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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 θ 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.

Key Words: *Bankacılık Sektörü, Etkinlik, VZA, Çıktı Yönlü CCR Modeli*

1. Introduction

The banking sector is a fundamental player that rapidly responds to economic developments and actively shapes the financial landscape. Its primary role ensures that any economic fluctuations, whether at a national or international level, directly impact its positive or negative outcomes, making it an indicator of global connectivity. Therefore, consistently enhancing the sector's performance is vital for healthy financial development and resilience. The efficiency of banking operations drives economic growth while supporting market expansion and vitality. In the intense competitive environment of the sector, banks' profitability and efficiency emerge as critical determinants of success. Their core mission is to maximize output from existing resources, thereby channeling surplus funds into productive investments to stimulate economic activity. Bank management plays a key role in macroeconomic stability and influences resource allocation within the financial ecosystem. However, the degree of performance improvement depends on how inputs are utilized by management, intertwining effectiveness, efficiency, and quality. Thus, this study

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aims to conduct an in-depth examination of the efficiency and effectiveness of the Turkish banking sector, shedding light on its intricacies and implications. A study on profitability concerning deposits and loans aims to inform future banking policies and practices to enhance overall sector performance. Recent positive developments in the Turkish banking sector, coupled with intense competition, have distinguished it from other economic sectors. This necessitates banks to fulfill their financial intermediation function, determining resource allocation and maximizing their resources' efficiency. Collecting public savings and using these funds most efficiently are generally recognized as banks' most important activities. If banks cannot utilize their resources in productive investments as necessary, 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 Analysis (DEA) method. Data from 24 deposit banks operating in the Turkish banking sector from 2012 to 2022 were used for this analysis. DEA was preferred for this analysis because it can be used more comfortably in cases where other approaches used in efficiency analysis are inadequate. The variables to be included in the analysis for efficiency measurement were determined by considering the impact of input and output variables on efficiency measurement, and the data for the period 2012-2022 were obtained from the Turkish Banks Association (TBB) data internet system. First, theoretical explanations about the concept of efficiency, efficiency measurement methods, and the DEA method used in the analysis are provided. Additionally, a literature review on studies conducted on this topic is presented due to the importance and relevance of the efficiency concept. Finally, the findings and evaluations of the analysis are presented. Through the exploration of these dynamics, this study aims to contribute to the ongoing debate surrounding banking sector efficiencies, providing insights critical for informed decision-making and strategic planning.

2. The Concept of Efficiency and Measurement Systems Used in Efficiency Analysis

The term "efficiency" differs from "effectiveness," although both are used to evaluate a business's performance. According to Jouadi and Zorgui (2014), efficiency encompasses the idea of producing in the most optimal manner, emphasizing the judicious use of resources. It involves achieving the best output with the minimum input, essentially ensuring the optimal utilization of resources to generate top-quality products at minimal costs. In management contexts, efficiency refers to the optimal utilization of internal factors within the company. On the contrary, effectiveness focuses on the attainment of goals and outcomes, irrespective of the specific methods or forms used to optimize resource utilization (Naber 2019).

Measuring the performance of the banking sector necessitates the identification of its outputs. However, the literature lacks consensus on what precisely banks produce. Serving as economic decision-making units, banks operate with a multitude of inputs and outputs, functioning as intermediary institutions striving to maximize capital returns while delivering financial services. Yet, defining the output vector in banking proves to be a complex endeavor. A variable considered as an output in one study measuring bank performance might be construed as an input in another. There exist two primary approaches to gauging efficiency or performance: the production approach and the intermediation approach. The methodologies and criteria employed in efficiency measurement significantly influence the evaluation of attained outcomes (Yolalan 2001).

Production Approach: Banks engage in the provision of services to depositors. Under the production approach, banks are viewed as entities utilizing inputs such as capital, labor, branches, and inventory to "produce" outputs like deposits, loans, security portfolios, and other items on their balance sheets. Output measurement in this approach often revolves around metrics such as the quantity of accounts (Bilişik, 2015).

