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Measuring technical financial efficiencies and performances in the emerging markets: evidence from Turkish banking sector

Abstract

Measuring the financial efficiencies and performances of the banking sector has played a crucial role in quantitative finance. Turkish banking sector, achieved TL 1,732 billion asset size as of December 2013, has a promising role in the emerging markets within the global economy. Charnes, Cooper and Rhodes (1978) had first introduced Data Envelopment Analysis (DEA), a valuable *non*-parametric and deterministic mathematical programing methodology for determining the efficient frontier that depends on the selected input and output variables of the DMUs. The principle form of DEA is CCR model, depends upon the constant returns to scale assumption, and measures the technical efficiency. The goal of this study is to analyze technical financial efficiencies and performances of 30 commercial and 13 development and investment banks for Turkey in 2012-2013. It has been observed that Turkish banks demonstrated better financial efficiencies in terms of intermediation approach rather than operating approach. In particular, commercial banks have shown higher technical financial efficiencies in comparison to development and investment banks. According to the results, Turkish banks require some improvements in input and output variables. As a consequent, both DEA analyses and selected bank performance indicators have revealed that Turkish banks have demonstrated significant financial technical efficiencies and bank performances for 2012-2013. In further, the DEA technique is regarded as a valuable quantitative tool for financial decision makers in analyzing the financial efficiencies of the banks.

Keywords: data envelopment analysis, technical financial efficiency, operation, intermediation, bank performance indicators, banking sector, Turkey.
JEL Classification: C60, C61, C67, G21.

Introduction

Financial efficiency analysis has become crucial for the decision makers who need to measure the efficiency level of a decision making unit (DMU) through considering the positive and negative aspects of the given conditions. Efficiency analysis provides a valuable tool for the decision makers in determining the relative efficiencies of the financial institutions that operate within global financial market conditions.

Charnes et al. (1978) was first time introduced an efficiency measurement technique which is known as Data Envelopment Analysis (DEA). This technique depends upon to analyze the functional relationship between inputs and outputs (Charnes et al., 1978; Choi and Murthi, 2001).

In the initial studies, DEA has been used to analyze the relative efficiency of *non-profit* organizations and public sector activities. Subsequently, this efficiency technique has been successfully applied to *profit-oriented* organizations (Busso and Funari, 2001).

Ruggiero (2000) affirms that DEA has become popular in analyzing technical and pure efficiencies since the method smoothly operates multiple inputs and outputs, and does not require input price data.

There are numerous efficiency studies which applied particularly on the banking and finance sector in the efficiency literature. Some empirical studies such as Baurer (1993), Berger and Humprey (1997) and Berger et al. (1993) had carried out frontier efficiency analyses for the US banks.

Follow up studies have been carried out by Carbo et al. (2002) and Conceicao et al. (2007) for efficiency measurements of the banks in the European Union. On the other side, there are some efficiency analysis studies for the Turkish banking sector performed by Zaim (1995), Ertuğrul and Zaim (1999), Mercan and Yolalan (2000), Çingi and Tarım (2000), Karacabey (2002), Kasman (2002) and Gökgöz (2009a, 2009b).

Due to the global financial crises, Turkish banking sector encountered financial distress in the period 2000-2001. Thus, measuring the financial efficiency with DEA models which are established for the Turkish banking sector has become significant in analyzing the dynamics of the Turkish financial system.

The goal of this paper is to measure the technical financial efficiency of the Turkish commercial and development, and investment banks for the period 2012-2013 in terms of operating and intermediation approaches.

In this regard, CCR input-oriented model and CCR output-oriented model have been implemented onto Turkish commercial, and development and investment banks in order to reveal the technical financial efficiencies for operating and intermediation perfor-mances in the said time interval.

In this framework, the rest of the paper has been organized as follows. Section 1 summarizes the

characteristics of Turkish banking and finance sector, and section 2 includes the technical efficiency models used in DEA technique. Section 3 gives the methodology and the data used, and presents the results. The final section comprises the concluding remarks.

1. Banking and finance sector in Turkey

Macroeconomic and financial stability and structural reforms has become more crucial in Turkish banking and finance sector due to the financial crisis experience encountered a decade ago (BRSA, 2010). Turkish economy has been affected by global financial crises in 2000 and 2001 due to the weak banking sector dynamics. SDIF (2003) refers that these financial crises caused the Turkish banking sector undergo a restructuring process, during which 14 national banks were transferred to the Turkish Saving Deposits Insurance Fund (SDIF) in 2000-2003 period.

Due to the financial crises in 2000-2001 period, Turkish economy performed lower average growth rate (~1%) in the period of 2000-2002. After having carried out the reforms in the banking sector, significant financial difficulties of the Turkish banking sector have been solved and the banking sector were regulated in accordance with the international standards.

