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A DEA AND TOBIT ANALYSIS OF THE DETERMINANTS OF COST AND PROFIT EFFICIENCY IN THE TURKISH BANKING SECTOR

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ABSTRACT

This paper aims to determine the factors affecting cost and profit efficiency of commercial banks in Turkey and to examine the ownership effect on cost and profit efficiency in an emerging market. Another aim of the study is to carry out the most recent and longitudinal (2006-2020) analysis of efficiency in the Turkish banking industry. This study uses an intermediation approach with data envelopment analysis (DEA) as its methodology. A total of 23 commercial banks were selected as the study sample and their quarterly data from 2006-2020 was collected. In addition, an external two-stage DEA model with Tobit regression was applied to examine the determinants of cost and profit efficiency. The results show that Turkish banks currently work with relatively higher cost efficiency than profit efficiency. On the other hand, foreign banks display a lower cost and profit efficiency performance. The downward trend in profit efficiency in the Turkish banking system sends a warning signal on the health and stability of

the banking sector. Multivariate Tobit regression analysis reveals how Total Assets, Deposit Share, Asset Growth, Time Deposits, NPL, and Ownership Structure significantly affect cost and profit efficiency. Ratio of liquid assets to total assets is positively correlated with the efficiency values, in contrast to results from previous studies. Previous studies have mostly been limited to scale and technical efficiency and focused on the cost efficiency of Turkish banks. In this study, the gap in the literature is filled by a comparative examination of the cost and profit efficiency at the scale of bank ownership. The study will look at and discussed these issues at the most stable period and the pre-pandemic period in the Turkish economy.

Keywords: Efficiency, data envelopment analysis, Tobit regression, two-stage DEA.

JEL Classification: G21, F30, M21, E50.

INTRODUCTION

As elsewhere in the world, the banking sector is a vital part of the financial system in Turkey. In the Turkish economy, the banking sector's total assets realized was USD 823 Billion, and the ratio of total assets to GDP was around 115 percent in 2020. In addition, the loan volume of the banking sector was USD 482 billion, and the percentage of loans to GDP was 74 percent in the same year. These figures underscore the significance of the banking sector in the Turkish economy.

Structural arrangements in Turkish banking have emerged due to the financial liberalization and domestic and foreign financial crises experienced after the 1980s. Among them, the November 2000 and February 2001 crises in Turkey arose directly from the banking system and affected the entire economy. The Weak equity structure of the banking system, faulty asset components, and bad management decisions resulted in the spread of the crisis throughout the economy. To protect the banking system from the occurrence of similar problems, central regulation and supervision activities in the banking system were increased between 2001 and 2005. As a result, the banking system gained a healthy appearance in the following years, profitability and efficiency values increased, and foreign capital inflows increased between 2003 and 2011. Compared to other

developed and developing countries, the effect of the 2009 mortgage crisis on Turkish banking was limited, and it did not cause structural problems, except the temporary loan crunch. This situation is a positive result of the 2001 and 2005 banking regulations. Fifty-four banks were in operation in the banking sector as of 2020 (See Table 1). The share of foreign banks in the industry increased from 45 percent to 62 percent between 2006 and 2020 as foreign investment inflows increased with the structural arrangements made after 2002. The share of loans in state banks increased from 23 percent to 45 percent in 2020 compared to 2006. In the same period, the share of total assets in private banks decreased from 57 percent to 33 percent. It is seen that state banks have increased their claims, especially in loans in recent years, while foreign banks have rapidly increased in numbers. As can be seen in Table 1, deposit banks represented almost 90 percent of the total banking system. For this reason, the research is focused only on deposit banks. In recent years, structural and capital-based changes in the banking system have made it necessary to investigate the capital structure and the related technologies and diversification effects in efficiency analysis.

Table 1

Structure of Turkish Banking Sector

	Number of Banks		Assets (Billion TL)			Deposits (Billion TL)			Loans (Billion TL)		
	2006	2020	2006	2020		2006	2020		2006	2020	
Deposit Banks	33	34	470	5,276	86%	313	3,308	91%	208	3,323	86%
State-owned Deposit Banks	3	3	143	2,321	38%	112	1,501	41%	47	1,489	39%
Privately-owned Deposit Banks	14	8	266	1,732	28%	164	1,051	29%	128	1,056	27%
Foreign Banks	15	21	59	1,220	20%	37	755	21%	33	776	20%
Banks Under the Deposit Insurance Fund	1	2	1	3	0%	0	0	0%	0	2	0%
Development and Investment Banks	13	14	15	387	6%	-		0%	10	284	7%
Participation Banks	4	6	14	437	8%	11	322	9%	10	240	7%
Total	50	54	499	6,100	100%	324	3,630	100%	228	3,847	100%

Source. The Banks Association of Turkey

In recent times, the banking sector has experienced technological developments, intense competition caused by acquisitions and mergers brought about by financial liberalization, consumer rights, and structural regulations of regulatory institutions. These developments have reduced bank revenues, and in turn put the profitability of banks under pressure. As a result, there has been an increase in research on determining efficiency. In the first part of the present study, the efficiency values of 23 commercial banks from the Turkish banking sector were determined using their quarterly financial data between 2006 and 2020. First, the DEA method determines the cost and profit efficiency (CPE) values according to the intermediation approach. Then, R Project, a free mathematical software program, calculates the efficiency values. In the second part of the study, Tobit regression analysis was carried out to detect the determinants of efficiency values.

Efficiency in the Turkish banking sector, as one of the top 20 economies of the world, is a critical area of research. The present study is unique in that it analyzes both cost and profit efficiency separately, using the Tobit method, which is rarely used in studies of Turkish banking. The effect of bank ownership on cost and profit efficiency has been examined with data that are more recent, making this study relevant to today's dynamic banking environment.

The study spans the period of 2006-2020, which is the most recent and comprehensive period examined to date. No other studies thus far have looked at such a wide range of variables together in the Turkish banking sector, making this research a valuable contribution to the literature. The DEA method was used to analyze the cost and profit efficiency of 23 commercial banks in order to provide insights into the structural and capital-based changes in the banking system and their impact on efficiency.

The present study is also notable for its thorough analysis of the determinants of efficiency, including recent technological developments, intense competition, consumer rights, and structural regulations, which are all crucial factors to consider in determining bank efficiency. Such an analysis is of great importance for policy makers, regulators, and practitioners to enable them to make informed decisions about improving the overall efficiency and stability of the banking sector in Turkey. Overall, this research fills a significant gap in the literature by providing the most recent and comprehensive

analysis of the efficiency of the Turkish banking sector, making it a valuable resource for scholars, policymakers, and practitioners alike.

The paper on the study is organized as follows. Section 2 presents an overview of efficiency studies on banking. In section three, the description of a conceptual framework for measuring cost and profit efficiency is introduced. In section four, data and variables are described, and hypotheses on determinants of CPE presented. The empirical findings are discussed in section five. Section six discusses the results, and finally, in the concluding section, policy implications are highlighted.

LITERATURE REVIEW

In studies about the banking sector in developing countries, they have always been attempts about determining the effects of market structure, concentration, competition, financial liberalization, mergers and acquisitions and the internal factors on the efficiency figures. One of the first researches in developing countries is that by Bhattacharyya et al. (1997), study on the Indian banking sector. In that study, the production activities of 70 commercial banks were analyzed during the financial liberalization term. The results showed that state banks had the highest efficiency values (Bhattacharyya et al., 1997). Rezvanian and Mehdian (2002) studied efficiency analysis on the production performance and cost structure of the Singapore banking sector. They showed that there were scale economies in the sector and that the cost inefficiency was caused equally by allocative and technical inefficiency. Another study from India analyzed the effects of liberalization on the CPE in India. The study showed that the decrease in profit efficiency (PE) was due to allocation ineffectiveness. High cost efficiency (CE) and low-PE were indicators of income inefficiency in banking activities. According to the study, bank size, ownership, product variety and positive economic indicators were significant variables that influenced efficiency values (Das & Ghosh, 2009).