Intermediation Approach: Contrarily, the intermediation approach conceptualizes banks primarily as financial intermediaries. They mobilize funds from depositors and utilize these resources to extend loans and other assets, thereby generating profits. In this perspective, deposits and similar resources are regarded as inputs, while loans and other assets constitute the bank's outputs. Consequently, the unit of measurement for inputs and outputs in this approach is typically currency rather than the number of accounts.

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, a method widely employed in efficiency measurement, involves the ongoing monitoring of a ratio derived from comparing a single input to a single output over time. This method operates on a ratio scale and is favored for its ease of application and interpretation. However, it is not typically used to assess the efficiency of the banking sector due to the complexity of decision-making units within this domain, which involve numerous inputs and outputs.The frontier efficiency approach, on the other hand, begins by identifying the most efficient frontier. Within this approach, two main methods are utilized: parametric and nonparametric. Parametric methods typically define a set of observations and assume that the best performance lies along the regression line, known as the efficiency frontier. Observations deviating from this line are deemed inefficient, reflecting either high costs at a given output level or low output at a given input level. Efficient observations are characterized by zero error, indicating homogeneity among observed production units. Therefore, identifying inefficiencies relies on eliminating measurement errors. In parametric methods, it is initially assumed that the banking sector's production function follows an analytical structure, and the parameters of this function are determined. Regression techniques are commonly employed for estimation in parametric performance measurement, with regression analysis being the most prevalent method. This aims to ascertain the causal relationship between dependent and independent variables known to exhibit cause-and-effect dynamics. Parametric methods fall into three categories: the stochastic frontier approach, distribution-free approach, and thick frontier approach. The stochastic frontier approach, an econometric method, establishes a functional relationship between explained variables (e.g., cost, profit, production) and explanatory variables (e.g., input, output, environmental factors), incorporating an error

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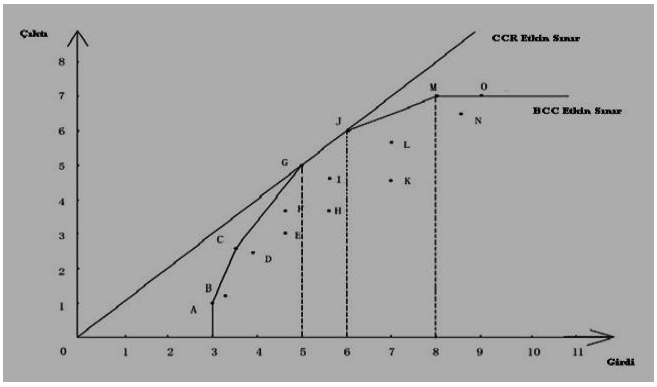
term into the model. Critiques of this approach often center on its distributional assumptions. In contrast, the distribution-free approach operates under the assumption that error terms and their components can have any distribution within certain constraints. It presupposes that efficiency remains constant, or at least stable, for each enterprise and that measurement errors tend toward zero over time, provided inefficient observations are positive. Lastly, the thick frontier approach diverges from the stochastic and distribution-free approaches in its lack of assumptions regarding the distributions of inefficient observations and random errors. This approach does not impose expectations about the distributions of these elements, setting it apart from the other two methodologies. In this approach, it is assumed that the random error comprises the largest and smallest differences between observed and expected values, while the remaining discrepancies represent inefficient observations (Ekodiyalog, ...). However, this method is not suitable for estimating the efficiency of a single production unit. Within the productivity literature, there is no consensus on which approach is superior or more suitable compared to 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.

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

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variables, and provides rational suggestions for improvement based on input and output variables (Gökgöz, 2009: 31).

5. Literature

Below is the literature review conducted on the subject of the study.