Besides, as of 2003, the economy started to recover, and it has achieved a 6.9% average growth rate in the period of 2003-2007. However, in 2008 the financial crisis in global environment has begun to affect all countries' economic stability and due to 2008 crisis, growth rate has decelerated and there has been a negative drift in growth objectives. Further, Turkish economy began to accelerate the growth rate of the country after 2002 and then the banking sector has been positively affected in 2002-2008.

According to BRSA (2011), sustainability of Turkish economy was affected unfavorably due to the mortgage crisis encountered in global markets within 2008. Afterwards, Turkish economy showed better performance in 2010-2011 period so that, the Turkish banking sector was demonstrated positive results in this period and the operational efficiency had been improved.

Furthermore, Turkish financial institutions correspond to small number however, they have a broad structure of branches and the number of bank branches has increased within the 2008-2011 period. Due to the global financial crisis, the increasing rate of bank branching in December 2011 has reduced when compared to 2010. In total numbers, increasing rate of new branches of banks has diminished by 57% within 2008-2011.

As we analyze the period before the financial crisis, Turkish banks had to reevaluate branching predictions of their own. For 2008-2011 period, Turkish finance sector has demonstrated a growth rate by 40.2% with the contribution of stock markets and by 29.0% in real terms without including stock markets (BRSA, 2011).

Asset sizes of the main financial services sub-sectors in Turkey as they stood during the period of 2002-2012 are illustrated at Table 1.

Table 1. Asset size of the banking and finance sector in Turkey (2002-2012)

Billion TL	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Deviation (%) in 2011-2012
Banks	212.7	249.7	306.4	406.9	499.7	581.6	732.5	834	1,006	1,217	1,371	12.4
Financial leasing	3.8	5	6.7	6.1	10	13.7	17.1	14.6	15.7	18.6	20.9	15.3
Factoring	2.1	2.9	4.1	5.3	6.3	7.4	7.8	10.4	14.5	15.7	18.1	32.6
Consumer financing	0.5	0.8	1.5	2.5	3.4	3.9	4.7	4.5	6.0	8.9	11.8	27.8
Insurance	5.4	7.5	9.8	14.4	17.4	22.1	26.5	31.8	35.1	39.9	51.0	12.7

Source: BRSA (2009, 2011, 2012).

As we analyze 2002-2012 period, assets size of Turkish banking sector has increased substantially by 1,158.3 billion TL and reached to 1,371 billion TL. Although, non-banking financial sector has grown in number and size in Turkey, however banks still dominates the sector. Asset size of Turkish banks has grown 12.4% during 2011-2012. Set alongside banks, the Turkish finance sector largely comprises financial leasing, factoring and consumer financing and insurance companies. Non-banking financial institutions such as factoring, leasing, consumer financing companies are the intermediary institutions which also operate within the banking and finance sector and have demonstrated 12%-32.6% growth in 2011-2012 period (BRSA 2009, 2011, 2012).

On the other side, profitability of the Turkish banking sector varied since 2000 due to the changes in profits and growth of assets of the banks. During the financial crisis in the global market, the Turkish banking sector succeeded to maintain the return on assets ratio in the period of 2008-2011 (TBB, 2011).

The banking sector provides strong capital structure which contributes to the maintenance of the economic growth at a sustainable level since the Capital Adequacy Ratio (CAR) of banks have been

properly regulated. Moreover, the CAR of the Turkish banks tends to decrease since 2003 since the assets increases relatively high.

CAR was 30.9% as of 2003, whereas *CAR* for banking sector declined until 2008 to the level of 18%. Global financial crisis affected the *CAR* so that the ratio achieved to 20.6% within 2008-2009. In addition, it was diminished to 16.5% in period 2010-2011. At present, *CAR* of the Turkish banking sector is regulated above 12% which is in threshold limits of Basel-III (Treasury, 2013).

2. Literature review

2.1. Efficiency analysis in brief. Farrell (1957) performed one of the earliest productive efficiency studies regarding the efficiency measurement for the homogeneous DMUs. However, Farrell (1957) comprehended the efficiency measurement within two perspectives such as technical and allocative basis and determined the efficiencies under the framework of one output and multiple inputs.

DMU term was first used in the CCR model which has been introduced by Charnes et al. (1978). However, Charnes, Cooper and Rhodes extended Farrell's approach and first time introduced DEA technique as a benchmark mathematical programing model into a new *era* for the efficiency analysis.

DEA has significant advantage in having multiple output structure for the efficiency analysis. DEA would be referred as a *non*-parametric, *data-oriented* and a linear programing based technique which has been used to make a comparison within the *technical efficiency* of relatively homogeneous sets of DMUs.

