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A Study on the Efficiency of Turkish Deposit Banks for the Period 2012-2022: DEA Model

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Abstract. The profitability and efficiency of banks are decisive parameters in an intensely competitive industry. The up-to-dateness and remarkable importance of the concepts of efficiency and effectiveness in the banking sector have led to this study. In this study, the efficiency of the Turkish banking sector will be tested with the Data Envelopment Analysis (DEA) method. In the study, data from 24 deposit banks operating in the Turkish banking sector for the period 2012-2022 were used. When the 0 efficiency of the banks was evaluated according to the output-side CCR model of 24 banks in the 11 periods included in the analysis, it was determined that 146 of the 264 bank periods were efficient with an efficiency score of 1. It has been observed that 55.3% efficiency has been achieved in 11 periods of 24 banks examined in the last 11 years.

Keywords: Banking Sector, Efficiency, DEA, Output-Oriented CCR Model.

1. INTRODUCTION

The banking sector is one of the indispensable actors that reacts most strongly to developments and changes in the economy and plays an active role in the financial system. For this reason, the positive or negative consequences of any economic change that may arise in the national or international scenes primarily affects the banking sector of the country due to the fundamental role it plays and the whole world as a direct effect of globalization. In this respect, maintaining the performance level of the banking sector in an upward trend is crucial for the healthy development and improvement of the financial system. The efficiency of the banking sector's activities contributes to the growth of the country's economy, while helping the expansion and development of the markets. As is known, the banking sector is a highly competitive industry. Therefore, the profitability and efficiency of banks are decisive parameters in this highly competitive field. Banks, which have a key role in the improvement of the national economy, strive to achieve maximum output from the resources they have. Their purpose in doing so is largely to contribute to the functioning of the economy by converting surplus funds into capital within the financial system. The management of banks is one of the most critical indicators of macroeconomic stability. Banks also determine the allocation of resources within the financial system. The extent to which the quality of bank performance can be improved depends on the extent to which those in management use inputs effectively. Performance is associated with effectiveness, efficiency and quality. Therefore, the parameters to be measured should be evaluated in different dimensions and various measures of efficiency and effectiveness should be utilized. Measuring efficiency is also crucial for banks because these financial institutions, which operate in an intensely competitive field, can determine how to maximize output from existing inputs. In this context, efficiency and effectiveness measures need to be analyzed in order to assess the performance of the banking sector. Profitability, deposits and loans are generally taken into account for the analysis in order to determine the policies to be adopted by banks in the future and to reveal their performance. In this way, the banking sector can take remedial measures such as providing better service, adopting technological innovations, improving marketing methods, ensuring a competitive advantage over other banks in the sector, improving the staff quality and creating an effective network in branches by taking into account the economic conditions. Banks that improve their efficiency can reduce their costs, attract more customers and increase their capital, which can lead to higher levels of profitability. Inefficient banks, by contrast, face underperformance and high risk. In general, the lack of a clear standard and supervision on the quality of performance and inadequate efficiency and effectiveness can be considered as negative factors for banks to exhibit low productivity. In this context, the currency of the concepts of efficiency and effectiveness in the banking sector and the fact that they have received considerable attention have led to a great deal of research on this subject in the literature. The positive developments in the Turkish banking sector, especially in recent periods, and the intense competitive environment that comes with it have set the banking sector apart from other economic sectors. This requires banks to fulfill their financial intermediation function, which determines the allocation of resources, and to use their resources with maximum efficiency. It is a generally accepted fact that the most important activities of banks are to collect the savings of the public and to use these funds in the most efficient way. If banks cannot utilize their resources in productive investments as required, then we cannot speak of the efficiency of the banking sector. Therefore, the focus of this study is to test the efficiency of the Turkish banking sector using the Data Envelopment Method (DEA). The data of 24 deposit banks operating in the Turkish banking sector for the period 2012-2022 were used in the present study. DEA is a method that can be used more conveniently since it has few assumptions when other approaches used in efficiency analysis fall short. Therefore, this model was

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preferred for the analysis conducted in this study and the CCR model, which was introduced by Charnes, Cooper and Rhodes (1978) and assumes constant returns to scale, was used among the two widely used DEA models. The reason for using the output-oriented CCR model in the analysis is to investigate the rate at which outputs should be increased while keeping inputs constant. In other words, to determine to what extent resources should be increased in order to improve the efficiency of banks. The variables to be included in the analysis for measuring efficiency were determined by considering the effect of input and output variables on efficiency measurement and the data for the period 2012-2022 were taken from the financial statements of the Banks Association of Turkey (BAT) data internet system. Firstly, the theoretical explanations are provided on the concept of efficiency, the efficiency measurement methods and the DEA method used in the analysis. In addition, a literature review is provided regarding studies conducted on this subject due to the significance and currency of the concept of efficiency. Finally, the findings of the analysis and the evaluations are presented.

2. THE CONCEPT OF EFFICIENCY AND MEASUREMENT SYSTEMS USED iN EFFICIENCY ANALYSIS

The term efficiency is different from the term effectiveness, both are used to describe the performance of a business, but according to Jouadi and Zorgui (2014), efficiency sums up the idea of producing in the best way, which means that the focus is on the use of efficiency. It is the minimum input to produce the best output, in other words, the optimized use of resources to produce the best products at minimum cost. In management, efficiency is the optimized use of the company's internal factors. On the other hand, the concept of efficiency outlines the efficiency of factors and goal achievement, without considering the form and means of the optimized use of resources (Naber 2019).

