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Evaluating the Relative Efficiency of Commercial Banks in Turkey: An Integrated AHP/DEA Approach

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Abstract

This study measures the relative efficiency of 13 commercial banks in Turkey for the year of 2011 with an integrated approach includes Analytic Hierarchy Process and Data Envelopment Analysis. It uses two inputs (personnel expenditures and number of branch) and four outputs (deposits-national currency, deposits-foreign currency and precious metal, cash loans, and non-cash loans) in terms of production approach. According to empirical result, state-owned commercial banks are efficient in both CCR (Charnes-Cooper-Rhodes) and BCC (Banker-Charnes-Cooper) model. However, foreign-owned commercial banks have the lower efficiency scores than both state-owned and private-owned commercial banks. The results also suggest that inefficient banks should especially improve their non-cash loans and should focus on their annual personnel expenditure. Moreover, more than half of the commercial banks are scale inefficiency. The results of the study may be useful for the bank managers in assessing their performance.

Keywords: efficiency analysis, data envelopment analysis, analytic hierarchy process, weight restrictions, commercial banks, Turkey

1. Introduction

Banking sector in transition and developing economies has experienced major transformations since the 1990s. Over the last few decades, the banking sectors around the world have experienced financial globalization, technological changes, and competition. Banks are also faced with increasing competition and rising costs as a result of regulatory requirements, financial and technological innovation, and challenges of the recent financial crisis. Moreover, banking sector has changed with the advanced applications in computer and communications technology and introduction of new financial instruments. Such changes have significantly modified bank production. In this regard, a frequently asked question is about the effect of these changes on the efficiency of banks (Grigorian & Manole, 2002). So, efficiency analysis of banks has received increasing attention from researchers in recent years. It has also become important to assess the relative role of different institutional and policy settings in explaining the difference between banks (Grigorian & Manole, 2002).

Due to the increased competition in developed countries, financial institutions look for expanding their market shares in developing countries as Turkey. The banking system in Turkey is the most common instrument in exercising economic and monetary policy. Thus, efficiency analysis of the banks is the key issue in the Turkish managers' agenda. Also, efficiency measurement of the banks has an important role in the efficiency of Turkish financial system. It is not surprising that the banking sector and its efficiency is one of the most popular issues in Turkey.

Turkey has a notably (8.5%) economic growth while average economic growth rate of the world is 3.9% in 2011 (The Banks Association of Turkey, 2012). Therefore, Turkish banking sector has been taken attention all over the world. According to data from The Banks Association of Turkey (2012), Figure 1 presents proportion of size Turkish banking sector to Gross Domestic Product (GDP) by years. As shown the Figure 1, proportion of total assets, loans and deposits to GDP invariably in last seven years exception for decrease deposit rate in 2011. Especially it can be said that increase of asset/GDP with 90% is most remarkable growing. Consequently, Turkish banking sector has grown as far as GDP upward.

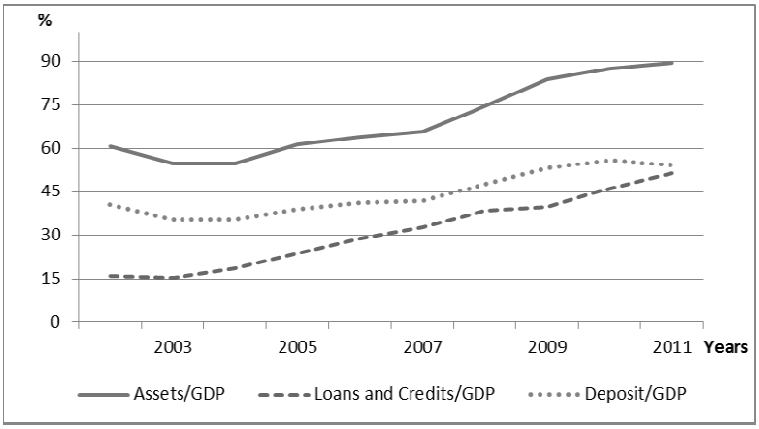

Figure 1. Turkish banking sector (2002-2011)

Turkish banking system constitutes three functional banking groups such as commercial banks, participation banks, and development and investment banks. The number of these banks is 31, 4 and 13 respectively (Banking Regulation and Supervision Agency, 2011). According to statistics from Banking Regulation and Supervision Agency (2011), they reached the total assets of 1217.7 billion TRY by the year of 2011. Thus, commercial banks have an important role in Turkish banking system. According to Yue (1992), commercial banks have a vital role in the economies for two reasons. Firstly, they provide a major source of financial intermediation. Secondly, their checkable deposit liabilities represent the bulk of the nation's money stock. Measuring and evaluating their overall performance and monitoring their financial condition is important to depositors, owners, potential investors, managers and, of course, regulators (Yue, 1992).

Data Envelopment Analysis (DEA), which is a mathematical programming approach, has become the most commonly used non-parametric approach to estimating the efficient frontier. DEA clearly brings out the firms that are operating more efficiently in comparison to other firms in the industry. Moreover, it points out the areas in which poorly performing firms need to improve (Malhotra et al., 2009). So, it is also the most widely used methods in order to measure the relative efficiency of financial institutions. In the banking sector, DEA approach allows us to measure an individual bank performance by measuring its efficiency compared to the peer group banks. This study has combined the Analytic Hierarchy Process (AHP) which is a popular tool in the field of multiple criteria decision making and DEA to create a suitable performance evaluation model.

This study aims to measure the relative efficiency of commercial banks in Turkey by DEA. It is organized as follows: Section 2 gives a brief review of the relevant literature and specifically variables used as inputs and outputs in similar studies. Section 3 gives a theoretical background on the research methods. Section 4 describes the model used in this study and introduces the data. Results are given in section 5. Finally, section 6 concludes the study.

2. Literature Review

Effective working of banking sector has a substantial position on development of financial markets. So, there are a lot of studies on efficiency of banks in the literature. There are two measurement techniques as parametric and non-parametric methods for efficiency measurement of banks in the literature. Financial ratio analysis, regression analysis, and stochastic frontier analysis are general parametric methods. These parametric approaches specify a functional form for the cost, profit, or production relationship among inputs, outputs and environmental factors, and allow for random error (AlKhathlan & Malik, 2010).