Parametric and non-parametric approaches are the well-known quantitative techniques which can be included in the *Efficient Frontier Approach*. In further, there are some popular parametric efficiency measurement techniques such as Stochastic Frontier Approach (SFA), Distribution Free Approach (DFA) and Thick Frontier Approach (TFA). On the other side, Free Disposal Hull (FDH) and Data Envelopment Analysis (DEA) are appeared in the *non*-parametric techniques.

Murthi et al. (1997) affirms major advantages of the DEA technique in financial efficiency as given below:

- The DEA method is a non-parametric analysis technique that does not require theoretical models (CAPM/APT) as measurement benchmarks.
- DEA is able to address the problem of the endogeneity of transaction costs by taking into consideration transaction costs such as expense ratio, turnover etc.
- The DEA model is flexible and may evaluate performance on a number of outputs and inputs simultaneously.
- The DEA method ensures the possibility of observing the marginal contribution of each input and how it affects outputs.

An efficiency score of particular DEA would be defined as the ratio between a weighted sum of outputs and a weighted sum of inputs. However, the objective function of DEA for "n" DMUs consuming "k" inputs and producing "m" outputs is given below in equation (1):

$$\text{Max } u'y_i / v'x_i, \quad (1)$$

where, u' is output weight vector ($m \times 1$), y_i is amount of output produced by DMU i, v' is input weight vector ($k \times 1$), x_i is amount of input utilized by DMU i.

The efficiency score varies through "0" and "1" for input-oriented model, while output-oriented model efficiency score ranges between "1" to "∞". For both models, the DMUs having efficiency score as "1" are considered efficient.

Figure 1 illustrates the characteristics of both variable returns to scale (VRS) and constant returns to scale (CRS) assumptions with the DEA models and shows the envelopment surfaces of the efficiency models (Coopers et al., 2006).

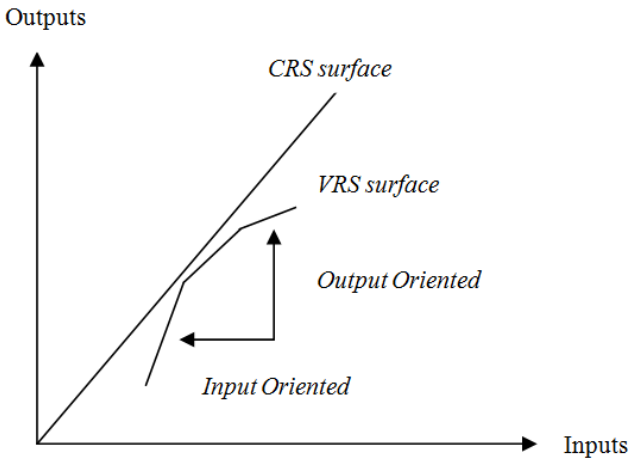

Fig. 1. Envelopment surface in DEA analysis and its orientation for the DMUs

The models assuming CRS in the envelopment surface may have an increase in the inputs which result in a proportional increase in the outputs. Efficiency results of DEA would give efficient and inefficient DMUs according to CRS and VRS assumptions. However, these results would also reveal slack inefficiency levels for the inefficient observations.

2.2. Technical efficiency models. There are two basic DEA models on the basis of orientation. The output-oriented model assumes the capacity of a DMU to reach the maximum production level (output) under available inputs. The input-oriented model refers the ability to produce same capacity of production with the minimum input level (Cooper et al., 2000; Cooper et al., 2006).

Technical efficiency (TE) scores of DMUs are measured by CCR model which was introduced by Charnes et al. (1978). The technical efficiency model depends upon CRS assumption (Fandel, 2003). However, CRS assumes a proportional relationship between the increases in the inputs and outputs. Fandel (2003) states that a particular DMU would demonstrate technical efficiency if *TE* equals to "1" according to CCR model approach. On the other side, if technical efficiency $TE < 1$ then, it reveals to what extend a DMU should minimize inputs for producing its level outputs as efficient as technically efficient DMUs.

2.2.1. Input-oriented CCR model. An input-oriented model postulates the ability to maintain the same capacity of production using a minimum of inputs. Cooper et al. (2000) and Cooper et al. (2006) introduce the input-oriented CCR model which is defined as in the formulation given below:

$$(LP_0)\text{Max } uy_i, \tag{2}$$

s.t.

$$vx_i = 1, \tag{3}$$

$$u'y_i - v'x_i \le 0, \quad (i = 1,..., n) \tag{4}$$

$$u \ge 0, \quad v \ge 0,$$

where, u' is output weight vector ($m \times 1$), y_i is amount of output produced by DMU i, v' is input weight vector ($k \times 1$), x_i is amount of input utilized by DMU i, u is output weights, v is input weights.

