Cost Efficiency, Scale Economies, and Technological Progress in Turkish Banking

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Abstract

This paper uses a three input–three output Fourier-flexible cost function specification to investigate cost efficiency, scale economies, and technological progress in the Turkish banking system over the period 1988-1998. Our findings suggest that the Turkish banking system has a significant inefficiency problem. Although the annual inefficiency average decreased over the sample period due to the financial liberalization, commercial banks in the sector operated more inefficiently than their U.S. and European counterparts. The results suggest the existence of significant economies of scale for all groups in the sample and no evidence of diseconomies of scale even for larger banks. The results also indicate the existence of technological progress between 1988 and 1991.

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1. Introduction

The objective of this paper is to measure the cost efficiency, scale economies, and technological progress of Turkish commercial banks in the deregulated period 1988-1998. The cost efficiency of banking has been investigated in numerous studies for the U.S. and other advanced countries [see Berger et al. (1993) and Berger and Humphrey (1997)].[1] However, little research has been carried out on the efficiency of banking sector in developing countries.

The Turkish banking system, like banking in many other countries, experienced legal, structural, and institutional changes as a result of the financial liberalization program in the 1980s. Prior to 1980, the Turkish banking system was characterized by a number of features that resulted in inefficiencies and distortions in resources allocations. The Turkish banking system was a closed system and heavily regulated in terms of market entry and interest rates due to inward-oriented economic policies. Furthermore, international capital movements and foreign exchange operations were subject to tight controls.

The main goal of the financial liberalization program was to increase the efficiency of the financial intermediaries by fostering competition among banks. To encourage foreign banks and national banks to enter the market, most restrictions on market entry, interest rates, and exchange rates were eliminated. As a result of the deregulation, the number of banks in the industry increased from 43 in 1980 to 75 in 1998, of which 21 were foreign banks. As a result of the increasing number of institutions and branches, competition has considerably increased in the sector and the five-firm concentration ratio (CR5) decreased from 60% in 1988 to 44% in 1998. Developments in computing and communications, increased international trade, and also increased exchange volatility have contributed to a global explosion of financial innovations such as consumers loans, credit cards, swaps, factoring, repurchase agreement, futures, forwards, etc. Today, the banking system is facing both intra-industry and inter-industry competition, both domestic and international, for the same customers.

The removal of legal barriers on commercial banking was intended to enhance the efficiency of Turkish banks. The effect of the new regulatory and competitive environment on banks can be judged by measuring their performance. Relative to

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[1] Berger and Humphrey (1997) review 130 studies of financial institution efficiency, using data from twenty-one countries. Of the 130, 116 of the studies were written between 1992 and 1996.

the U.S. and Western European countries, the knowledge of technology, cost structure, and efficiency of the banking industry is in a very early stage in Turkey. Both bank managers and regulators of banking need information on the cost efficiency and technological structure of the industry in order to support their business and policy decisions. Zaim (1995), Ertugrul and Zaim (1996), and Denizer et al. (2000) examine the effectiveness of these liberalization efforts in the Turkish banking system. Zaim (1995) and Ertugrul and Zaim (1996) investigate the impact of financial liberalization on the efficiency of Turkish banking using the data employment analysis method (DEA)[2] and find positive effect on efficiency. Denizer et al. (2000) examine the efficiency of Turkish commercial banks in a pre and post-liberalization environment using DEA approach and find that liberalization program were followed by an observable decline in efficiency. Mercan and Yolalan (2000) provide a survey of the other studies on the efficiency of the Turkish banking system.

In this paper, we examine the productive efficiency of Turkish commercial banks in the deregulated period. This study significantly differs from earlier studies in two respects. First, in contrast to Zaim (1995), Ertugrul and Zaim (1996), and Denizer et al. (2000) we use stochastic frontier methodology to estimate X-inefficiency, scale economies, and technological change for a panel of Turkish commercial banks using a three input-three output Fourier-flexible cost function specification. This approach allows us to separate random noise from the inefficiency. This is important because measurement errors are the main problem in banking data. Therefore, the main objective of this study is to provide such information using answers to the following in the rest of the paper: a) Have banks become more efficient over the sample period? b) Do big banks enjoy cost advantages over smaller banks? c) What is the effect of technological progress on costs? Secondly, in this study, we examine the performance of the banking system in the deregulated period. This period witnessed rapid technological change in the production of financial and banking services. Banks operating in the industry had to make strategic decisions to adjust themselves to the new legal and economic environment.

[2] The data envelopment analysis (DEA) approach is a non-parametric methodology in which linear programming is used to measure the distance of individual banks from the efficient, or "best-practice", frontier. All deviations from the efficient frontier are assumed to be due to inefficiency. Therefore, it is not stochastic. The main disadvantage of the DEA approach is that it does not allow banks to deviate from the frontier due to random errors.

The rest of the paper is organized as follows. Section 2 gives a brief overview on the Turkish banking system. Section 3 introduces the model and the econometric specification and estimation methods. Section 4 reports the empirical results. The paper's conclusions are summarized in section 5.

