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Efficiency, Technological and Total Factor Productivity Change in Turkish Banking Sector

Türk Bankacılık Sektörünün Toplam Faktör Verimliliği, Etkinlik ve Teknolojik Değişiminin Analizi

Onur Akkaya, Kilis 7 Aralık University, Turkey, onurakkaya@kilis.edu.tr

Abstract: Especially, November 2000 and February 2001 crises adversely affected Turkish economy and particularly Turkish banking sector. In the post-crisis period, extensive structural changes have taken place in Turkish banking sector. Interest of foreign banks for Turkish market increased. Some new foreign banks entered into Turkish banking sector through acquisition, while existing foreign banks increased their operations. Foreign banks are expected to bring new practices and advance technology to the market and enhance competitive pressure in banking (Aysan et al.;2011). In this context, this paper addresses the following questions: How does technology change after the post-crisis period in Turkish banking sector? How affected the technology change in Turkish banking sector? How affected the technical efficiency change and the scale efficiency change in Turkish banking sector? and finally, how affected the total factor productivity change in Turkish banking sector? So, in this paper, I analyse the changes efficiency and technology change in Turkish banking sector in the light of the facts discussed above, and focus on the total factor productivity of Turkish banking sector and the existence of the relationship between efficiency and technology change.

Keywords: Efficiency, Stochastic Frontier Approach, Total Factor Productivity, Turkish Banking Sector

Öz: 2000 ve 2001 ekonomik krizleri Türkiye ekonomisi ve Türk bankacılık sektörünü derinden etkilemiştir. Krizler sonrası bankacılık sektörü yapısal değişimlere maruz kalmıştır. Yabancı yatırımcının Türk bankacılık sektöründeki ağırlığının arttığını kriz sonrası dönemde görebiliriz. Bu yabancı yatırımcılardan yeni deneyimler ve ileri teknolojiyi sektöre dahil edip sektörün rekabet koşullarını arttırmaktır (Aysan ve diğerleri ;2011). Bu bağlamda, bu çalışmanın cevap aradığı sorular; 2000 ve 2001 krizleri sonrası; Türk bankacılık sektöründeki teknolojik değişimin durumu, sektördeki teknik etkinlik ve ölçek etkinliğinde yaşanan değişimin boyutu ve aynı dönemde sektördeki toplam faktör etkinliği ölçümü ve değerlendirilmesi yapılmıştır. Çalışmada, ağırlıklı olarak sektördeki etkinlik ve teknolojik değişim üzerinde durulduğu söylenebilinir.

Anahtar Kelimeler: Etkinlik, Stokastik Sınır Yaklaşımı, Toplam Faktör Verimliliği, Türkiye Bankacılık Sektörü

1. Motivation

The improvement that Turkey economy experienced after the year 2001, rising economic stability and the anti-inflationary program that was put in place positively influenced the banking sector. Additionally, restructuring of the banking system ensured that the significant structural problems that dragged the industry into a crisis overcome.

Thanks to the consolidation and positive economic developments that took place in the restructuring process, the banking system started to grow again, and the balance sheet structure was re-shaped. With the rising demand for loans, the share of loans within assets increased, the proportion of securities portfolios with low liquidity decreased the financial structure became stronger, and profitability performance improved. The large growth potential of the Turkish banking industry and the acceleration of Turkey's EU accession process brought about an exponential interest by foreign capital into the industry and direct investments by foreign investors and banks and other financial institutions increased. The New Banking Law[1], which regulates and directly influences the activities of banks, was significantly harmonized with the EU regulations. Almost all of the sub-regulations related to the New Banking Law were completed and made applicable within the year 2006.

New regulations put into implementation in areas such as the identification of corporate management principles and measuring liquidity adequacy of banks. Importance was attached to developing risk management and organizational structure, improving the asset quality and strengthening liquidity and capital adequacy.

As part of the regulations, the decision was taken to make sure that capital adequacy is at or above 12%. These regulations, which are of direct interest to the banking activities, will have a positive contribution to enlarging and deepening the financial industry and further bolstering competition. The number of banks with

[1] The new banking law, Banks Act No. 4389, was enacted in order to both simplify supervision standards as well as bring these standards in line with EU directives, international practices and core principles stated by the Bank for International Settlements (BIS). In addition, the new law stipulated the establishment of the Banking Regulation and Supervision Agency (BRSA) as an independent entity with the mission "to safeguard the rights and benefits of depositors and to create the proper environment, in which banks and financial institutions can operate with market discipline in a healthy, efficient and globally competitive manner, thus contributing to the achievement of long-run economic growth and stability of the country."