It is crucial to identify the outputs produced by the banking sector in order to measure its performance. However, there is little consensus in the literature on what banks produce. Banks are economic decision-making units with numerous inputs and outputs, and they are intermediary institutions that aim to maximize the return on capital and provide financial services. However, identifying the output vector in banking is not a simple task. A variable considered as output in one bank's performance measurement study may be considered as input in that of another. There are two main approaches to measuring efficiency or performance: The production approach and the intermediation approach. The methods and criteria used in efficiency measurement are important in the evaluation of the results achieved (Yolalan 2001).

Production Approach: Banks produce services for depositors. The production approach considers banks as units that use capital, labor, branches and inventory as inputs and 'produce' deposits, loans, security portfolios and other balance sheet items. This approach measures outputs in terms of the number of accounts (Bilişik 2015). Intermediation Approach: This approach considers banks to act as financial intermediaries and lend the funds they receive from account owners against their liabilities in order to earn profits in return. This approach sees deposits and other resources as the bank's input and loans and other assets as the bank's output. Therefore, this approach uses currency, not the number of accounts, as the unit of measurement for inputs and outputs.

3. EFFICIENCY MEASUREMENT METHODS

Efficiency Measurement Methods Efficiency measurement allows for determining the position of banks in the competitive landscape and explains how banks can produce maximum output from the inputs at their disposal. Efficiency measurement methods can be explained in two categories: ratio analysis and frontier efficiency analysis. Frontier efficiency analysis is also divided into two categories: parametric and nonparametric methods. Both methods have different disadvantages and advantages, regardless of the method selected for measurement. Ratio analysis, which is defined as the monitoring over time of a ratio formed as a result of the ratio of a single input and a single output to each other in efficiency measurement, is a widely used method. This method uses the ratio scale. It is often preferred because it is easy to apply and interpret. However, it is not used to analyze the efficiency of the banking sector. The reason behind this is that it is not possible to make a decision and reveal the efficiency of the bank by looking at a single ratio in decision-making units with a large number of inputs and outputs in the banking sector. The frontier efficiency approach first determines the most efficient frontier. There are two methods under this approach: parametric and nonparametric. A set of observations is usually defined in parametric methods. Then, it is assumed that the best performance within the set is on the regression line, i.e. the efficiency frontier, and observations that do not deviate from this line are considered efficient, while other failed observations are considered inefficient. This means that there are failed observations under the assumption of high cost at the same output level or low output at the same input level and that the observed production units are homogeneous. Observations with zero error are fully efficient observations. Therefore, it can be decided that an observation is inefficient only after the measurement errors are eliminated. In parametric methods, it is first assumed that the production function of the banking sector has an analytical structure and the parameters of this function are determined. When parametric methods are preferred in performance measurement, estimation is generally made using regression techniques. Regression analysis is the most popular of the parametric efficiency measurement methods and aims to determine the causal structure of the relationship between dependent and independent variables, which are known to have a cause-and-effect relationship between them. Parametric

methods are categorized into three groups: stochastic frontier approach, distribution-free approach and thick frontier approach. The stochastic frontier approach is an econometric approach. This approach establishes a functional relationship between explained variables such as cost, profit and production and explanatory variables such as input, output and environmental factors and includes the error term in the model. The most significant criticism of this approach concerns its distributional assumptions. The distribution-free approach assumes that error terms and their components can have any distribution under certain constraints. This approach assumes that efficiency is constant, or at least stable, for each enterprise and that measurement errors approach zero in the long run. The assumptions are valid provided that inefficient observations are positive. Finally, the thick frontier approach differs from the other two approaches in its assumptions about the distribution. The main difference between the stochastic frontier approach and the distribution-free approach is their assumptions regarding the distributions of inefficient observations and random errors, which constitute the difference between the observed values and the assumed values. In contrast, the thick frontier approach does not make any assumptions about the expected distributions of these two elements. It is only assumed that the largest and smallest values of the differences between the observed and expected values constitute the random error and the remaining values constitute inefficient observations. (Ekodiyalog, ...) This approach is an inappropriate method for estimating the efficiency of a single production unit. There is no consensus in the productivity literature on which approach is better or more convenient than the others.

4. DATA ENVELOPMENT ANALYSIS (DEA)

A review of the literature reveals that the original DEA model or its derivatives have been used to analyze the efficiency of commercial banks. DEA is a method that can be used more conveniently in cases where other approaches used in efficiency analysis fall short, since it has fewer assumptions. The total factor productivity logic can provide the holistic approach that traditional methods cannot provide for the evaluation of multiple inputs and multiple outputs. The method can be used to estimate the production process without the need for an analytical function (as in regression), it can evaluate multiple inputs and outputs simultaneously; therefore, it is preferred due to the fact that it distinguishes between relatively efficient and inefficient decision-making units and determines reference groups consisting of efficient ones for inefficient ones and the targets they can achieve. DEA is widely used in the private sector as well as for public organizations (education, health, social services). It is a suitable method for various institutions and organizations operating in different fields such as supply chain, banking, healthcare, education and local government.

There are two commonly used DEA models in the literature: the CCR model introduced by Charnes, Cooper and Rhodes (1978), which assumes constant returns to the scale, and the BCC model introduced by Banker, Charnes and Cooper (1984), which is based on the assumption of variable returns to the scale (Charnes et al., 1994: 23). The difference between the CCR and BCC models can be better explained by the visualization of the efficiency frontier shown in Figure 1. In the CCR model, the shape of the efficiency frontier for a single input and a single output is a line passing through the origin due to the assumption of constant returns to the scale. In the BCC model, it is piecewise linear and concave due to the assumption of variable returns to the scale.