2. A Brief Overview on the Turkish Banking System

In Turkey, there were 75 banks, of which 15 were development and investment banks and the rest were commercial banks. These 75 banks had 7,370 branches. That means approximately one branch for each 8,500 inhabitants in 1998. Commercial banks are the dominant institution in the Turkish banking system. Because of less developed capital markets, the banks are the main source of funding for the industrial and commercial businesses. Although the newly developing capital markets are able to compete with the banking sector, banks are still dominant in the financial system, as in other developing countries' financial systems. Investment banks specialize in underwriting securities. Development banks, on the other hand, obtain funds from the government or other international institutions like the World Bank. The acquired funds have traditionally been used to make medium and long term loans to selected industries. Three types of ownership exist in the Turkish banking system; state-owned banks, private national banks, and foreign banks. Four state-owned banks held more than 35% of industry's total assets in 1998 and control the bulk of the funds in the banking industry.

The Turkish banking system was a closed system and heavily regulated with respect to market entry and interest rates before 1980. To increase efficiency and create competition in the financial system, the Turkish government announced a liberalization program in January 1980. The main objective of this program was to establish a Western-type free market economy and competition. Most of the 1980s witnessed continues legal and institutional changes in the financial system. The banking system was deregulated and a new banking law was enacted in 1985. Most restrictions concerning market entry and interest rates were eliminated. Opening the banking system to the foreign banks was intended to be a crucial element of competition. The new banks started to enter the market, and severe competition started in the first part of 1980. The number of banks increased from 43 in 1980 to 75 in 1998.

There have been also several important technological developments in the industry in recent years. Banks have started computerizing all their operations and have introduced Automatic Teller Machines (ATMs), on-line system of communication, and PC banking since 1987. They have also changed their product mix and introduced new products to the markets. Therefore, the period between 1988 and 1998 seems to be the most suitable for studying the Turkish commercial banks in terms of cost efficiency and technological progress since the fundamental institutional framework necessary for the operation of the financial markets was established immediately before this period.

3. Model

For a given technology, the production function represents the maximum amount of output that can be produced from a given combination of inputs. From microeconomic theory, we know that a production plan is efficient if there is no way to produce more output with the given inputs or to decrease inputs leaving output unchanged.[3] Farrell (1957) defines a measure of technical efficiency as one minus the maximum equiproportionate reduction in all inputs that still allows continued production of given outputs (Lovell, 1993). Since production functions are usually unobservable, duality theory (Shephard, 1970) indicates that, under certain conditions, the properties of a production function can be studied through the cost function or profit function. If a cost function satisfies linear homogeneity and concavity in input prices, then the production function can be studied indirectly.

Assuming that banks are cost minimizing organizations, their production process can be represented by the function $C = f(p, y)$. In theory, production plans and cost levels are derived from rational and efficient decisions, and all firms perform on their frontiers. Therefore, there is no inefficiency in production. In practice, on the other hand, observations on cost levels and production plans indicate that they are not derived from rational and efficient decisions due to errors, poor production plans, managerial inability, and distorted communication (e.g. X-inefficiency). These factors cause a firm to produce inside of its frontier. Thus, estimation techniques must be able to separate this error component from the theoretical frontier. Two main estimation methodologies have been developed to serve this purpose – the econometric frontier approach and the mathematical programming approach or data envelopment analysis (DEA).[4]

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[3] See Varian (1992) for technical details.

[4] See Bauer (1990), Greene (1993), and Ali and Seiford (1993) for further information.

In the present paper, we use the econometric frontier approach to estimate the cost efficiency of the Turkish banking industry since econometric frontier techniques can separate random noise from inefficiency.[5] There are various econometric frontier techniques. The stochastic econometric frontier approach (SFA) and the distribution free approach (DFA) are commonly used methods. The SFA was developed independently by Aigner et al (1977) and Meeusen and Broeck (1977). The primary advantage of this approach is to separate the random noise from inefficiency components. An important criticism of the SFA is that the distributional assumptions are overly restrictive to be used in estimation using a single year's data (Allen and Rai, 1996).

It is possible to avoid distributional assumptions on the error terms by using panel data. The "distribution free" model developed by Schmidt and Sickles (1984) and Berger (1993) uses panel data for estimating efficiency. Unfortunately, their model assumes that inefficiency is constant over time. Since our task is to examine changes in the efficiency and technological progress of the banking over the sample period, the assumption that efficiency is constant over time is not reasonable. In our case, the Turkish banking industry experienced some major changes over the sample period. Therefore, we will assume that inefficiency varies across observations and time, and we use the stochastic econometric frontier approach to estimate the efficiency and technological progress for each year in the sample period. The cost frontier is obtained by estimating a Fourier-flexible cost function with a composite error term.