foreign capital, which was 15 in the year 2001, decreased to 13 in the year 2003. The crisis that afflicted the banking industry at that time can indicate as the primary reason for this decline. Following the year 2003, the number of banks with foreign capital started to increase and reached 17 in the year 2009.Considering the number of commercial banks in the same period, the number of banks, which was 22 in 2002, dwindled to 11 in 2009. In spite of this significant fall in the number of commercial banks between the years 2001-2009, a change of similar rate was not observed in the number of banks with foreign capital. The reason behind is that the banks with foreign capital operating in Turkey conducted attempts to merge by acquiring the commercial banks at stake. The Turkish banking sector restructured following the crisis that took place in the year 2001, and it became equipped with an effective control and monitoring system. Especially the increase in foreign capital that entered the industry using banking acquisition and mergers after the crises in 2001-2002 brought about a new beginning in the Turkish banking system. Accordingly, the banks with foreign capital became active in addition to the banks with public capital and private local capital present in the system.

A key motivation for this paper is that after the financial crisis, it demonstrates the efficiency of the banking system. Also, it takes a look at the issue from the perspective of both foreign entrants and the host country for the Turkish banking sector. Given the focus of this research motivation above, the focus of this thesis can be summarized by the following main research questions: How does technology change after the post-crisis period in Turkish banking sector? How affected the technology change in Turkish banking sector? What is the technology change advantage or disadvantage for Turkish banking sector? Is there a relation between efficiency and technology change?

Analyzing the efficiency and technological change in the Turkish banking sector in the light of the relationships previously discussed, the focus of this analysis is on efficiencies of the Turkish banking sector and the existence of the relationship between efficiency and technological change. The first step was to test "*the global advantage hypothesis*" (Berger, 1997b), which highlights the increased importance of foreign bank entry. Levine (1996) considers that the entry of foreign banks into the domestic economy has improved the quality and availability of financial services in the domestic financial market by increasing competition, and enabling a greater application of more modern banking skills and technology. Levine (1996) and Berger (1997b), which compare the performance and efficiency of foreign and domestic banks, show conflicting results. Claessens et al. (2001) finds that foreign banks make higher profits than domestic banks in developing countries, but the opposite is true in developed countries. This perhaps indicates that foreign banks have newer technology than domestic banks in developing countries, whereas in developed countries this advantage does not exist. In this paper, I analyze the changes in efficiency and technology change in Turkish banking sector in the light of the facts discussed above, and focus on efficiencies of Turkish banking sector and the existence of the relationship between efficiency and technology change. The plan of the paper is as follows. Section 2 scans a literature review of technology change approach and related banking sector. Section 3 descriptive the methodology. Section 4 describes the data and the empirical results. Section 5 concludes.

2. Literature Review of Total Factor Productivity

Ican obtain a measure Total Factor Productivity (TFP) change that has two components, a technical change component and a technical efficiency change component. Nishimizu and Page (1981) estimated translog production frontiers using the Aigner and Chu (1968) linear programming methods and proposed a measure of TFP growth that was the sum of an efficiency change component and a technical change component. However, it should be noted that they did not derive their TFP induces directly using ratios of distances but instead via derivative concepts.

Zhang et al. (1994) take the Malmquist Index of TFP growth and describe how one can decompose the Malmquist TFP change measures into various components, including technical change and efficiency change. They also show how these measures could be calculated using distances measured relative to Data Envelopment Analysis frontiers.

The distance measures required for the Malmquist TFP index calculations can also be measured relative to a parametric technology. A number of papers have been written in recent years that describe ways in which this can be done. The majority of these can be classified into two groups: those that derive the measures using derivative-based techniques and those that seek to use explicit distance measures. The two approaches tend to provide TFP formulate and decompositions that are quite similar (Coelli et al.;2005).

Lovell et al. (2000) based on the measures using derivative-based techniques. FThey investigated the impact of regulatory reform on the performance of Spanish savings banks. A flexible variable profit function that incorporated time-varying technical efficiency. The focus is whether increased competition brought on by deregulation affected performance of banks over time. Bank performance, measured by the percentage change in profitability, ceteris paribus, was decomposed into technical change and change in technical efficiency both of which are defined in terms of the profit function. An empirical result showed declining levels of output technical efficiency along with a significantly high rate of technical progress. In spite of declining technical efficiency during this period, they found evidence of an increasing trend in productivity growth.