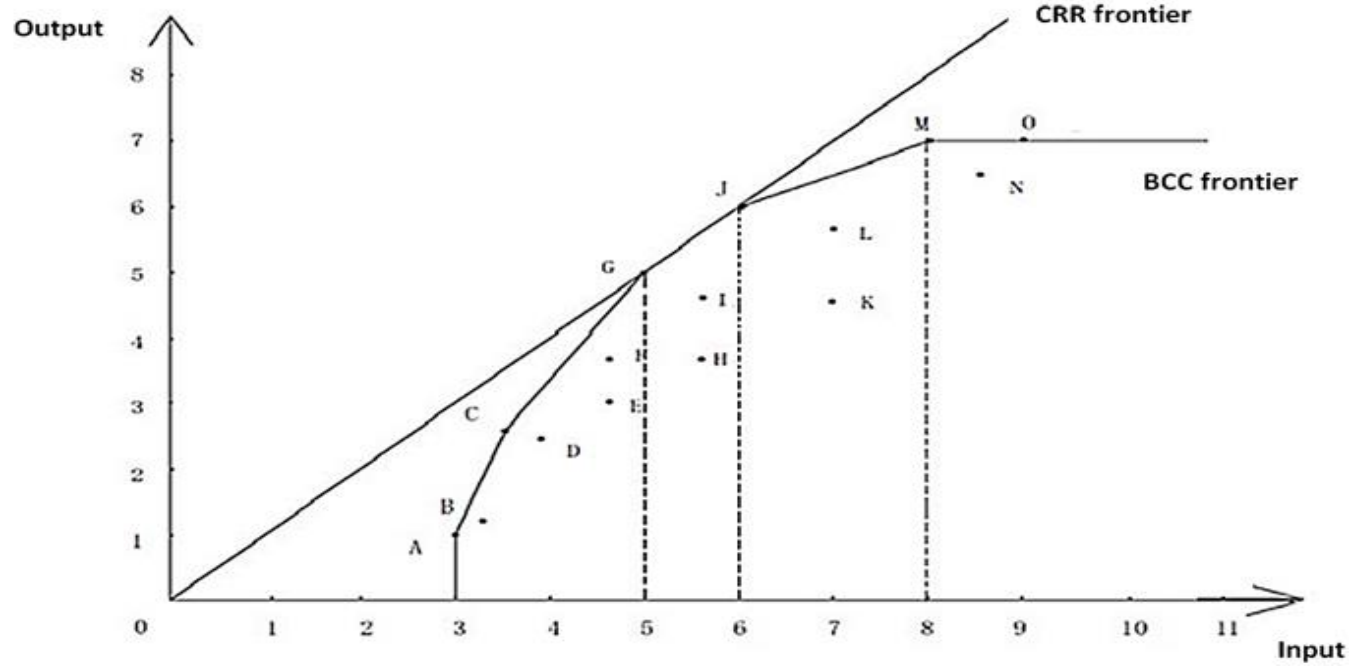


Figure 1: Input-Output CCR and BCC interaction.
Source: Cook, 2009.

The CCR model aims to minimize inputs to meet a minimum level of output (Cooper et al., 2000, p. 41). The first model proposed by Charnes et al. in the 'Management and Economics 21/2 (2014) 1-18 5 (1978)' (Charnes et al., 1978: 430) is a fractional programming model and its solution is quite difficult (Ray, 2004: 29). For this reason, the model was reorganized and transformed into a linear programming (LP) model (Cooper et al., 2000: 23); the envelopment model was developed by examining the dual form of the LP model, since it has fewer constraints and provides important information to managers (Cooper et al. 2000: 43). θ (theta) indicates the efficiency score in the Data Envelopment model (Coelli et al., 2005: 163). In other words, θ gives the efficiency measure calculated based on radial distances from the efficient frontier. Decision-making units with $\theta > 0$ are considered efficient and these decision-making units constitute the reference set for inefficient ones (Tarım, 2001: 65). The BCC model takes into account the returns varying according to the scale with the convexity constraint. The BCC model is divided into input-oriented BCC and output-oriented BCC models. If the sum of the decision-making unit's λj is greater than one, the decision-making units (DMUs) operate at decreasing returns to the scale; if the sum is less than one, the decision-making units (DMUs) operate at increasing returns to the scale; and if the sum of λj is equal to 1, the decision-making units (DMUs) operate at constant returns to the scale. The implementation of DEA takes place in three fundamental steps: determining the parameters to be analyzed, determining the appropriate input and output variables to evaluate the efficiency of the selected parameters, and evaluating the efficiency results (θ) for the parameters by applying the DEA model. In DEA, inputs should be economic units that can be converted into outputs. Since DEA is a comparative analysis, there are very important points for the analysis to give accurate results. The first point is the homogeneity of the parameters, the second is the number of inputs and outputs, and the third is that the number of outputs is greater than the number of inputs (Cooper et al. 2000: 43). CCR and BCC models can be applied as input- and output-oriented models. Output-oriented CCR and BCC models explore the rate at which outputs should be increased by keeping inputs constant. The objective of the input-oriented CCR and BCC models is to find the optimal input combination to be used in order to produce a given output combination. The last step in the application of DEA is to calculate the efficiency results by using the most appropriate DEA model for the purpose and to evaluate these efficiency results. DEA determines whether all resources subjected to efficiency comparison are used efficiently, identifies whether there is any potential for improvement in input and output variables, and provides rational suggestions for improvement based on input and output variables (Gökgöz, 2009: 31).

5. LITERATURE

Berger and Mester (1997) analyzed the efficiency and productivity growth of the US banking sector for the late 1980s and the first half of the 1990s. The results shed light on how banks responded to changes in technology, regulations, and business conditions, suggesting that the transformation was significant given the importance of the banking sector to the economy as a whole. The researchers found that the concepts of cost, standard profit and alternative profit were more explanatory than the other measures. The reason for this is that these measures result from economic optimization in response to relative prices rather than optimization based solely on physical technology. As a result, cost efficiency for banks of all sizes was found to average 80% in 1984-89 and declined to 77% in 1990-95, and profit efficiency estimates were similar for the standard and alternative profit function.