The cost function is specified as follows:

$$\ln tc_i = \ln f\left(p_i, y_i, B\right) + u_i + v_i \quad for \quad i = 1, \ldots\ldots\ldots, N \tag{1}$$

where tc_i represents observed total cost for firm *i*, and p_i and y_i represent vectors of input prices and output, respectively. *B* is a vector of parameters. u_i is an error term $\left(u_i \geq 0\right)$ that represents inefficiency, and v_i is a random error term distributed independently of u_i. The SFA requires specific distributional assumptions for the two components of error term and generally assumes that

[5] Cost efficiency refers to both technical and allocative efficiency. Technical efficiency is defined using minimal level of inputs given output and the input mix. Allocative efficiency, on the other hand, implies that a firm uses its inputs in the optimal proportions.

inefficiencies follow an asymmetric half-normal distribution, while random errors follow a symmetric normal distribution.[6]

The general procedure for estimating efficiency using equation (1) is to estimate equation coefficients and $\varepsilon_i = u_i + v_i$, and to calculate efficiency for each observation in the sample. The log-likelihood function of this model is

$$\ln L = \frac{N}{2}\ln\frac{2}{\pi} - N\ln\sigma - \frac{1}{2\sigma^2}\sum_{i=1}^{N}\varepsilon_i^2 + \sum_{i=1}^{N}\ln\left[\Phi\left(\frac{\varepsilon_i\lambda}{\sigma}\right)\right] \qquad (2)$$

where N is the number of firms and $\varepsilon_i = u_i + v_i$. Jondrow et al. (1982) show that the ratio of variability, σ, can be used to measure a firm's mean efficiency, where $\sigma^2 = \sigma_u^2 + \sigma_v^2$, $\lambda = \sigma_u / \sigma_v$, and Φ is the standard normal cumulative distribution function.

Bank-level measures of inefficiency are usually given by the mean and mode of the conditional distribution of u_i given ε_i. Inefficiency measures can be derived as follows:

$$E(u_i \mid \varepsilon_i) = \frac{\sigma\lambda}{(1+\lambda^2)}\left[\frac{\phi(\varepsilon_i\lambda/\sigma)}{\Phi(\varepsilon_i\lambda/\sigma)} + \frac{\varepsilon_i\lambda}{\sigma}\right] \qquad (3)$$

where ϕ and Φ are the standard normal density function and the standard normal distribution, respectively. $E(u_i \mid \varepsilon_i)$ is an unbiased but inconsistent estimator of u_i, since regardless of N, the variance of estimator remains non-zero. To obtain an estimate of inefficiency for each bank in the sample, the estimated distributional parameters and the estimated ε_i are substituted into equation (3). Inefficiency measures are calculated in this paper for each of eleven years for each bank in the sample.

Estimation of the Frontier Function

Banks, like other firms, use a set of inputs to produce a certain amount of output. The methods that a bank uses to combine financial input (borrowed funds) and physical inputs (labor and capital) define its underlying production technology. Observations on financial and physical input prices and output quantities are used to

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[6] Greene (1990) shows that the half-normal assumption on the inefficiencies is inflexible relative to other distribution, such as the gamma, and it arbitrarily restricts most firms to be clustered near full efficiency. Nevertheless, the half-normal assumption is the most common in this literature.

estimate a cost function that helps us to examine the underlying technology of banks in the industry.

There is little agreement in the banking literature on the explicit definition and measurement of banks' inputs and outputs. One of the main problem faced by researchers examining banks' cost efficiency relates difficulties in the definition and measurement of the concept of bank output, mainly as a result of the nature and functions of financial intermediaries. The most controversial issue regards the role of deposits: on one hand, it is argued that deposits are an input to the production process - intermediation approach; on the other hand, it is argued that they are an output - production approach. Berger and Humphrey (1997) pointed out that, although there is no 'perfect approach', the intermediation approach may be more appropriate for evaluating entire financial intuitions because this approach is inclusive of interest expenses, which account for one-half to two-thirds of total costs. Since total interest expenses account more than two-thirds of total costs and the deposits are the main sources of funds in the Turkish banking we use intermediation approach, which views financial institutions as mediators between the supply and the demand of funds.[7] The intermediation approach assumes that banks collect deposits and other purchased funds with the assistance of labor and physical capital and intermediate these sources of funds into earning assets such as loans and investment securities. The intermediation approach concentrates on the total costs that include both operation and interest expenses. Three outputs are used in this study y_1 = short-term loans, y_2 = long-term and specialized loans, and y_3 = securities.

We specify the Fourier-Flexible nonparametric form for the cost function to characterize the efficient frontier for the Turkish commercial banks. This specification allows the data a large degree of flexibility in choosing the global shape of the cost frontier, and avoids the problems associated with local approximations, such as translog.[8] The multi-product cost function for a given bank *s* at time *t* can be specified as follows:

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[7] Interest expenses account about 77% of total costs in the Turkish banking system between 1988 and 1999.