Fuentes et al. (2001) and Orea (2002) based on the translog distance function methods. Fuentes et al. (2001) confirmed that parametric distance functions could be used as an alternative method for Malmquist index estimation. They also showed that within the period under analysis, which corresponded to a period of deregulation of insurance markets in Europe, the sector showed very low rates of productivity change. Some evidence of positive technical change appeared, yet this could not be attributed to output or input technical bias in insurance production.

Orea (2002) investigated the advantages of the suggested method compared to Balk (2001)'s approach. The results showed an increase in total factor productivity for both merged and non-merged banks. Although the main factor contributing to this increase was strong technical progress, returns to scale also have a positive effect on productivity growth, indicating that the scale effect should be included when examining bank productivity growth.

3. Methodology

3.1 Technical Efficiency

The technical efficiency is the maximum output to produce when a firm's input can be expressed as. It described that input efficiency resulting from the suboptimal use of inputs can be decomposed into allocative and pure technical in efficiency.

Consider a panel data for N firms observed over T periods. Let y_{it} and x_{it} represent, respectively, the logarithms of a scalar output level and the input vector of k inputs for firm i at time t. The production function is specified as:

$$y_{it} = \alpha_{it} + \beta x_{it} + v_{it} \quad (1)$$

Where v_{it} is the error term that represents random shocks β is the vector of k parameters for the input vector. The firm and time specified intercept, α_{it}, is a function of a firm specific intercepts (α_i) systematic factors that might persistently influence the firm's productivity and the position of the firm's production frontier over time (w_{it}). Random factors relating to technical inefficiency are modeled as a one-sided error term (u_{it}). The firm specific intercept is assumed ton systematically evolve over time as an auto regressive (AR(1)) process;

$$\alpha_{it} = \alpha_i + \varphi\alpha_{i,t-1} + \gamma w_{it} - u_{it};\ u_{it} \geq 0 \quad (2)$$

Since technical inefficiency is introduced into the model through the intercept and not as a deterministic function of time, Ican include time as one of the explanatory variables in the vector α_{it}. This allows us to distinguish between technical change and efficiency change. The above model can rewritten as

$$y_{it} = \alpha_i + \varphi y_{i,t-1} + \beta x_{it} - \beta\varphi x_{i,t-1} + \gamma w_{it} - \varepsilon_{it} \quad (3)$$

$$\text{where } \varepsilon_{it} = (v_{it} - \varphi v_{i,t-1}) - u_{it};\ u_{it} \geq 0$$

The composed error term εin (9) has one component ($v_{it} - \varphi v_{i,t-1}$) that follows an MA(1) process that is two sided and the other component (u_{it})is one-sided. Technical inefficiency of a firm i at time t is measured by $y^f{}_{it} - y_{it}$(i.e., the deviation of the observed output y_{it} from the maximal producible output ($y^f{}_{it}$)given by

$$y^f{}_{it} = \alpha_i + \varphi y_{i,t-1} + \varphi\beta x_{i,t-1} + \gamma w_{it} \quad (4)$$

Technical efficiency (TE) is measured by

$$TE_{it} = e^{y_{it} - y^f{}_{it}} = e^{-u_{it}} \quad (5)$$

3.2. Scale Efficiency

The scale efficiency shows that firm operates a minimum point in the long-term cost curve. Scale efficiency addresses the question as to whether a banking firm has the right size. It refers to the relationship between a firm's per unit average production cost and production volume. When a firm's per unit production cost declines as its output increases, the firm is said to enjoy economies of scale. Diseconomies of scale may also exist when per unit cost of production begins to rise beyond a certain level of production. Scale dis economies may arise because it may become more costly to manage a very large firm or due to management laxity. A U-shaped average cost curve would imply economies of scale at the early stages of output technology, induced over staffing and operation of uneconomic branches (Ikhide; 2000).

Measures of returns to scale are also available in the multi-output case, and they can be defined in terms of the cost function. For example, a measure of overall scale economies is

$$\varepsilon_c = [\textstyle\sum^{M}{}_{m=1} dlnc(w,q)/dlnq_m]^{-1} \quad (6)$$

The firm will exhibit increasing, constant or decreasing returns to scale as ε_c is greater than, equal to, or less than one. In the multiple-output case, it is also meaningful to consider the cost savings resulting from producing different numbers of outputs. Three measures of so-called economies of scope are:

$$S = [\sum^{M}{}_{m=1} c(w, q_m)/c(w, q)] - 1 \ (7)$$

$$S = c(w, q_m) + c(w, q_{M-m}) - c(w, q)/c(w, q) \ (8)$$

and

$$S = d^2c(w, q)/dq_m dq_n \ (9)$$

where $c(w, q_m)$ denotes the cost producing the m_{th} output only; and $c(w, q_{M-m})$ denotes the cost of producing all outputs except the m_{th} output. The measure defined by a measure of global economies of scope, and gives the proportionate change in costs if all outputs are produced separately – if S>0 then it is best to produce all outputs as a group; if S<0 then it is best to produce all outputs separately.