In order to analyze *TE* scores for DMUs, input-oriented model has "n" optimizations, and all individual DMU would choose input and output weights that maximize *TE* scores.

2.2.2. Output-oriented CCR model. Cooper et al. (2000) and Cooper et al. (2006) also introduce the optimal efficiencies of the DMUs which would be analyzed by output-oriented CCR model as given in the formulations below.

The output-oriented models ensure to the capacity of a DMU to achieve the maximum level of production (output) with the available inputs. Besides, an *output-oriented* CCR model is focused to maximize output variables whereas the model restricts the input utilization to a specified level. Dual form of *output-oriented* maximization model can be formulated as the following (Cooper et al, 2000; Cooper et al. 2006):

$$(DLP_0)\text{Max}_{\eta,\mu}\ \eta, \tag{5}$$

s.t.

$$x_i - X\mu \ge 0, \quad (i = 1,..., n), \tag{6}$$

$$\eta y_i - Y\mu \le 0, \tag{7}$$

$$\mu \ge 0, \tag{8}$$

where, η is output enlargement rate, y_i is the amount of output produced by DMU i, x_i is the amount of input utilized by DMU i, μ: $n \times 1$ sized vector, Y: $n \times s$ sized output matrice, X: $n \times m$ sized input matrice.

As seen in the above model, optimal efficiency would be calculated as η^* which defines the optimal output enlargement rate and this ratio also satisfies $\eta^* \ge 1$. In order to compare the input-oriented CCR scores with output-oriented efficiency results, Cooper et al. (2006) defined the η^* value. This value can be calculated by inversing this enlargement rate into input reduction rate $\theta = 1/\eta^*$ and satisfies $\theta \le 1$ and this new term is called as output-oriented CCR score.

As per to constant returns to scale assumption, CCR model can measure the technical efficiency *(TE)* levels of the DMUs. Under the framework of the above efficiency models, Cooper et.al. (2006) affirms that an *input-oriented* CCR model would be efficient for a particular DMU if and only if it is also found as efficient when the *output-oriented* CCR model has used in order to calculate its performance.

3. Empirical findings

3.1. Data and methodology. Technical financial efficiencies were analyzed for Turkish banking sector in 2012-2013 period. Data set regarding 30 commercial banks and 13 development and investment banks were provided by Banking Regulation and Supervision Agency of Turkey (BRSA). The financial efficiency analysis has been carried out both for operating and intermediation approaches which are mentioned in the following sections. On the other side, bank performance

indicators (*net interest income, non-interest income, ROA and ROE*) have also been evaluated for the said banks in the period of 2012-2013.

3.2. Financial efficiency analyses for the Turkish banks. *3.2.1. Operating approach.* Under the operating approach, the cost efficiency of the Turkish banks has been measured by the following input and outputs given in Table 2. In the operating approach, the objective function is established in order to minimize the input consumption in providing the banking services such as services for customers and fee requiring products.

In other words, the main obligation of the banks is to give service with a minimum cost to their customers. Accordingly, the *input-oriented* DEA model which is given in equations (2), (3) and (4) has been used for the technical efficiency analysis of operating approach.

Table 2. Input and output variables used in the efficiency analysis for operating approach

Decision variable	Definition
Input 1	Total personel expenses (TL)
Input 2	Interest expenses (TL)
Input 3	Administrative costs (TL)
Input 4	Non-Interest expenses (TL)
Input 5	Number of employees
Output 1	Total loans (TL)
Output 2	Total deposits (TL)

As seen in Table 2, total operating expenses, administrative costs and labor are the input variables whereas total loans and total deposits have selected as output variables. According to the operating approach, demand of the customers should be provided under minimum costs. Input-oriented DEA analysis can lead financial decision makers to measure whether the DMUs are operating under cost efficiency or not.

3.2.2. Intermediation approach. One of the other objective of the banks which can be defined with intermediation approach aims at analyzing the capacity of the banks in collecting the funds under some particular intermediation costs due to fixed assets, interest and *non-interest* expenditures and provide loans to the customers by earning interest and *non-interest* revenues. Intermediation approach aims to analyze efficiency of the banks which consume capital and labor in order to produce loans and revenues.

As per to the intermediation approach, the fund raising efficiency of the Turkish banks under the referred intermediation costs has been measured by the following input and outputs given in Table 3.