The study on banks in Latin America compared foreign and domestic banks in terms of the CPE. These studies, conducted in 16 countries and 427 banks, showed that environmental factors were at the forefront concerning efficiency differences between states, and the

most critical ineffectiveness was income-related (Kasman et al., 2005). Another research approach analyzed liberalization effects on bank efficiency values in Southeast Asian countries. The results revealed a positive relationship between a high liquidity ratio and high-efficiency values and that the efficiency of public and family holding banks was lower than private ones (Williams & Nguyen, 2005). The effect of privatization and foreign ownership on efficiency values in Chinese banks has also been determined. It was found that foreign banks had the highest efficiency values in China (Berger et al., 2009). Kocisova (2014) analyzed the cost, income, and profit efficiencies of Czech and Slovak commercial banks between 2009-2013 by using the DEA method. According to the results, the Czech and Slovak banks were more efficient in terms of income than cost and profit efficiencies. Sufian et al. (2016) found that domestic banks showed higher efficiency values than foreign banks in their studies on the Malaysian banking sector. However, contrary to most of the findings in the literature, their study revealed that capital market movements negatively affected the technical efficiency of the banking system.

The first significant work on efficiency analysis in the Turkish banking sector was the work of Zaim in 1995. In the study, the technical and allocative efficiencies of banks between 1981 and 1990 were calculated using the DEA method, and the effects of liberalization on efficiency values were examined. The findings showed that the reforms influenced technical and allocative efficiency, and the state banks worked more effectively than private banks (Zaim, 1995). Following Zaim (1995), there were other studies by Yolalan, (1996), Yildirim (1999), Cevdet et al. (2007). Jackson and Fethi (2000), Işik and Hassan (2002), and Demir et al. (2005) on the efficiency of Turkish banks by focusing on financial liberalization, ownership, and scale efficiency. According to the results, the effect of liberalization on the sector was limited, and scale inefficiency existed in the sector (Yildirim, 1999). There was however, a positive relationship between bank size and the CPE (Jackson & Fethi, 2000). Competition in the credit and deposit market was below the optimal competition. The oligopolistic structure of the sector had decreased efficiency (Işik & Hassan, 2002).

Studies on the Turkish banking industry mainly focused on the cost side of efficiency; however, findings showed that profit efficiency remained limited. One of the few researchers on profit efficiency

was the study by Isik and Hassan (2002). They found that Turkish banks were highly profit efficient, and the link between cost and profit efficiency was shallow. This revealed that high-profit efficiency did not require high-cost efficiency in the industry. Gunalp and Celik (2004) investigated the relationship between efficiency and competition in the Turkish banking industry between 1990 and 2000. By using the Stochastic Boundary approach, they found a positive correlation between efficiency values and profitability. Abbasoglu et al. (2007) also analyzed the efficiency values of the Turkish banking industry between 2001 and 2005, using the stochastic boundary approach. According to the study results, it was concluded that the concentration in the sector increased, the level of competition followed a fluctuating course, and the sector displayed a monopolistic competitive market structure. Fukuyama and Matousek (2011) analyzed the changes in the efficiency levels of the banking industry during the two crisis periods which occured in Turkey between 1991 and 2007. Unlike the other studies, the "two-stage network model" was used, and the efficiency values were determined only by the VRS method. Yilmaz (2013) conducted a one stage efficiency analysis of the Turkish banking industry between 2007 and 2010 using the DEA method. According to the results, it was determined that domestic banks were more efficient than foreign banks and that the 2009 global crisis harmed efficiency scores. Gunes and Yildirim (2016) concluded that the Turkish banking industry, which has close relations with European countries, was not adversely affected by the 2010 European banking crisis and 2008 financial global crisis. Furthermore, it was observed that the cost efficiencies of Turkish banks did not decrease during these two crises. In the study by Batir et al. (2017), it was seen that based on the data collected between 2005-2013, participation banks had a higher efficiency value than traditional banks. Partovi and Matausek (2019) analyzed the efficiency values in the Turkish banking system through the effect of the NPL. This study showed results supporting the "bad management" hypothesis and revealed that the efficiency values of banks differ according to the capital structure. One of the most recent Turkish banking system studies has been the work by Ozbey and Akan (2021). The study which covered the 2000-2018 period determined that the most efficient banks were private banks, and the effect of personnel expenses on efficiency values was high (Ozbey & Akan, 2021).

This study makes important contributions to the literature in several ways. Firstly, it differs from previous researches in the Turkish

banking industry by analyzing the profit efficiency, which has been rarely studied in recent years. While previous studies (Günalp & Çelik; 2004, Abbasoglu et al., 2007; Fukuyama & Matousek; 2011, Gunes & Yildirim; 2016, Batir et al., 2017; Partovi & Matausek, 2019; Ozbey & Akan; 2021) mainly focused on cost efficiency, this study calculates both cost and profit efficiency separately for commercial banks operating in the Turkish banking system. This comprehensive analysis provides insights into the structural and capital-based changes in the banking system and their impact on efficiency.

Secondly, the study uses both variable returns to scale (VRS) and constant returns to scale (CRS) methods to calculate efficiency values. As each method has its strengths, this approach helps to determine which method is more appropriate to calculate efficiency in the Turkish banking system. Thirdly, the study aims to determine the effect of bank ownership on efficiency values. As Turkey is considered one of the developing economies, it is crucial to understand the efficiency differences between private foreign banks and public banks in the country. The study by Ozbey and Akan (2021) filled a gap in the literature by providing recent data on this aspect. Fourthly, the study included the diversification effect of technological developments, which has been much neglected in previous studies (Günalp & Çelik, 2004; Abbasoglu et al., 2007; Gunes & Yildirim, 2016; Partovi & Matausek, 2019; Ozbey & Akan, 2021). The analysis included the types of activities that were becoming increasingly important in providing non-interest incomes in banking, and it had been able to determine the effect of diversification on profit efficiency. Finally, this research provides the most recent and longest-term (2006-2020) analysis of efficiency in the Turkish banking system. The study's findings offer insights into the impact of recent technological developments, intense competition, consumer rights, and structural regulations on the efficiency of banks. The results could be useful for policymakers, regulators, and practitioners to understand the current state of the banking sector in Turkey and help them make informed decisions to improve its overall efficiency and stability.

METHODOLOGY

The efficiency of a unit is obtained by comparing the realized inputs and outputs of the unit with the optimum inputs and outputs. Efficiency is divided into technical and allocative efficiency (Farrell, 1957). Technical efficiency refers to a unit's capability to get the

most significant number of outputs from inputs. However, allocative efficiency refers to the unit's ability to use inputs optimally according to their prices. Efficiency measures developed over a period of time are primarily split into two parts, namely non-parametric and parametric methods. The most basic non-parametric method is the DEA. The analysis is widely used in the banking sector to compare the efficiency performances of numerous banks, or to estimate the efficiencies between particular bank units. DEA studies are based on Farell's linear convex hull approach in estimating the efficiency line. It is developed and applied to multiple inputs and outputs (Charnes et al., 1978).