[8] Fourier-Flexible form is a global approximation that has been shown to dominate the commonly specified translog form. The global property of Fourier-Flexible form is important in banking, where scale and product mix are often far from the mean. When using translog cost function, one holds the maintained hypothesis that the banking industry's true cost function has the translog form. If this maintained hypothesis is false misspecification error occurs. When using the Fourier-Flexible functional form, one avoids holding any maintained hypothesis by allowing the data to reveal the true cost function

$$\ln C = \alpha_0 + \sum_{i=1}^{3} \alpha_i \ln y_{ist} + \frac{1}{2}\sum_{i=1}^{3}\sum_{k=1}^{3} \alpha_{ik} \ln y_{ist} \ln y_{kst} \quad (4)$$

$$+ \sum_{j=1}^{3} \beta_j \ln p_{jst} + \frac{1}{2}\sum_{j=1}^{3}\sum_{m=1}^{3} \beta_{jm} \ln p_{jst} \ln p_{mst}$$

$$+ \sum_{i=1}^{3}\sum_{j=1}^{3} \delta_{ij} \ln y_{ist} \ln p_{jst} + \gamma_1 \ln BR_{st} + \frac{1}{2}\gamma_2 \left(\ln BR_{st}\right)^2$$

$$+ \sum_{i=1}^{3} \psi_i \ln y_{ist} \ln BR_{st} + \sum_{j=1}^{3} \xi_j \ln p_{ist} \ln BR_{st}$$

$$+ \theta_1 t + \frac{1}{2}\theta_2 t^2 + \sum_{i=1}^{3} \phi_i y_{ist} t + \sum_{j=1}^{3} \tau_j p_{jst} t + \nu_1 \ln(NPL/L) + \nu_2 \ln(L/TA)$$

$$+ \sum_{i=1}^{3} [\eta_i \cos(z_{ist}) + \lambda_i \sin(z_{ist})] +$$

$$\sum_{i=1}^{3}\sum_{j=1}^{3} [\eta_{ij} \cos(z_{sti} + z_{jst}) + \lambda_{ij} \sin(z_{ist} + z_{jst})] + u_{st} + v_{st}$$

Where C = total cost function; y_i = outputs (short-term loans, long-term and specialized loans, and securities); p_j = input prices (borrowed funds, labor, and capital); BR = number of branches; t = a proxy of technological index; NPL/L is the ratio of non-performing loans to total loans; L/TA is the ratio of liquid assets to total assets; z_i = the adjusted values of the log output $\ln Y_i$ such that they span the interval $[0, 2\pi]$.[9,10] Following Berger et al. (1997) we restrict the z_i to span $[0.1 \cdot 2\pi, 0.9 \cdot 2\pi]$, cutting 10% off of each end of the $[0, 2\pi]$ interval to reduce approximation problems near the end points.

In theory, the duality condition implies that the cost function must be monotonically increasing in input prices and outputs and concave in input prices. To ensure monotonicity requirement, two standard properties of the cost function -

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through a large value of fitted parameters. See Mitchell and Onvural (1996), Berger et al. (1997), and McAllister, P. H. and D. McManus (1993) for further discussion.

[9] The formula for z_i is $0.2\pi - \mu \cdot a \ln Y_i$, where $\mu \equiv (0.9 \cdot 2\pi - 0.1 \cdot 2\pi)/(b-a)$ and [a, b] is the range of $\ln Y_i$.

[10] Since the input prices show very little variation across banks we exclude Fourier terms for the input prices in order to have limited number of Fourier terms to measure scale economies.

symmetry and linear homogeneity in input prices - are imposed before estimation. The symmetry condition requires:

$$\alpha_{ik} = \alpha_{ki} \text{ and } \beta_{jm} = \beta_{mj}$$

The linear homogeneity condition, on the other hand, requires:

$$\sum_{j=1}^{3} \beta_j = 1, \sum_{j=1}^{3} \xi_j = 0, \sum_{m=1}^{3} \beta_{jm} = 0, \sum_{i=1}^{3} \phi_i = 0,$$

$$\sum_{j=1}^{3} \delta_{ij} = 0, \sum_{j=1}^{3} \tau_j = 0, i = 1, 2, 3, j = 1, 2, 3.$$

For linear homogeneity, we can rewrite cost and prices using p_3 (price of capital) as a numeraire. The number of branches is treated as a technological condition of the production.[11] It characterizes the technology of firms and interacts with all other exogenous variables in the model. We also include linear and square time trends (t and t^2) in our cost frontier to capture the missing time dimension of inputs or other dynamics that are not modeled explicitly.

Following Mester (1996) we use the ratio of non-performing loans to total loans NPL/L as the output quality proxy. We also use the ratio of liquid assets to total assets to account for liquidity risk.