Non-parametric techniques do not require the specification of an a priori functional form and therefore is the most favored approach (AlKhathlan & Malik, 2010). DEA, as a non-parametric technique, is one of the most popular tools for performance measurement. It determines the productive efficiency of a system or decision-making-unit (DMU) by comparing how well the DMU converts inputs into outputs. DEA is also the most commonly used non-parametric technique in the banking sector. Barr et al. (2002) indicated that DEA is a reliable tool for determining banks operation efficiencies.

There are numerous applications of DEA in the bank performance literature. For example many scholars (Vassiloglou & Giokas, 1990; Al-Faraj et al., 1993; Sherman & Ladino, 1995; Athanassopoulos, 1997; Lovell & Pastor, 1997; Golany & Storbeck, 1999; Dekker & Post, 2001; Porembski et al., 2005; Mansoury & Salehi,

2011) evaluated the branch efficiency. They focused on branches of the only one bank.

DEA was also used to measure the bank efficiency for various countries by many researchers (Berg et al., 1993; Altunbas & Molyneux, 1996; Allen & Rai, 1996; Pastor et al., 1997; Kuosmanen & Post, 2001; Grigorian & Manole, 2002; Maudos et al., 2002; Maea, 2010). They aimed to present the effects of country's regulatory environments on bank efficiency.

This study focuses on the efficiency measurement of commercial banks in Turkey. So, its literature review was restricted with studies using DEA models for efficiency measurement of commercial banks. As a conclusion, much information about selected studies is given in Table 1.

Table 1. Selected studies focus on the efficiency measurement of commercial banks

Study	Sample	Inputs	Outputs	Model
Yue (1992)	60 Missouri (USA) commercial banks	-Interest expenses -Non-interest expenses -Transaction deposits -Non-transaction deposits	-Interest income -Non-interest income -Total loans	CCR
Taylor et al. (1997)	13 Mexican commercial banks	-Total deposits -Non-interest expense	-Total income (interest income plus non-interest income)	CCR and BCC-Input oriented
Al-Shammari and Salimi (1998)	16 Jordan commercial banks	No inputs were specified	-Return on investment -Return on equity -Earnings per share -Credits to total assets -Credits to deposits -Cash and portfolio investment to deposits	DEA - Ratio model
Avkiran (1999)	23 Australian trading banks	*Model A* -Interest expense -Non-interest expense *Model B* -Net-interest income -Non-interest income	 -Deposits -Staff numbers -Net loans -Non-interest income	DEA
Saha and Ravisankar (2000)	25 Indian commercial banks	-Number of branches -Number of employees -Establishment expenditure -Non-establishment expenditure	-Deposits -Advances -Investments -Spread -Total income -Interest income -Non-interest income -Working funds	CCR-Input oriented model
Barr et al. (2002)	50 US commercial banks	-Laboring costs -Fixed assets -Interest and Non-interest costs -Deposits	-Revenues -Interest incomes -Non-interest incomes	CCR-Input oriented
Sathye (2003)	94 Indian commercial banks	*Model A* -Interest expenses -Non-interest expenses *Model B* -Deposits -Staff numbers	 -Net interest income -Non-interest income -Net loans -Non-interest income	BCC- Input oriented
Halkos and Salamouris (2004)	15, 17, and 19 Greek commercial banks for each	No inputs were specified	-Return difference of interest bearing assets -Return on equity -Return on total assets -Efficiency ratio -Net interest margin	CCR and BCC- Ratio model
Portela and Thanassoulis (2005)	60 Portuguese bank branches	-Number of staff -Value current accounts	-Supply costs -Value other resources -Value credit by bank -Value credit associates	BCC-Input oriented

Li (2006)	14 Chinese commercial banks	-Employees -Capital -Operating charge rate	-Profit -Rate/person -Income rate of assets -Returning rate of capital -Trading volume by cards/person	CCR
Chen-guo et al. (2007)	14 Chinese commercial banks	-The average number of workers -Net amount of fixed capital -The total amount of costs (cost of interest)	-Total amount of deposit -Total amount of loan -Total amount of profit before paying tax	BCC
Navabakhsh et al. (2007)	20 Iranian commercial banks	-Payable interest -Personnel -Non-performing loans -Number of branch	-Main deposits -Other deposits -Loans granted -Received interest -Fee	CCR-Input and Output oriented
Chansarn (2008)	13 Thai commercial banks	*Operational Approach* -Interest expenses -Labor related expenses -Capital related expenses *Intermediation Approach* -Total deposits -Total expense	 -Interest and dividend incomes -Non-interest incomes -Total loans -Net investments	CCR
Weiguo and Ming (2008)	5 American and 4 Chinese commercialbanks	*American Banks* -Operational expense -Total deposit -Provision for bad debt *Chinese Banks* -Work force -Physical assets -Loanable funds	 -Net profit -Total loan -Interest income -Non-interest income	CCR and BCC
Subramanyam and Reddy (2008)	63 Indian commercial banks	-Number of employees -Fixed assets	-Deposits -Loans and advances -Investments -Non-interest income	CCR
Moffat and Valadkhani (2009)	10 major banks in Botswana	*Value-added approach* -Labour (salaries) -Capital related operating expenses -Interest expenses *Intermediation approach* -Deposits -Labour (salaries) -Capital related operating expenses *Operating approach* -Interest expenses -Labour (salaries) -Capital related operating expenses	 -Loans -Investment -Deposits -Loans -Investment -Interest income -Non-interest income	CCR and BCC
Tahir et al. (2009)	22 Malaysian commercial banks	-Total deposits -Total overhead expenses	-Total earning assets	BCC-Input oriented
AlKhathlan and Malik (2010)	10 Saudi Arabian commercialbanks	-Operating expenses -Equity capital -Deposits	-Loans and advances (net)	CCR and BCC- Input oriented
Akhtar et al. (2011)	12 commercial banks in Pakistan	-Operating expense -Advances -Capital	-Operating income -Net-interest income	CCR andBCC - Input oriented
Varias and Sofianopoulou (2012)	19 biggest Greek commercial banks	-Interest expenses/deposits -Other overhead expenses/fixed assets -Personnel expenses/total assets	-Loans -Other earning assets -Deposits	BCC-Input oriented
Ji et al. (2012)	17 Chinese commercial banks	-Number of employees -Interest expense -Non-interest expenses -Total assets	-Non-interest income -Interest income -Non-performing loan ratio	CCR-Input Oriented