In all DEA models, due to the nature of the efficiency measurement, the transformation of inputs (X_1, X_2, ….X_N) to outputs (Y_1,Y_2,….Y_N) is defined, and then the economic decision making units (DMUs) are ranked from the most efficient to the most inefficient. For this purpose, the efficiency value is applied to the entire data set through a virtual efficiency frontier. The virtual efficiency value is estimated by the ratio of weighted outputs to weighted inputs. When the efficiency frontier is estimated, all data points are folded in a convex hull. The efficiency of the DMU which is above the efficiency frontier is evaluated as efficient, and the one below is evaluated as inefficient. The essential feature that distinguishes the DEA from other methods is that it does not require a mathematical or statistical form of production. Moreover, in contrast to parametric methods, since no production function is predicted in the model, false results are also eliminated due to the incorrect estimation of the production function.

Cost and Profit Efficiency

The CE measures the change in cost variables when compared to the estimated cost to obtain the production output set of the best-performing bank. Considering only the costs in evaluating efficiency is insufficient to get an idea about the entire performance of the bank. Although a bank is cost-efficient in output, it may need to be more efficient in income or profitability. The PE occurs once banks demand higher prices for higher quality serving when costs are controlled. Each *k* firm in the industry produces *n* outputs using *m* inputs. For firm *k*, the inputs are represented by the vector *m* and the outputs by the vector *n*. The set of (*x, y*) is formed as a result of the production or technology process, which is summarized as obtaining outputs from inputs. Mechanical, technical, and social elements in the production process set the "technology". The technology or production

possibilities set (PPS) is not precisely known in actual practice, but is estimated from a set of observations. The technology or PPS of a firm can be defined as Equation 1 below (Bagetoft & Otto, 2011):

$$T = \{ (x^k , y^k \in R_+^m \text{ x } R_+^n \mid x \text{ produces } y \} \quad (1)$$

The first of the assumptions used in estimating the PPS is the free disposability assumption. The overused input can be freely disposed of if a firm uses more input than usual to get a standard number of outputs. Likewise, if fewer outputs are obtained with a certain number of inputs, less output can be freely disposed of. This assumption is called the free-disposable hull (FDH). The second assumption regarding the technology set is convexity. Accordingly, since the PPS is convex, if any two points are in the T technology set, their weights or their weighted sums are also in the T technology set (Färe & Primont,1995).

The smallest PPS that meets the convexity and free disposability is as expressed in Equation 2 below.

$$T = \{(x,y): \chi \geq \sum_{k=1}^{K} \lambda_k x^k ; y \leq \sum_{k=1}^{K} \lambda_k y^k ; \sum_{k=1}^{K} \lambda_k = 1; \lambda_k \geq 0; \quad (k = 1,2,\ldots\ldots,K)\} \quad (2)$$

Suppose w is the input price vector of a firm with an input-output set (x^0 , y^0). In this case, the current cost is $C^0 = w'x^0$. The min. cost of producing the targeted output is as follows in Equation 3:

$$C\ (w, y^0) = min\ w'x : (\ x,y^0\ ) \in T. \quad (3)$$

Based on the estimated set of production possibilities T, the minimum cost is obtained as $C^* = min\ w'x$ (Das & Ghosh, 2009).

$$\sum_{k=1}^{K} \lambda_k y^k \geq y^0;$$

$$\sum_{k=1}^{K} \lambda_k x^k \leq x;$$

$$\sum_{k=1}^{K} \lambda_k = 1; \tag{4}$$

$$\lambda_k \geq 0; (k = 1,2,\ldots\ldots,K)$$

In this case, the firm's CE is measured as $\gamma = C^*/C^0 \leq 1$.

In order to measure the CE, outputs are considered exogenous data. Therefore, there is a restraint on the applicability of the chosen set. In such a case, profitability provides a more appropriate criterion for efficiency measurement. Profit maximization under DEA is obtained as follows in Equation (5) (Ray, 2004).

$$\Pi^* = maks\ p'y - w'x$$

s.t.

$$\sum_{k=1}^{K} \lambda_k y^k \geq y;$$

$$\sum_{k=1}^{K} \lambda_k x^k \leq x;$$

$$\sum_{k=1}^{K} \lambda_k = 1; \tag{5}$$

where, $\lambda_k \geq 0; (k = 1,2,\ldots\ldots,K)$

p = the vector of output prices.

A firm's PE is measured as $\delta = \Pi^0/\Pi^*$. This measure is limited between 0 and 1, except when realized profit is minus and max. profit is greater than zero. In these cases, the δ value is negative. When max. profit is also minus, δ transcends 1.

Data and Analysis

In the DEA, the data set must be homogeneous so that the efficiency values can be appropriately determined. It can be said that the data set is homogeneous if the banks in the data have the same inputs and outputs, have similar goals, perform similar tasks, and respond similarly to external factors (Golany & Roll, 1989). For this purpose,

the banks in the study were selected from deposit banks with the same inputs and outputs. At the end of 2020, deposit banks constituted 91 percent of total deposits, 87 percent of total assets, and 86 percent of total loans. Thus, the analysis also reflects the entire banking sector. In the present study, quarterly data between 2006 and 2020 of 23 deposit banks in Turkey were taken as a basis. Of the 23 banks, three were publicly owned, nine were privately owned, and 11 were foreign banks. In this study, banks were analyzed according to their ownership structures. The data were obtained from statistical and financial reports posted in The Banks Association of Turkey (BAT)'s website. All banks included in the survey consisted of commercial and deposit-accepting banks. Before starting the DEA, it is of great importance to note that the inputs and outputs to be selected will depend on which application model that will be used. In selecting inputs and outputs, the intermediary approach is used as it allows bank profitability to be seen more clearly.

According to the intermediation approach, financial institutions act as intermediaries between depositors who provide funds and investors who demand funds (Sealey & Lindley, 1977). While institutions fulfill this intermediary function, using personnel costs, capital, non-interest expenses, total deposits, and issued securities as inputs, they obtain outputs such as deposits, loans, securities, investments, non-interest incomes, fees, and commissions from other banks. In developing countries, the intermediation approach is mainly used to determine the efficiency of financial institutions (Williams & Nguyen, 2005; Das & Ghosh, 2009; Hermes & Nhung, 2010; Işik & Hassan, 2002; Jackson & Fethi, 2000).

The analysis uses three inputs, three outputs, three inputs, and three output prices. Inputs are Deposits, Personnel, and Tangible Assets. Non-interest Incomes, Interest bearing assets, and Loans & Receivables are used on the output side. Based on the mediation method in determining the inputs and outputs, the most significant and stable variables were preferred among the variables frequently used in the studies of developing countries, as was the case in Turkey. The following studies by Denizer et al. (2000), Ertugrul and Zaim (1996), Isik and Hassan (2002), Eleren and Ozgur (2006), Das and Ghosh (2009), Matousek et al. (2016), Sufian and Kamarudin (2016), Fukuyama and Matousek (2016), and Batir et al. (2017) used similar input and output variables. The data were adjusted for the effect of inflation by using the Consumer Price Index. Description of inputs, outputs, input prices and output prices and are as presented in Table 2.

Table 2

Description of Input and Output Variables in DEA

	Input	Description
X_D	Deposits (Mio TL)	Total Deposits
X_P	Personnel	Number of Employees
X_A	Tangible Assets (Mio TL)	Total Tangible Assets (Net)
	Input Prices	
W_D	Price of Deposit	Average interest expense paid per one unit deposit
W_P	Price of Personnel	Personnel expense per one personnel.
W_A	Price of Tangible Assets	Share of general administrative expenses (excluding the personnel expenses) for tangible fixed assets.
	Output	
Y_1	Non-Interest Incomes (Mio TL)	The total of Net Fees and Commissions Income
Y_2	Interest Bearing Assets (Mio TL)	Total of "Banks, Money Market Securities, Financial Assets For Sale and Investments Held to Maturity (Net)"
Y_3	Loans and Receivables (Mio TL)	Sum of Loans and Receivables
	Output Prices	
P_1	Price of Non-Interest Income	It is taken as 1 in all periods.
P_2	Price of Interest-Bearing Assets	It is one unit interest yield obtained from investments.
P_3	Price of Loan and Receivabl	It is one unit interest income obtained from Loans and Receivables

The summary statistics of inputs, outputs, input prices and output prices are as presented in Table 3. A second issue that needs to be decided before starting the analysis is the variability according to the scale. In CRS models, the efficiency frontier is always below that of the VRS, so the efficiency value according to the CRS is less than or equal to the efficiency value according to the VRS (Hollingsworth & Smith, 2003). Both CRS and VRS models are used for the CE measurement. In the measurement of profit, the VRS model is used. This is because of the very low and high variance values determined by the CRS.