Yıldırım (2002) analyzed the period between 1988 and 1999, investigating the efficiency performance of the Turkish banking sector during this period of increased macroeconomic instability. The technical and scale efficiencies of deposit banks operating in the banking sector were measured using Data Envelopment Analysis. It was concluded that both pure technical and scale efficiency measures showed a large variability for the period under investigation and that the sector failed to achieve sustained efficiency gains. The author stated that the banking sector had a predominantly scale inefficiency problem, which was caused by diminishing returns to the scale.

Halkos and Salamouris (2004) employed a nonparametric analytical technique to measure the performance of the Greek banking sector. The efficiency of Greek banks was investigated using a proposed set of financial efficiency ratios for the period 1997-1999. The model proposed in the study provides an empirical reference set to compare inefficient banks with efficient ones. The ratios were used as output measures without using input measures. This is unlike most studies on bank performance. The proposed model was compared with traditionally used input-output analysis and simple ratio analysis. This study shows that data envelopment analysis can be used as an alternative or complement to ratio analysis to evaluate the performance of an organization.

Debasish (2006) aimed to measure the relative performance of Indian banks over the period 1997-2004 using the output-oriented CRR model. Nine input variables and seven output variables were identified for the analysis. The Indian banking sector was categorized according to the size of bank assets, ownership status and years of operation. The results show that small banks are globally efficient while large banks are locally efficient. Moreover, this study provides evidence of concentration of efficiency parameters across comparable bank groups.

Mostafa (2007) measured the relative efficiency of the 50 largest Gulf Cooperation Council (GCC) banks. Data envelopment analysis (DEA) was used to assess the relative efficiency of GCC banks. Horizontal cross-sectional data for 2005 were used in the analysis. The results indicate that the performance of a few banks is sub-

optimal, but that there is significant room for potential improvements.

Nıţoı (2009) analyzed the efficiency and productivity of Romanian banks between 2006 and 2008. The author used nonparametric data envelopment analysis (DEA) to analyze the efficiency of banks. Analyzing a dataset of 15 commercial banks, it was found that after 2006, the productivity ratio of Romanian commercial banks improved and their cost efficiency scores relatively decreased. It was also found that although total factor productivity increased in 2007, the average efficiency score of banks decreased in 2008.

Shawtari (2015) presented new empirical findings on the efficiency of Islamic and conventional banks operating in Yemen. The objective of the study was to analyze the efficiency of the Yemeni banking sector. A two-stage analysis was used to assess efficiency in the study. In the first stage for the period 1996-2011, Data Envelopment Window Analysis (DEWA) was employed and the stability and efficiency of the sector were considered in a two-dimensional matrix to assess the sustainability capabilities of banks. In the second stage, a panel data analysis was conducted by identifying a set of bank-specific and macroeconomic variables related to the efficiency of the banking sector in Yemen in a comparative manner between Islamic and conventional banks. The findings of the study indicated that, in general, the Yemeni banking sector was on a declining efficiency trend with increasing instability. It was also found that most of the conventional banks were stable despite being inefficient, while Islamic banks had become more efficient over time. Panel data regression results revealed that efficiency was associated with a number of determinants. Loan/financing and profitability were found to be common key determinants of efficiency for both Islamic and conventional banks, while other determinants affected Islamic and conventional banks differently.

Othman et al. (2016) reviewed the literature on measuring the relative efficiency of banks using data envelopment analysis (DEA).

Lago Cotrim et al. (2018) assessed bank efficiency by analyzing data from 37 Brazilian banks obtained from the Central Bank of Brazil using Data Envelopment Analysis (DEA) for the period from 2012 to 2016. The researchers identified the variables using an intermediation approach, analyzed the main causes of bank inefficiency, and determined how banks that are inefficient at the scale can improve their efficiency. As a result, Brazilian banks were found to have an average efficiency of 51.4% according to the Charnes, Cooper and Rhodes (CCR) model and 69.8% according to the Banker, Charnes and Cooper (BCC) model. The inefficiency of Brazilian banks was found to be related to technical and administrative issues. Large banks had many opportunities for improvement in these latter aspects. Bank size was not related to efficiency and the efficiency of the sector could be improved if necessary policies were adopted to increase the participation of small banks.

Mahfooz and Ansari (2021) conducted an empirical evaluation of the performance of commercial banks operating in India. The efficiency of commercial banks was evaluated using a data envelopment analysis (DEA) approach. An extended DEA window analysis approach based on a panel sample of 47 banks operating in the Indian banking sector was preferred. The results suggest that Indian banks are unable to efficiently manage their inputs and convert them into outputs. The authors also conclude that Indian banks are not operating at an optimal level. Analyzing the performance of Indian banks at the individual level, the authors found that public banks are the most efficient, followed by foreign banks, while private banks are the least efficient.

Qingquan et al. (2022) investigated commercial banks that have an significant leadership position for China's banking sector and whose efficiency reflects the current state of the Chinese economy, and calculated the efficiency of 19 commercial banks from 2016 to 2020 using two-stage DEA with constant returns to the scale. The researchers found that the calculated values were more accurate than the DEA values measured directly by the two-stage network, and the banks with an efficiency value 1 were more distinguishable. According to the analysis, ICBC Bank's operating efficiency was the highest and the operating efficiency of the entire banking sector was found to be at a medium level.