The measure defined by a measure of product-specific economies of scope, and gives the proportionate change in costs if the m_{th} output is produced separately and all other outputs are produced as a group if S_m>0 then it is best to produce all outputs as a group; S_m<0 then it best to produce the m_{th} output separately. It gives the change in the marginal cost of producing the m_{th} output with respect to a change in the production of the n_{th} output. The firm experiences economies of scope with respect to the n_{th} output if this derivative is negative.

3.3. Technological Change

Until now, I have only analyzed cross-sectional data, i.e. all observations refer to the same period of time. Hence, it was reasonable to assume that the same technology is available to all firms (observations). However, when analyzing time series data or panel data, i.e. when observations can originate from different time periods, different technologies might be available in the different time periods due to technological change. Hence, the state of the available technologies must be included as an explanatory variable in order to conduct a reasonable production analysis. Usually, a time trend is used as a proxy for a gradually changing state of the available technologies.

3.3.1. Production Functions with Technological Change

In case of an applied production analysis with time-series data or panel data, usually the time (t) is included as additional explanatory variable in the production function:

$$y = f(x, t). \ (10)$$

This function can be used to analyze how the time (t) affects the (available) production technology.

Estimation methods:

The *average* production technology can be estimated from panel data sets by the OLS method (i.e. “pooled") or by any of the usual panel data methods (e.g. fixed effects, random effects). The *frontier* production technology can be estimated by many different specifications of the stochastic frontier model. will focus on three specifications that are all nested in the general specification:

$$lny_{kt} = lnf(x_{kt}, t) - u_{kt} + v_{kt}, \ (11)$$

where the subscript $k = 1, ..., K$ indicates the firm, $t = 1, ..., T$ indicates the time period, and all other variables are defined as before. Iwill apply the following three model specifications:

1.Time-invariant individual efficiencies, i.e. $u_{kt} = u_k$, which means that each firm has an individual fixed efficiency that does not vary over time;

2.Time-variant individual efficiencies, i.e. $u_{kt} = u_k exp(-\eta(t-T))$, which means that each firm has an individual efficiency and the efficiency terms of all firms can vary over time with the same rate (and in the same direction).

Cobb-Douglas Production Frontier with Technological Change:

in case of a Cobb-Douglas production function, usually a linear time trend is added to account for technological change:

$$lny = \alpha_0 + \sum \alpha_i lnx_i + \alpha_t t \ (12) \ \textit{(Model-1)}$$

Given this specification, the coefficient of the (linear) time trend can be interpreted as the rate of technological change per unit of the time variable t:

$$\alpha_t = \delta lny/\delta t = \delta lny/\delta y * \delta y/\delta t \sim \frac{\frac{\Delta y}{y}}{\Delta x}$$

Translog Production Function with Constant and Neutral Technological Change:
a translog production function that accounts for constant and neutral (unbiased) technological change has following specification:

$$lny = \beta_0 + \sum\beta_i lnx_i + 1/2\sum\sum\beta_{ij} lnx_i lnx_j + \beta_t t \text{ (13) } \textit{(Model-2)}$$

In this specification, the rate of technological change is

$$\Delta lny/\delta t = \beta_t \text{ (14)}$$

and the output elasticises are the same as in the time-invariant Translog production function :

$$\epsilon_i = \delta lny/\delta lnx_i = \beta_i + \sum\beta_{ij} lnx_j \text{ (15)}$$

In order to be able to interpret the first-order coefficients of the (logarithmic) input quantities (β_i) as output elasticities (ϵ_i) at the sample mean, mean-scale the input quantities. Additionally, we mean-scale the output quantity in order to obtain the same estimates as Coelli et al.(2005, p.250).
Translog Production Function with Non-Constant and Non-Neutral Technological Change:
Technological change is not always constant and is not always neutral (unbiased). Therefore, it might be more suitable to estimate a production function that can account for increasing or decreasing rates of technological change as well as biased (e.g. labor saving) technological change. This can be done by including a quadratic time trend and interaction terms between time and input quantities:

$$lny = \delta_0 + \sum\delta_i lnx_i + 1/2\sum\sum\delta_{ij} lnx_i lnx_j + \delta_t t + \sum\delta_{ti} lnx_i + 12\delta_{tt} t^2 \text{(16) } \textit{(Model-3)}$$

