

**THE REPUBLIC OF TURKEY  
BAHCESEHIR UNIVERSITY**

**EFFICIENCY OF COMMERCIAL BANK IN TURKEY**

**Master's Thesis**

**AFROUZ ALIDOUST**

**İSTANBUL, 2015**



**THE REPUBLIC OF TURKEY  
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**GRADUATE SCHOOL OF SOCIAL SCIENCES  
CAPITAL MARKETS AND FINANCE**

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## ABSTRACT

### EFFICIENCY OF TURKISH COMMERCIAL BANK IN TURKEY

Afrouz ALIDOUST

Capital Markets and Finance

Thesis Supervisor: Assoc.Prof.Dr Hüseyin KAYA

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The aim of this study is to determine the efficiency of Turkish commercial banks for the period of 2002-2014 and the effect of financial crisis on the efficiency of banking system in Turkey. There are different kinds of tools to measure the efficiency of banks. Data Envelopment Analysis (DEA) is one of the most popular tool. Data Envelopment Analysis which is a mathematical program measure relative efficiency of decision-making units (DMUs). In this research, both Intermediation and Production approaches are considered based on input-oriented model. Total deposits/Total assets, Total interest expenditure/Total assets and Non-interest expenditure/Total assets, are determined as input, Total loans/Total assets, Interest income/Total assets, Non-interest income/Total assets and (Shareholders' Equity+ Total Income)/Total assets are determined as output in terms of Intermediation Approach. According to Production Approach, three inputs (Total personal expenses/Total assets, Non-interest expenses/Total assets, and Total number of employees) and two outputs (Total deposits/Total assets, Total loans/ Total assets) are chosen. Regarding the sample of 14 commercial banks, our findings reveal that regarding intermediation approach the efficiency of commercial Turkish banking system during the period of 2002-2014 were higher and more stable than production approach and the effect of financial crisis was more obvious on production approach.

**Keywords:** Efficiency, Data Envelopment Analysis, Intermediation Approach, Production Approach, Turkish Commercial Banks

## ÖZET

### TÜRKİYE'DE TİCARET BANKALARININ VERİMLİLİĞİ

Afrouz ALIDOUST

Sermaye Piyasaları ve Finans

Tez Danışmanı: Assoc.Prof.Dr Hüseyin KAYA

Mayıs 2015, 39 sayfa

Bu çalışmanın amacı, 2002-2014 döneminde Türkiye ticari bankaların etkinliklerini ve finansal krizin bankaların etkinlikleri üzerindeki etkilerini incelemektir. Bankaların etkinliğini ölçmek için yazında farklı yöntemler vardır. Veri Zarflama Analizi (VEA) bu yöntemlerin en yaygın kullanılanlarından biridir. Ticari bankaların etkinliğini karşılaştırmak için bu çalışmada Aracılık yaklaşımı ve Üretim yaklaşımı kullanılmıştır. Aracılık yaklaşımında; toplam mevduat / toplam aktifler, toplam faiz giderleri / toplam aktifler ve faiz dışı darlama/toplam aktifler girdiler olarak, toplam krediler/toplam aktifler, faiz geliri/toplam aktifler, faiz dışı gelir/toplam aktifler ve (özkaynak + toplam gelir toplam gelir)/toplam aktifler ise çıktılar olarak kullanılmıştır. Üretim yaklaşımında toplam kişisel harcamalar/toplam aktifler, faiz dışı giderler/toplam aktifler ve toplam çalışan sayısı girdiler olarak, toplam mevduat/toplam aktifler, toplam krediler/toplam aktifler ise çıktılar olarak belirlenmiştir. 2002-2014 döneminde incelenen 14 ticari bankaların etkinlikleri Aracılık Yaklaşımı kullanıldığında daha yüksek ve daha istikrarlı bir yapı göstermektedir. Finansal krizin bankaların etkinlikleri üzerindeki etkisi Üretim Yaklaşımı kullanıldığında daha belirgin hale gelmektedir.

**Anahtar Kelimeler:** Verimlilik, Tarih Zarflama Analizi, Aracılık Yaklaşımı, Üretim Yaklaşımı, Türk Ticaret Bankaları

## CONTENTS

<b>TABLES.....</b>	<b>v</b>
<b>FIGURES.....</b>	<b>vi</b>
<b>ABBREVIATIONS.....</b>	<b>vii</b>
<b>1. INTRODUCTION.....</b>	<b>1</b>
<b>2. LITERATURE OVERVIEW.....</b>	<b>3</b>
<b>3. DATA AND METHOD.....</b>	<b>12</b>
<b>3.1 INTERMEDIATION APPROACH.....</b>	<b>12</b>
<b>3.2 PRODUCTION APPROACH.....</b>	<b>13</b>
<b>4. FINDING AND DISCUSSION.....</b>	<b>18</b>
<b>5. CONCLUSION.....</b>	<b>39</b>
<b>REFERENCES.....</b>	<b>40</b>

## TABLES

Table 2.1: Previous studies focus on efficiency of commercial bank in Turkey .....	5
Table 3.1: The list of commercial banks as DMUs.....	15
Table 5.1: Efficiency of commercial banks for each year (Intermediation approach) .....	19
Table 5.2: Efficiency of commercial banks for each year (Production approach).....	20
Table 5.3: Average Efficiency of 13 years for each bank (2002-2014).....	22
Table 5.4: Efficiency of each bank for 13 years (Intermediation approach)....	23
Table 5.5: Efficiency of each bank for 13 years (Production approach) .....	24

## FIGURES

Figure 5.1: Changes in efficiency of Ziraat bank (2002-2014).....	25
Figure 5.2: Changes in efficiency of Halk bank (2002-2014).....	26
Figure 5.3: Changes in efficiency of Vakif bank (2002-2014).....	27
Figure 5.4: Changes in efficiency of Ada bank (2002-2014).....	28
Figure 5.5: Changes in efficiency of Ak bank (2002-2014).....	29
Figure 5.6: Changes in efficiency of Alternative bank (2002-2014).....	30
Figure 5.7: Changes in efficiency of Seker bank (2002-2014).....	31
Figure 5.8: Changes in efficiency of Tekstil bank (2002-2014).....	32
Figure 5.9: Changes in efficiency of Teb bank (2002-2014).....	33
Figure 5.10: Changes in efficiency of Garanti bank (2002-2014).....	34
Figure 5.11: Changes in efficiency of Is bank (2002-2014).....	35
Figure 5.12: Changes in efficiency of Yapikredi bank (2002-2014).....	36
Figure 5.13: Changes in efficiency of Finance bank (2002-2014).....	37
Figure 5.14: Changes in efficiency of HSBC bank (2002-2014).....	38

## ABBREVIATIONS

DEA	:	Data Envelopment Analysis
DMUs	:	Decision-making Units
RA	:	Ratio Analysis
CONT'D:		Continued
CCR	:	Charnes-Cooper-Rhodes
BCC	:	Banker-Charnes-Coopr
CRS	:	Constant Returns to Scale
EMS	:	Efficiency Measurment System

## 1. INTRODUCTION

The purpose of this study is analyzing efficiency of commercial bank in Turkey for the period of 2002-2014. Measuring and evaluating of bank efficiency system is considered to be important for managers, depositors and potential investors to evaluate the goals, monitor the financial situation, develop the construction strategies, and make decisions.