Our database was built on information from the annual reports of individual banks, which includes their balance sheets and income statements for the years 1988 to 1998. These reports were obtained from the Banks Association of Turkey. There were 60 commercial banks in 1998. One national private (Site Bank) and three foreign banks (Habib Bank, Kibris Bank, and Ulusal Bank) were omitted from the sample due to data inconsistency. We include banks that operated at least four years. Therefore, four banks (ING Bank, Rabobank, Anadolu Bank, Deniz Bank) that operated in the sector less than four years were eliminated from the sample due to high start up costs. The state-owned banks were also excluded form the data set. The state-owned banks and private banks have significantly different goals and objectives. The main objective of private banks is to maximize profits. The state-owned banks, on the other hand, do not attempt to maximize profits and also carry a huge amount of duty losses in their balance sheets. The state-owned banks may also

[11] See Mester (1987).

have different cost structures from those of the private banks and are not independent in selecting their portfolio structure.[12]

Our unbalanced panel data include eleven years. Table 1 provides the descriptive statistics for the input and output variables, and total assets for 1998. Total assets of banks range from $12.41 million to $7.73 billion. The Turkish banking industry includes a few large private and state-owned banks. More than 20 banks had assets less than $500 million. Although small and medium-size banks are numerically dominant in the industry, the concentration ratio is still high.

Table 1
Summary Statistics of Data for 1998

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
Total Assets	1405.02	634.99	2049.12	12.41	7731.02
Total Costs	311.07	173.91	383.09	2.81	1383.72
S-T Loans	495.91	245.53	808.49	0.75	3820.64
L-T Loans*	83.17	12.19	235.56	0.00	1364.10
Securities	244.58	104.03	366.78	0.36	1706.66
Price of Labor	0.023	0.019	0.013	0.006	0.065
Price of Funds	0.281	0.201	0.293	0.048	0.727
Price of Capital	0.396	0.283	0.377	0.007	1.650
Branches	92.60	41.00	153.90	1.00	838.00

*About ten banks in the sample did not produce long-term loans in the sample period. Therefore, in order to estimate the normalized cost function specified in equation (4), banks reporting zero long term loans, we added $1,000 to long term loans for all banks in the sample as suggested in the literature (Mester, 1987).
Note: Assets, costs, and loans are in millions of U.S. dollars.

Economies of Scale and Technological Progress

Overall scale economies measure the relative change in a firm's total cost for a given proportional change on all outputs. We use following form in equation (4) to estimate overall (or ray) economies of scale:

$$\hat{\rho} = Scale = \sum_{i=1}^{3} \frac{\partial(\ln C(p, y, BR, t)}{\partial \ln y_i}$$

$$= \sum_{i=1}^{3} \left[\alpha_i + \sum_{k=1}^{3} \alpha_{ik} \ln y_{kst} + \sum_{j=1}^{3} \delta_{ij} \ln p_{jst} + \psi_i \ln BR + \sum_{i=1}^{3} \phi_i t \right] \qquad (5)$$

[12] One referee suggested that because the state-owned banks do not attempt to maximize profits their behaviors in the financial markets cannot be explained by the usual economic rationale and therefore, efficiency scores from a common cost frontier are not comparable.

$$+\mu_i \sum_{i=1}^{3} [-\eta_i \sin(z_{ist}) + \lambda_i \cos(z_{ist})]$$

$$+2\mu_i \sum_{i=1}^{3} \sum_{j=1}^{3} [-\eta_{ij} \sin(z_{ist} + z_{jst}) + \lambda_{ij} \cos(z_{ist} + z_{jst})]$$

Scale measures are estimated for each bank in the sample at its respective output levels y_1, y_2, and y_3. If $\hat{\rho}$ is less than one (indicating economies of scale), then banks are operating below the optimal scale levels and can reduce costs by increasing output further. If $\hat{\rho}$ is greater than one (indicating diseconomies of scale), then banks should reduce their output level to achieve optimal input combinations.

We assume that costs are also influenced by technological progress in addition to factor prices and output levels. Therefore, we include linear and squared times trends in the cost specification and allow them to interact with other exogenous variables. The effect of technological change on aggregate cost can be calculated as follows:

$$\hat{\mathrm{T}} = \frac{\partial \ln C(p, y, BR, t)}{\partial t} = \left[\theta_1 + \theta_2 t + \sum_{i=1}^{3} \phi_i y_{ist} + \sum_{j=1}^{3} \tau_j p_{jst} \right] \qquad (6)$$

Technological progress exists when $\hat{T}$ is negative. The first two elements on the right hand side of Equation 6 represent pure technological change, while the third element is associated with scale augmenting technological change (technological change due to modification in the scale of production). The last element of Equation 6 measures non-neutral technological change (Kumbhakar and Heshmanti, 1996).

4. Empirical Results[13]

Parameter estimates are presented in Appendix.[14] The implication of the empirical results is discussed based on the average values of the inefficiency scores

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[13] McAllister and McManus (1993) argue that fitting a single cost function for both large and small banks might result in a misspecification problem. To check whether parameters are stable for large and small banks, we divided sample into two sub-samples of small and large banks, by using total assets. We considered banks having total assets less than $1000 million as small banks. Then, we estimated regressions for both samples and used the Chow-test to test stability of the parameters. The null hypothesis of identical parameters for both sub-samples cannot be rejected at the 5% significance level. Therefore, all measures of efficiencies are based on the parameter estimates of the full sample.