In this specification, the rate of technological change depends on the input quantities and the time period:

$$\Delta lny/\delta t = \delta_t + \sum\delta_{it} lnx_i + \delta_{tt} t \text{ (17)}$$

and the output elasticities might change over time:

$$\epsilon_i = \delta lny/\delta lnx_i = \delta_i + \sum\delta_{ij} lnx_j + \delta_{ti} t \text{ (18).}$$

In order to be able to interpret the first-order coefficients of the (logarithmic) input quantities (δ_i) as output elasticities (ϵ_i) at the sample mean and the coefficient of the linear time trend (δ_t) as rate of technological change at the sample mean, it is not sufficient to use mean-scaled input quantities but I also have to adjust the time trend (t) so that it is zero at the sample mean. If I subtract the sample mean, the sample mean of the adjusted time trend is zero and the difference between two successive years remains one so that the marginal effects can still be interpreted as annual rates of technological change is zero.

4. Data and Definition of Variables

The data used in this study were obtained from the Banks Association of Turkey, which is a professional organization, which is a legal entity with the status of a public institution, established pursuant to Article 79 of the Banks Act. The data set was prepared by using the balance sheet and revenue charts of banks pertaining to the period from 1999 to 2013. Seventeen banks operating in the banking industry of Turkey as of 1999 are included in the scope of the study. The total assets of these 17 banks constitute 83% of the total assets of the industry. Four of the banks that are not included in this study were transferred to the Savings Deposit Insurance Fund for liquidation. The other excluded banks either had data reporting issues or have been more recently established.

The general tendency in studies conducted on the activity of banks is to measure the bank activity by following either intermediation or production approach. According to the intermediation approach, banks are financial brokerage institutions used in producing financial services and products with their deposits and purchased inputs. Studies examining bank activity using the cost function generally use the intermediation approach and the same method is followed here. In that respect, it is assumed that the banks in Turkey use three inputs and produce one output. Descriptive statistics of the key variables are presented in [Table 1].

Table.1 Descriptive statistics

Variable Description	**Name**	**Mean**	**Minimum**	**Maximum**	**Std. Deviation**
The total value of *output* (in TL) for Banks involved	***ln(OUTPUT)***	21095547	5831	1.62E+08	32930252
The total value of *deposit* (in TL) for Banks involved	**ln(DEP)**	14370228	212	1.26E+08	22852317
The total value of *equity* (in TL) for Banks involved	***ln(EQ)***	2306079	283	17921364	3539053
Total value of *labor expenditure* (in TL) for Banks	***ln(LABOR)***	257358.3	15	1819222	329895

5. Empirical Results

In this section, I presented and discussed the empirical results obtained indirectly from a functional form on product behaviors of individual banks in Turkish Banking Sector.

In Cobb-Douglas production frontier with time invariant (CD with time-invariant), the elasticity associated with the Deposit is the largest. The sum of the three production elasticities (0.42+0.22+0.27) is 0.91 suggesting very mild decreasing, returns to scale at the sample mean data point. The coefficient of time is 0.002, which indicates mean technical progress of 0.2% per year.In Translog Production Function with Constant and Neutral Technological Change (TPF with Time-invariant), the elasticity associated with the Deposit is the largest.The sum of the three production elasticities (0.57+0.15+0.30) is 1.02 suggesting very mild increasing, returns to scale at the sample mean data point. The coefficient of time is 0.003, which indicates mean technical progress of 0.3% per year. In Translog Production Function with Non-Constant and Non-neutral Technological Change (TPF with Time-invariant)[2], the sum of the three production elasticities (0.59+0.19+0.23) is 1.01, suggesting very mild increasing returns to scale at the sample mean data point. The coefficient of time is -0.005, which indicates mean technical progress of 0.5 % per year (Table.2).

The percentage change measures of technical efficiency change (TEC), technical change (TC), scale change (SC) and total factor productivity change (TFPC) were calculated for each model. These measures have been averages across banks and then converted into cumulative percentage change measures, which are reported in Table.3.

[2] is based on Fuentes et al. (2001)

Table.3 Cumulative Percentage Change Measures of Technical Efficiency Change (TEC), Technical Change (TC),Scale Change (SC) and Total Factor Productivity Change (TFPC)

Models	**TEC**	**TC**	**SC**	**TFPC**
CD with Time-invariant	0.670	0.002	0.91	1.582
TPF with Time-variant	0.713	-0.005	1.011	1.720
TPF with Time-invariant	0.712	0.002	1.013	1.735

The following likelihood ratio tests compare a biased technological change with the Cobb- Douglas production frontier as well as the Translog production frontier that can account for constant rates of technological change that does account for technological change and with the Cobb-Douglas production frontier that only accounts for constant and neutral technological change (Table.4).