Rao and Lakew (2012)	8 and 12 Ethiopian commercialbanks	-Total expenditures on employees -Book value of physical capital and premises	-Total customer loans less provision for doubtful -Loans -Total customer deposits	BCC-Input oriented

There are a number of studies about commercial banks in Turkey. Denizer et al. (2000) employed the DEA to estimate the relative efficiency of 49 commercial banks in Turkey for each year from 1970 to 1994. Jackson and Fethi (2000) investigate the performance of Turkish commercial banking sector. Isik and Hassan (2002) investigated input and output efficiency in the Turkish banking industry to understand the impact of various measures. They also estimated the efficiency of Turkish banks over the 1988-1996 periods. Yunten and Caner (2004) investigated the relative efficiencies of 19 Turkish commercial banks that have been operated between 1999 and 2002.Ozkan-Gunay and Tektas (2006) determined the relative technical efficiency of non-public commercial banks in Turkey between 1990 and 2001 by DEA model. Percin and Ayan (2006) evaluated the efficiency of 31 commercial banks in Turkey using DEA and Malmquist Productivity Index methodologies for the year 2003 and 2004. Ayranci (2011) analyzed the private Turkish commercial banking sector (48 banks) with DEA.

AHP is a tool at the hands of decision makers as one of the most widely used multiple criteria decision making tools. Many studies have been done based on AHP including applications of AHP in different fields such as planning, selecting a best alternative, resource allocations, resolving conflict, optimization, etc. (Vaidya & Kumar, 2006). Many studies have indicated that AHP can be applied form an AHP/DEA ranking model for improving DEA usability by deriving comparative weight from inputs/outputs via AHP pair wise comparison (Tseng & Lee, 2009).

Efficiency analysis via a combined method with AHP and DEA can be performed by two approaches. In the first approach, DEA is run for each pair of units separately and then the pair wise evaluation matrix generated DEA stage is utilized to rank scale the units via AHP approach. This approach was used in many fields such as 3PL vendor selection (Zhang et al., 2006) and hotel ranking (Rouyendegh & Erkan, 2010).

In the second approach, AHP was used to determine the weight of any qualitative criteria (input or outputs) verified and then, the DEA model was used for solving the multi-objective model to identify the best alternatives. AHP is used for the weight determination or restriction in this approach. It was used in warehouse operators selection (Korpela et al., 2007), bridge risks assessment (Wang et al., 2008),relative efficiency of greenhouse gas technologies (Lee et al., 2008), supplier performance (Yuan et al., 2008), the efficiency of R&D management activities in universities (Feng et al., 2004) and also hydrogen R&D programs (Lee et al., 2010), smartphone comparisons (Peaw & Mustafa, 2006), evaluating the flexible manufacturing systems (Rezaie at al., 2010), measuring the agility of manufacturing systems (Saleeshya & Babu, 2012).

As shown in literature review, there is no study focus on relative efficiency of commercial banks by integrated with AHP and DEA approach. Furthermore, such a study that analyzes the relative efficiency of commercial banks in Turkey can be considered an important contribution to the literature.

3. Research Method

3.1 Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a non-parametric approach to efficiency measurement of similar organizational units called Decision Making Units (DMUs). Its basic foundation was generated from Farrell's (1957) original work that was later popularized by Charnes et al. (1978). DEA provides a single measure and easily deals with multiple inputs and multiple outputs (Agha et al., 2011).

DEA has two models as CCR and BCC. CCR (Charnes-Cooper-Rhodes) model is the basic DEA model which assumes constant returns to scale (CRS) was proposed by Charnes et al. (1978). This model assumes that all DMUs are operating at an optimal scale. However, Banker et al. (1984) suggested BCC (Banker-Charnes-Cooper) model as an extension of the CRS model to account for variable returns to scale (VRS) situation.

DEA models typically measure technical efficiency in one of two ways. Input oriented models measure how much each DMU can reduce its inputs while producing the original level of output. However, output oriented models measure how much each DMU can expand its output while holding inputs unchanged.

Assuming n DMUs with m inputs and s outputs, the primal output CCR and BCC model related to DMU_k are as shown in Equations 1 and 2. Efficiency score is less than or equal to 1. When the efficiency score is 1, DMU is

regarded as an efficient frontier.

Output Oriented CCR Model

$$\min E_k = \sum_{r=1}^{m} v_i x_{ik} (1)$$

$$st$$

$$\sum_{r=1}^{s} u_r y_{rk} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$$

$$u_r, v_i \geq$$

$$j = 1, \ldots, n \; r = 1, \ldots, s \; i = 1, \ldots, m$$

Output Oriented BCC Model

$$\min E_k = \left(\sum_{r=1}^{m} v_i x_{ik}\right) - \mu_0 \; (2)$$

$$st$$

$$\sum_{r=1}^{s} u_r y_{rk} = 1$$

$$\left(\sum_{r=1}^{s} u_r y_{rj}\right) - \left(\sum_{i=1}^{m} v_i x_{ij}\right) + \mu_0 \leq 0$$

$$u_r, v_i \geq \mu_0 = \text{serbest}$$

$$j = 1, \ldots, n \; r = 1, \ldots, s \; i = 1, \ldots, m$$

E_k=the efficiency score of k^{th} DMU

v_{ik}: weight given to i^{th} input by k^{th} DMU

x_{ik}: amount of i^{th} input utilized by k^{th} DMU

u_{rk}: weight given to r^{th} output by k^{th} DMU

y_{rk}: amount of r^{th} output produced by k^{th} DMU

x_{ij}: i^{th} input of the j^{th} DMU

y_{rj}: r^{th} output of the j^{th} DMU

ε: sufficiently small positive number (e.g. 0,00001)

According to Bobe (2009), DEA is a powerful tool in that because (i) it evaluates the efficiency performance of a DMU relative to other DMUs either for a period or over number of periods (benchmarking); (ii) it provides monitoring information for a specific DMU over a period of time; (iii) it suggests the benchmark DMUs (reference set) that can be used to estimate the efficient amount of resources required to achieve the same level of outputs; and (iv) it estimates the potential reductions in inputs needed to achieve the same level of outputs and/or the potential increase in outputs using the same level of inputs. There are, however, some limitations of DEA. First, the efficiency score obtained by a DMU is sensitive to the number of inputs and outputs used in the analysis. Second, classical DEA does not provide statistical inferences. Third, DEA results may be misleading. An efficiency score of 1 does not necessarily mean that the performance of a DMU is the best. It only indicates, relative to the other DMUs in the group, that the DMU is considered to be efficient. Fourth, specification of inputs and outputs may appear to be more subjective.