This thesis work is conducted since commercial banks have important roles in Turkish banking system. The most important role of banks, as (Yue, 1992) mentioned, is Commercial banks act as financial intermediation and provide a main volume of the nation's money stock.

Managing deposits and withdrawals, checking and saving accounts of customers, supplying home mortgages, giving short-term loan to individuals and overall linking customers who have capital deficits with those with capital surpluses are part of responsibilities of commercial banks. Commercial banks have an important role in the economics for two reasons. First reason is, commercial banks performed as financial intermediary which means receiving deposit from depositors at low interest rates and channels those into lending activities, either directly through lending them out to borrowers at higher interest rates or indirectly by capital markets. Second reason is the total amount of monetary assets in the economic which called nation's money supply is shown by bank checkable deposit liabilities.

The study analyses the efficiency measurement of 14 Turkish commercial banks in the period of 2002-2014, the effect of 2008 financial crisis on the banking system and differences between efficiency scores of banks based on Data Envelopment Analysis (DEA) regarding both intermediation approach and production approach.

Efficiency measurement is considered as an important activity to recognize shortcomings and improve the goals in managerial efficiency. To measure efficiency, DEA as the efficient frontier of a set of decision-making units (DMUs) need to be expressed as a transduction of inputs to outputs. Therefore, the first step would be determining the input and output variables for each approach.

[Total deposits/ Total assets, Total interest expenditure/ Total assets and Non-interest expenditure/ Total assets], are determined as input. [Total loans/ Total assets, Interest income/ Total assets, Non-interest income/ Total assets and (Shareholders' Equity+ Total Income)/ Total assets] are determined as output in terms of intermediation approach. According to production approach, three inputs [Total personal expenses/ Total assets,

Non-interest expenses/ Total assets, and Total number of employees] and two outputs [Total deposits/ Total assets, Total loans/ Total assets] are chosen.

Data Envelopment Analysis (DEA) as a non-parametric linear program measures the efficiency level of Turkish commercial bank for the period of 2002-2014 and figures out which banks are more efficient rather than other banks and also shows the areas in which inefficient banks need to be efficient. (Malhorta et al, 2009)

Evaluating efficiency of banking system has two important aims. First aim is benchmarking in bank industry which means comparing one's bank performance against the most efficient and best practice banks. Second aim is estimating the effect of different measures on the efficiency of banks and their performances. (Das et al, 2009)

Unvan & Tatlidil was explained the role of bank (2012, p. 168) as below ;

*Banks have a significant role in both the financial sector and in economic growth as they provide funds for investments and keep the cost of capital low and as are financial intermediaries. First, banks are the largest source of financing investments by providing loans to companies. Therefore, investment which has a crucial role in growth, is sensitive to changes in the banking sector. Second, the banking system is the preferred way of financial intermediation thus, the banks' role in the finance sector has increased.*

Since the efficiency of banks are effected on the performance and stability of banking industry and monetary system, it would be considered as one of the most important issues in the financial market.

The study is included parts as follows. The following part is the literature. The third part covers the Data and Method. The finding part, Discussion and Conclusion parts would be discussed in the section fourth, fifth and sixth, respectively.

1

Y. A. Unvan & H. M. Tatlidil, Efficiency in the Turkish Banking System, p. 168.

## **2. LITERATURE REVIEW**

There are some global researches which evaluate the performance and efficiency for different kind of industries. Also, the efficiency of banking industry is estimated by different methods. In literature there are two measurement techniques for performance of banks as parametric and non-parametric. The alternative tools are ratio analysis (RA) and Data Envelopment Analysis (DEA) which both focus on the performance of a unit rather than other units in the same sector and get an idea to improve the performance of units. The difference between techniques is how they handle about resources and outputs. Ratio analysis is able to produce only one output from one input at a time, While DEA technique relates multiple resources to multiple outputs to assess performance. This technique defines the productive efficiency of a system or DMUs by comparing how well the DMUs translate inputs into outputs. DEA is considered one of the most popular tools as non-parametric technique to measure efficiency in the banking sector. (Barr et al, 2002) indicated that: DEA is a reliable tool to determine banks operation efficiencies.

The work of (Charnes, Cooper, Rhodes, 1978) was the origin of non-parametric programming methodology in respect to relative efficiency measurement lies. DEA has been used for measuring efficiency for different kind of industries. For instance it was performed to measure efficiency of hospitals and restaurants by Banker and Morey in 1986 and efficiency of universities by Athanassoupoulos, Shale in 1997.

Also, there have been some studies of DEA on banking efficiency of different countries. For example the study of (Casu and Molyneux, 2000) is about efficiency of European banking system to examine between 1993–1997. The study of (Jemric and Vujcic, 2002) is about the relative efficiency of banks in the Croatia in the period of years 1995-2000.

The study of (Halkos and Salamouris, 2002) is about the efficiency of Greek commercial banks for the period of 1997-1999. The study of (Wu, 2005) is about changes efficiency of Australian banks over the period years of 1983 to 2001.

Also, there have been some studies of DEA on the efficiency of Turkish banking system.

For instance, the study of (Isik and Hassan, 2002) is figure out the impact of various measures in the efficiency of Turkish banking industry in 1988-1996.

The study of (Yunten and Caner, 2004) is about the efficiency of 19 Turkish commercial banks between 1999-2002. The study of (Ozkan, Gunay and Tektas, 2006) is about the relative technical efficiency of non-public commercial banks in Turkey between 1990-2001. The study of (Ayranci, 2011) is about efficiency of 48 private commercial bank in Turkey. Much information with details about selected studies is shown in the Table 2.1.

This study focuses on the efficiency measurement of 14 commercial banks in Turkey. So, its literature review was included studies using DEA models for efficiency measurement of Turkish commercial banks.