The following likelihood ratio tests compare a biased technological change with the Cobb- Douglas production frontier as well as the Translog production frontier that can account for non-constant rates of technological change that does account for technological change and with the Cobb-Douglas production frontier that only accounts for constant and neutral technological change (Table.5).

The following likelihood ratio tests compare the Translog production frontier that can account for non-constant rates of technological change as well as biased technological change with the Translog production frontier that does not account for technological change and with the Translog production frontier that only accounts for constant and neutral technological change (Table.6).

The result of likelihood ratio test shows that the Cobb-Douglas with time-invariant model is fit model about our estimation. Figure.3 provides a summary of individual technical efficiency scores of individual banks in Turkish Banking Sector.

On the other hand, these tests indicate that the translog production frontier that can account for non-constant rates of technological change as well as biased technological change is superior to the translog production frontier that does not account for any technological change but it is not significantly better than the Translog production frontier that accounts for constant and neutral technological change. Although it seems to be unnecessary to use the translog production frontier that can account for non-constant rates of technological change as well as biased technological change, I use it in our further analysis for demonstrative purposes. The following commands create short-cuts for some of the estimated coefficients and calculate the rates of technological change at each observation: The following command visualizes the variation of the individual rates of technological change. The resulting graph is shown in histogram in figures.3. Most individual rates of technological change are between−3.5% and +3.5%, i.e. there is technological regress at some observations, while there is strong technological progress at other observations. This wide variation of annual rates of technological change is not unusual in applied banking production analysis because of the stochastic nature of banking production.

The results in Table 7 indicate that about half of the sample banks seem to have been brought about mainly by a positive technical efficiency change, suggesting that sampled banks seem to have been able to exploit also some catching up effect. Then, the Adabank is had the lowest technical efficiency score in all of the banking sector. So, the Türkiye Vakıf Bank is had the highest technical efficiency score in all of banking sector. The eight different banks are under the average score of banking sector and the nine different banks are over the average score of banking sector. The Türkiye Vakıf Bank is most efficient in the all of public banks. Then, the Akbank is the most efficient in all of private sector banks. The Habib Bank is the most efficient in all of foreign banks.

6. Conclusion

This paper presents an empirical study of TFP in the Turkish banking sector during the post-reform period from 1999 to 2013. The key motivation for this paper is that after the financial crisis, it demonstrates the efficiency of the banking system. Also, it takes a look at the issue from the perspective of both foreign entrants and the host country for the Turkish banking sector. A Cobb-Douglas and Translog input distance function is chosen to represent the production technology, and each component of the Malmquist index is computed using the estimated parameters. This parametric approach allows us to test statistical hypotheses regarding different components of the Malmquist index and the nature of production technology. The main findings are:

- The empirical application to the Turkish banking sector shows that productivity grows at 3.5 percent per year on average from 1999 through 2013. The growth mostly drove by technical change, which is found to be technology neutral.
- The level of technical efficiency averages 0.882, with high-efficiency scores in all of the sector. The recent rise in technical efficiency is a reason for concern, suggesting sufficient the banking sector infrastructure and supportive policies. On average, productivity grows at 3.5 percent per year was mostly driven by technical change.
- The result of the decomposition of the technical change indicates that it is technology neutral despite the input mix moving closer to the technical optimal. Scale efficiency marginally contributes to productivity growth.
- The coefficients of time interacted with the deposit, equity, and labour input variables are near zero, positive and negative, respectively, suggesting that technical change has been deposit-saving but labour-using over this period. Visually, this indicates that the isoquant is shifting inwards at a faster rate over time in the labour-intensive part of the input space. This result most likely a consequence of the rising relative cost of labour as the process of development continues in Turkey. However, Turkey, which is the biggest and fastest developing country in the Eastern European area. Low profitability in the home country was one of the most cited push factors that led foreign banks to pursue opportunities in the Turkish financial market with high-profit potential.
- I tested "*the global advantage hypothesis*" states that foreign-owned banks to be more efficient due to some comparative advantage that domestic-owned banks lack. These advantages stem from advanced technologies, more superior managerial skills, more efficient organizations due to stiff competition in the home market, a more active market for corporate control and better access to an educated labour force with the ability to adapt to new technologies. Claessens et al. (2001) find that foreign banks make higher profits than domestic banks in developing countries, but the opposite is the case in developed countries, which indicates that foreign banks have better technology than domestic banks in developing countries. The findings have clear foreign banks in the Turkish banking sector are more efficient than domestic banks (Claessens et al., 2001).