3.2 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) enables decision makers to structure a complex problem in the form of a simple hierarchy and to evaluate a large number of quantitative and qualitative factors in a systematic manner under multiple conflicting criteria (Lee et al., 2008).

According to Saaty (2008), to make a decision in an organized way to generate priorities we need to decompose the decision into the following steps: (i) Define the problem and determine the kind of knowledge sought. (ii) Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria) to the lowest level (alternatives). (iii) Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it. (iv) Use the priorities obtained from the comparisons to weight the priorities in the level immediately below. Then for each element in the level below add its weighted values and obtain its global priority.

To make comparing, AHP uses the scale for pairwise comparisons. The numbers 1, 3, 5, 7, and 9 are used as

scaling ratios, and correspond to the strength of preference for one element over another. For example, the number 9 indicates a case of extreme importance over another element. After pairwise comparisons are conducted, the weights of the criteria are calculated and checked for consistency. Then, a review of the consistency ratio (CR) is conducted in order to ensure that it falls between 0 and 0.10. CR is determined to be the ratio of Consistency Index (CI) to Random Index (RI). The fact that CR is determined to be greater than 0 but less than 0.10 implies a satisfactory degree of consistency in the pairwise comparisons matrix. We then aggregate the weights.

3.3 Integrated with AHP and DEA

Efficiency that refers to the relationship between output and input does not employ multiple inputs to produce multiple outputs because it is limited only to a single output and a single input. Hence, it is extended into weighted sum of outputs and weighted sum of inputs. So, it can be said that the key issue is how to assign weights to each input and output in the efficiency analysis. Thus, the weights, u_j and v_j, are determined by solving the DEA model. These weights developed by DEA may not represent the same relative subjective weights that management might apply as to the relative importance of the variables (especially the output variables) used in the DEA models (Al-Delaimi & Al-Ani, 2006). This is a significant point to management when evaluating the performance of a DMU. Thus, weights have an important effect on the efficiency of the DMU.

Literature proposes to several approaches to determine weights. Majority of them can be classified into subjective approaches and objective approaches (Ma et al., 1999). Subjective approaches determine the weights according to the preferential judgments of decision maker. Eigenvector method, weighted least square method, and Delphi method can be example for these approaches (Ma et al., 1999).On the other hand, objective approaches determine the weights by making use of mathematical models, but they neglect subjective judgment (Liu, 2003). They include principal element analysis, entropy method, and multiple objective programming model (Ma et al., 1999; Ginevicius & Podvezko, 2004).

This paper proposes AHP as a subjective method to determine weights. The AHP approach was employed to ascertain the relative weights of the criteria. It makes use of pairwise comparison matrices, hierarchical structures, and ratio scaling to apply weights to attributes (Lee et al., 2008). The advantage of this method is that experts can reasonably identify the weight index that corresponds to the real problems (Liu, 2003). Thus, despite the different placement of weights on the index, the method can still determine the order of priority and avoid conflicts between the reality and the index weights (Liu, 2003). Furthermore,AHP which is technically valid and practically useful does not need to large sample (Lam & Zhao, 1998). It also can be used in combination with other methods. DEA is proposed in this study to generate local weights of criteria from pairwise comparison judgment matrices used in the AHP.

4. Model and Data

4.1 Input and Output Variables

Using DEA model in measuring bank efficiency requires selection of appropriate input and output variables. However, there is no consensus in the banking literature regarding the proper selection of inputs and outputs (Rao & Lakew, 2012). Furthermore, commercial banking is a very difficult service industry in which to measure output, technical change, or productivity growth (Berger & Humphrey, 1992).

The choice of output and input variables is the first difficult question that must be addressed by any study on banking. Such a choice will be influenced by the selected concept of banking firm, by the particular question under consideration and, also, by the availability of data (Pastor et al., 1997). Two different approaches appear in the literature regarding the measurement of banks inputs and outputs, popularly known as *production* approach and *intermediation* approach (Berger & Humphrey, 1997). The production approach views banks as using purchased inputs to produce deposits and various categories of bank assets. It considers to banks as institutions that use capital and labor to produce loans and deposit account services. In this approach, labor, capital and operating costs are treated as inputs and loans, deposits, and transactions are considered the outputs.

The intermediation approach, on the other hand, views banks as financial intermediaries whose primary business is to borrow funds from depositors and lend those funds to others for profit (Yue, 1992). It generally uses loans as output and various costs such as interest expense, labor, capital and operating as outputs. It views the banks as using deposits together with purchased inputs to produce various categories of bank assets. However, there is still no current consensus on which of the two methodologies outlined above should be utilized in bank efficiency analysis. We have used production approach with restricted choice of variables.

To obtain input and output variables in this study, a preliminary list was composed using all input and output variables used in the literature. This list was shown to three branch managers of different banks who were asked to give their feedback whether the list is reasonable. Further, they were asked to add, delete or combine variables. Based on these responses, a refined list was compiled and shown again to bank administration until a consensus was reached on what variables should be used to better represent the efficiency of the department. Thus, a final list of variables was obtained. These variables are shown in Table 2. It also gives more details about the measures.