**Table 2.1: Previous studies using DEA model to measure efficiency of Turkish commercial banks (cont'd)**

Who worked on this study	Technique	Input	Output	Result
--------------------------	-----------	-------	--------	--------

<p><b>Zaim (1995)</b> measured the efficiency of Turkish banks to determine the effect of post-1980 financial liberalization policies. The years 1981 and 1990 were selected as representative years for pre and post Liberalization periods, respectively.</p>	<p>DEA The intermediation approach is used to select bank inputs and outputs.</p>	<p><b>1</b>-total number of employees, <b>2</b>- total interest expenditures, <b>3</b>-depreciation expenditures, <b>4</b>-expenditures on materials.</p>	<p><b>1</b>-total balance of demand deposits, <b>2</b>- total balance of time deposits, <b>3</b>- total balance of short-term loans <b>4</b>-total balance of long-term loans</p>	<p>The results indicated that the financial reforms had a positive effect on the efficiency of bank.</p>
<p><b>Yolalan (1996)</b> determined the efficiency of the Turkish commercial banking sector using financial ratios in a study that covered the years 1988-1995.</p>		<p><b>1</b>-non-interest expenses/total assets <b>2</b>-non-accruing loans/total assets.</p>	<p><b>1</b>-commission revenues/total assets, <b>2</b>-current assets/total assets <b>3</b>-(equity + net profit)/ total assets.</p>	<p>The findings indicate that foreign banks were more efficient than their domestic competitors.</p>

**Table 2.1: Previous studies using DEA model to measure efficiency of Turkish commercial banks (cont'd)**

Who worked on this study	Technique	Input	Output	Result
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<p><b>Jackson, Fethi and Inal (1998)</b> analyzed the efficiency and productivity growth in the Turkish banking system. They investigated the efficiency and productivity changes of each bank for the 1992–1996 period.</p>	<p>using the DEA-based Malmquist TFP index</p>	<p><b>1</b>-number of employees <b>2</b>-total non-labor operating expenses</p>	<p><b>1</b>-Total loans, <b>2</b>-total demand deposits <b>3</b>- total time deposits</p>	<p>The empirical results revealed that except during the financial crisis period of 1993–1994, foreign and private banks were more efficient than their state counterparts owing to the developments in competition and technological advancements.</p>
<p><b>Yildirim (1999)</b> examined the policy and performance in the Turkish banks in response to the financial liberalization after 1980 and the macroeconomic instability. The study covered the period of 1988-1996)</p>	<p>DEA</p>	<p><b>1</b>-demand deposits, <b>2</b>- time deposits, <b>3</b>-interest expenses <b>4</b>-non-interest expenses</p>	<p><b>1</b>-loans, <b>2</b>-interest income <b>3</b>-non-interest income</p>	<p>The results showed that the sector did not achieve any sustained efficiency gains in the liberalized period with continuing scale inefficiency. The efficient banks were noted as less profitable. In particular, the less profitable state-owned banks seemed to be more efficient than the others.</p>

**Table 2.1: Previous studies using DEA model to measure efficiency of Turkish commercial banks (cont'd)**

Who worked on this study	Technique	Input	Output	Result
<p><b>Denizer, Dinc, and Tarimcilar (2000)</b> examined the bank</p>	<p>Both the “intermediation” and the</p>	<p><b>For the intermediation approach:</b></p>	<p><b>For the intermediation approach:</b></p>	<p>Their results suggest that liberalization</p>

<p>efficiency before and after liberalization. They also analyzed the scale effect on efficiency by type of ownership. This study focus on the years from 1970 to 1994.</p>	<p>“production” approaches are used</p>	<p><b>1</b>-commission revenue  <b>2</b>- total Deposits  <b>3</b>-operational expenses  <b>For the production approach:</b>  <b>1</b>-the banks’ own funds,  <b>2</b>-interest expenses  <b>3</b>-personnel outlays.</p>	<p><b>1</b>-total loans  <b>2</b>-revenues from banking activities.  <b>For the production approach:</b>  <b>1</b>-commission revenue  <b>2</b>- total deposits</p>	<p>programs were followed by an observable decline in efficiency, not an improvement. Another unexpected result was that efficiency was no different between state-owned and privately owned banks. Banks that were privately owned or foreign owned had been expected to respond better to liberalization, because they were smaller and more dynamically structured, but they were no more efficient than state-owned banks.</p>
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**Table 2.1: Previous studies using DEA model to measure efficiency of Turkish commercial banks (cont’d)**

<b>Who worked on this study</b>	<b>Technique</b>	<b>Input</b>	<b>Output</b>	<b>Result</b>
<p><b>Karacabey (2002)</b> analyzed the efficiency of Turkish commercial banks and changes in productivity from 1997 to 2000.</p>	<p>The study utilizes the “production” approach. (DEA)</p>	<p><b>1</b>- the number of banking personnel branches  <b>2</b>-the amount of paid capital.</p>	<p><b>1</b>-total deposits  <b>2</b>-loan amounts</p>	<p>The result shows the efficiency levels of the banks were low, but during that year, the economic</p>

				program that began in 2000 was found to slightly raise the efficiency levels.
<b>Sen (2006)</b> took government intervention into account in measuring the efficiency of the Turkish banking sector. Study covered the years 1960-2004.	Data envelopment analysis	1-Total deposits 2-total expenses	1-total profit, 2-total revenues 3-total loans	The efficiency of the Turkish banking sector during the selected period was found to fluctuate greatly, and a negative correlation is detected between the bank efficiency and the election periods.

**Table 2.1: Previous studies using DEA model to measure efficiency of Turkish commercial banks (cont'd)**

<b>Who worked on this study</b>	<b>Technique</b>	<b>Input</b>	<b>Output</b>	<b>Result</b>
<b>Ahmet AKIN, Merve KILIÇ, Selim ZADM (2009)</b> examined the efficiency of Turkish banking industry with Data Envelopment Analysis (DEA) methodology between 2002 and 2007. All the banks that constantly operated in the years	DEA	1-number of employees, 2- interest expenses, 3- non-interest expenses 4- total deposit	1-total credits, 2- interest revenue 3- non-interest revenue	According to results, the efficiency levels did not change very much between 2002 and 2007. The efficiency scores reached top level in 2005 and 2006. The

between 2002 and 2007, excluding investment and development, participation banks, get into the analysis.				<p>results of regression application denote that all of the explanatory variables had a significant effect on banks' efficiency levels. According to regression analysis results, size negatively affected the efficiency levels of banks. Publicly listed banks operate more efficient than not publicly listed banks. Foreign owned banks operate more efficient than their domestic peers.</p>
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**Table 2.1: Previous studies using DEA model to measure efficiency of Turkish commercial banks (cont'd)**

<b>Who worked on this study</b>	<b>Technique</b>	<b>Input</b>	<b>Output</b>	<b>Result</b>
<p><b>Ilker Murat Ar, Ahmet Kurtaran (2011)</b> measured the relative efficiency of 13 commercial banks in Turkey for the year of 2011.</p>	<p>With an integrated approach includes Analytic Hierarchy Process and Data Envelopment Analysis</p>	<p>1-personnel expenditures 2-number of branch)</p>	<p>1-deposits-national currency, 2-deposits-foreign currency and precious metal, 3-cash loans, 4-non-cash loans</p>	<p>According to empirical result, state-owned commercial banks were efficient in both CCR (Charnes-Cooper-Rhodes) and BCC (Banker-Charnes-Cooper) model. However, foreign-owned</p>

				commercial banks had the lower efficiency scores than both state-owned and private-owned commercial banks.
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**Table 2.1: Previous studies using DEA model to measure efficiency of Turkish commercial banks (cont'd)**