[14] The estimated function verifies regulatory conditions which require that the cost function must be a positive non-decreasing function in respect to *y*; monotonic, concave, linearly homogenous, and twice differentiable in input prices *p*. Linear homogeneity and symmetry conditions are imposed during the estimation, but other theoretical conditions can be tested. For monotonicity, we calculated the derivates for each bank with respect to input prices and outputs. The derivatives are all positive and therefore, the cost function is monotonically increasing.

obtained for the 48 private commercial banks in the sample, for eleven time periods. Table 2 shows the estimated X-inefficiency, scale economies, and technological progress results. Although the average estimated inefficiency scores fluctuates along the eleven years it decreases by 3.3 percent between 1988 and 1993 and 4.5 percent between 1995 and 1998. There is a jump in average inefficiency in 1994 due to the currency crisis. The value of the U.S. dollar nearly tripled against Turkish lira in January 1994. Commercial banks, representing a significant part of the financial sector, were the most affected by this crisis because about half of their liabilities were in foreign currencies. In 1994, the banks operating in the industry were trying to manage high amounts of cash withdraws, to decrease the portfolio risk, and to pay back short-term foreign debt. Some banks had difficulties in paying out their liabilities and therefore, the banking activities of three banks were suspended. The government intervened and introduced full guarantee to all saving deposits in order to prevent the deepening of crisis in the banking sector. The average estimated inefficiency score begins to decrease again between 1995 and 1998. The average value of 0.236 means that Turkish commercial banks could have annually saved about 23.6% of variable cost if they were all able to use the best practice technology. We may conclude that the increased competition in the banking industry due to deregulation in the 1980s led to a better overall performance from the standpoint of costs. Despite the decreased average inefficiency over time due to the deregulation, the Turkish banking sector remains more inefficient than the U.S. and European banking sectors.[15]

Table 2
Average cost efficiency, scale economies, and technological Progress

Year	Inefficiency (u)	Scale Economics		Technological Progress	
1988	0.255	0.702*	(0.035)	-0.029*	(0.0017)
1989	0.226	0.778*	(0.021)	-0.024*	(0.0011)
1990	0.234	0.753*	(0.049)	-0.014*	(0.0013)
1991	0.217	0.783*	(0.023)	-0.008*	(0.0033)
1992	0.221	0.734*	(0.051)	0.003**	(0.0028)
1993	0.222	0.706*	(0.032)	0.016**	(0.0015)
1994	0.269	0.690*	(0.025)	0.027*	(0.0063)
1995	0.270	0.721*	(0.027)	0.033*	(0.0051)
1996	0.234	0.759*	(0.041)	0.038*	(0.0030)
1997	0.221	0.779*	(0.022)	0.049*	(0.0034)
1998	0.225	0.769*	(0.069)	0.056*	(0.0025)
1988-1998	0.236	0.743		0.013	

Standard errors are in parentheses.
* denotes significance level at 1%.
** denotes significance level at 5%.

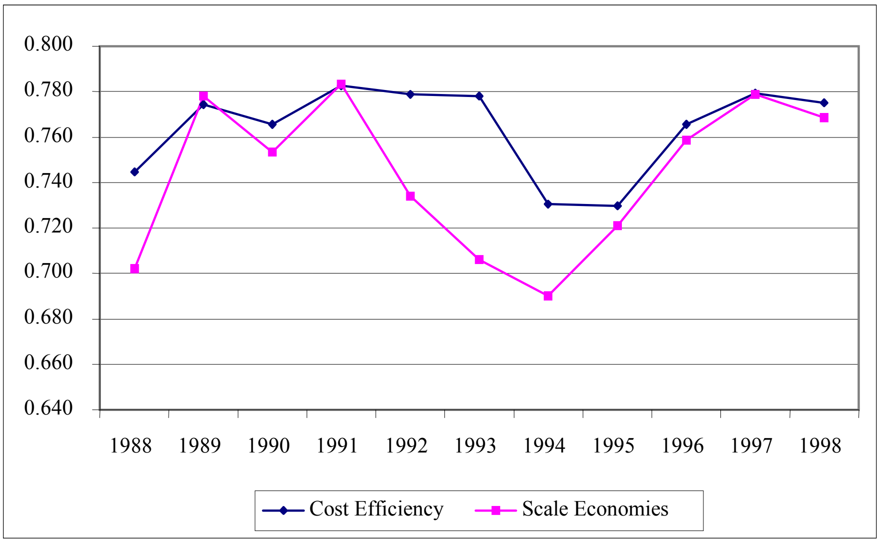
[15] Berger et al. (1993) found that the X-inefficiency for the U.S. depository institutions is around 20 percent of costs. Allen and Rai (1996) report that the average cost inefficiency for the European countries is around 15 percent of cost.

The third column in Table 2 shows scale economies of the banks in our sample. These estimates provide evidence for the existence of significant economies scale in each year in the sample. Although the scale inefficiency decreased over time, there still exists the significant economies of scale. The eleven-year average of scale economies is 74.3%. The results also suggest that scale inefficiencies dominate X-inefficiencies.