Table 3. Input and output variables used in the efficiency analysis for intermediation approach

Decision variable	Definition
Input 1	Fixed assets (TL)
Input 2	Total deposits (TL)
Input 3	Interest expenses (TL)
Input 4	Non-interest expenses (TL)
Output 1	Total loans (TL)
Output 2	Interest revenue (TL)
Output 3	Non-interest revenue (TL)

As illustrated in Table 3, the costs covered by the banks for the intermediation function which are originated from fixed assets, total deposits, interest and *non-interest* expenditures have selected as the inputs. In intermediation approach, financial sustainability of the banks has been measured by *output-oriented* DEA model which is mentioned in equations (5), (6), (7) and (8).

In this respect, technical financial efficiency analyses have been carried out for the Turkish commercial and development and investment banks in 2012-2013 period. Thus, cost efficiency of the banks has been analyzed with operating approach whereas financial sustainability of the banks has been analyzed with intermediation approaches.

3.2.3. Technical efficiency results for commercial banks. Technical efficiencies of the Turkish commercial banks have been measured by *input-oriented* DEA model (CCR-I) and *output-oriented* DEA model (CCR-O). The efficiency scores regarding the commercial banks for 2012 and 2013 are illustrated in Table 4.

Table 4. Technical efficiency results for Turkish commercial banks in 2012-2013

Commercial banks	Operating approach		Intermediation approach	
	2012	2013	2012	2013
T.C. Ziraat Bank (TCZB)	0.907	0.881	1	1
Turkish Halk Bank	1	0.899	1	1
Turkish Vakiflar Bank	0.990	0.845	0.955	1
Turkish Economy Bank (TEB)	0.646	0.726	0.929	0.838
Akbank	1	0.904	1	1
Sekerbank	0.569	0.694	0.828	0.870
Turkish Garanti Bank	1	0.823	0.931	0.971

Table 4 (cont.). Technical efficiency results for Turkish commercial banks in 2012-2013

Commercial banks	Operating approach		Intermediation approach	
	2012	2013	2012	2013
Turkish Is Bank	0.847	0.803	0.935	0.949
Yapi Kredi Bank	0.948	0.853	0.978	1
Turkish Bank	0.363	0.733	0.768	0.725
Fibabanka	1	0.881	1	1
Tekstil Bank	0.856	0.753	0.936	1
Anadolu Bank	0.638	0.745	0.998	0.989
Arab Turk Bank	0.584	1	1	1
Citibank	0.347	0.924	1	0.969
ING Bank	0.717	0.824	0.911	0.884
Turkland Bank	0.774	0.741	1	1
Finansbank	0.687	0.669	1	0.942
Deutsche Bank	0.679	1	1	1
HSBC Bank	0.511	0.728	0.853	0.831
Altertatif Bank	0.816	0.665	0.912	1
Burgan Bank	0.615	0.692	0.741	0.925
Denizbank	0.606	0.755	0.906	0.824
Odea Bank	1	1	1	1
The Royal Bank of Scotland PLC.	0.762	0.858	1	1
Bank Mellat	0.154	1	1	1
Habib Bank Ltd.	0.492	1	1	1
JP Morgan Chase Bank National Association	0.092	0.004	1	1
Portigon A.G.	0.137	N.A.	1	N.A.
Societe Generale S.A.	0.298	0.169	1	1
Average	0.668	0.778	0.953	0.956

As shown in Table 4, technical efficiency analyses have shown that 5 banks are efficient both in 2012 and 2013 in operating approach. In further, 25 banks are found inefficient and the average technical efficiency score for the commercial banks is 0.668 and 0.778 for 2012-2013 in operating approach.

On basis of intermediation approach, 16 banks have shown full technical efficiency in 2012 whereas 17 banks have been found fully efficient in 2013. Besides, 14 banks are inefficient in 2012 and 13 banks have demonstrated technical inefficiency in 2013. Average efficiency scores for the intermediation approach are higher than operating approach which correspond 0.953 and 0.956 for 2012-2013, respectively.

3.2.4. Technical efficiency results for development and investment banks. The financial efficiencies of the development and investment banks operating under Turkish banking sector have been analyzed with both CCR-I and CCR-O models. The technical efficiency scores regarding the development and investment banks for 2012 and 2013 are illustrated in Table 5.