Table 2. Variables and descriptions

Variables	Description	Code
Input		
Personnel Expenditures	It is the total annual expenditure of each bank (Million TRY)	PE
Number of Branch	It is the total number of branches which operated during the study period	NB
Output		
Deposits-National Currency	It is composed of saving deposits with Interbank, Public Sector, and Commercial Institutions Deposits (Million TRY)	DNC
Deposits-Foreign Currency and Precious Metal	It is composed of foreign exchange and precious metal as Gold (Million TRY)	DFCPM
Cash Loans	It is loans have been used as cash in current period (Million TRY)	CL
Non-Cash Loans	It is loans have been used as non-cash in current period (Million TRY)	NCL

4.2 Sample Selection

Turkish banking system consists of three functional bank types such as commercial banks, development and investment banks, and participation banks (noninterest banking). The goal of the sample selection was to find comparable banks. Thereby, we decided to include only commercial banks and to neglect other types of banks. Commercial banks produce 92% of the Turkish banking sector's total assets (Banking Regulation and Supervision Agency, 2011). Thus, commercial banks have an important role in Turkish banking system. Bank sample was also restricted to large banks which are more than one percent market share. As the market share, it has been taken account of total assets.As a result, the thirteen of 31 commercial banks operated in Turkey were chosen as the sample. Thus, this study applies DEA to compare operational performance of 13 commercial banks in Turkey. Much information about these banks according to 2011 statistics can be seen in Table 3.

Table 3. Much information about the sample

Banks*	Ownership	Assets (Million TRY)	General Market Share (%)**	Banks*	Ownership	Assets (Million TRY)	General Market Share (%)
İşbankası	Private-owned	161775	14.45	Finansbank	Foreign-owned	46199	4.13
Ziraat	State-owned	160681	14.35	Teb	Private-owned	38092	3.40
Garanti	Private-owned	146642	13.09	Denizbank	Foreign-owned	36032	3.22
Akbank	Private-owned	133552	11.93	Hsbc	Foreign-owned	24172	2.16
Yapıkredi	Private-owned	108103	9.65	Ing	Foreign-owned	21066	1.88
Halkbank	State-owned	91404	8.16	Şekerbank	Private-owned	14400	1.29
Vakıfbank	State-owned	89465	7.99				

Source: Banking Regulation and Supervision Agency (2011)

Notes: *Ordered by general market share. **According to total assets.

To ensure meaningful efficiency scores, the number of DMUs must be large enough relative to the number of input and output variables. A rule of thumb is given by Boussofiane et al. (1991) and Ramanathan (2003) as [$N \geq 2*(s+m)$], where s is the number of output variables, m is the number of input variables, and N is the number of DMUs. In this research, the number of DMUs (13) is more than twice the sum of the number of input and output variables. However, small sample size in this study can be compared with some of the other small sample sizes in the DEA literature (Oral & Yolalan, 1990; Haag & Jaska, 1995; Li, 2006; Cronje, 2007; Chen-guo et al., 2007; Akhtar et al., 2011; Rao & Lakew, 2012).

4.3 Data

We use annual data compiled mainly from balance sheet and income statements of banks in database of The Banks Association of Turkey (2011) and The Banking Regulation and Supervision Agency (2012). We cover

only thirteen out of 31 commercial banks operating in Turkey which can be seen in Table 4. It also includes data of each bank and descriptive statistics of each variable.

Table 4. Data and descriptive statistics

		Inputs		Outputs			
Banks*	Code	PE	NB	DNC	DFCPM	CL	NCL
Akbank	DMU_1	1002	927	52084	24730	70213	14635
Denizbank	DMU_2	670	588	14486	5580	22196	9745
Finansbank	DMU_3	752	522	21446	7830	30435	6986
Garanti	DMU_4	1248	914	49087	35456	83533	21022
Halkbank	DMU_5	732	771	47836	18411	55236	17846
Hsbc	DMU_6	455	330	8214	5033	13662	2824
Ing	DMU_7	383	322	9129	2402	15265	5864
İşbankası	DMU_8	1819	1201	61727	36586	91621	25850
Şekerbank	DMU_9	228	272	6596	2482	8500	4794
Teb	DMU_{10}	579	507	14923	7963	25444	8063
Vakıfbank	DMU_{11}	834	680	46023	14916	57201	15664
Yapıkredi	DMU_{12}	1138	907	35395	28122	67045	26135
Ziraat	DMU_{13}	1313	1458	89866	23200	71173	11979
Mean		*858*	*723*	*35139*	*16362*	*47040*	*13185*
SD		*439*	*355*	*25335*	*12283*	*28835*	*7793*
Min.		*228*	*272*	*6596*	*2402*	*8500*	*2824*
Max.		*1819*	*1458*	*89866*	*36586*	*91621*	*26135*

Note: * Alphabetical order.

Due to the fact that operational performance was measured by outputs in banks, this study employs the output-oriented model. Efficiency Measurement System (EMS) software version 1.3 (Scheel, 2000) is used in this research to measure the technical efficiency of the departments based on both CCR and BCC models.

5. Results

5.1 Weight Restrictions

Pairwise comparison matrix should be done before the generate weight restriction. Thus, constrained weighting vectors were obtained from the AHP pairwise matrix. Then, in order to take the decision maker's preferences into the evaluation, extra constraints were added to model.

Pairwise comparison matrix were constituted based on data from three experts from three commercial banks. They work as a department manager in their banks. Data collection phase are combined using the geometric mean approach to obtain the corresponding consensus pairwise comparison judgment matrices. Finally, AHP pairwise matrix can be seen in Table 5. All the consistency rates are less than 0.10.