<b>Who worked on this study</b>	<b>Technique</b>	<b>Input</b>	<b>Output</b>	<b>Result</b>
<b>Dr. Yuksel Akay Unvan1, Dr. Huseyin Tatlidil (2012)</b> analyzed the productivity of Turkish banks between the years 2002 and 2008.	DEA In this study, a CCR model is used under two different approaches in evaluating the efficiency of the banks in Turkey for the period 2002–2008: 1) intermediation approach and 2) Production approach.	<b>For the intermediation approach:</b> 1- Total deposits/Total assets 2- Total interest expenditure/Total assets 3- Non-interest expenditure/Total assets <b>In following production approach:</b> 1- Total personal expenses/Total assets	<b>For the intermediation approach:</b> 1- Total loans/Total assets, 2- Interest income/Total assets, 3- Non-interest income/Total assets, 4- (Shareholders' Equity+ Total Income)/Total assets. <b>In following</b>	The results confirm that the efficiency of the Turkish banking system via production approach was very high and stable while efficiency via the intermediation approach was moderately high and somewhat volatile. Based on the production approach, the

		<p>2- Non-interest expenses/Total assets</p> <p>3- Total number of employees</p>	<p><b>production approach:</b></p> <p>1- Total deposits/Total assets,</p> <p>2- Total loans/Total assets.</p>	<p>banks experienced a decrease in efficiency from 2005 to 2008, especially between the years 2007 and 2008. Based on the intermediation approach, medium sized banks were the most efficient banks during 2007–2008.</p>
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### 3. DATA AND METHOD

Using DEA model to measure the efficiency, developed by (Charnes Cooper and Rhodes in 1978), need to select input and output for decision making units. There is no consensus and agreement to select suitable inputs and outputs in the banking literature (Roa and Lakew, 2012). The framework of DEA is based on multi-input and multi-output variables and selecting the variables would be effected by some factors such as selecting the concept of banking firm, availability of data and also, particular question under consideration. (Pastor et al, 1997).

Regarding (Sealey and Lindly, 1977) & ( Thanassoulis,1999) in DEA methodology there are two approaches to determine the inputs and outputs such as Intermediation approach and Production approach. Choosing the input and output variables of each approaches are up to which components of banks are used.

The study of (Avkiran, 2006), summarized both approaches and determined input and output variables for each of them. Regarding definition of this study for intermediation approach, banks are considered to use deposits to generate loans. For production approach, banks are considered to convert labor and capital to deposits and loans.

In this study, for evaluating the efficiency of 14 Turkish commercial banks for the period of 2002-2014 both approaches are chosen:

### **3.1 INTERMEDIATION APPROACH**

Regarding this approach, banks are considered as a typical financial intermediaries which connect borrowers and depositors as two parties to make profit. (Yue, 1992)

Regarding intermediation approach, banks are acted as financial intermediaries whose primary business is to borrow funds from depositors and lend those funds to others to make profit (Yue, 1992).

Based on intermediation approach, banks are performed as intermediaries between two parties in a financial transaction to use deposits and funds to convert them into loans. Capital and labor are required for his conversion procedure. Based on this definition, combination of funds and the cost of collecting funds are chosen as inputs. Then, loans, interest revenue and investments are chosen as output. (Drake et al, 2005)

For this study input and output variables are chosen based on the study of Unvan & Tatlidil. (2012, p. 173-174) which determined three inputs and four output for each banks as below:

- a, Input 1: Total deposits/Total assets,
- b, Input 2: Total interest expenditure/Total assets,
- c, Input 3: Non-interest expenditure/Total assets,

While the outputs are given below:

- a, Output 1: Total loans/Total assets,
- b, Output 2: Interest income/Total assets,
- c, Output 3: Non-interest income/Total assets,
- d, Output 4: (Shareholders' Equity+ Total Income)/Total assets.

### **3.2 PRODUCTION APPROACH**

Regarding production approach, banks are considered as financial institution which use labor, capital and operating expenses to provide financial services for those who needs loans and deposits.

Based on production approach, banks using capital and workforce to produce deposits and provide loans. In production approach views, labor, capital and operating costs are chosen as inputs and the combine of deposits and loans are considered as outputs. (Drake, 2005).

The study of Unvan & Tatlidil. (2012, p. 173-174) , determined three inputs and two outputs for production approach of each banks as follows:

- a, Input 1: Total personal expenses/Total assets,
- b, Input 2: Non-interest expenses/Total assets,
- c, Input 3: Total number of employees,

And two outputs are used

- a, Output 1: Total deposits/Total assets,
- b, Output 2: Total loans/ Total assets.

As (Murat.L and Kurtaran, A, 2013) mentioned, there are three types of banks in Turkish banking system such as Commercial banks, Development and investment banks and Participation banks.

State-owned banks, Privately-owned banks and foreign banks are subcategories of each groups. The research sample of this study decided to choose only commercial banks group and its subcategories.

In table 3.1, the list of 14 commercial banks which used as DMUs are shown.

**Table 3.1: The list of commercial banks as DMUs**

<b>DMU1</b>	State-owned	<b>Ziraat bank</b>	<b>DMU8</b>	Private-owned	<b>Tekstil bank</b>
<b>DMU2</b>	State-owned	<b>Halk bank</b>	<b>DMU9</b>	Private-owned	<b>Teb bank</b>
<b>DMU3</b>	State-owned	<b>Vakif bank</b>	<b>DMU10</b>	Private-owned	<b>Garanti bank</b>
<b>DMU4</b>	Private-owned	<b>Ada bank</b>	<b>DMU11</b>	Private-owned	<b>Is bank</b>
<b>DMU5</b>	Private-owned	<b>Ak bank</b>	<b>DMU12</b>	Private-owned	<b>Yapikredi bank</b>
<b>DMU6</b>	Private-owned	<b>Alternative bank</b>	<b>DMU13</b>	Foreign-owned	<b>Finance bank</b>
<b>DMU7</b>	Private-owned	<b>Seker bank</b>	<b>DMU14</b>	Foreign-owned	<b>Hsbc bank</b>

*Source: Bank association of Turkey (2015)*

To be sure the efficiency scores would be meaningful, there is a rule which indicates the relationship between the number of DMUs and number of input and output variables. The rule is defined as the formula 3.1 which is given by (Boussofiene et al, 1991) and (Ramanathan, 2003).

$$[N \geq 2*(S+M)] \quad (3.1)$$

N= the number of DMUs

S= the number of output variables

M= the number of input variables

In this research, the number of DMUs are considered 14 that is more than the sum of number of input and output variables for each approaches.