Table 5. Technical efficiency results for Turkish development and investment banks in 2012-2013

Development & investment banks	Operating approach		Intermediation approach	
	2012	2013	2012	2013
Turkish İller Bank	1	1	1	1
Turkish Eximbank	1	1	1	1
Turkish Development Bank	0.576	0.587	0.608	0.682
Turkish Industrial Development Bank (TSKB)	1	0.793	1	1
Istanbul Settlement and Custody Bank Inc.(Takasbank)	0.069	0.081	1	1
Diler Investment Bank	1	1	1	1
GSD Investment Bank	0.424	0.549	1	1
Nurol Investment Bank	0.291	0.160	0.591	0.513
Aktif Investment Bank	0.381	0.188	0.798	0.541
Bankpozitif Credit and Development Bank	0.459	0.287	0.737	0.593
Merrill Lynch Investment Bank	0.036	0.020	1	1
TAIB Investment Bank	0.008	0.237	1	0.258
Standard Chartered Investment Bank Turk	0.001	1	1	1
Average	0.481	0.531	0.903	0.814

As given in Table 5, technical financial efficiency results have revealed that 4 banks are fully efficient both in 2012 and 2013 in operating approach. Besides, 9 banks are found inefficient and the average technical efficiency score for the development and investment banks is 0.481 and 0.531 for 2012-2013 in operating approach.

According to the technical efficiency results for the intermediation approach, 9 banks have shown full efficiency in 2012 and 8 banks have been found fully efficient in 2013. On the other side, 4 banks are inefficient in 2012 and 5 banks have demonstrated technical inefficiency in 2013. Average efficiency scores for the intermediation approach is significantly higher than operating approach which corresponds to 0.903 and 0.814 for 2012-2013.

In this framework, Turkish commercial and development and investment banks have better technical financial efficiencies for intermediation approach when compared to operating approach in the period of 2012-2013. Besides, technical financial efficiency scores of the commercial banks are found higher than development and investment banks in the aforementioned period.

3.2.5. Results for the improvement ratios. The improvement ratios of the commercial and development and investment banks for CCR-I model can be seen in Table 6 and Table 7 which summarize the results for 2012-2013 period.

Table 6. Improvement ratios of the operating approach for the commercial and development and investment banks for 2012-2013

Improvement ratios	Operating approach			
	Commercial banks		Development & investment banks	
	2012	2013	2012	2013
Total personel expenses	-0.424	-0.308	-0.542	-0.514
Interest expenses	-0.434	-0.222	-0.540	-0.487
Administrative costs	-0.425	-0.323	-0.569	-0.528
Non-interest expenses	-0.401	-0.320	-0.531	-0.505
Number of employees	-0.358	-0.376	-0.556	-0.498
Total loans	0.383	0.028	0.000	0.000
Total deposits	0.635	0.374	-	-

Table 6 summarizes the average improvement ratios for Turkish commercial and development and investment banks under operating approach. According to the 2012 improvement results, inputs for CCR-I model should be decreased 35.8%-43.4% for commercial banks and 53.1%-56.9% for development and investment banks whereas as per to the 2013 results inputs should be diminished by 22.2%-37.6% range in commercial banks and 49.8%-52.8% for development and investment banks.

Besides, 2012 results also have shown that output of the CCR-I model should be increased by 38.3%-63.5% in 2012 and 2.8%-37.4% range in 2013 for the commercial banks. However, CCR-I model does not propose an improvement in the outputs for the development and investment banks in 2012-2013 period. Table 7 illustrates the improvement ratios of the commercial and development and investment banks for CCR-O model.

Table 7. Improvement ratios of the intermediation approach for the commercial and development and investment banks for 2012-2013

Improvement ratios	Operating approach			
	Commercial banks		Development & investment banks	
	2012	2013	2012	2013
Fixed assets	-0.056	-0.048	-0.051	-0.126
Total deposits	-0.030	-0.033	-	-
Interest expenses	-0.022	-0.035	-0.041	-0.049
Non-interest expenses	0.000	-0.002	0.000	-0.049
Total loans	0.056	0.075	0.307	0.748
Interest revenue	0.066	0.068	0.180	0.696
Non-interest revenue	0.078	0.117	0.224	0.522

As per to the 2012 results, inputs for CCR-O model should be decreased 3%-5.6% for commercial banks and 4.1%-5.1% for development and investment banks while the inputs of the 2013 results should be decreased by 0.2%-4.8% range in commercial banks and 4.9%-12.6% for development and investment banks.

In further, as we analyze the improvement ratios of the Turkish banks in the intermediation approach, results for the improvement ratios have shown that CCR-O model should have an output increase in 6.6%-7.8% and 6.8%-11.7% for commercial banks in 2012-2013 and 18%-22.4% and 52.2%-69.6% for development and investment banks in 2012-2013.

Technical financial efficiency results of the Turkish commercial and development and investment banks are illustrated in Figure 2.

As we summarize the technical efficiency results for the Turkish banking sector in Figure 2, it is obvious that intermediation approach results have demonstrated significantly higher efficiencies than operating approach results for both commercial and development and investment banks in 2012-2013 period. On the other side, commercial banks have relatively higher technical efficiency scores than development and investment banks.