As for technological progress, which indicates the possible contribution of technical advance in reducing average banking costs, our results suggest the existence of technological progress from 1988 to 1991. The banking sector witnessed a technological recess between 1992 and 1998, partly due to the currency crises in 1994 and spending great deal of money on technology. The average value of 0.013 for the entire decade implies that the costs of commercial banks increased by about 1.3% during the sample period.

Figure 1 shows the volatility of the estimates of average cost efficiency and scale efficiency. As seen in Figure 1, cost efficiency score fluctuates along the eleven years of our sample, reaching the minimum in 1995 (73%) and maximum in 1997 (77.9%) but increases about 3 percent over the sample period. The average scale efficiency score, on the other hand, fluctuates wildly, reaching the minimum in 1994 (69%).

Fig. 1. Cost Efficiency and Scale Economies



We further examine cost inefficiency, scale economies, and technological progress in the Turkish banking industry by dividing banks into six classes with respect to their total assets. Table 3 shows the measures of cost inefficiency, scale economies, and technological progress for each of these groups. The results suggest that medium-size banks (those with assets more than 400 million and less than 600 million US dollars) and largest banks (those with assets in excess of 2,000 million US dollars) are the most efficient. The less efficient banks are both large banks and small banks. Therefore, there is no clear relationship between size and cost inefficiency.

As for scale economies, our results suggest the existence of significant economies of scale for all classes. In contrast to the findings of the other empirical studies where larger banks were usually seen to be facing scale diseconomies or decreasing scale economies (e.g. Berger et al., 1987), we found evidence of scale economies for each size class in our sample. As seen in Table 3, the measures for all classes are statistically significant at one-percent level. Small banks particularly have great opportunity to move to the right on their average cost curves. The findings of the paper also indicate that magnitude of scale economies is in the range from 41.2 percent for very small banks to 12.2 percent for very big banks.

Observing significant economies of scale for small and medium-size banks raises the question of why these banks did not react to this opportunity and move rightward on their average cost curve, either by increasing output levels or by merging with other banks. The Turkish banking sector has not witnessed any merger activity among private banks in its recent history. Because of significant economies scale in the industry, more merger activity between small banks and medium-size banks would seem likely in near future. Given our findings that Turkish commercial banks suffered both from cost inefficiency and scale inefficiency between 1988 and 1998, an increase in size would realize some cost advantages for all banks, especially small and medium-size ones.

Table 3
Average inefficiency, scale economies, and technological progress, by asset size

Asset Classes (Million US Dollars)	Number of Banks	Inefficiency	Scale Economies	Technological Progress
0-200	11	0.234	0.588* (0.019)	0.024* (0.0006)
200-400	7	0.253	0.708* (0.014)	0.024* (0.0019)
400-600	4	0.233	0.715* (0.057)	0.048* (0.0038)
600-1,000	5	0.241	0.761* (0.062)	0.017* (0.0041)
1,000-2,000	14	0.237	0.801* (0.021)	0.013* (0.0014)
+2,000	6	0.221	0.878* (0.039)	0.005* (0.0026)

Standard errors are in parentheses.
* denotes significance level at 1%.

The fourth column in Table 3 shows the measures of technological progress, which indicates the possible contribution of technical advances in reducing average banking costs. In recent years, banks operating in Turkey have invested tremendous amounts of money in technology. They computerized their operations and built many ATMs around the country. As seen in Table 3, all measures have positive signs. Technological change has not played a role in reducing average costs during the sample period.

5. Conclusion

The main objective of the financial liberalization program was to promote financial market development through deregulation and create competitive and efficient banking sector by encouraging new entrants (both private nationals and foreigners). The program either eliminated or relaxed most restrictions on interest rates and market entry. The goal of this paper was to examine the performance of Turkish commercial banks in the deregulated period 1988-1998. We have used stochastic frontier methodology to measure the cost efficiency of Turkish commercial banks. The findings of paper indicate that although the efficiency of banks operated in the sector increased during the sample period, Turkish banks had a serious efficiency problem. The average inefficiency was 0.236. That means Turkish commercial banks could have annually saved about 23.6% of variable cost if they were all able to use the best practice technology.

Our results indicate that there are statistically significant economies of scale for all size groups in the sample and no evidence of diseconomies of scale even for larger banks. It seems that the large banks in the sample enjoyed a cost advantage over the smaller banks. Since our results suggests significant economies scale particularly for small and medium-size banks, there is room to increase production of outputs by either increasing the scale or merging with other banks to move right on the average cost curve. Therefore, small banks should be encouraged to become larger. In short, an average bank in the sample has not reached the optimal size.

Our results also suggest the existence of technological progress between 1988 and 1991 and technological recess between 1992 and 1998. Banks operating in the industry invested a great amount of money in technology over the period between 1988 and 1998. This increased the fixed costs of all banks. The introduction of advance technology has not been fully utilized. The further increase of outputs may decrease unit cost of new technology.

We stress the fact that this study was conducted using a cost function. Banks may increase their competitive position via diversification as well as income side. Revenue and profit frontiers may provide a more appropriate estimate of efficiency since unlike costs, revenues and

profits reflect the quality of output. Therefore, we intend to investigate further the efficiency of the Turkish banking industry by using revenue and profit functions.