In their study, Berger and Mester (1997) examined the productivity and efficiency growth of the US banking sector during the late 1980s and the early 1990s. Their findings demonstrated how banks adapted to changes in technology, regulations, and business conditions, highlighting the critical importance of the banking sector for the economy. The researchers identified concepts such as cost, standard profit, and alternative profit as more explanatory than other measures. It was emphasized that these concepts were based on economic optimization and developed in response to technological advancements. The study observed that the cost efficiency of banks averaged 80% during the period of 1984-89 but declined to 77% during 1990-95. It was also found that profitability efficiency estimates were similar for standard and alternative profit functions.

Yıldırım (2002) examined the efficiency performance of the Turkish banking sector for the period between 1988 and 1999, during which macroeconomic instability increased. Data Envelopment Analysis was employed to measure the technical and scale efficiencies of deposit banks. The research findings indicate significant variability in both pure technical and scale efficiency measures during the examined period, suggesting that the sector did not consistently achieve efficiency gains. Particularly, the banking sector was noted to face the problem of scale inefficiency, which was attributed to decreasing returns to scale.

The study presented by Halkos and Salamouris (2004) involves the use of a non-parametric analytical method to evaluate the performance of the Greek banking sector. The research examined the efficiency of Greek banks using a set of proposed financial efficiency ratios for the period 1997-1999. The proposed model provides an empirical reference set to compare inefficient banks with efficient ones. This study offers an original approach by not using input measures and considering the identified ratios as output criteria. This differs from other studies evaluating bank performance. The research was compared with traditional input-output analysis and simple ratio analysis. The results indicate that Data Envelopment Analysis can be used as an alternative or complementary method to ratio analysis in assessing organizational performance.

The study by Debasish (2006) examined the relative performance of banks in India using the output-oriented CRR VZA model during the period 1997-2004. The research identified nine input variables and seven output variables for analysis. The banking sector in India was classified based on bank asset size, ownership status, and years of operation. The findings indicate that small banks tend to be generally efficient globally, while large banks are efficient locally. Additionally, this study provides evidence of the concentration of efficiency parameters among similar groups of banks.

Mostafa (2007) conducted a study to evaluate the relative efficiency of the top 50 banks in the Gulf Cooperation Council (GCC). Data envelopment analysis (DEA) was employed to assess the relative efficiency of these banks. The analysis utilized horizontal cross-sectional data for the year 2005. Findings revealed that while the performance of some banks fell below optimal levels, there existed substantial scope for potential enhancements.

Nıţoı (2009) conducted an analysis on the efficiency and productivity trends of Romanian banks spanning the period from 2006 to 2008. Employing nonparametric data envelopment analysis (DEA), the author examined the efficiency levels of these banks. Using a dataset comprising 15 commercial banks, the study revealed that following the year 2006, the productivity ratio of Romanian commercial banks exhibited improvement, while their cost efficiency scores relatively declined. Additionally, it was observed that although total factor productivity experienced an increase in 2007, the average efficiency score of banks decreased in 2008.

Shawtari (2015) introduced novel empirical discoveries regarding the effectiveness of Islamic and traditional banks operating within Yemen. The main aim of the research was to scrutinize the efficacy of Yemen's banking industry. The study employed a dual-stage analysis to evaluate efficacy. Initially, for the timeframe spanning 1996 to 2011, Data Envelopment Window Analysis (DEWA) was utilized, considering both sector stability and efficacy within a two-dimensional framework to gauge the sustainability of banking institutions. Subsequently, a panel data examination was carried out, contrasting Islamic and traditional banks by identifying a range of bank-specific and macroeconomic variables associated with Yemen's banking sector efficacy. The outcomes of the investigation revealed a general decline in efficacy within Yemen's banking sector, coupled with escalating instability. Notably, despite their inefficiency, the majority of traditional banks exhibited stability, whereas Islamic banks demonstrated an enhanced level of efficacy over time. Panel data regression outcomes indicated that efficacy was influenced by various factors. Loan/financing and profitability emerged as common pivotal determinants of efficacy for both Islamic and traditional banks, whereas other factors exerted differential effects on these two types of banks.

