkish (%7.4)	Akbank (%6.2)	Adabank (%11.8)	-	Adabank (%11.8)	Akbank (%2.3)
Foreign banks	Societe Generale (%22.6)	Deutsche (%15)	WestLB AG (%16.3)	Societe Generale (%8)	The Royal Bank (%20.9)	HSBC (%6.5)

Source: Authors' calculation.

Turkish and Societe Generale are observed to be the banks with highest level of technical efficiency improvement. Ziraat, Akbank and Deutsche bank are the banks with the highest level of technical efficiency retrogression. Besides, the banks with highest level of technological progress are Vakıf, Adabank and WestLB AG. Ziraat and Societe Generale are turned out to be those which made the lowest technological progress. Thus, it is concluded that the banks with the highest total factor productivity growth rate are Vakıf, Adabank and The Royal Bank. The top three highest retrogressions in terms of this criterion were experienced by Ziraat, Akbank and HSBC. In the light of all measured performances; the banks with the highest and the lowest performance among all deposit banks are listed below.

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

	Technical efficiency change		Technological change		Total factor productivity (TFP) change	
	The highest progress	The greatest decline	The highest progress	The greatest decline	The highest progress	The greatest decline
Bank in each group	ING (% 9.5)	Deutsche (% 15)	Adabank (% 18.7)	Eurobank (% 7.9)	Societe Generale (% 26.1)	Deutsche (% 8.9)

Source: Authors' calculation.

ING bank is observed to have improved technical efficiency at optimum level, and Deutsche bank is observed to have experienced the greatest decline. In terms of technological change, the bank with the highest progress is Adabank while Eurobank Tekfen is the one who experienced the greatest retrogression. In detail, while Societe Generale is discovered to have seen the highest level of total factor productivity growth rate while Deutsche is observed to have had the lowest. Turkish (private bank) and Societe Generale (foreign bank) - banks that recorded the highest increase in terms of technical efficiency while Ziraat (public/state bank), Akbank (private bank) and Deutsche Bank (foreign bank) are those who underwent the greatest decline. At the same time Ziraat and Societe Generale are the banks with the lowest technological progress.

As the tables suggest, the foreign banks, thanks to positive changes in their technology, are found to be more effective than other groups in terms of technical efficiency and total factor productivity. Even if the main aim of this paper is not to sort out the effects of the recent global crisis of 2007-2008, we can underline an important point: even if the government officials have insisted that the recent global crisis changed the environment of financial sector all over the world, banks in the body of TBS did not suffer any setbacks because of stronger capital asset ratio along with other financial reforms. However, the recent global crisis has, even so in small amounts, affected all deposit banks; they operate better afterwards in terms of TFP: in detail, technical efficiency change went down in 2007-2008 period as technical change increased strangely.

In terms of groups, foreign banking group reflects more response to the crisis since it has been observed that these banks have been very responsive to any small fluctuations in macroeconomic variables such as interest rate, exchange rate, inflation rate, etc. Reason of this is that when we compare national/domestic banks (combination of private and state or public banks) with foreign banks, the latter has higher liquidity ratio, lower interest rate risk, and higher capital adequacy ratio. Besides, their customer profile, financial management, and the usage of more technology are different compared with private and state banking groups. In this picture, decline in technological change plays a larger role than decline in technical efficiency change.

Having started in the early 1980s, the globalization of capital around the world left Turkey to the following situation with regard to policy implication: TBS must improve itself by means of the competition between domestic and foreign banks in a competitive market structure supported by competent governmental bodies. Besides, there are also defendants of the idea implying that BRSA must efficiently and effec-

tively control banking system and that participation of foreign banks in TBS serves the interests of the sector itself and then, of the Turkish economy. Finally, given bank size, profitability level and equity variables are key determinants of a bank's decision to securitize in Turkish case, how changes in the TFP affect securitization decisions of the banks in TBS would be of high importance in terms of policy implication. Considering the popularity of the said securitization among the banks during the period of 2004-2009, this interaction may be handled in a further study. In the scope of such study, it may be also interesting to see to measure efficiency in terms of input and output simultaneously, and to transfer input contractions and output improvements into our current model.

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