Lastly, the contribution for this paper is twofold. Firstly, *the global advantages hypothesis* was the first time tested with the literature of Stochastic Frontier approaches for Turkey case. Secondly, it shows the structure factor of the banking system. Then, this results showed that technological change in the Turkish banking sector is so slowly developments after the banking crisis. So, it can form an opinion for policy makers about the structural reforms need to keep up the Turkish banking sector. The results may help in future decisions of policy makers and bankers.

REFERENCES

Abbasoğlu, O. F., Aysan, A. F., & Gunes, A. (2007). Concentration, competition, efficiency and profitability of Turkish banking sector in the post-crises period.

Ahmet Faruk Aysan, Mustafa Mete Karakaya, Metin Uyanik (2011). Panel stochastic frontier analysis of profitability and efficiency of Turkish banking sector in the post-crisis era, Journal of Business Economics and Management, 12:4, 629-654.

Aigner, D. J., & Chu, S. F. (1968). On estimating the industry production function. The American Economic Review, 58(4), 826-839.

Balk, B. M. (2001). "Scale Efficiency and Productivity Change." Journal of Productivity Analysis 15 (3): 159–183.

Berger A., Mester L. 1997a. "Inside the Black Box: What Explains Differences in the Efficiency of Financial Institutions?" *Journal of Banking and Finance*; 21(7); pp.895–947.

Berger AN., DeYoung R. 1997b. "Problem Loans and Cost Efficiency in Commercial Banking." *Journal of Banking and Finance*; 21(6); pp.849–870.

Berger AN., Humphrey DB. 1997c. "Efficiency of Financial Institutions: International Survey and Directions for Future Research." *The Wharton School*; 05; pp.175–212.

Claessens S., Demirgüç-Kunt A., Huizinga H. 2001. "How Does Foreign Entry Affect the Domestic Banking Market?" *Journal of Banking and Finance*; 25(5); pp.891–911.

Coelli, T., and S. Perelman. (2000). "Technical Efficiency of European Railways: A Distance Function Approach." Applied Economics 32 (15): 1967–1976.

Coelli, T. J., P. D. S. Rao, and G. E. Battese. (2005). An Introduction to Efficiency and Productivity Analysis. Boston: Kluwer.

Erdogan, Niyazi. (2002). Financial crises in Turkey and in the world. Yaklasım Publishing, Ankara.

Fuentes, H., E. Grifell -Tatje, and S. Perelman. (2001). "A Parametric Distance Function Approach for Malmquist Productivity Index Estimation." Journal of Productivity Analysis 15: 79 – 94.

Gunay Ozkan, N.E.; Tektas A. (2006). Efficiency analysis of Turkish banking sector in pre-crisis and crisis period: a DEA approach, Contemporary Economic Policy (ISSN 1074-3529),Vol. 24, No. 3, 418–431.

Handoussa, H., Nishimizu, M., & Page, J. M. (1986). Productivity change in Egyptian public sector industries after 'the opening', 1973–1979. Journal of Development Economics, 20(1), 53-73.

Ikhide, S. (2000). Efficiency of Commercial Banks in Namibia. BON Occasional Paper No. 4.

Isik, I.; Hassan, M. K. (2002b). Cost and profit efficiency of Turkish banking industry: an empirical investigation, The Financial Review 37: 257–280.

Karluk, Rıdvan. (1999). Turkish economy . Beta Publishing Press, Istanbul.

Kasman, A.; Kasman, S. (2011).Efficiency, Productivity and Stock Performance: Evidence from the Turkish Banking Sector, PANOECONOMICUS, Vol.3, 355-372.

Kasman, A. (2002).Cost Efficiency, Scale Economies, and Technological Progress in Turkish Banking, Central Bank Review, 1-20.

Levine R. 1996. "Foreign Banks, Financial Development and Economic Growth." In: Claude, E.B. International Financial Markets; AEI Press; Washington; DC.

Lovell C.A.K. 2000. "The Decomposition of Malmquist Productivity Indexes." *Journal of Productivity Analysis*; 20; pp.437– 458.

Lovell, C. A. K. (2003). "The Decomposition of Malmquist Productivity Indexes." Journal of Productivity Analysis 20: 437– 458.

Nishimizu, M., J. M. Page (1982). "Total Factor Productivity Growth, Technological Progress And Technical Efficiency Change : Dimensions Of Productivity Change" Economic Journal, 920–936.

Orea, L. (2002). "Parametric Decomposition of a Generalized Malmquist Productivity Index." Journal of Productivity Analysis 20: 437– 458.