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

The study by Lago Cotrim and colleagues (2018) aims to examine banking efficiency in Brazil during the period 2012-2016 by analyzing data from 37 banks. The research focuses on using Data Envelopment Analysis (DEA) to determine bank efficiency through variables and to enhance the efficiency of inefficient banks. The findings indicate that Brazilian banks demonstrate an average efficiency of 51.4% for the Charnes, Cooper, and Rhodes (CCR) model and 69.8% for the Banker, Charnes, and Cooper (BCC) model. It was found that bank inefficiency stems from both technical and managerial issues. It is emphasized that large banks have many opportunities to address these issues. The study concludes that bank size is not directly related to efficiency and that policies aimed at increasing the participation of small banks could enhance the overall efficiency of the sector.

The study by Mahfooz and Ansari (2021) aims to empirically evaluate the performance of commercial banks in India. In the study, the efficiency of commercial banks is examined using the Data Envelopment Analysis (DEA) approach. A wide panel sample consisting of 47 banks in India is used, and a DEA window analysis approach is preferred. The findings indicate that Indian banks are unable to manage inputs efficiently and convert them into outputs. Additionally, it is noted that Indian banks do not

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operate at an optimum level. According to individual performance analysis, it is found that public banks are the most efficient, followed by foreign banks, while private banks are the least efficient.

The study by Qingquan and colleagues (2022) examined the efficiency of commercial banks operating in China, a significant leader in the banking sector. The study utilized a two-stage Data Envelopment Analysis (DEA) method with fixed scale variables to measure the efficiency of 19 commercial banks between 2016 and 2020. The results indicate that the calculated values are more accurate than the direct DEA values, and banks with an efficiency value of 1 are better distinguished. According to the analysis, ICBC Bank has the highest operational efficiency, while the entire banking sector has an average operational efficiency.

The study by Ünlü and colleagues (2022) utilizes a new integrated multicriteria decision-making (MCDM) approach to evaluate the efficiency and productivity of banks during and after the Covid-19 pandemic. In the study, banks are grouped and examined in terms of efficiency and productivity, including public banks, foreign banks, and domestic private banks. Subjective weighting methods such as SWARA II, objective weighting methods such as MEREC, and a ranking method like MARCOS are used to analyze bank efficiency and productivity. The findings indicate that banks with foreign investment demonstrate higher efficiency compared to other bank groups, and particularly during the COVID-19 period, there has been a decrease in the efficiency of public banks.

6. Research Methodology and Empirical Findings

6.1. Research Method, Data Set and Variables

In this study, Data Envelopment Analysis (DEA) was employed, which is an effective method for examining the pairwise correlation coefficients of input and output variables to investigate whether meaningful variable clusters were used. DEA is a method that can be more easily used when other approaches used in efficiency analysis are weak, as it has fewer assumptions. Therefore, in the analysis of this study, this model was preferred, and the Charnes, Cooper, and Rhodes (1978) CCR model, which has the constant returns to scale assumption, one of the widely used VZA models, was used. The reason for using output-oriented CCR models in the analysis is to examine how much outputs need to be increased while keeping inputs constant. In other words, it determines to what extent resources need to be increased to improve the efficiency of banks. In the study, 24 deposit banks listed in Table 2 were selected for analysis. Although studies in the literature were considered in determining the necessary variables for the analysis, it was observed that there was no consensus. In this context, considering the impact of the input and output variables to be included in the analysis on efficiency measurement, the variables were determined, and the data for the period 2012-2022 were obtained from the financial statements of banks via the Turkey Banks Association (TBB) data internet system. The efficiency values calculated according to the VZA model of deposit banks included in the analysis in this study were found using the DEAP 2.1 program. Correlation and chi-square tests at the 0.05 significance level were conducted using SPSS 25.00 software for the evaluations of the analyses conducted using the output-oriented CCR model. The limitation of this study is that efficiency was determined based on input and output levels between 2012 and 2022. In other words, efficiency was generated according to the determined parameters (Interest Income, Net Period Profit, Total Loans, Non-Performing Loans and Interest Expenses, Total Assets, Number of Employees, Total Deposits, ROA, Number of Branches). All comments and discussions were made accordingly. It is acknowledged that different periods and different parameters may lead to different results.