Intermediation approach:

$$[14 \geq 2* (4+3)]$$

$$14=14$$

Production approach:

$$[14 \geq 2 * (2+3)]$$

$$14 > 12$$

Based on DEA programming methodology, the efficiency score formula in case of multiple input and output factors is defined as:

$$(3.2)$$

Which introducing the usual notation can be written as:

$$(3.2a)$$

Where  $w_i$  = the weight given to output  $i$   
 $x_{ij}$  = amount of output  $i$  from unit  $j$   
 $v_l$  = weight given to input  $l$   
 $x_{lj}$  = amount of input  $l$  to unit  $j$ .

(Note efficiency is usually constrained to the range  $[0, 1]$ ).

Linear programming expression of the DEA model is like that:

$$(3.2b)$$

Subject to

Maximize the efficiency of unit  $j_0$ ,

Subject to the efficiency of all units being  $\leq 1$ .

The variables of the above problem are the weights and the solution produces the weights most favorable to unit  $j_0$  and also produces a measure of efficiency.

The formula of DEA makes this study to estimate some features about DMUs such as which banks are efficient and those that are inefficient what the unit of reference can be

and how would change to efficient by best possible situation. Regarding orientation, there are two models of DEA; Input-orientation and output-orientation. Their performance are different based on their efficiency score range which is between 0 and 1 for input-orientation and between 1 to infinity for output-orientation. The efficient score for both models is 1. (Cooper, seiford and Tone, 2000).

DEA is considered as a potent program for different reasons. First reason is DEA is performed as benchmarking which means estimating the efficiency of one DMU relative to others for a period of time or over number of periods. The second reason is DEA is able to act as monitoring information for a specific DMU over a period of time. The other reason is estimating how much each DMU can reduce its input while producing the original level of output or how much each DMU can expand its output while holding inputs unchanged (Bobe, 2009)

#### **4. FINDINGS AND DISCUSSION**

The data used for this study are collected from the Bank Association of Turkey Statistical Reports which cover financial statements-consolidated including investments and

associates, subsidiaries, joint ventures (business partners) and selected statistics for banks, branches and employees for Turkish banks on its web site.

Due to the fact the efficiency was measured by inputs in banks, this study employs the Input-oriented model. Efficiency Measurement System (EMS) software version 1.3.0 is used in this research to measure the technical efficiency of banks based on CRS model.

The efficiency scores of each bank are shown in Tables 5.1, 5.2, 5.3, 5.4. The efficiencies of the banks are examined between the years 2002-2014 for both intermediation and production approaches. According to tables, commercial banks are classified to State-owned, Private-owned and Foreign banks.

**Table 5.1: Efficiency of commercial banks for each year (Intermediation approach)**

Banks	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
<b>Commercial Banks</b>	<b>I</b>	<b>I</b>	<b>I</b>	<b>I</b>	<b>I</b>	<b>I</b>	<b>I</b>	<b>I</b>	<b>I</b>	<b>I</b>	<b>I</b>	<b>I</b>	<b>I</b>
<b>State-owned Commercial banks</b>													
1.Ziraat	0.90	0.99	1.00	1.00	1.00	1.00	1.00	0.88	1.00	1.00	1.00	1.00	1.00
2.Halkbank	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99
3.Vakifbank	0.84	0.62	0.98	0.92	0.97	0.96	0.95	0.98	0.93	0.95	0.96	0.96	0.96
<b>Average Efficiency</b>	<b>0.91</b>	<b>0.87</b>	<b>0.99</b>	<b>0.97</b>	<b>0.99</b>	<b>0.99</b>	<b>0.98</b>	<b>0.95</b>	<b>0.98</b>	<b>0.98</b>	<b>0.99</b>	<b>0.99</b>	<b>0.98</b>
<b>Privately-owned Commercial banks</b>													
4.Adabank	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5.Akbank	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6.Alternative bank	0.69	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7.sekerbank	1.00	0.86	1.00	0.98	1.00	0.92	0.92	0.76	0.93	0.97	0.99	0.95	0.92
8. Tekstil Bank	0.87	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.97	1.00
9.Teb (teb economy )	1.00	1.00	0.94	1.00	1.00	0.92	0.95	0.98	0.92	1.00	0.95	0.96	0.98
10.Garanti	0.89	0.91	0.85	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11.Isbankasi	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12.Yapikredi	1.00	0.94	0.93	0.63	0.94	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<b>Average Efficiency</b>	<b>0.94</b>	<b>0.97</b>	<b>0.97</b>	<b>0.95</b>	<b>0.99</b>	<b>0.97</b>	<b>0.99</b>	<b>0.97</b>	<b>0.98</b>	<b>1.00</b>	<b>0.99</b>	<b>0.99</b>	<b>0.99</b>
<b>Foreign Banks</b>													
13.Financebank	1.00	1.00	1.00	1.00	0.97	1.00	1.00	0.89	1.00	1.00	1.00	1.00	1.00
14.Hsbc	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98	0.92
<b>Average Efficiency</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>0.98</b>	<b>1.00</b>	<b>1.00</b>	<b>0.94</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>0.99</b>	<b>0.96</b>

Source: Bank association of Turkey (2015)

**Table 5.2: Efficiency of commercial banks for each year (production approach)**

Banks	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Commercial Banks	P	P	P	P	P	P	P	P	P	P	P	P	P
<b>State-owned Commercial banks</b>													
1.Ziraat	0.66	0.90	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.93	0.93	1.00
2.Halkbank	0.62	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3.Vakifbank	0.66	0.86	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.95	1.00	0.97	0.98
<b>Average Efficiency</b>	<b>0.65</b>	<b>0.91</b>	<b>0.98</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>0.99</b>	<b>0.98</b>	<b>0.98</b>	<b>0.97</b>	<b>0.99</b>
<b>Privately-owned Commercial banks</b>													
4.Adabank	1.00	0.52	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.14	1.00
5.Akbank	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00
6.Alternative bank	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7.sekerbank	0.65	0.63	0.65	0.56	0.61	0.65	0.74	0.78	0.91	0.87	0.89	1.00	1.00
8. Tekstil Bank	0.93	1.00	1.00	1.00	1.00	1.00	0.91	0.91	1.00	1.00	1.00	1.00	1.00
9.Teb (teb economy )	1.00	1.00	1.00	0.99	1.00	0.79	0.78	0.73	0.85	0.81	0.90	0.93	0.97
10.Garanti	0.86	0.88	0.90	0.82	0.92	0.90	0.91	0.89	0.82	0.85	0.83	0.86	0.82
11.Isbankasi	0.45	0.45	0.52	0.58	0.67	0.56	0.65	0.61	0.57	0.62	0.68	0.66	0.97
12.Yapikredi	0.78	0.70	0.67	0.71	0.65	0.63	0.78	0.77	0.80	0.83	0.85	0.94	0.87
<b>Average Efficiency</b>	<b>0.85</b>	<b>0.80</b>	<b>0.86</b>	<b>0.85</b>	<b>0.87</b>	<b>0.84</b>	<b>0.86</b>	<b>0.86</b>	<b>0.88</b>	<b>0.89</b>	<b>0.91</b>	<b>0.84</b>	<b>0.96</b>
<b>Foreign Banks</b>													
13.Financebank	1.00	1.00	1.00	0.89	0.95	0.86	0.89	0.70	0.78	0.74	0.80	0.72	0.80
14.Hsbc	0.78	0.57	0.76	0.70	0.73	0.72	0.69	0.53	0.64	0.64	0.67	0.65	0.80
<b>Average Efficiency</b>	<b>0.89</b>	<b>0.79</b>	<b>0.88</b>	<b>0.80</b>	<b>0.84</b>	<b>0.79</b>	<b>0.79</b>	<b>0.62</b>	<b>0.71</b>	<b>0.69</b>	<b>0.73</b>	<b>0.69</b>	<b>0.80</b>