Ünlü et al. (2022) evaluated the efficiency and productivity of banks during and after the Covid 19 pandemic as an external shock by using a new integrated multi-criteria decision making (MCDM) approach. The differences between banks in terms of efficiency and productivity were evaluated by grouping them as public banks, foreign banks and domestic private banks. A new integrated MCDM approach was used to evaluate bank efficiency and productivity, including SWARA II as a subjective weighting method, MEREC as an objective weighting method and MARCOS as a ranking method. The researchers found that banks with foreign investors achieved higher efficiency compared to other bank groups, while the efficiency of public banks declined, particularly during the COVID-19 period.

6. RESEARCH METHODOLOGY AND EMPIRICAL FINDINGS

6.1. Research Method, Data Set and Variables

This study employs DEA, which is an effective method to explore the pairwise correlation coefficients of input and output variables and to investigate whether significant sets of variables are used. The reason for using output-oriented CCR model in the analysis is to explore to what extent outputs should be increased while keeping inputs constant. In other words, the objective is to determine to what extent resources should be increased in order to improve the efficiency of banks. 24 deposit banks listed in Table 2 were selected for the analysis within the scope of the study. The studies in the literature were taken into consideration in determining

the variables required for the analysis; however, it was observed that there was no consensus. In this context, the variables were determined by taking into account the effect of input and output variables to be included in the analysis on efficiency measurement and the data for the period 2012-2022 were taken from the financial statements of the Banks Association of Turkey (BAT) data internet system. The efficiency values calculated according to the DEA model of the deposit banks included in the analysis in this study were found with the help of DEAP 2.1 software. Correlation and chi-square tests were conducted using SPSS 25.00 at 0.05 significance level to evaluate the results of the analysis performed using the output-oriented CCR model. The limitation of the study is that efficiency was measured according to input and output levels for the period 2012-2022. In other words, efficiency was measured according to the parameters determined (Interest Income, Current Period Profit, Total Loans, Non-Performing Loans and Interest Expenses, Total Assets, Number of Personnel, Total Deposits, Capital Adequacy Ratio (CAR), Number of Branches). All interpretations and discussions are based on these parameters. It is recognized that different results may be found if different periods and different parameters are selected.

Table 1: Turkish deposit banks subjected to data analysis.

Public Banks	Private Banks
TC. Ziraat Bankası AŞ.	Akbank
Türkiye Vakıflar Bankası T.A.O.	Anadolu Bankası AŞ
Türkiye Halk Bankası A.Ş	Fibabanka AŞ
	Şekerbank TAŞ
	Turkish Bank AŞ
	Türk Ekonomi Bankası AŞ
	Türkiye İş Bankası AŞ
	Yapı ve Kredi Bankası AŞ
	Alternatifbank AŞ.
	Arap Turk Bank
	Burgan Bank AŞ.
	Citibank AŞ.
	Denizbank AŞ
	Deutsche Bank AŞ
	ICBC Turkey Bank AŞ
	ING Bank AŞ.
	Odea Bank AŞ
	QNB Finansbank AŞ
	Turkland Bank AŞ
	Türkiye Garanti Bankası AŞ
	HSBC Bank AŞ

Table 2: Variables Used in the Analysis.

Inputs	Outputs
Interest Income	Total Loans
Total Assets	Current Period Profit
Number of Personnel	Interest Expenses
Total Deposit	Non-performing Loans
Capital Adequacy Ratio (CAR)	
Number of Branches	

6.2. Empirical Findings and Discussion

This section analyzes the selected input and output variables of deposit banks operating in the Turkish banking sector between 2012 and 2022 using data envelopment analysis. The correlation coefficients of the input and output variables of the Turkish banking sector are calculated, Levene's test is performed and the efficiency scores of the banks are determined by evaluating the efficiency θ of the banks according to the CCR model.

Table 3: Relations Between Input and Outputs.

		Interest Expenses	Total Assets	Number of Personnel	Total Deposit	CAR	Number of Branches
Interest Income	r	0.974*	0.982*	0.604*	0.984*	-0.069	0.591*
	p	0.01	0.01	0.01	0.01	0.266	0.01
Current Period Profit	r	0.688*	0.766*	0.414*	0.755*	0.058	0.386*
	p	0.01	0.01	0.01	0.01	0.347	0.01
Total Loans	r	0.972*	0.996*	0.693*	0.989*	-0.112	0.683*
	p	0.01	0.01	0.01	0.01	0.068	0.01
Non-performing Loans	r	0.901*	0.940*	0.580*	0.932*	-0.059	0.541*
	p	0.01	0.01	0.01	0.01	0.341	0.01

Note: *Level of significance at the 0.05 level.

Table 3 shows the correlation coefficients of the input and output variables used in the analysis. The results

show that there is a high level of correlation between the variables, while only the CAR levels do not have a significant relationship with the inputs. The smallest correlation coefficient is 0.386, whereas the highest correlation coefficient was calculated as 0.386. Since the CAR is not significantly related to the input variables, it is not included in DEA analysis.

According to the results of Levene's test, Interest Income, Current Period Profit, Total Loans and Non-Performing Loans meet the homogeneity assumption. Similarly, Interest Expenses, Total Assets, Number of Personnel, Total Deposits and Number of Branches also meet the homogeneity assumption (p>0.05).

Table 4: CCR results.

Efficiency Values θ Lower Limit	Upper Limit	CCR	%
0	0.99	118	44,7
1	1>	146	55,3
Total		264	100

Evaluating the efficiency θ of the 24 banks in the 11 periods included in the analysis according to the output-oriented CCR model, 146 of the 264 bank periods were found to be efficient with an efficiency score of 1. To summarize, 55.3% efficiency was achieved by 24 banks in 11 periods over the last 11 years.