Table 3

Summary Statistics of Inputs, Outputs, Input Prices and Output Prices

		2006		2007		2008		2009		2010	
		Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev
	Number of Observations	23		92		92		92		92	
	Input										
X_D	Deposits (Mio TL)	9,976	12,454	10,244	12,840	11,526	14,163	12,510	15,871	13,660	17,574
X_P	Personnel	5,803	6,025	6,127	6,135	6,800	6,597	6,958	6,925	7,201	7,246
X_A	Tangible assets (Mio TL)	250	346	241	331	245	314	245	309	231	287
	Input Price										
W_D	Price of Deposit	0.08	0.02	0.06	0.03	0.06	0.03	0.04	0.02	0.03	0.02
W_P	Price of Personnel	36,342	13,511	27,701	33,487	25,274	17,366	25,203	16,674	24,577	16,019
W_A	Price of Tangible Assets Price Output	2.28	2.26	1.26	1.47	1.14	1.09	1.39	1.81	2.59	5.41
Y_1	Non-Interest Incomes (Mio TL)	241	316	166	243	171	251	174	256	167	246
Y_2	Interest Bearing Assets (Mio TL)	5,891	8,663	5,803	8,835	5,895	8,945	7,401	11,265	7,734	11,744
Y_3	Loans And Receivables (Mio TL)	6,597	7,382	7,317	8,121	9,072	10,013	9,135	10,183	10,398	11,636
	Output Price										
P_1	Price of Non-Interest Income	1	0	1	0	1	0	1	0	1	0
P_2	Price of Interest-Bearing Assets	0.15	0.10	0.20	0.54	0.11	0.12	0.09	0.14	0.05	0.02
P_3	Price of Loan and Receivables	0.13	0.02	0.09	0.04	0.09	0.05	0.09	0.04	0.06	0.03

(continued)

		2011		2012		2013		2014		2015	
		Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev
	Number of Observations	92		92		92		92		92	
	Input										
X_D	Deposits (Mio TL)	15,207	18,548	15,359	17,665	16,725	15,207	18,548	15,359	17,665	16,725
X_P	Personnel	7,610	7,535	7,741	7,641	8,125	7,610	7,535	7,741	7,641	8,125
X_A	Tangible assets (Mio TL)	220	266	205	243	201	220	266	205	243	201
	Input Price										
W_D	Price of Deposit	0.03	0.02	0.04	0.02	0.03	0.01	0.03	0.02	0.03	0.02
W_P	Price of Personnel	24,824	15,465	25,602	16,200	25,708	16,253	26,805	16,636	27,090	16,084
W_A	Price of Tangible Assets Price	2.04	3.11	2.32	3.57	2.49	4.06	2.74	4.95	2.81	5.01
	Output										
Y_1	Non-Interest Incomes (Mio TL)	187	265	197	267	215	294	234	315	239	319
Y_2	Interest Bearing Assets (Mio TL)	7,155	10,335	6,609	9,176	6,178	8,267	6,143	7,971	6,120	7,979
Y_3	Loans and Receivables (Mio TL)	13,468	14,851	14,479	15,893	16,893	18,709	18,864	20,769	21,572	23,961
	Output Price										
P_1	Price of Non-Interest Income	1	0	1	0	1	0	1	0	1	0
P_2	Price of Interest-Bearing Assets	0.06	0.08	0.15	0.68	0.05	0.05	0.06	0.04	0.08	0.19
P_3	Price of Loan and Receivables	0.06	0.03	0.07	0.03	0.06	0.03	0.06	0.03	0.06	0.03

(continued)

		2016		2017		2018		2019		2020	
		Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev
	Number of Observations	92		92		92		92		92	
	Input										
X_D	Deposits (Mio TL)	20,511	23,451	22,081	25,280	23,195	26,838	23,785	28,291	27,822	34,807
X_P	Personnel	8,281	8,381	8,172	8,349	8,093	8,364	7,957	8,318	7,842	8,268
X_A	Tangible assets (Mio TL)	366	512	381	502	362	468	454	539	438	527
	Input Price										
W_D	Price of Deposit	0.03	0.02	0.03	0.02	0.04	0.03	0.05	0.03	0.02	0.01
W_P	Price of Personnel	28,344	16,752	28,707	17,349	28,614	18,826	31,631	21,388	31,127	19,182
W_A	Price of Tangible Assets Price	3.07	5.89	3.06	5.97	2.54	4.32	0.25	0.77	0.31	0.84
	Output										
Y_1	Non-Interest Incomes (Mio TL)	239	315	239	323	225	313	216	314	195	281
Y_2	Interest Bearing Assets (Mio TL)	5,900	7,647	6,010	7,627	6,683	8,287	4,919	7,114	6,068	8,753
Y_3	Loans and Receivables (Mio TL)	22,510	22,374	24,662	28,321	25,469	29,840	24,962	30,138	28,284	35,227
	Output Price										
P_1	Price of Non-Interest Income	1	0	1	0	1	0	1	0	1	0
P_2	Price of Interest Bearing Assets	0.07	0.11	0.09	0.15	0.09	0.14	0.12	0.12	0.09	0.08
P_3	Price of Loan And Receivables	0.06	0.03	0.06	0.03	0.08	0.05	0.09	0.04	0.05	0.03

Determinants of the Bank Efficiency

The empirical methods identifying the determinants of bank efficiency are divided into univariate and multivariate methods. The univariate method involves the empirical analysis of the CPE and depends on ownership and scale group. However, this method needs to be more satiable to clarify the connection between efficiency measures and the financial factors of the bank. To explain this and to explore the broader determinants of efficiency, the efficiency values obtained by the DEA are associated with bank-specific variables in the second stage (Coelli et al., 2005).

The second stage of analysis investigates various factors deemed to explain efficiency. The main factors in explaining efficiency in the literature are ownership, scale, corporate governance, market power, financial statement composition, etc. The applied hypotheses gleaned from the literature (Berger & Mester, 2003; Altunbas et al., 2001; Bonin & Hasan, 2005; Maudos & Pastor, 2003; Das & Ghosh, 2006; 2009; DeYoung & Hasan, 1998; Berger et al., 2008; Partovi & Matousek, 2019) are efficient structure hypothesis, market discipline hypothesis, global advantage hypothesis, agency theory hypothesis, structure performance hypothesis, moral hazard theory hypothesis, and bad management hypothesis.

Reviewing the efficiency literature found in Batir et al. (2017), Ismail et al. (2017), Gardener et al. (2011), and Das and Ghosh (2009) the use of the Tobit Model easily handles the sources of efficiency differentials. The estimated value of the CPE (dependent variable) is limited between 0 and 1, and the proper theoretic description is a Tobit model with a two-sided sensor. However, banks with zero efficiencies should be seen in practice. Hence, the results will not change using a one or two-sided model. The Tobit model uses CPE values found in the first stage as dependent variables (Das & Ghosh, 2009).

$$y_0^* = \beta x_0 + \varepsilon_0$$
$$y_0 = y_0^* \text{ , If } y_0^* > 0 \quad \text{otherwise} \quad (6)$$
$$y_0 = 0, \quad \varepsilon_0 \sim N(0, \sigma^2)$$

Where, x_0 is a vector of explanatory variables. β is the set of parameters to estimate.