Table 5. Pairwise comparison matrix for inputs and outputs

	PE	NB	DNC	DFCPM	CL	NCL
PE	-	1.00				
NB	1.00	-				
DNC			-	2.29	1.00	3.63
DFCPM			0.44	-	0.37	1.26
CL			1.00	2.70	-	3.63
NCL			0.27	0.79	0.28	-

Based on this matrix, new eight constraints were added to DEA models. One of them is about inputs while other is about outputs. These constraints were formed as follows:

$$\frac{v_{1k}}{v_{2k}} \geq 1 \quad \frac{u_{1k}}{u_{2k}} \geq 1 \quad \frac{u_{1k}}{u_{2k}} \geq 2.29 \quad \frac{u_{1k}}{u_{3k}} \geq 1 \quad \frac{u_{1k}}{u_{4k}} \geq 3.63 \quad \frac{u_{2k}}{u_{3k}} \geq 0.37 \quad \frac{u_{2k}}{u_{4k}} \geq 1.26 \quad \frac{u_{3k}}{u_{4k}} \geq 3.63$$

5.2 Efficiency Scores

Table 6 shows the efficiency scores and the reference set(s) for each DMU. According to CCR efficiency scores

in the second column, four (Garanti, Halkbank, Vakıfbank, and Ziraat) of the thirteen banks under evaluation are best performers. These banks require neither input reduction nor output augmentation. However, Denizbank turned out to be the bank with the lowest performance (0.438). Moreover, average CCR score of thirteen banks is 0.674. It means that an average bank should produce 48.4% ($\frac{1-0.674}{0.674}$) more output with the same input level if it wishes to do business more efficiently.

Table 6. Efficiency scores, reference set and scale efficiency

DMUs	CCR Model		BCC Model		Scale Efficiency	Returns to Scale
	Efficiency Scores	Reference Set	Efficiency Scores	Reference Set		
Akbank (DMU_1)	0.943	DMU_5 (0.63) DMU_{11}(0.65)	0.999	DMU_{13} (0.15) DMU_5 (0.50) DMU_4 (0.35)	0.944	DRS
Denizbank (DMU_2)	0.438	DMU_5 (0.24) DMU_{11} (0.59)	0.464	DMU_5 (0.11) DMU_{11} (0.63) DMU_9 (0.26)	0.944	IRS
Finansbank (DMU_3)	0.656	DMU_{11} (0.73) DMU_4 (0.03)	0.752	DMU_{11} (0.61) DMU_9 (0.39)	0.872	IRS
Garanti (DMU_4)	**1.000**		**1.000**		**1.000**	CRS
Halkbank (DMU_5)	**1.000**		**1.000**		**1.000**	CRS
Hsbc (DMU_6)	0.451	DMU_{11} (0.14) DMU_4 (0.25)	0.817	DMU_{11} (0.14) DMU_9 (0.86)	0.552	IRS
Ing (DMU_7)	0.510	DMU_5 (0.06) DMU_{11} (0.41)	0.925	DMU_{11} (0.12) DMU_9 (0.88)	0.551	IRS
İşbankası (DMU_8)	0.874	DMU_{11} (0.90) DMU_4 (0.65)	**1.000**		0.874	IRS
Şekerbank (DMU_9)	0.485	DMU_5 (0.31)	**1.000**		0.485	DRS
Teb (DMU_{10})	0.559	DMU_5 (0.20) DMU_{11} (0.52)	0.630	DMU_{11} (0.57) DMU_9 (0.43)	0.887	IRS
Vakıfbank (DMU_{11})	**1.000**		**1.000**		**1.000**	CRS
Yapıkredi (DMU_{12})	0.801	DMU_{11} (1.06) DMU_4 (0.20)	0.832	DMU_{13} (0.04) DMU_5 (0.22) DMU_4 (0.74)	0.963	DRS
Ziraat (DMU_{13})	**1.000**		**1.000**		**1.000**	CRS
Mean	*0.674*		*0.834*		*0.852*	
SD	*0.235*		*0.173*		*0.190*	
Min.	*0.438*		*0.464*		*0.485*	
Max.	*1.000*		*1.000*		*1.000*	

The third column includes the corresponding reference units for the inefficient DMUs and the λ values which are the raw weights assigned to peer units when solving the DEA optimization problem. The higher the contribution, the closer in performance is the peer to the unit under consideration (Marschall & Flessa, 2008). For example, Akbank can virtually become efficient by combining the Halkbank and Vakıfbank as peers, with weights of 0.63 and 0.65 respectively. Vakıfbank is the peer unit with the highest value in the reference set and thus the most comparable unit according to CCR results.

According to BCC results, six banks (Garanti, Halkbank, İşbankası, Şekerbank, Vakıfbank, and Ziraat) operate with technical efficiency. Moreover, average BCC score of thirteen banks is 0.834. It means that an average bank should produce 19.9% more output with the same input level if it wishes to do business more efficiently.

In terms of the reference set, Vakıfbank and Şekerbank are the most comparable units with their reference number in BCC efficient banks. Denizbank, which has the lowest BCC efficiency score, can virtually become efficient by combining the Halkbank, Vakıfbank, and Şekerbank as peers, with weights of 0.11, 0.63, and 0.25 respectively.

Scale efficiency shows how close or far the size of the DMU is from its optimal size (Sporcic et al., 2009). So, scale efficiency scores allow for some interesting remarks. It can be said that the average efficient score is 0.852

based on the scale efficiency results. It means that an average bank should increase their relative efficiency on average by 17.4% if it adapted their size or volume of activities to the optimal value. The size and volume of activities of four banks (Garanti, Halkbank, Vakıfbank, and Ziraat) are well balanced because they have the efficiency of 100%. However, other banks, which have the efficiency values lower than 100%, partly under influence of size or volume of activities.

The issue of scale inefficiencies is explored with greater detail by considering returns to scale indicators. Among 13 banks, 6 banks operate under increasing returns to scale (IRS), 4 banks operate under constant returns to scale (CRS), and the remaining 3 banks operate under decreasing returns to scale (DRS). Both CCR efficiency and scale efficiency are equal to 1 are considered as operating at the most productive scale size.

Relatively scale efficient banks are also efficient according to CCR model. However, two banks (İşbankası & Şekerbank) are efficient only according to the BCC model. They do not show the same efficiency level in terms of scale efficiency. According to it, it can be said that their inadequate size or volume of activities expressed by the main parameters of their performance (Sporcic et al., 2009). In other words, the banks of İşbankası and Şekerbank which are efficient on BCC model but inefficient on CCR model have been efficiently operated except the effect of scale. The major causes of inefficiency are from scale inefficiency. In other words, they operate locally efficiently whereas its overall technical inefficiency is caused by its failure to achieve scale efficiency. These banks should enhance their own efficiency by increasing their input level as these have IRS characteristics.