Table 5: Efficiency Level by Year.

Yıl	Efficiency				p
	Not efficient		Efficient		
	n	%	n	%	
2012	24	100.0%	0	0.0%	
2013	22	91.7%	2	8.3%	
2014	18	75.0%	6	25.0%	
2015	17	70.8%	7	29.2%	
2016	12	50.0%	12	50.0%	
2017	7	29.2%	17	70.8%	0.01*
2018	7	29.2%	17	70.8%	
2019	5	20.8%	19	79.2%	
2020	4	16.7%	20	83.3%	
2021	4	16.7%	20	83.3%	
2022	2	8.3%	22	91.7%	

Note: *Level of significance at the 0.05 level.

An analysis of the efficiency levels by year shows that the concept of efficiency gained importance especially after 2017. It was found that efficiency levels differed significantly by year. It was observed in the present study that the efficiency levels of 24 banks were quite low before 2017. The efficiency level was 70.8% in 2017, 79.2% in 2019, 83.3% in 2020 and 91.7% in 2022 (p=0.01). The main reason behind these increases is that interest income and current period profit levels increased while all other outputs, especially the number of branches, remained constant or decreased.

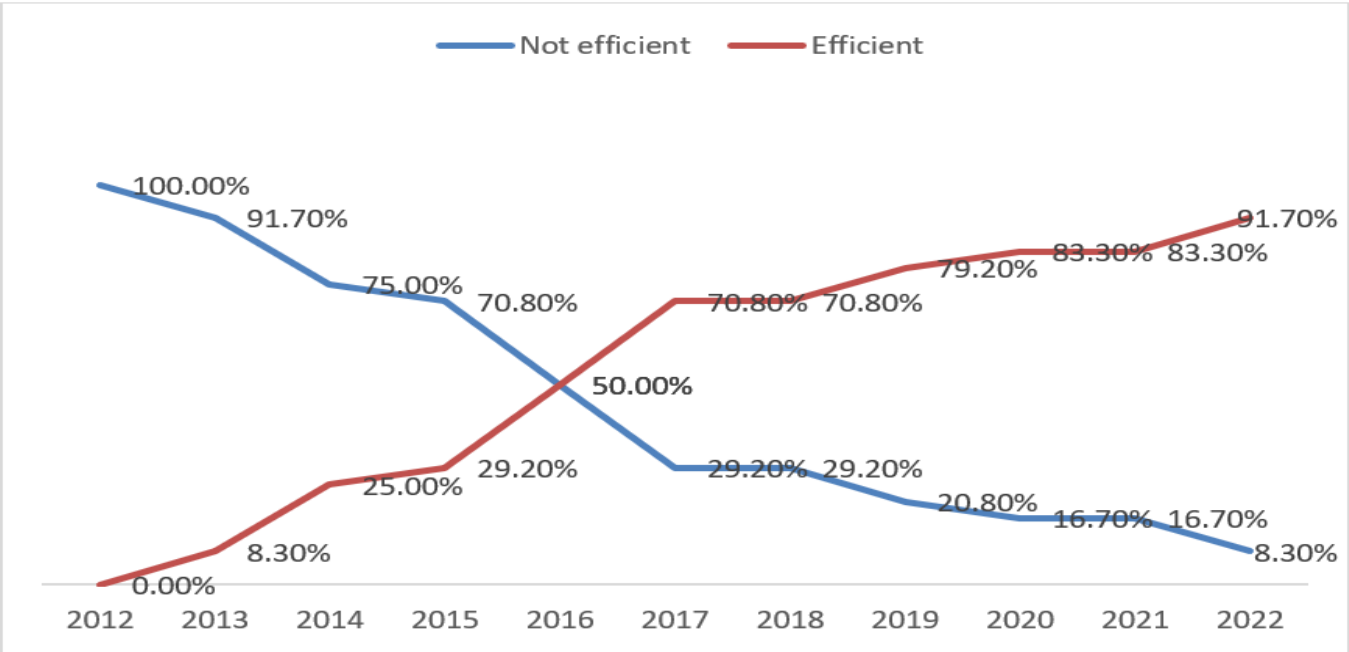


Figure 2: Efficiency Level by Year.

As seen in Figure 2, 2016 can be considered a turning point for efficiency.

Table 6: Efficiency Levels of Banks by Sector (Private or Public).

Bank Type	Efficiency				p
	Not efficient		Efficient		
	n	%	n	%	
Private	46	52.3%	42	47.7%	0.01*
Public	72	40.9%	104	59.1%	