$\varepsilon_0 \sim N(0, \sigma^2)$ represents the error term. y_0^* is latent variable and y_0 is the CPE value found by the DEA in the first stage. The following regression model is estimated with the CPE values.

$$\Theta_{kt} = \beta_0 + \beta_1 SIZE_{kt} + \beta_2 DEP_{kt} + \beta_3 TERMDEP_{kt} + \beta_4 CURRENTDEP_{kt} + \beta_5 LOAN_{kt} + \beta_6 LIQUIDITY_{kt} + \beta_7 HHI_{kt} + \beta_8 ASSETGRW_{kt} + \beta_9 NPL_{kt} + \beta_{10} CRAR_{kt} + \beta_{11} RWA_{kt} + \beta_{12} DCRISIS_{kt} + \beta_{13} DSTATE_{kt} + \beta_{14} DPRIVATE_{kt} + \beta_{15} DFOREIGN_{kt} + \beta_{16} DPUBLIC_{kt} + \varepsilon_{kt} \quad (7)$$

Where,
Θ_{jt} is the CPE value of *kt* bank obtained with the DEA model in t time.
k = (1,2,…23)

The present study considers a variety of variables that may impact a bank's cost and profit efficiency (CPE) ratio. On the source side, the bank's share of total deposits in the banking sector (DEP) is used as an indicator of market concentration, and a positive relationship with the CPE is hypothesized (H_0). Conversely, the ratio of time deposits to total deposits (TERMDEP) is expected to have a negative relationship with the CPE. High deposit shares in total deposits may lead to high costs in an environment where interest rates have decreased. A higher ratio of demand deposits to total deposits (CURRENTDEP) is expected to increase profitability and thus have a positive relationship with the CPE. This ratio is used to investigate the effect of diversification on resources. On the asset side, a higher ratio of loans to total assets (LOAN) may indicate higher risk and greater market share in the credit market, leading to a positive relationship with the CPE. Conversely, a higher level of liquidity (LIQUIDITY) may signify poor cash management and lead to lower interest income, resulting in a negative relationship with the CPE.

Bank-specific variables, such as the HHI index used to measure diversification, are also considered. A positive relationship is expected between the HHI index and CPE, as banks offering a wider range of services are predicted to be more cost-effective. The indicators added to the HHI index are Loan Interest Income, Investment Interest Income, Other Interest Income, Net Fee and Commission Income, and Other Non-Interest Income. The log of total assets (SIZE) is expected to have a positive relationship with the CPE, as larger banks can adjust their costs and profits more effectively. The growth of total assets (ASSTGRW) is also expected to have a positive relationship with the CPE, although its effect on the cost side is unpredictable.

Risk structure variables are also included. The rate of credit losses to total loans (NPL) is expected to have a negative relationship with the CPE, as it raises costs and reduces profits. Conversely, the ratio of a bank's capital to its risk-weighted assets (CRAR) is expected to have a positive relationship with the CPE, as a higher CRAR is associated with a higher CPE, in line with the postulations of Moral Hazard Theory. Finally, the ratio of a bank's weighted exposures according to the risk to its total assets (RWA) is expected to have a negative relationship with the CPE, as significant exposures can create higher credit losses.

Dummy variables are also considered. The dummy variable for public banks (DPUBLIC) is expected to have a positive relationship with the CPE, as public companies are predicted to have a higher efficiency due to the market discipline hypothesis (See Table 4 for References). Dummy of crisis (DCRISIS) is included in the model to determine the impact of the 2008-2009 mortgage crisis on the CPE. A dummy variable for state banks (DSTATE) is expected to have a negative relationship with the CPE, as state banks are predicted to be less efficient than private banks due to the market discipline hypothesis. The dummy variable for private banks (DPRIVATE) is expected to have a positive relationship with the CPE. Finally, the dummy variable for foreign banks (DFOREIGN) is expected to have a positive relationship with the CPE, as foreign banks are predicted to have a higher CPE than domestic banks due to the global advantage hypothesis. Definitions of independent variables, hypotheses and cited studies in the literature are as presented in Table 4.

RESULTS

In the analysis carried out in the present study, the R program is used to measure the cost-efficiency. The program calculates the cost efficiency values with the "cost.opt" method in the Benchmarking package developed by Bogetoft and Otto (2011). The cost efficiencies of banks were calculated separately according to CRS and VRS methods and the results are as presented in Table 5 and Table 6. The CE values according to ownership are as given in Table 7. Table 7 shows that state banks had better CE values than private and foreign banks. Table 5 shows that the banking system experienced a decrease in cost and profitability efficiency after 2009 (See Table 5).

Table 4

Description of Tobit Variables

Variables on the source side	Description	Hypothesis	Literature
DEP	The share of deposits of the bank in the total deposits of the banking sector	Market Concentration H_0: Deposits have a positive relation with the CPE.	Das and Ghosh (2009), Stiroh and Strahan (2003)
TERMDEP	This is the ratio of the Bank's time deposits to its total deposits.	Market Concentration H_0: Ratio of time deposits have a negative relation with the CPE	Das and Ghosh (2009), Stiroh and Strahan, (2003)
CURRENTDEP	The ratio of demand deposits to total deposits.	Diversification effect H_0: Ratio of demand deposits have a positive relation to the CPE.	Das and Ghosh (2009), Berger and Mester (2003)
Variables on the asset side			
LOAN	The ratio of loans to total assets.	Efficient Structure Hypothesis H_0: Ratio of loans have a positive relation to the CPE.	Berger et al. (2008), Das and Ghosh (2009)
LIQUIDITY	It is the ratio of liquid assets to gross assets.	Bad cash management H_0: Level of liquidity have a negative relation to the CPE	Berger and DeYoung (1997), Beck and Hesse (2006).
Bank-specific variables			
HHI	HHI index to determine the diversification	Efficient Structure Hypothesis H_0: Diversification value have a positive relation to the CPE.	Isik and Hassan(2003)

(continued)

Variables on Risk Structure	Description	Hypothesis	Literature
SIZE	Log of total assets.	Efficient Structure Hypothesis H_0: Asset size have a positive relation to the CPE.	Berger and Hannan (1998), Hauner (2005),Kasman (2002), Isik and Hassan (2003), Delis and Papanikolaou (2009), Batir et al. (2017)
ASSTGRW	Growth of total assets	Efficient structure hypothesis H_0: Asset growth ratio have a positive relation to PE.	Das and Ghosh (2009), Jackson and Fethi (2000), Kasman (2002)
NPL	It is the rate of credit losses to total loans.	Bad Management Hypothesis H_0: NPL ratio have a negative relation to the CPE.	Berger and DeYoung (1997), Lall (2014) Lee & Chih (2013), Miller and Noulas (1997), Partovi and Matousek (2019), Berger and Mester (1997), Sufian and Noor (2009), and Ismail et al. (2013), Batir et al (2017).
CRAR	The ratio of bank's capital to its risk weighted assets.	Moral Hazard Theory H_0: CRAR ratio have a positive relation to the CPE.	(Berger & Humphrey, 1997), (Casu & Molyneux, 2003). Catalbas and Atan (2005) Isik and Hassan (2003), Belas, Kocisova and Gavurova (2019), Fukuyama and Matousek (2011)
RWA	The ratio of bank's weighted exposures according to the risk to its total assets.	Bad management hypothesis H_0: RWA have a negative relation to the CPE	Berger and DeYoung (1997), Das and Ghosh(2009)
Dummy Variables			
DPUBLIC	Dummy variable to define public offering	Market Discipline Hypothesis H_0: Public banks have a higher CPE.	Berger and Mester (1997), Isik and Hassan (2002), Das and Ghosh (2009)