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

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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

		Faiz gideri	Top Aktif	Personel sayısı	Toplam Mevduat	SYO	Şube sayısı
Faiz	r	,974*	,982*	,604*	,984*	-0,069	,591*
Geliri	p	0,01	0,01	0,01	0,01	0,266	0,01
Net	r	,688*	,766*	,414*	,755*	0,058	,386*
Kar	p	0,01	0,01	0,01	0,01	0,347	0,01
Toplam	r	,972*	,996*	,693*	,989*	-0,112	,683*
Kredi	p	0,01	0,01	0,01	0,01	0,068	0,01
Takip	r	,901*	,940*	,580*	,932*	-0,059	,541*
kredi	p	0,01	0,01	0,01	0,01	0,341	0,01

*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

Etkinlik Değerleri θ		CCR	%
Alt Limit	**Üst Limit**		
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.

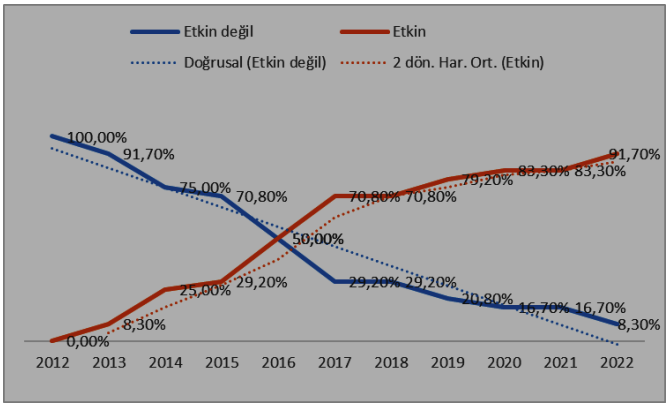
Table 5: Efficiency Level by Year

Yıl	Etkinlik				p
	Etkin değil		Etkin		
	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%	

*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

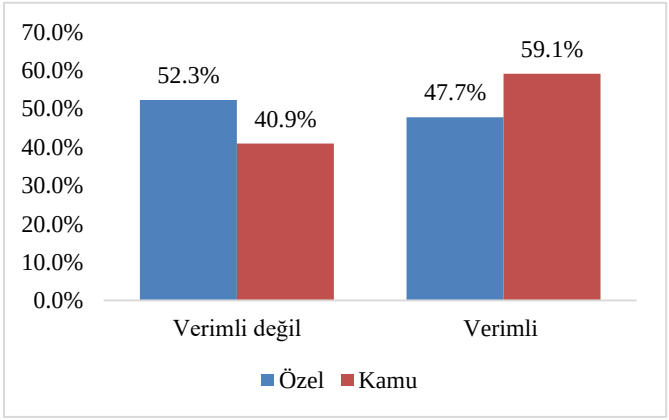


As seen in Figure 2, 2016 can be considered a turning point for efficiency.

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

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

*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

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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%

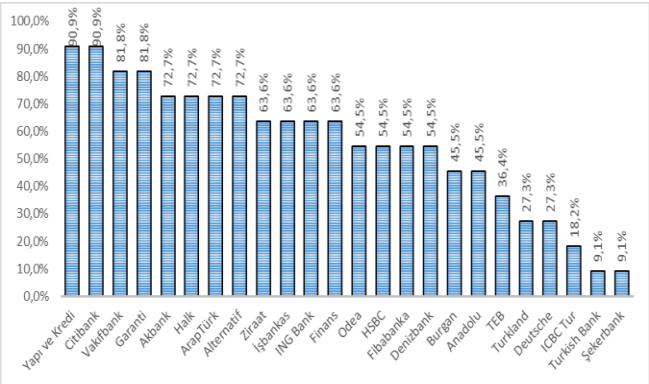

Table 7 shows the results achieved, which are also shown as a bar chart. An analysis of 11-period efficiency levels shows that Yapı Kredi Bank, Citibank, Vakıfbank T.A.O., Garanti Bank had the highest level of efficiency above 80%.