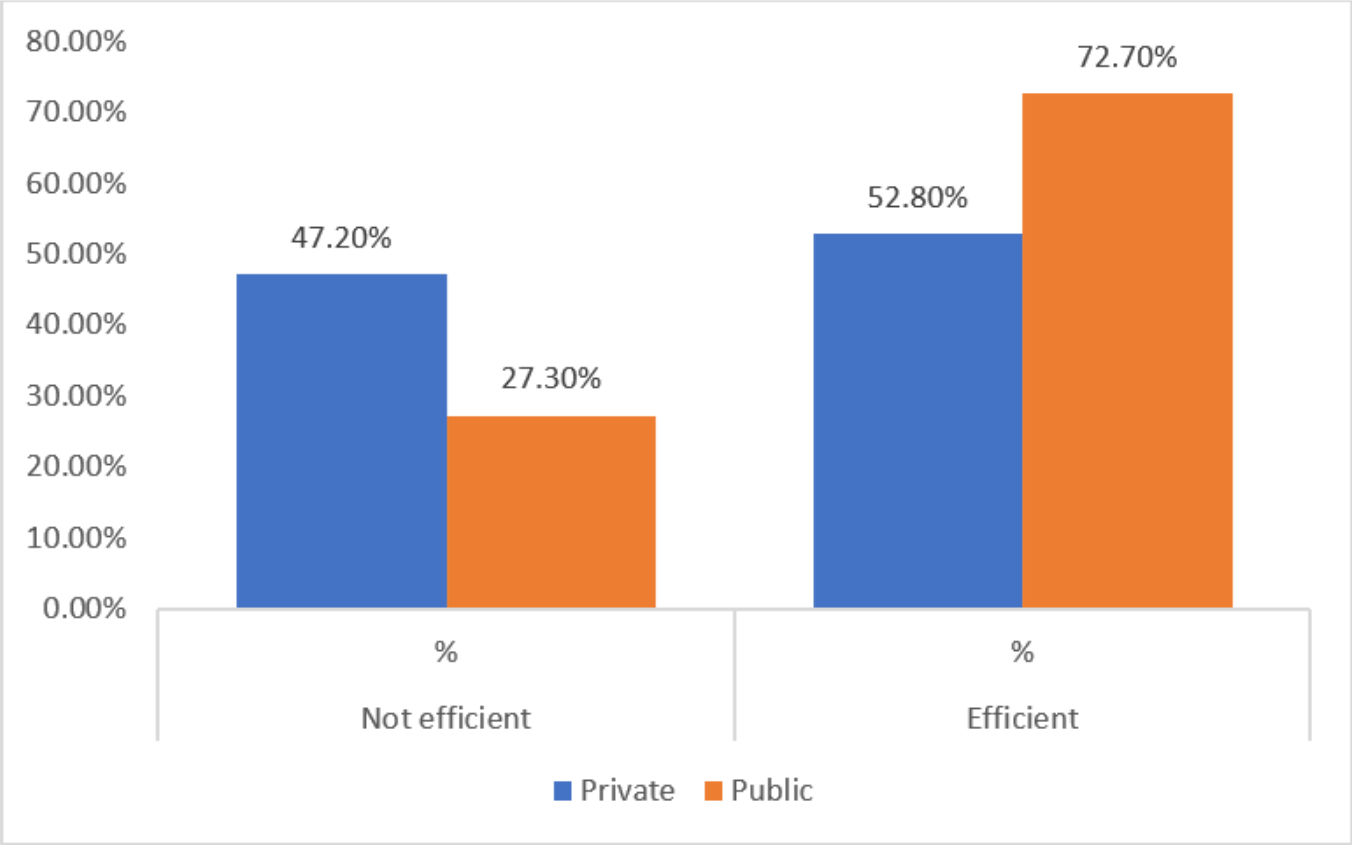


Figure 3:
Note: *Level of significance at the 0.05 level.

It was found that the efficiency levels of the banks in the 11 periods analyzed differed by whether they were in the public or private sector. According to the results, public banks had an efficiency level of 59.1%, while this rate was 47.7% in the private sector (p=0.01). It was observed that public banks were more efficient according to the input and output levels in the relevant period.

Table 7: Banks and efficiency ratios.

BANK	Not efficient		Efficient	
	n	%	n	%
Yapı ve Kredi	1	9.1%	10	90.9%
Citibank	1	9.1%	10	90.9%
Vakıfbank	2	18.2%	9	81.8%
Garanti	2	18.2%	9	81.8%
Akbank	3	27.3%	8	72.7%
Halk	3	27.3%	8	72.7%
ArapTürk	3	27.3%	8	72.7%
Alternatif	3	27.3%	8	72.7%
Ziraat	4	36.4%	7	63.6%
İşbankas	4	36.4%	7	63.6%
ING Bank	4	36.4%	7	63.6%
Finans	4	36.4%	7	63.6%
Odea	5	45.5%	6	54.5%
HSBC	5	45.5%	6	54.5%
Fibabanka	5	45.5%	6	54.5%
Denizbank	5	45.5%	6	54.5%
Burgan	6	54.5%	5	45.5%
Anadolu	6	54.5%	5	45.5%
TEB	7	63.6%	4	36.4%

Turkland	8	72.7%	3	27.3%
Deutsche	8	72.7%	3	27.3%
ICBC Tur	9	81.8%	2	18.2%
Turkish Bank	10	90.9%	1	9.1%
Şekerbank	10	90.9%	1	9.1%