Source: Bank association of Turkey (2015)

The banking sector operated higher than 0.62 of average efficiency scores in the whole research period. The results reveal that in 2002, the average efficiency of foreign banks were most efficient and state-owned banks were the least efficient according to the two approaches. In 2003,2004,2005,2007,2008, 2010,2011 and 2012, the average efficiency of foreign banks were more efficient than two other types of banks via intermediation approach. Whiles, state-owned banks were most efficient according to the production approaches of these years. In 2006, regarding both approach state-owned banks are most efficient with efficiency score of 99% according to intermediation approach and efficiency score of 1 according to production approach, whereas foreign banks considered as least efficient in both approaches.

In 2009, Private-owned banks were most efficient in intermediation approach and state-owned banks were the most efficient with efficiency score of 1 in production approach.

In 2011, Private-owned and foreign banks were most efficient with efficiency score of 1 via intermediation approach. Whiles, in the production approach the average of efficiency for state-owned banks were more efficient than other types and foreign banks were the least efficient.

In 2013, regarding intermediation approach the average efficiency score for all group of banks were 99% and regarding production approach, state-owned banks were more efficient rather than two other groups. In 2014, regarding intermediation approach private-owned banks and regarding production approach state-owned banks were the most efficient with efficiency score of 99%.

The average efficiency for foreign banks were considered to be efficient in 2002, 2003, 2004, 2005, 2007, 2008, 2010, 2011 and 2012 with efficiency score of 1 via the intermediation approach. In production approach, the average efficiency of state-owned banks were efficient in 2005, 2006, 2007, 2008, 2009 with efficiency score of 1.

In tables 5.1, 5.2 efficiency of each group of banks shown separately by each approach and the summary of results for the analysis of both approaches for all years of each banks is presented in table 5.3. Regarding table 5.3, the average efficiencies of Turkish banks during 2002-2014 period shown foreign banks are most efficient by average efficiency score of 1 based on intermediation approach. While, state-owned commercial banks are more efficient by average efficiency score of 1 rather than other commercial banks using Production approach.

**Table 5.3 : Average Efficiency of 13 years for each bank (2002-2014)**

<b>Commercial Banks</b>	<b>I</b>	<b>P</b>
<b>State-owned Commercial banks</b>		
<b>1.Ziraat</b>	1.00	1.00
<b>2.Halkbank</b>	1.00	1.00
<b>3.Vakifbank</b>	0.89	1.00
<b>Average Efficiency</b>	<b>0.96</b>	<b>1.00</b>

<b>Privately-owned Commercial banks</b>		
<b>4.Adabank</b>	1.00	1.00
<b>5.Akbank</b>	1.00	1.00
<b>6.Alternative bank</b>	1.00	1.00
<b>7.sekerbank</b>	1.00	0.78
<b>8. Tekstil Bank</b>	1.00	1.00
<b>9.Teb (teb economy )</b>	1.00	0.95
<b>10.Garanti</b>	0.99	0.86
<b>11.Isbankasi</b>	1.00	0.58
<b>12.Yapikredi</b>	0.94	0.78
<b>Average Efficiency</b>	<b>0.99</b>	<b>0.88</b>
<b>Foreign Banks</b>		
<b>13.Financebank</b>	1.00	0.92
<b>14.Hsbc</b>	1.00	0.68
<b>Average Efficiency</b>	<b>1.00</b>	<b>0.80</b>

*Source: Bank association of Turkey (2015)*

**Table 5.4: Efficiency of each bank for 13 years (Intermediation approach)**

	Ziraat	Halkbank	Vakifbank	Adabank	Akbank	Alternative bank	sekerbank
2002	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2003	1.00	1.00	0.90	1.00	1.00	1.00	1.00
2004	1.00	1.00	1.00	0.67	1.00	1.00	1.00
2005	1.00	1.00	1.00	1.00	0.95	1.00	1.00
2006	0.99	1.00	1.00	0.89	0.96	1.00	1.00
2007	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2008	0.90	0.99	0.97	1.00	0.93	0.92	1.00
2009	1.00	1.00	1.00	1.00	0.95	1.00	1.00
2010	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2011	0.93	1.00	1.00	0.99	1.00	0.96	0.97
2012	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2013	1.00	1.00	1.00	0.97	1.00	1.00	1.00
2014	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<b>Average Efficiency</b>	<b>0.99</b>	<b>1.00</b>	<b>0.99</b>	<b>0.96</b>	<b>0.98</b>	<b>0.99</b>	<b>1.00</b>
	Tekstil Bank	Teb (teb economy )	Garanti	Isbankasi	Yapikredi	Finacebank	Hsbc
2002	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2003	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2004	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2005	0.98	1.00	1.00	1.00	0.88	1.00	0.97
2006	1.00	1.00	1.00	0.98	0.93	0.95	1.00
2007	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2008	1.00	1.00	1.00	1.00	1.00	1.00	0.94
2009	1.00	1.00	1.00	1.00	1.00	1.00	0.95
2010	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2011	1.00	1.00	1.00	0.95	1.00	1.00	1.00
2012	0.98	1.00	1.00	1.00	1.00	1.00	1.00
2013	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2014	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<b>Average Efficiency</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>0.99</b>	<b>0.99</b>	<b>1.00</b>	<b>0.99</b>

Source: Bank association of Turkey (2015)

Based on intermediation approach, the average efficiency of banks shows not only Halk bank and Seker bank but also Tekstil, Teb, Garanti and Finace banks were efficient with average efficiency of 1. Efficiency of Ziraat, Vakif, Akbank, Alternativebank and Hsbc were reduced in 2008 which effected by economic crisis. The average efficiency scores of Ziraat, Vakif, Alternative, Isbank, Yapikredi and Hsbc banks were 0.99 for all years which were close to be efficient. The least average efficiency was related to Adabank with average efficiency score of 0.96. Therefore, regardin intermediation approach the average efficiency scores of banks were high and stable for the period year of 2002-2014.