(continued)

Variables on Risk Structure	Description	Hypothesis	Literature
DCRISIS	Dummy variable for 2009 mortgage crisis.	H_0: 2009 Global Crisis has a negative effect on the CPE.	Aysan and Darendeli (2010),Yilmaz (2013), Gunes and Yildirim (2016), Ozkan- Gunay et al. (2013)
DSTATE	Dummy variable to define state banks	Market Discipline Hypothesis H_0: State banks have a lower CPE.	Berger et al. (2000), Isik and Hassan (2002), Sturm and Williams (2004); Bonin et al. (2005); Berger et al. (2005; 2009); Delis and Papanikolaou (2009), Altunbas et al. (2001), Aysan and Darendeli (2010), Gunes and Yildirim (2016)
DPRIVATE	Dummy variable to define private banks	Market Discipline Hypothesis H_0: Private banks have a higher CPE	Same as DSTATE
DFOREIGN	Dummy variable to define foreign banks	Global advantage hypothesis H_0: Foreign banks have a higher CPE.	Same as DSTATE

Table 5

Cost and Profit Efficiency Values for the Banking Sector (VRS Method)

	Cost Efficiency				Profit Efficiency			
Years	Obs.	Mean	Std. Dev.	Geo.Mean	Obs.	Mean	Std. Dev.	Geo.Mean
2006	23	0.94	0.11	0.93	20	0.36	0.36	0.14
2007	92	0.88	0.12	0.87	92	0.18	0.24	0.03
2008	92	0.88	0.11	0.87	91	0.16	0.22	0.03
2009	92	0.89	0.11	0.88	85	0.22	0.26	0.07
2010	92	0.87	0.12	0.86	83	0.2	0.24	0.06
2011	92	0.85	0.15	0.83	87	0.22	0.27	0.05
2012	92	0.88	0.12	0.87	88	0.23	0.27	0.07
2013	92	0.83	0.14	0.81	89	0.23	0.27	0.08
2014	92	0.81	0.17	0.79	92	0.23	0.28	0.07
2015	92	0.8	0.19	0.77	92	0.25	0.28	0.07
2016	92	0.83	0.15	0.81	62	0.26	0.26	0.10
2017	92	0.83	0.17	0.81	76	0.32	0.32	0.11
2018	92	0.85	0.18	0.82	75	0.31	0.33	0.10
2019	92	0.81	0.16	0.79	68	0.32	0.93	0.07
2020	92	0.77	0.20	0.74	57	0.28	0.32	0.09

Table 6

Cost Efficiency Values for the Banking Sector (CRS Method)

Years	Obs.	Mean	Std. Dev.	Geo.Mean
2006	23	0.81	0.15	0.79
2007	92	0.72	0.16	0.70
2008	92	0.78	0.15	0.77
2009	92	0.80	0.16	0.78
2010	92	0.75	0.13	0.74
2011	92	0.60	0.13	0.59
2012	92	0.78	0.13	0.77
2013	92	0.58	0.12	0.57
2014	92	0.44	0.14	0.43
2015	92	0.43	0.16	0.41
2016	92	0.60	0.17	0.57
2017	92	0.58	0.16	0.57
2018	92	0.78	0.24	0.70
2019	92	0.76	0.17	0.74
2020	92	0.69	0.19	0.65

Table 7

Cost Efficiency and Ownership (VRS Method)

		State Banks			Private Banks			Foreign Banks		
Years	Obs.	Mean	Std. Dev	Geo. Mean	Mean	Std. Dev	Geo. Mean	Mean	Std. Dev	Geo. Mean
2006	23	0.96	0.03	0.96	0.94	0.11	0.93	0.93	0.13	0.92
2007	92	0.92	0.06	0.92	0.87	0.14	0.86	0.89	0.12	0.88
2008	92	0.86	0.09	0.86	0.87	0.12	0.86	0.88	0.1	0.88
2009	92	0.87	0.09	0.87	0.87	0.14	0.86	0.91	0.08	0.91
2010	92	0.89	0.09	0.89	0.86	0.14	0.85	0.88	0.1	0.87
2011	92	0.9	0.07	0.9	0.84	0.17	0.82	0.83	0.14	0.82
2012	92	0.87	0.11	0.86	0.87	0.14	0.86	0.88	0.11	0.88
2013	92	0.86	0.1	0.86	0.81	0.16	0.79	0.83	0.12	0.82
2014	92	0.91	0.09	0.9	0.77	0.19	0.75	0.82	0.16	0.8
2015	92	0.91	0.09	0.9	0.75	0.22	0.72	0.80	0.16	0.78
2016	92	0.91	0.06	0.91	0.77	0.17	0.75	0.84	0.13	0.83
2017	92	0.96	0.05	0.95	0.76	0.19	0.73	0.85	0.15	0.83
2018	92	0.96	0.04	0.96	0.78	0.15	0.77	0.86	0.21	0.82
2019	92	0.96	0.05	0.96	0.78	0.14	0.77	0.79	0.17	0.77
2020	92	0.95	0.05	0.95	0.70	0.18	0.68	0.76	0.20	0.73

The Benchmarking package was used in R program to calculate the PE by the DEA method. The VRS method was used to calculate the PE. PE values for the whole sector are as presented in Table 5. As can be seen in Table 8, the PE values of state banks were higher than those of private and foreign banks. In general, it is observed that the PE values of Private banks were better than that of foreign banks. However, it is observed that foreign banks have performed better in recent years (see Table 8).

The periods with negative profits were excluded from the data. As the majority share of some private domestic banks was sold to foreign banks during the research period, they were moved from the private banks' group to the foreign banks' group. In the present study, the group with the lowest profitability was identified as the group of foreign banks. It is seen that foreign banks have been working with shallow profit margins after 2009, and they had losses in specific periods. Banks with negative profitability were excluded from the

average. Even with positive profitability values, they had a very low PE (see Table 8).

Table 8

Profit Efficiency and Ownership (VRS Method)

	State Banks				Private Banks				Foreign Banks			
Years	Obs.	Mean	Std. Dev	Geo. Mean	Obs.	Mean	Std. Dev	Geo. Mean	Obs.	Mean	Std. Dev	Geo. Mean
2006	3	0.53	0.26	0.47	10	0.47	0.42	0.18	7	0.16	0.14	0.06
2007	12	0.34	0.16	0.3	40	0.25	0.31	0.07	40	0.06	0.08	0.01
2008	12	0.31	0.12	0.29	40	0.24	0.29	0.07	39	0.06	0.07	0.01
2009	12	0.39	0.15	0.36	39	0.26	0.31	0.07	35	0.11	0.18	0.04
2010	12	0.36	0.13	0.34	40	0.25	0.3	0.06	32	0.12	0.18	0.04
2011	12	0.35	0.13	0.33	38	0.27	0.32	0.06	37	0.13	0.23	0.03
2012	12	0.4	0.14	0.37	38	0.31	0.33	0.11	38	0.12	0.2	0.04
2013	12	0.41	0.14	0.38	39	0.29	0.33	0.08	38	0.13	0.19	0.05
2014	12	0.4	0.14	0.38	40	0.28	0.33	0.07	40	0.14	0.22	0.06
2015	12	0.49	0.15	0.46	35	0.30	0.33	0.08	45	0.15	0.21	0.04
2016	11	0.43	0.18	0.40	24	0.29	0.30	0.11	27	0.15	0.21	0.05
2017	12	0.60	0.26	0.54	23	0.32	0.29	0.13	41	0.24	0.30	0.07
2018	12	0.68	0.23	0.64	24	0.30	0.27	0.10	39	0.21	0.30	0.06
2019	12	0.47	0.27	0.40	20	0.27	0.21	0.14	36	0.30	1.25	0.03
2020	12	0.56	0.23	0.52	20	0.18	0.15	0.07	25	0.23	0.37	0.05

Regression Results

Tobit regression analysis was performed to determine the effects of sixteen independent variables on the PE and CE values. Since collinearity was found between the "CURRENTDEP" and "DFOREIGN" variables, these variables were dropped from the model. Therefore, total independent variables decreased to fourteen. Regression analysis was carried out in R program by using the AER package program. The AER package program is used for the second stage regression analysis of the detected efficiency values.