In this respect, we may conclude that Turkish commercial and development and investment banks have shown better financial efficiency in terms of *economic viability* which was measured by the intermediation approach. In other words, afore-mentioned Turkish banks have indicated a considerable amount of success in transforming their own deposits into total loans and revenues.

Besides, the said Turkish banks are found *cost efficient* in terms of operating approach however the technical financial efficiency scores for this approach is relatively smaller than the results for the intermediation approach. In this regard, there is clear evidence that the mentioned Turkish banks are more successful in economic sustainability rather than cost efficiency in the related term.

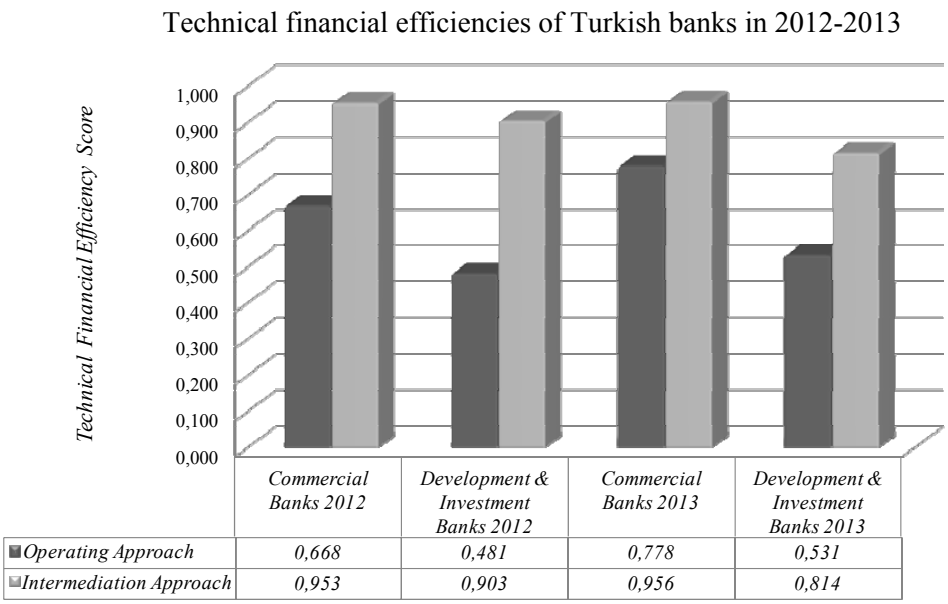

Fig. 2. Technical financial efficiencies of Turkish banks in 2012-2013 under operating and intermediation approaches

3.3. Evaluating the bank performance indicators for Turkish banks. Apart from the financial technical efficiency analyses which were presented in the previous section, bank performance analyses have also been carried out for the Turkish commercial and development & investment banks for the period of 2012 and 2013. In this regard, net interest income, non-interest income, return on assets (ROA) and return on equity (ROE) have been selected as bank performance indicators and then calculated for the aforementioned period via using the banking sector data provided by Banking Regulation and Supervision Agency of Turkey for 2012-2013.

Peterson and Schoeman (2008) affirm that *ROA* and *ROE* are two major measures of the bank profitability. *ROA* and *ROE* indicators may give valuable information about the profit generation of a particular bank so that these measures can lead the financial managers to determine and evaluate the performance levels of the banks.

3.3.1. Net interest income and non-interest income indicators of the Turkish banks. Table 8 and Table 9 indicate the performance levels of the Turkish banks on the basis of net interest income and non-interest income indicators for the period of 2012-2013.

As illustrated in Table 8, commercial banks have generally demonstrated better *net interest* income performances in 2012. However, commercial banks have shown a decrease in *non-interest* income performances in 2013.

According to Table 9, development and investment banks have demonstrated a slight decrease in terms of net interest income figure in 2013 in comparison to 2012. Besides, these banks have shown better non-interest income performances in 2013 rather than 2012.

Table 8. Net interest income and non-interest income figures for Turkish commercial banks in 2012-2013

Commercial banks	Net interest income		Non-interest income	
	2012	2013	2012	2013
T.C. Ziraat Bank (TCZB)	8.81%	6.69%	1.18%	1.45%
Turkish Halk Bank	8.09%	6.35%	1.49%	1.68%
Turkish Vakiflar Bank	8.35%	6.80%	1.33%	1.30%
Turkish Economy Bank (TEB)	8.89%	7.37%	3.11%	2.55%
Akbank	7.18%	6.15%	1.68%	1.62%
Sekerbank	11.42%	8.09%	3.38%	2.60%
Turkish Garanti Bank	7.79%	6.33%	1.87%	1.99%
Turkish Is Bank	7.53%	6.31%	2.06%	1.80%
Yapi Kredi Bank	7.45%	5.98%	2.42%	3.05%
Turkish Bank	12.02%	4.94%	1.90%	0.86%
Fibabanka	8.13%	6.51%	0.84%	0.83%