Appendix A

Parameter Estimates and Test Statistics. N=477

Parameters		Estimates	Standard Error	P-value
Constant		4.863*	2.656	0.067
α_1	$\ln y_1$	-0.831	1.540	0.589
α_2	$\ln y_2$	0.195**	0.098	0.047
α_3	$\ln y_3$	0.615	1.231	0.617
β_1	$\ln p_1$	0.889***	0.202	0.000
β_2	$\ln p_2$	0.060	0.127	0.638
γ_1	lnbr	0.507***	0.109	0.000
θ_1	t	-0.013	0.051	0.801
v_1	ln(NPL /L)	0.010*	0.006	0.082
v_2	ln(L /TA)	0.432***	0.071	0.000
α_{11}	$\ln y_1 \ln y_1$	0.405	0.395	0.305
α_{22}	$\ln y_2 \ln y_2$	-0.035*	0.146	0.812
α_{33}	$\ln y_3 \ln y_3$	-0.070	0.473	0.881
β_{11}	$\ln p_1 \ln p_1$	0.130**	0.061	0.035
β_{22}	$\ln p_2 \ln p_2$	0.152***	0.028	0.000
γ_1	lnbrlnbr	-0.004	0.031	0.888
θ_2	t^2	0.006	0.005	0.224
α_{12}	$\ln y_1 \ln y_2$	-0.025**	0.012	0.039
α_{13}	$\ln y_1 \ln y_3$	-0.108***	0.035	0.002
α_{23}	$\ln y_2 \ln y_3$	-0.011	0.010	0.257
β_{12}	$\ln p_1 \ln p_2$	-0.142***	0.037	0.000
δ_{11}	$\ln y_1 \ln p_1$	-0.042	0.031	0.174
δ_{12}	$\ln y_1 \ln p_2$	0.032	0.024	0.185
δ_{21}	$\ln y_2 \ln p_1$	0.009	0.009	0.299
δ_{22}	$\ln y_2 \ln p_2$	-0.006	0.007	0.429
δ_{31}	$\ln y_3 \ln p_1$	-0.015	0.029	0.601
δ_{32}	$\ln y_3 \ln p_2$	0.054**	0.022	0.014
ψ_1	$\ln y_1$lnbr	-0.014	0.022	0.511
ψ_2	$\ln y_2$lnbr	0.016***	0.006	0.009
ψ_3	$\ln y_3$lnbr	-0.041*	0.024	0.090
ξ_1	$\ln p_1$lnbr	0.000	0.032	0.997
ξ_2	$\ln p_2$lnbr	-0.029	0.029	0.310
ϕ_1	$\ln y_1 t$	0.001	0.007	0.912
ϕ_2	$\ln y_2 t$	0.000	0.002	0.996

ϕ_3	$\ln y_3 t$	-0.002	0.007	0.749
τ_1	$\ln p_1 t$	0.000	0.010	0.989
τ_2	$\ln p_2 t$	0.000	0.008	0.963
η_1	$\cos(z_1)$	-0.448	0.617	0.468
λ_1	$\sin(z_1)$	-0.679	2.132	0.750
η_2	$\cos(z_2)$	0.210	0.833	0.801
λ_2	$\sin(z_2)$	0.901	1.865	0.629
η_3	$\cos(z_3)$	0.620	0.907	0.494
λ_3	$\sin(z_3)$	1.546	3.685	0.675
η_{11}	$\cos(z_1+z_1)$	0.258	0.264	0.329
λ_{11}	$\sin(z_1+z_1)$	-0.092	0.170	0.589
η_{12}	$\cos(z_2+z_2)$	0.005	0.226	0.982
λ_{12}	$\sin(z_2+z_2)$	0.108	0.191	0.573
η_{13}	$\cos(z_3+z_3)$	0.045	0.392	0.909
λ_{13}	$\sin(z_3+z_3)$	0.332	0.209	0.112
η_{22}	$\cos(z_1+z_2)$	-0.096	0.087	0.268
λ_{22}	$\sin(z_1+z_2)$	-0.192*	0.112	0.087
η_{23}	$\cos(z_1+z_3)$	-0.406**	0.198	0.040
λ_{23}	$\sin(z_1+z_2)$	-0.192	0.162	0.235
η_{33}	$\cos(z_2+z_3)$	-0.115	0.113	0.310
λ_{33}	$\sin(z_2+z_3)$	0.015	0.103	0.885
R^2		0.97		

*, **, and*** denote significance level at 10%, 5%, and 1%, respectively.
All tests are two-tailed test.
y_1 = Short-term loans
y_2 = Long-term and specialized loans
y_3 = Securities
p_1 = Price of labor
p_2 = Price of borrowed funds
p_3 = price of capital (Note: p_3 was used as a numeraire)
br = Branches
t = Time index
NPL/L=ratio of Non-performing loans to total loans
L/TA=ratio of liquid assets to total assets

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