Zhang, Y., and B. Brummer. (2011). "Productivity Change and the Effects of Policy Reform in China's Agriculture since 1979." Asian- Pacific Economic Literature 25 (2): 131– 150.

APPENDIX

Table.2 Stachastic Production Frontier Estimation Results

Models	**TPF with Time-variant**	**TPF with Time-invariant**	**TPF**	**CD with Time-invariant**	**CD**
	Estimate	Estimate	Estimate	Estimate	Estimate
(Intercept)	0.1638852***	0.1678673**	0.189650***	3.6596157 ***	3.649595***
log(DEP)	0.5893934***	0.5724794***	0.570000***	0.4203312***	0.420046 ***
log(EQ)	0.1928298***	0.1495025***	0.152332***	0.2228031***	0.225954 ***
log(LABOR)	0.2311884**	0.3028173***	0.306691***	0.2704817***	0.269280 ***
I(0.5*log(DEP)^2)	0.2392697***	0.2397519 ***	0.240067***		
I(0.5*log(EQ)^2)	0.1341558**	0.1085661**	0.109869**		
I(0.5*log(DEP)^2)	0.4871883***	0.4419046 **	0.445712***		
I(log(DEP) * log(EQ))	-0.0295235	-0.0526732	-0.052766		
I(log(DEP) * log(LABOR))	-0.2723939***	-0.2557795***	- 0.256252***		
I(log(EQ) * log(LABOR))	-0.0928184	-0.0487053	-0.050425		
Year(*t*)	-0.0056021	0.0028122		0.0020803	
I(Year * log(DEP))	-0.0062856				
I(Year * log(EQ))	-0.0157427				
I(Year * log(LABOR))	0.0224463*				
I(0.5 * Year^2)	0.0049652				
SigmaSq(σ^2)	0.3378379***	0.3349520***	0.334615***	0.4702635***	0.468945 ***
gamma (γ)	0.9419821***	0.9297951***	0.929145***	0.7633851 ***	0.761361 ***
Mean Efficiency	**0.7139034**	**0.7127936**	**0.7123405**	**0.6700904**	**0.6705373**
signif. codes: 0 '***' 0.001 '**'	0.01 '*' 0.05 '.,	' 0.1 ' ' 1			

Table.4 TPF with Time-invariant and CD with Time-invariant Likelihood Ratio Test Results

1	Model 2	**TPF with Time-invariant**			
2	Model 1	**CD with Time-invariant**			
	#Df	LogLik	Df	Chisq	Pr(>Chisq)
1	13	-78.717			
2	7	-152.323	-6	147.21	< 2.2e-16 ***

signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table.5 TPF with Time-variant and CD with Time-invariant Likelihood Ratio Test Results

1	Model 3	**TPF with Time-variant**			
2	Model 1	**CD with Time-invariant**			
	#Df	LogLik	Df	Chisq	Pr(>Chisq)
1	17	-75.840			
2	7	-152.323	-10	156.81	< 2.2e-16 ***

signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table.6 TPF with Time-variant and TPF with Time-invariant Likelihood Ratio Test Results

1	Model 3	**TPF with Time-variant**			
2	Model 2	**TPF with Time-invariant**			
	#Df	LogLik	Df	Chisq	Pr(>Chisq)
1	17	-75.840			
2	13	-78.717	-4	5.7541	0.2183

signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table.7 Technical Efficiency Score of Individual Banks (from 1999 to 2011)

Banks	Technical Efficiency	List of Banks
Adabank	0.67491735	Private Bank
Akbank	0.96549944	Private Bank
Alternatif Bank	0.85460400	Foreign Bank
Anadolu Bank	0.78506822	Private Bank
Arap Turk Bankası	0.87739955	Foreign Bank
Bank Mellat	0.86138609	Foreign Bank

Deniz Bank	0.90854596	Foreign Bank
Finans Bank	0.87226198	Foreign Bank
Habib Bank	0.9470198	Foreign Bank
HSBC Bank	0.89814370	Foreign Bank
Seker Bank	0.82530512	Private Bank
Turk Ekonomi Bankası	0.83786480	Private Bank
Türkiye Ziraat Bankası	0.95598938	Public Bank
Türkiye Halk Bankası	0.90867608	Public Bank
Türkiye İs Bankası	0.93376852	Private Bank
Türkiye Vakıflar Bankası	0.97076991	Public Bank
Yapı Kredi Bankası	0.92870323	Private Sector
Average of Banking Sector	**0.88275325**	

Figure.3 Technological Change in the Turkish Banking Sector

from 1999 to 2011