Akbank, Şekerbank, and Yapıkredi showing DRS characteristics should decrease of their inputs or the increase of their outputs because they have been operated by the inputs over optimal scale. In the cases of the banks of which both BCC efficiency and scale efficiency is less than 1, both can be the causes of inefficiency (So et al., 2007).

5.3 Potential Improvements

One of the attractiveness of DEA is that it provides reference set so that inefficient DMUs have benchmark DMU to learn from their experiences (Bobe, 2009). So, in addition to providing efficiency measures, DEA also provides other information relevant for the inefficient DMUs. Because efficient DMUs do not have any slack, this information is only of interest for inefficient DMUs (Tongzon, 2011).

Table 7 shows the banks' target input/output data and projection obtained from the DEA calculations. A DMU is BCC efficient if it has no input excesses and no output shortfalls. Thus, the difference between original data and projection is 0.00%. So, it can be seen the potential improvements for the seven inefficient banks under BCC model (Marschall and Flessa, 2008).

Table 7. Target values (%) for inefficient banks according to BCC model

	Inputs				Outputs							
	PE		NB		DNC		DFCPM		CL		NCL	
DMUs	Target	%	Target	%	Target	%	Target	%	Target	%	Target	%
DMU_1	1002	0	927	0	52152	0.1	24762	0.1	70305	0.1	18048	23.3
DMU_2	670	0	588	0	31195	115.4	12017	115.4	47800	115.4	20985	115.4
DMU_3	599	-20.3	522	0	28506	32.9	10408	32.9	40454	32.9	11454	64.0
DMU_6	314	-31.0	330	0	10059	22.5	6163	22.5	16731	22.5	6339	124.5
DMU_7	302	-21.0	322	0	9865	8.1	2596	8.1	16495	8.1	6337	8.1
DMU_{10}	577	-0.4	507	0	23685	58.7	12639	58.7	40382	58.7	12796	58.7
DMU_{12}	1138	0	907	0	42545	20.2	33803	20.2	80588	20.2	31414	20.2

The projections suggest that particularly the analyzed banks are too big to be efficient. The results demonstrate that the efficiency of Denizbank which is the most inefficient can be improved when the personnel expenditure (PE) is reduced by 53.6%. Similarly, its efficiency can be attained if all of the output values are increased by 115.4%. When the number of branches (NB) is analyzed, it is seen that any DMU doesn't have to decrease it. So, it can be said that banks are working with optimal number of branches.

For inefficient banks to benefit from the study, the amounts by which these DMUs should increase their outputs to become efficient are calculated using the BCC model. In this study, the targeted value of a variable represents the amount to which a given DMU can increase its production of that specific variable. In the following figures (Figure 2-3-4-5), the light columns indicates the actual value of outputs while dark column indicates potential improvements to enhance required output amount.

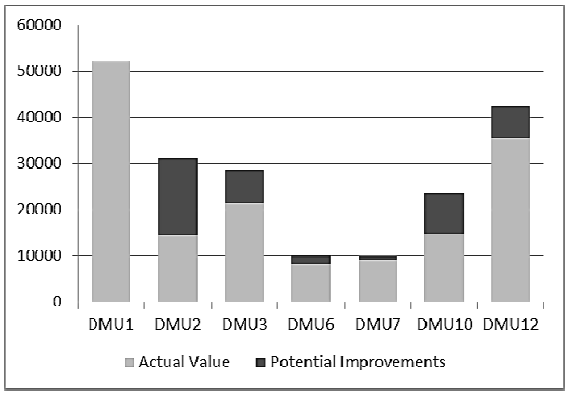

Figure 2. Actual values and potential improvements of deposits-national currency (DNC)

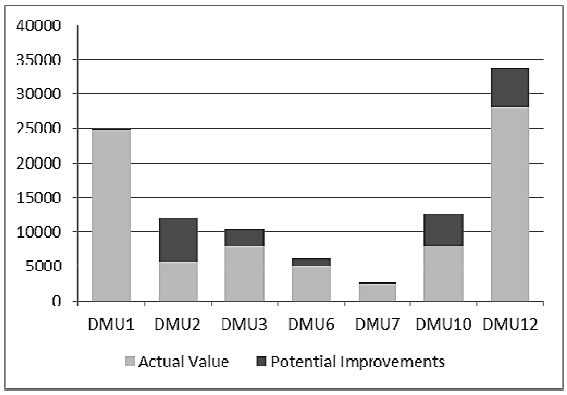

Figure 3. Actual values and potential improvements of deposits-foreign currency and precious metal (DFCPM)

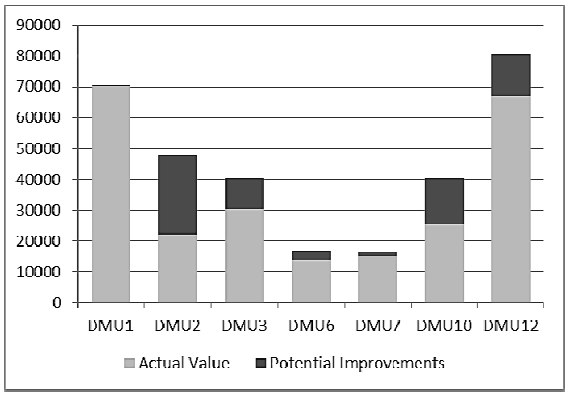

Figure 4. Actual values and potential improvements of cash loans (CL)

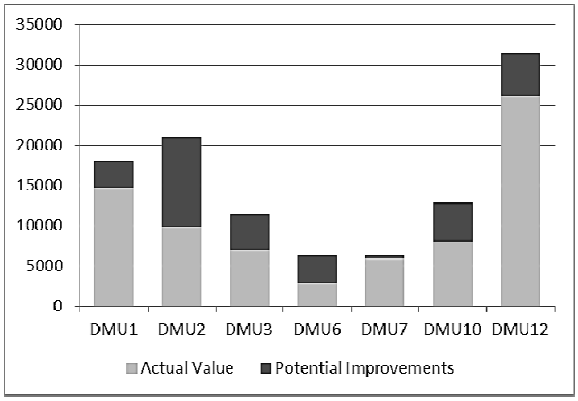

Figure 5. Actual values and potential improvements of non-cash loans (NCL)

Figure 2 shows the actual values and the potential improvements of the Deposits-National Currency (DNC). It is noticed that Denizbank and Teb requires the highest increase respectively as 16709 and 8761 million TRY. Akbank, Finansbank, Hsbc, Ing, and Yapıkredi should increase their DNC by certain amounts to reach the target value in order to be efficient. Akbank is the nearest bank to target value by 68 million TRY.