**Table 5.5: Efficiency of each bank for 13 years (Production approach)**

Years	Ziraat	Halkbank	Vakifbank	Adabank	Akbank	Alternative bank	sekerbank
2002	0.78	0.85	0.98	1.00	1.00	0.95	1.00
2003	0.81	1.00	1.00	0.50	0.96	0.93	0.99
2004	0.93	1.00	1.00	0.39	0.97	0.67	0.92
2005	0.97	0.99	1.00	0.61	1.00	0.69	0.89
2006	0.99	1.00	1.00	0.70	1.00	0.84	0.98
2007	1.00	1.00	1.00	0.69	1.00	0.93	0.87
2008	0.99	1.00	1.00	0.76	0.90	1.00	0.87
2009	0.97	0.98	0.98	1.00	0.88	0.91	0.89
2010	1.00	1.00	0.99	0.74	0.99	0.85	1.00
2011	0.91	1.00	1.00	0.73	1.00	0.94	1.00
2012	0.97	1.00	0.97	0.97	0.91	0.82	1.00
2013	0.96	0.97	0.91	1.00	0.95	1.00	1.00
2014	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<b>Average Efficiency</b>	<b>0.94</b>	<b>0.98</b>	<b>0.99</b>	<b>0.77</b>	<b>0.97</b>	<b>0.89</b>	<b>0.95</b>
Years	Tekstil Bank	Teb (teb economy )	Garanti	Isbankas i	Yapikredi	Financebank	Hsbc
2002	0.96	1.00	1.00	1.00	1.00	1.00	1.00
2003	0.82	1.00	0.94	0.92	1.00	0.98	0.93
2004	0.74	0.91	0.99	0.93	0.96	1.00	1.00
2005	0.79	1.00	0.98	1.00	1.00	0.95	1.00
2006	0.73	1.00	1.00	1.00	0.93	1.00	1.00
2007	0.75	0.79	1.00	0.93	0.90	1.00	0.98
2008	0.46	0.65	0.89	0.97	1.00	0.91	0.79
2009	0.90	0.74	0.89	0.91	0.95	0.76	0.79
2010	0.92	0.90	0.99	0.95	1.00	0.93	0.82
2011	1.00	0.85	1.00	0.85	1.00	0.99	0.90
2012	1.00	0.88	0.92	0.89	1.00	0.89	0.88
2013	0.97	0.90	0.92	0.93	1.00	0.80	0.85
2014	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<b>Average Efficiency</b>	<b>0.85</b>	<b>0.89</b>	<b>0.96</b>	<b>0.94</b>	<b>0.98</b>	<b>0.94</b>	<b>0.92</b>

Source: Bank association of Turkey (2015)

Regarding table 5.5, in general, production approach shows efficiency of banks experienced more volatility over time compared to intermediation approach. Because banks were more influenced by Global economic recession regarding production approach. The efficiency trend for most of banks shows a kind of downtrend during 2008 and 2009. The reason would be financial crisis and the effect of crisis on banks' efficiency.

According to the average efficiency in production approach, Adabank was the least efficient bank for all years with efficiency score of 77% and Vakifbank was the most efficient bank with the average efficiency score of 99%.

Based on both intermediation and production approach, all of chosen banks in this study are efficient in 2014 and Adabank was the least efficient bank according to the both approach for the period years of 2002-2014.

**Figure 5.1: Changes in efficiency of Ziraat bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.1 compares changes in efficiency of Ziraat bank in terms of both intermediation approach and production approach for the years 2002 to 2014. The figure indicates no overall pattern of increase or decrease of efficiency for Intermediation approach. In fact there were considerable fluctuations for efficiency in 2008 and 2011.

Regarding production approach, efficiency of Ziraat bank had an uptrend from 2002 to 2008. Then we can see a similar pattern in the production approach in comparison with intermediation approach, which shows that the efficiency had considerable fluctuation in 2011. Overall, the effect of financial crisis was so lightwas in both approaches between the years 2007 to 2009.

#### **Figure 5.2: Changes in efficiency of Halk bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.2 compares changes in efficiency of Halkbank regarding both intermediation and production approaches for the years 2002 to 2014. Regarding intermediation approach, Halkbank was efficient during this period of years except financial crisis years which were between 2007-2009.

In contrast, production approach indicates efficiency of Halkbank experienced a rapidly increase from 2002 to 2003 from 0.85 of efficiency to 1. Then we can see nearly similar pattern in both approaches.

Overall, efficiency based on intermediation approach was considerably higher than production approach. And we can see financial crisis's reflection on both approaches.

### **Figure 5.3: Changes in efficiency of Vakif bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.3 compares changes in efficiency of Vakifbank for both intermediation and production approaches during the years 2002 to 2014. Efficiency regarding intermediation approach indicates a rising trend before the years of crises. After that it had some fluctuations. Then suffered during the crises years and finally get efficient after 2009 till 2014. Whereas, regarding production approach, Vakifbank was more efficient in the years before financial crisis's years from 2004 to 2008. After that effected by financial crisis. Then, experienced some fluctuations and finally get efficient at the last year.

Overall, efficiency based on intermediation approach was considerably lower than production approach before crisis and higher after crisis.

### **Figure 5.4: Changes in efficiency of Ada bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.4 compares changes in efficiency of Adabank in terms of both intermediation approach and production approach for the years 2002 to 2014. The figure indicates similar pattern for both approaches. We see that Adabank was efficient in 2002 by both approaches. Regarding both approaches the efficiency of bank was decreased in 2004 and had an uptrend to 2009. Regarding intermediation approach Adabank started to be

efficient in 2007. While, production approach indicates that Adabank was efficient in 2009, 2013 and 2014 and it was inefficient between the years 2009 to 2013.

Overall, the effect of financial crisis was seen just on production approach and intermediation approach was not affected by it.

**Figure 5.5: Changes in efficiency of Ak bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.5 compares changes in efficiency of Akbank regarding both intermediation and production approaches for the years 2002 to 2014. Regarding intermediation approach, Akbank was efficient during period years of 2002 to 2004. Then it was effected by financial crisis in the years before and after crisis. After that bank was efficient again during the years of 2010 to 2014.

In contrast, production approach indicates that Akbank was efficient in 2002 and 2005. While it was inefficient between these years. Then Akbank was efficient again in 2006 and 2007. After that chart shows that Akbank was effected by crisis between the years 2007-2011. After crisis bank experienced to be efficient in 2011 and 2014.