Profit Efficiency Tobit Regression

Tobit regression analysis was performed with four different limitations. Table 9 shows the regression results for each limitation.

Table 9

Tobit Regression Results

	Dependent variables					
Independent variables	PE	PE	PE	PE	CE	CE
Intercept	-0.38 (-1.25)	-0.66** (3.16)	-0.65** (-3.24)	-0.3884 (-1.31)	0.6571*** (3.786)	0.4991*** (3.652)
SIZE	0.004 (0.37)	0.02*** (3.67)	0.02*** (3.75)	0.0047 (0.42)	0.0117 (1.85)	0.0169*** (3.308)
DEP	4.47*** (11.5)	3.54*** (13.40)	3.53*** (13.74)	4.4236*** (11.678)	1.4787*** (6.627)	0.9412*** (5.381)
TERMDEP	-0.10 (-1.01)	-0.25*** (-3.64)	-0.24*** (-3.61)	-0.0867 (-0.857)	-0.1389* (-2.316)	-0.1000* (-2.138)
LOAN	0.08 (0.59)	0.08 (0.89)	0.07 (0.82)	0.0578 (0.438)	0.1991** (2.602)	0.17774** (2.912)
LIQUIDITY	0.25* (2.2)	0.35*** (4.58)	0.34*** (4.59)	0.2320* (2.062)	0.1336* (2.055)	0.07564 (1.456)
HHI	0.19*** (3.32)	0.06 (1.56)	0.05 (1.55)	0.1928*** (3.32)	-0.0600 (-1.75)	-0.0690* (-2.575)
ASSETGRW	0.26*** (5.32)	0.30*** (8.58)	0.29*** (8.51)	0.2483*** (5.084)	0.1312*** (4.562)	0.1204*** (5.342)
NPL	-0.07 (-0.44)	-0.65*** (-4.13)	-0.63*** (-4.15)	-0.0734 (-0.461)	-0.9783*** (-10.931)	-0.8822*** (-12.009)
CRAR	0.002 (1.37)	0.001 (1.192)	0.001 (1.1702)	0.0027 (1.358)	0.0046*** (3.882)	0.0041*** (4.501)
RWA	0.08 (1.06)	0.04 (0.72)	0.0449 (0.817)	0.0983 (1.216)	-0.1679*** (-3.658)	-0.1208** (-3.236)
DCRISIS	0.01 (0.51)	0.02 (1.06)	0.0210 (1.036)	0.0147 (0.48)	0.0446* (2.541)	0.0459** (3.238)
DSTATE	-0.08* (-2.35)	-0.10*** (-4.18)	-0.1004*** (-4.288)	-0.0852* (-2.391)	-0.1216*** (-5.966)	-0.0962*** (-5.845)
DPRIVATE	0.01 (0.85)	-0.01 (-0.96)	-0.0131 (-0.987)	0.0172 (0.868)	-0.0804*** (-7.17)	-0.0718*** (-7.845)
DPUBLIC	0.02 (1.30)	0.04*** (3.39)	0.0470*** (3.491)	0.0276 (1.354)	-0.0050 (-0.429)	0.00039 (0.042)
Log(scale)	-1.25*** (-63.08)	-1.68*** (-78.63)	-1.7183*** (-82.144)	-1.2831*** (-65.704)	-1.8747*** (-81.537)	-2.0558*** (-105.27)
Observations	1311	1311	1311	1311	1311	1311
Right-censored=1	35					
Left-censored=0		152				
Right-censored=1		35				
Left-censored=0			152			
Right-censored=1					285	
Uncensored Observations	1276	1124	1159	1311	1026	1311
Log-likelihood	-254.2	143.1	245.5	-178	220.7	835
Wald-statistic	877.1***	1981***	2076***	904.4***	550.7***	609***
Scale	0.28	0.1846	0.1794	0.2772	0.1534	0.128

Values in parentheses are z -statistics.

*** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$

The left side is uncensored, and the right side is censored with "1": In this limitation, all negative values of the PE were taken as dependent variables, while the efficiency values with "1" were not taken. Therefore, the total numbers of observations decreased from 1311 to 1276 due to the negative values being uncensored. The left side is censored with 0 and the right side with "1". In this limitation, the PE values were only accepted when they were between 0 and 1. The total number of observations dropped to 1124.

The left side was censored with 0, and the right side with "1.1". Banks with a negative PE were excluded from the observation. Since there was no bank with efficiency values above 1.1, the observation set consisted of 1159 observations. The left-hand was uncensored, and the right-hand side was censored with "1.1". Here, the aim was to determine the regression result by taking the banks with a "1" total efficiency value into the observations. Since there was no bank with an efficiency value above 1.1, the observation set was analyzed as 1311 without censorship.

Cost Efficiency Tobit Regression

The Tobit regression analysis was similarly iterated with cost efficiencies as the dependent variable. The Tobit regression analysis has been studied with four different limitations. Table 9 shows the results.

The Left side was uncensored and the Right side censored with "1". In this limitation, all negative values of the CE were included in the observation, while efficiency values with a value of 1 were not taken. There were 285 banks with a value of 1 in the data set. As the values of 1 were censored, the observations were reduced from 1311 to 1026.

The left side is censored with "0," and the right side is censored with "1". In this limitation, the CE was accepted only between 0 and 1. The total number of observations was reduced to 1026. Tests a and b gave the same result since no banks had negative CE values.

When censored with "0" on the left and 1.1 on the right, there were no banks with a negative cost-efficiency value. Since there were no banks with an efficiency greater than 1, the entire observation set was included in the analysis.

When the left side was uncensored, and the right side was censored with 1.1, the aim was to determine the regression result by taking the banks with one total efficiency. Since no banks had more than 1.1 efficiencies, the observation cluster was analyzed as 1311 without censorship.

DISCUSSION

The total data observations covering 57 quarter periods between 2006 and 2020 was 1311. Tobit regression was performed in four different censors. When the data was censored with 0 and 1 in the PE analysis, it decreased to 1124. The censorship of negative efficiency values was widespread in profitability analysis. However, since banks could reach total efficiency value, the values in which the regression analysis was censored with 1.1 on the right side were used. According to the results, the independent variables of SIZE, DEP, TERMDEP, LIQUIDITY, ASSETGRW, NPL, DSTATE and DPUBLIC had significant effects on the PE values.

Tobit regression analysis was repeated to determine the relationship between cost efficiencies and independent variables. As in the PE analysis, the data was censored from the left and right, and two different regression results were obtained. Since the banks with one efficiency value were excluded from the observation in narrow regression analysis, the number of observations fell from 1311 to 1026. When the banks with one efficiency value were taken into the observation series, 1311 observations could be analyzed. According to the results, independent variables that affected the cost efficiencies were; SIZE, DEP, TERMDEP, LOAN, ASSETGRW, NPL, CRAR, RWA, DSTATE, DCRISIS and DPRIVATE.