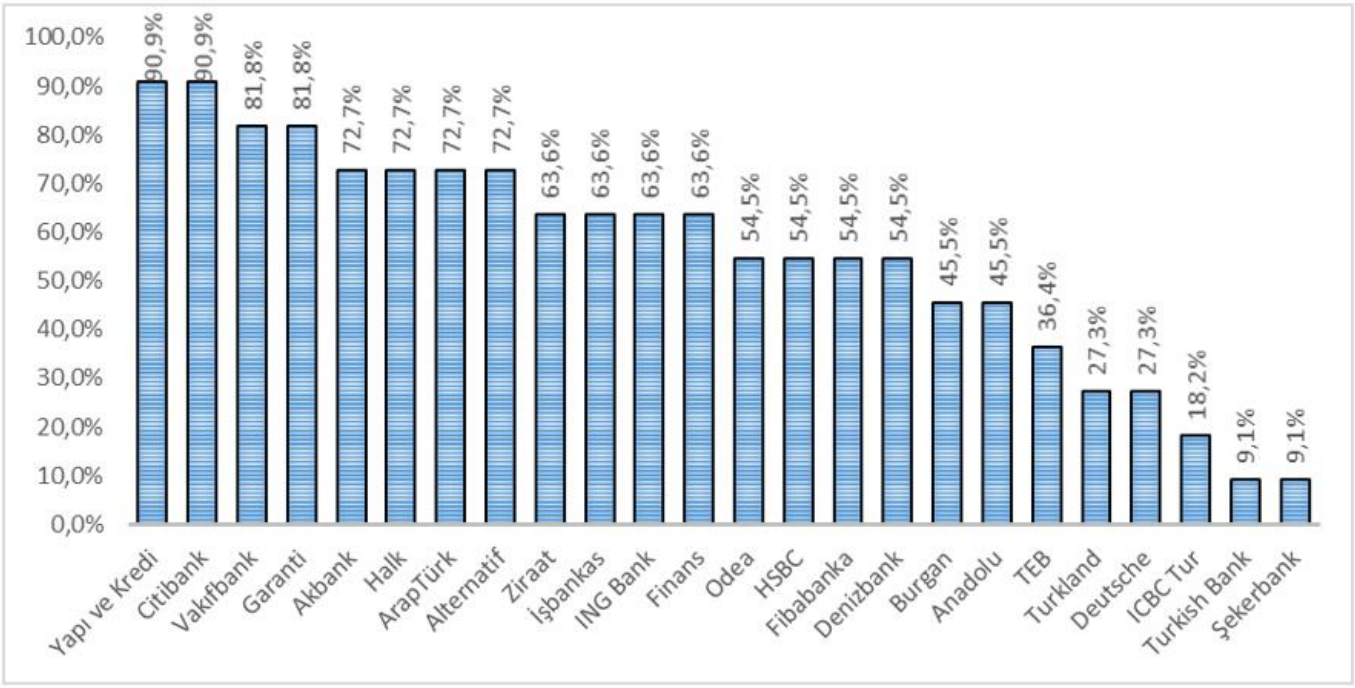


Figure 4:

Table 7 shows the results achieved, which are also shown as a bar chart. An analysis of 11-period efficiency levels shows that Yapı Kredi Bank, Citibank, Vakıfbank T.A.O., Garanti Bank had the highest level of efficiency above 80%.

TEB, Turkland Bank, Deutsche Bank, ICBC Turkey Bank, Turkish Bank and Şekerbank were found to be banks with 40% or less efficiency.

7. CONCLUSION

The Turkish banking sector, which constitutes a significant portion of the financial market, has undertaken an important task in increasing profitability and contributing to the national economy by ensuring strong capital adequacy. From this perspective, the more efficient and effective the banking sector operates, the more significant and meaningful it is for all service units and participants in the economy. Efficient and effective banks are the key to minimizing the damage caused by unexpected changes and crises that may occur in the financial system, even pandemics. Therefore, the main objective of this study is to measure the efficiency of deposit banks operating in the Turkish banking sector for the period 2012-2022 by using the Data Envelopment Analysis model. Correlation coefficients of input and output variables related to the sector were calculated, Levene's test was performed, and efficiency scores of banks were determined by evaluating the efficiency θ of banks according to the CCR model in order to measure the efficiency of Turkish deposit banks. While there was a high level of correlation between the variables in the analysis, it was observed that only CAR levels were not significantly related to the inputs. Therefore, CAR was not included in DEA analysis. According to the results of Levene's test, Interest Income, Current Period Profit, Total Loans and Non-Performing Loans meet the homogeneity assumption and similarly, Interest Expenses, Total Assets, Number of Employees, Total Deposits and Number of Branches also meet the homogeneity assumption. Evaluating the efficiency θ of the 24 banks in the 11 periods included in the analysis according to the output-oriented CCR model, 146 of the 264 bank periods were found to be efficient with an efficiency score of 1. An analysis of efficiency levels by year shows that the concept of efficiency gained importance especially after 2017. This is believed to be due to the fact that despite the slowdown in the growth rate in 2016 and the external shocks arising from global financial markets and the increase in geopolitical risks, the Turkish economy showed a high growth performance in 2017 and experienced a rapid recovery, and thanks to the multifaceted decisions taken to support economic activities, consumption, production and investment revived and loan demand accelerated. These positive developments led to positive developments in the banking sector, such as the increase in total assets in real terms, the increase in capital adequacy, the acceleration of loan growth and the corresponding increase in profit volume, the decline in the non-performing loan ratio and the increase in the market value of banks. In this context, 2016 could be considered a turning point for banks in terms of efficiency. The analysis shows that the efficiency of the banks was 70.8% in 2017, 79.2% in

2019, 83.3% in 2020 and 91.7% in 2022. The main reason for these increases is that while interest income and current period profit levels increased, while all other outputs, especially the number of branches, remained constant or decreased. In addition, it was found that the efficiency levels of the banks in the 11 periods analyzed in the study differed by whether they were in the public or private sector. Public banks were found to be more efficient according to the input and output levels in the relevant period. The analysis reveals that Yapı Kredi, Citibank, Vakıfbank, Garanti Bank had the highest level of efficiency above 80%, while TEB, Turkland, Deutsche Bank, ICBC Turkey, Turkish Bank and Şekerbank had efficiency levels of 40% and below.

This study evaluated the efficiency of the deposit banks included in the analysis for the period 2012-2022 and compared the efficiency levels between the private and public sectors, but did not differentiate between banks with foreign capital and private banks with domestic capital. In similar studies to be conducted in the future, it may be useful to test the necessity of working on the most favorable implementation methods by focusing on scale efficiency in order to create a competitive advantage for private banks established with domestic capital against foreign capital banks in the financial harmonization process. In addition, the efficiency scores according to the DEA CCR model for deposit banks operating in the Turkish banking sector in this analysis are the efficiency values tested according to the input-output variables for the specified period. It is recognized that if the model is applied using variables other than the input and output variables used in this analysis, the results may change.

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