Overall, efficiency's trend for approaches were acted in reverse before crisis. But, it had same trend during and after crisis. The efficiency of Akbank based on intermediation approach was considerably higher than production approach during and after crisis years and we can see financial crisis's reflection on both approaches as well.

**Figure 5.6: Changes in efficiency of Alternative bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.6 compares changes in efficiency of Alternativebank in terms of both intermediation approach and production approach for the years 2002 to 2014. The figure indicates no overall pattern of increase or decrease of efficiency for intermediation approach. Bank was efficient in most of the years except the years of 2008 and 2011 which were inefficient.

Regarding production approach, efficiency of Alternativebank had a considerable fluctuation during this period of years specially before and after crisis. Bank was efficient in 2008, 2013 and 2014.

Overall, the effect of financial crisis was more clear for intermediation approach rather than production approach between the years 2007-2009.

**Figure 5.7: Changes in efficiency of Seker bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.7 compares changes in efficiency of Sekerbank regarding both intermediation and production approaches for the years 2002 to 2014. Regarding intermediation approach, Sekerbank was efficient during all the period of years except 2011.

In contrast, production approach indicates efficiency of Sekerbank experienced a rapidly decrease in 2005 and 2007. Then we can see bank started to be efficient in 2010 till 2014. After 2012 there were a similar pattern in both approaches.

Overall, efficiency based on intermediation approach was considerably higher and more stable than production approach. And we can see financial crisis's reflection on production approach.

**Figure 5.8: Changes in efficiency of Tekstil bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.8 compares changes in efficiency of Tekstilbank regarding both intermediation and production approaches for the years 2002 to 2014. Regarding intermediation approach, Tekstilbank was efficient during all the period of years except 2005 and 2012 which efficiency scores were nearly 1.

Production approach shows efficiency of Tekstilbank experienced a rapidly decrease before financial crisis and also it was inefficient after crisis, also. Then, we can see bank was efficient in 2011, 2012 and 2014.

Overall, Tekstilbank was more efficient based on intermediation approach rather than production approach. And we can see financial crisis's reflection on production approach clearly.

**Figure 5.9: Changes in efficiency of Teb bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.9 compares changes in efficiency of Tebbank regarding both intermediation and production approaches for the years 2002 to 2014. Regarding intermediation approach, Tebbank was efficient during all the period of years from 2002 to 2014 with efficiency score of 1.

While, production approach shows efficiency of Tebbank was efficient in 2002,2003,2005,2006 and 2014. Bank experienced a rapidly decrease during financial crisis and also it was continued after crisis.

Overall, efficiency score of Tebbank was 1 for all of the years based on intermediation approach. Whereas, it was inefficient in most of the years and effected by financial crisis by production approach.

**Figure 5.10: Changes in efficiency of Garanti bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.10 compares changes in efficiency of Garantibank regarding both intermediation and production approaches for the years 2002 to 2014. Regarding intermediation approach, Garantibank was efficient during all the period of years except 2008 which was approximately close to efficiency score of 1.

Efficiency of Garantibank had fluctuation during these years and was effected by financial crisis by Production approach. The figure shows Garantibank was efficient in 2002,2006,2007,2011 and 2014.

Overall, Garantibank was more efficient based on intermediation approach. Whereas, we can see financial crisis's reflection on production approach.

**Figure 5.11: Changes in efficiency of Is bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.11 compares changes in efficiency of Isbank regarding both intermediation and production approaches for the years 2002 to 2014. Regarding intermediation approach, Isbank was efficient during all the period of years except 2006, 2011.

Regarding production approach, efficiency of Isbank had substantial fluctuation during these years and was effected by financial crisis. The figure shows Isbank was efficient in 2002, 2006, and 2014.

Overall, Isbank was more efficient based on intermediation approach rather than production approach. And, production approach was more effected by financial crisis.

**Figure 5.12: Changes in efficiency of Yapikredi bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.12 compares changes in efficiency of Yapikredibank in terms of both intermediation approach and production approach for the years 2002 to 2014. The figure indicates similar pattern of efficiency for both approaches at the first of period in 2002-2003 and at the end of period after 2010. We see that bank was efficient in 2002,2003,2008,2010,2011,2012,2013 and 2014 by both approaches. Regarding intermediation approach Yapikredibank experienced being inefficient in 2005. And, production approach indicates that Yapikredibank had significant fluctuation between2003 to 2010 and again it was efficient after 2010.

Overall, the efficiency of Yapikredi bank was more stable based on intermediation approach. While, production approach was more effected by financial crisis.

**Figure 5.13: Changes in efficiency of Finance bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.13 compares changes in efficiency of Financebank regarding both intermediation and production approaches for the years 2002 to 2014. Regarding

intermediation approach, Financebank was efficient during all the period of years except 2006 which was approximately close to efficiency score of 1.

Production approach shows that efficiency of Financebank had fluctuation during these years and was effected by financial crisis. The figure shows Financebank was efficient in 2002, 2004, 2006, 2007, 2011 and 2014.

Overall, efficiency of Financebank was higher and more stable based on intermediation approach. Whereas, we can see fluctuation and financial crisis's reflection on production approach.

### **Figure 5.14: Changes in efficiency of HSBC bank (2002-2014)**

*Source: Bank association of Turkey (2015)*

Figure 5.14 compares changes in efficiency of HSBC bank in terms of both intermediation approach and production approach for the years 2002 to 2014. Regarding intermediation approach, we see that the HSBC bank was efficient during these period of years except during the financial crisis's years. Whereas, regarding production approach HSBC bank was inefficient most of the years specially during crisis and after crisis.

Overall, the effect of financial crisis was clear on both approaches and it was more considerable on production approach.

## **6. CONCLUSION**

This study aims to determine the efficiency of 14 Turkish commercial banks between 2002 and 2014 by DEA to create a suitable performance evaluation model for these banks. In this study DEA as one of the most popular and non-parametric technique is used to measure the efficiency of decision-making units (DMUs) based on both intermediation and production approaches with different input and output variables for each approaches. The choice of the input/output measures have a directly effect on the DEA results. Therefore, it would be nice if future researchers focus on the selection for

framework of input/output variables. Our study uses a CRS DEA based on the input-oriented for 14 banks. According to the results, overall the efficiency level of commercial Turkish banking did not change very much in the analysis period. Since we determined both approaches, there are different kind of results for each of them. The results show via intermediation approach, the efficiency of the Turkish banking system during the period of 2002-2014 were higher and more stable than production approach. Regarding production approach, efficiency of banks were lower and more fluctuated. On the other, the effect of financial crisis was more obvious on production approach. In overall intermediation approach shows better results for efficiency of banks rather than production approach.

According classification of commercial banks to state-owned, private-owned and foreign banks, based on intermediation approach foreign banks and in terms of production approach state-owned banks were considered most efficient rather than other groups.

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