The results show a positive and significant relationship between SIZE and the CPE. Large banks were seen as having the ability to adjust their output scales more optimally, thus increasing their profitability. Larger banks also have the opportunity to diversify their risks. This result supports the efficient structure hypothesis and corroborates the findings of Hauner (2005), Berger et al. (1993), Berger and Hannan (1998), Isik and Hassan (2002), Kasman (2002), and Ozkan and Gunay et al. (2013). Growth in total assets (ASSETGRW) has a positive effect on the CE as well as profit efficiency. The results are

consistent with those in previous research, such as in Das and Ghosh (2009), Jackson and Fethi (2000), and Kasman (2002). Furthermore, consistent with the efficient structure hypothesis, the results reveal that the growth rate in a bank's asset structure enables that bank to offer tools to increase profitability. The results also reveal a positive and statistically significant relationship between a bank's deposit market share (DEP) and the PE. If it is the case that a market concentration leads to high prices and profitability, the coefficient is expected to be positive—accordingly, the more open the market, the greater the relationship between profitability and market share. According to the results, the share of deposits also has a positive and significant effect on the CE. The market share in deposits also provides banks with the advantage of reducing their deposit costs. These results were also obtained in the studies by Stiroh and Strahan (2003) and Das and Ghosh (2009). The high rate of time deposits in total deposits (TERMDEP) can lead to high costs in an environment where interest rates are falling. Therefore, the coefficient of this variable is expected to be negative. As is consistent with the literature, such as in Das and Ghosh (2009), the results show that the share of time deposits in total deposits negatively affects the PE and CE of the bank.

According to these results, there is a positive relationship between the bank's liquidity and PE. The high rate of liquid assets is a sign of bad cash management and leads to low interest-income. It is expected that this variable will harm the PE. The difference between the results obtained from present study and the studies in developed countries can be explained by the fact that banks can even profit from liquid assets because of Turkey's high cost of short-term funding. Therefore, the banks prefer to hold a certain amount of liquid assets for caution and make a profit from it. The NPL variable is expected to be negatively correlated with the PE and CE. According to the results, there is a significant relationship between the NPL variable and the PE and CE. The results are consistent with the bad management hypothesis introduced by Berger and De Young (1997). Recently Partovi and Matousek (2019) found similar results for the Turkish banking industry. The rise in the loan ratio (LOAN) indicates the high-risk structure of the bank's statements and the higher market share in the loan market. According to the efficient structure hypothesis adduced by Berger et al. (2008) and Das and Ghosh (2009), banks with higher loan ratios are expected to have higher efficiencies. According to the results, there is a positive relationship between the loan ratio and CE

at a high significance level. This result shows that banks with higher loans/assets ratios can better control the costs of banks.

Empirical studies which included Berger and Humphrey (1997) and Casu and Molyneux (2003). Belas et al. (2019), Isik and Hassan (2003), and Fukuyama and Matousek (2011) showed that well-capitalized banks had higher efficiencies. The results show a positive but shallow relationship between the CE and capital adequacy ratio (CRAR). It is expected that the banks with lower capital funding costs will increase due to the high leverage ratio. In addition, they are expected to be more vulnerable to possible credit risks. According to Berger and Deyoung's (1997) bad management hypothesis, increasing the riskiness of a bank harms its profitability. The results show a negative relationship between the CE and the risk-weighted assets (RWA) ratio. In the analysis, DSTATE dummy was used for the control variable of bank ownership. The results show that state ownership affects the PE and CE negatively and significantly. This is because the results reflect the market regulator functions of state banks. This result is inconsistent with Zaim (1995) 's findings, but supports that of Isik and Hassan (2002b) which found that private banks were more efficient than state banks. This result is obtained because the state banks finance projects that private banks are unwilling to finance due to their market regulatory and social responsibility. The impact of the 2008-2009 mortgage crisis on Turkish banking started to be seen in 2010.

Therefore, 2010 is included in the model as a crisis dummy variable. According to censored Tobit regression results, positive relation is found between the Crisis dummy and cost efficiencies. This result is not compatible with the research carried out in Ozkan-Gunay et al. (2013) and Aysan and Darendeli (2010), Yilmaz (2013), Gunes and Yildirim (2016) which showed that the global crisis harmed the Turkish economy. This result shows that the regulations after 2002 in the banking system made the banking industry more resistant to crises. The DPRIVATE dummy variable is used to see the effect of private banks on efficiency values. According to the Tobit regression result, private banks harm cost-efficiencies with an 8 percent coefficient. Therefore, the market discipline hypothesis says that private banks have higher efficiencies. However, the results do not support the hypothesis and reveal the opposite results as in Isik and Hassan (2002). Therefore, it can be concluded that intensive banking system regulations negatively affect private banks' cost efficiency.

The DPUBLIC is the Dummy variable that measures the effect of being listed on the stock market on the PE and CE. The year in which the bank offers its shares to the public takes the value 1. Publicly traded companies are expected to have higher efficiency. The market discipline hypothesis tested by Berger and Mester (1997) and Das and Ghosh (2009) found that publicly traded banks had higher cost and profit efficiencies. However, Isik and Hassan (2002) found that public offering had a positive effect just on cost efficiency. Similarly, this study has found that if a bank was publicly traded, that bank would have a higher profit efficiency.

CONCLUSION

In this study, the CPE values of 23 commercial and deposit banks operating in the Turkish banking industry were analyzed by the DEA method. Quarterly data between 2006 and 2020 from these banks were collected and analyzed. In addition, Tobit regression analysis was also performed to identify the determinants of the efficiency values obtained. The study aimed to obtain the most recent and long-term results on profit and cost efficiency in the Turkish banking industry.

The results show that Turkish banks work with relatively higher cost efficiency than profit efficiency. In 2020, it was seen that the COVID-19 pandemic harmed the cost efficiency and profit efficiency of the banks studied. On the cost efficiency side, state banks were the category of banks least affected by the pandemic, while a 10 percent decrease in efficiency was observed in private banks.

On the other hand, in the first year of the pandemic, there was an average of 25 percent depreciation in private and foreign banks in terms of profit efficiency. In contrast, in the same period an increase was observed in state banks. The study found that during the pandemic period, state banks gained market share on the credit and deposit side and acted as a locomotive in the banking sector. According to multivariate the Tobit regression analysis carried out in this study, Total Assets, Deposit Share, Time Deposits, Liquidity, Asset Growth, NPL, Ownership and Publicly when traded significantly affect profit efficiency. Therefore, the results show that there are some particular implications. One of them is that the ratio of liquid assets to total assets was positively correlated with the efficiency values. This was

in contrast to the findings in previous studies. The difference can be explained by the fact that the banks in the study could even get interest income from liquid assets because the short-term funding costs were relatively high in Turkey.

The second implication is that foreign banks need to perform better in both CPE. This result is in contrast to the findings in Berger et al. (2009) and Catalbas and Atan (2005). As a result of the decrease in PE, it is observed that the interest of foreign financial institutions in the Turkish banking sector in 2011, and in the intense acquisitions and mergers seen in 2002-2007, had decreased significantly. Consequently, some foreign banks have closed down their SME segments because of the high-risk and low profit. In addition, M&A can be seen in the sector because the size and deposit share have both affected PE positively.

Finally, the downward trend in the PE values in the Turkish banking sector is a warning signal on its financial health and stability. Therefore, to maintain the healthy growth of the banking sector and ensure the continuation of foreign capital inflows to the sector, it is essential to analyze, especially the factors affecting PE. Making new researches on the variables that are determinants in the CPE; detailing the research based on scales, segments and regions will give the parties concerned a broader view and enable a comprehensive analysis of the relevant issues involved.

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