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 industry, a substantial component of the financial market, plays a pivotal role in enhancing profitability and bolstering the national economy through robust capital adequacy. Hence, the more proficient and impactful the banking sector's operations, the more significant and meaningful its role becomes for all economic stakeholders. Efficient and effective banks serve as a crucial buffer against the adverse effects of unforeseen changes and crises, including pandemics, within the financial system. This study aimed to measure the efficiency of deposit-taking banks in the Turkish banking sector spanning from 2012 to 2022 using the Data Envelopment Analysis (DEA) model. To achieve this, correlation coefficients were calculated for input and output variables related to the sector, and Levene's test was conducted to assess homogeneity. Subsequently, banks' efficiency scores were evaluated based on the CCR model to assess the efficiency of Turkish deposit-taking banks, determining the efficiency (θ) levels of banks. While strong correlations were observed among most variables in the analysis, it was noted that only the levels of Capital Adequacy Ratio (CAR) did not significantly correlate with inputs. Therefore, CAR was excluded from the DEA analysis. According to Levene's test results, variables such as Interest Income, Current Period Profit, Total Loans, and Non-Performing Loans exhibited homogeneity, as did Interest Expenses, Total Assets, Number of Employees, Total Deposits, and Number of Branches. Upon evaluating the efficiency (θ) of the 24 banks across the 11 periods under analysis using the output-oriented CCR model, it was found that 146 out of the 264 bank periods demonstrated efficiency scores of 1, signifying efficiency. An examination of efficiency levels over the years indicates a notable emphasis on efficiency, particularly post-2017. This trend is attributed to the Turkish economy's resilient performance amidst the slowdown in 2016 and subsequent global financial market disruptions and geopolitical tensions. The economy's robust recovery in 2017, supported by multifaceted measures to stimulate economic activities, consumption, production, and investment, catalyzed a surge in banking sector indicators such as total assets, capital adequacy, loan growth, profitability, and market value.

The analysis identifies 2016 as a pivotal year, marking a turning point for banking sector efficiency. Efficiency levels surged to 70.8% in 2017, 79.2% in 2019, 83.3% in 2020, and 91.7% in 2022. These increases were primarily driven by elevated interest income and current period profit levels, coupled with stable or declining outputs, particularly the number of branches. Furthermore, efficiency levels varied across public and private sector banks throughout the analyzed periods. Public banks exhibited higher efficiency levels based on input and output metrics during the relevant periods.

Specific banks, including Yapı Kredi, Citibank, Vakıfbank, and Garanti Bank, demonstrated efficiency levels surpassing 80%, while others such as TEB, Turkland, Deutsche Bank, ICBC Turkey, Turkish Bank, and Şekerbank exhibited efficiency levels of 40% or lower.

This study aims to evaluate the efficiency of deposit banks operating in the Turkish banking sector between 2012 and 2022

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and to compare them between the private and public sectors. However, it did not distinguish between foreign-owned and domestically-owned private banks. The novelty of this study lies in its potential to serve as a guide for testing the most suitable practice methods by focusing on scale efficiency for domestically-owned private banks to create a competitive advantage against foreign-owned banks. Additionally, the efficiency scores obtained according to the VZA CCR model used in this study are values tested based on input-output variables for the specified period. It is acknowledged that variations in the variables used in the analysis may lead to different results. Therefore, the distinctiveness of this study lies in evaluating and comparing the efficiency of deposit banks in the Turkish banking sector based on specific variables.

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