As for Deposits-Foreign Currency and Precious Metal (DFCPM), Figure 3 shows the actual and target values for this output. If inefficient departments can enhance their outputs to the corresponding potential improvement levels, then, they would become more efficient. In parallel with this, Denizbank, Yapıkredi, Teb, Finansbank, Hsbc, Ing, and Akbank need to enhance their DFCPM respectively in order to become more efficient.

When potential improvement of Cash Loans (CL) is analyzed in Figure 4, it is seen that Denizbank, Teb, and Yapıkredi are the banks need to the most improvements as 24604, 14138, and 13543 million TRY respectively. However, Akbank and Ing need to less improvements of CL than other inefficient banks.

In figure 5, it is demonstrated actual value and potential improvement of non-cash loans (NCL). Akbank is also closer to target values than other inefficient banks in terms of NCL. However, Denizbank is the farthest bank from target values by 11240 million TRY.

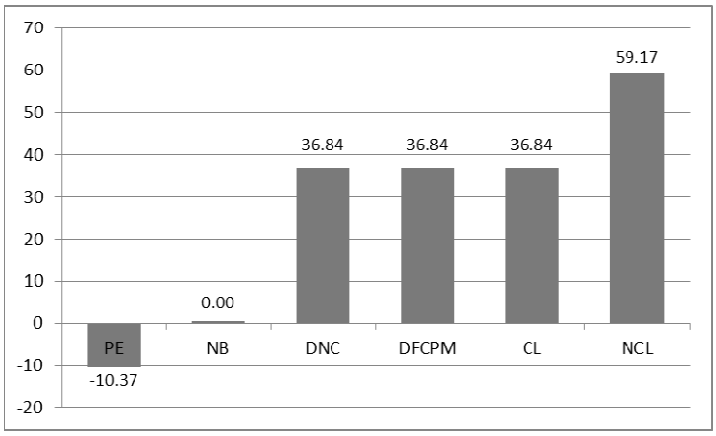

Figure 6. Average improvement rate (%) of input and output value for inefficient banks

Figure 6 indicates the average improvement rates of both inputs and outputs for efficient. According to it, three of the four outputs, DNC, DFCPM, and CL, have same (36.84%) average improvement rate. On the other hand, NCL have been expanded to average 59.17% by inefficient banks. With respect to average input decreasing, it is interesting note that inefficient banks have not to change their NBs. However, PE should reduce average 10.37% by inefficient banks. Thus, these banks can produce same level outputs with less PE.

6. Discussion and Conclusion

This study measure the relative efficiency of 13 commercial banks in Turkey. It combines the AHP and DEA to create a suitable performance evaluation model for these banks. The fact that all the products and services are similar for all banks ensures maximum feasible comparability among banks. Therefore, any observed difference in efficiency should be explained by differences in technical efficiency and not in lack of comparability. The following findings and insights from CCR and BCC model are summarized.

Nine banks are identified as being inefficient according to the CCR model while seven banks are identified according to the BCC. It is noted that BCC yields more efficient banks than CCR. These results are expected due to two reasons according to Agha et al. (2011). First, theoretically the numerator of BCC ratio is greater than the numerator in CCR. Secondly, BCC relaxes the slack variables to be greater than zero and adding lambda constraint. Further, the values of CCR and BCC efficiencies are close to each other, which imply that either the CCR or BCC may be adopted for this research.

Three state-owned banks (Halkbank, Ziraat, and Vakıfbank) are efficient in both CCR and BCC model. Moreover, these banks operate at the most productive scale size according to scale efficiency. These results are similar to empirical results from Aydin et al. (2009) shows that the most efficient banks in Turkey are state-owned banks. However, foreign-owned banks have the lower efficiency scores than both state-owned and private-owned banks.

The results of the analysis show a first insight into the inefficient banks. They should especially improve their non-cash loans. Furthermore, they should focus on their annual personnel expenditure. Moreover, more than half (64.3%) of the banks are scale inefficiency. These banks should improve tactical actions according to their working region (IRS or DRS).

This study has some limitations that need to be acknowledged, but which at the same time lend themselves towards identifying future research avenues. First of all, the quality of the DEA results depends heavily on the choice of the input/output measures. So, quality related measures such as customer satisfaction or responsiveness should also be included to the models. In this regard, future studies could also try to develop for qualitative outputs such as customer satisfaction, customer responsiveness, and service quality and apply DEA for investigating their productivity impact. Furthermore, models that further add similar constraints on the input multipliers, based on personnel salary, were used to identify cost efficient banks. Future researches could also investigate whether the same conclusions can be replicated and generalized in different bank segments such as participation, development and investment and/or countries.

Another limitation is the choice of variables for inclusion in a DEA analysis. In literature a lot of studies focus on bank efficiency analysis with DEA. These studies use various inputs and outputs set. While this is largely left up to management judgment, there should be a more rigorous method for selecting input and output variables for

productivity assessment. Therefore, future researchers may focus on developing a framework for input/output variable selection.

One limitation is that this study has not implications from a customer's perspective. Technical efficiency can vary widely across commercial banks. So, in future studies, the model should be expanded to customer perspective with including related outputs such as customer satisfaction, transactions time.

A last limitation is about some special problems of DEA. Since it is a deterministic procedure, it does not provide fit statistics such as r-square or p-value that can be used for statistical inferences. Moreover, there is no role for statistical error in the calculations and a number of questions need to be answered about the validity of the DEA score.

Managerial relevance of our research is quite important. It is widely accepted that to succeed a company must perform well. Moreover, the simplicity of the results, and the fact that they arise directly from observed input/output data that allow for better acceptance of the results by the bank managers. Bank management should pay more attention to personnel expenditure among the input variables and non-cash loans among the output variables. Furthermore, managers can use DEA to compare their business units.

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