Table 8 (cont.). Net interest income and non-interest income figures for Turkish commercial banks in 2012-2013

Commercial banks	Net interest income		Non-interest income	
	2012	2013	2012	2013
Tekstil Bank	9.14%	7.53%	1.15%	2.42%
Anadolu Bank	11.37%	7.87%	1.86%	1.61%
Arab Turk Bank	4.32%	3.09%	1.65%	1.42%
Citibank	9.75%	8.36%	4.12%	4.48%
ING Bank	9.26%	6.81%	2.41%	1.68%
Turkland Bank	8.78%	6.71%	1.21%	1.28%
Finansbank	9.35%	7.82%	3.77%	3.50%
Deutsche Bank	23.24%	6.73%	4.76%	3.58%
HSBC Bank	9.69%	6.21%	2.47%	1.96%
Altertatif Bank	10.13%	6.95%	2.72%	2.38%
Burgan Bank	10.85%	5.86%	1.79%	2.39%
Denizbank	9.14%	7.50%	3.15%	2.62%
Odea Bank	1.21%	4.12%	0.15%	0.16%
The Royal Bank of Scotland PLC.	17.69%	6.29%	6.38%	2.33%
Bank Mellat	18.46%	4.24%	3.07%	0.74%
Habib Bank Ltd.	7.82%	5.33%	1.01%	0.96%
JP Morgan Chase Bank National Association	31.40%	12.55%	3.07%	2.37%
Portigon A.G.	10.00%	N.A.	4.82%	N.A.
Societe Generale S.A.	16.31%	4.63%	7.50%	7.53%
Average	10.79%	6.52%	3.44%	2.54%

Notes: * Author's calculations. ** Net interest and non-interest income figures have been calculated as percentage of total assets.

Table 9. Net interest income and non-interest income figures for Turkish development and investment banks in 2012-2013

Development & investment banks	Net interest income		Non-interest income	
	2012	2013	2012	2013
Turkish İller Bank	5.12%	4.66%	0.61%	1.24%
Turkish Eximbank	3.71%	2.43%	0.60%	0.37%
Turkish Development Bank	5.78%	4.07%	0.94%	0.51%
Turkish Industrial Development Bank (TSKB)	5.27%	4.49%	1.04%	0.83%
Istanbul Settlement and Custody Bank Inc.(Takasbank)	2.43%	2.20%	1.57%	1.26%
Diler Investment Bank	9.20%	6.45%	0.49%	0.70%
GSD Investment Bank	15.06%	9.26%	2.11%	3.80%
Nurol Investment Bank	7.74%	7.27%	2.26%	1.49%
Aktif Investment Bank	9.53%	10.12%	2.60%	2.50%
Bankpozitif Credit and Development Bank	8.26%	6.29%	0.93%	1.36%
Merrill Lynch Investment Bank	6.22%	15.58%	1.95%	9.83%
TAIB Investment Bank	3.55%	2.62%	13.59%	0.56%
Standard Chartered Investment Bank Turk	6.54%	4.28%	7.30%	20.29%
Average	6.80%	6.13%	2.77%	3.44%

Notes: * Author's calculations. ** Net interest and non-interest income figures have been calculated as percentage of total assets.

3.3.2. ROA and ROE performance indicators for the Turkish banks. Performance levels of Turkish commercial and development & investment banks have been calculated in terms of *ROA* and *ROE* indicators for the period of 2012-2013 and illustrated in Table 10 and Table 11.

As seen in Table 10, both the calculated *ROA* and *ROE* performance indicators of the Turkish commercial banks have generally demonstrated a certain decrease in 2013 in comparison to the results for the same indicators in 2012.

As illustrated in Table 11, Turkish development & investment banks have shown a slight decrease in *ROA* figure in average for 2013. On the other side, these banks have demonstrated a significant decrease in *ROE* performance figures in 2013.

Table 10. ROA and ROE figures for Turkish commercial banks in 2012-2013

Commercial banks	*ROA*		*ROE*	
	2012	2013	2012	2013
T.C. Ziraat Bank (TCZB)	1.63%	1.60%	15.44%	18.13%
Turkish Halk Bank	2.38%	1.96%	21.06%	19.45%
Turkish Vakiflar Bank	1.39%	1.17%	12.25%	12.57%
Turkish Economy Bank (TEB)	1.12%	1.00%	10.11%	10.12%
Akbank	1.89%	1.60%	13.46%	13.79%
Sekerbank	1.65%	1.12%	13.17%	10.23%
Turkish Garanti Bank	1.92%	1.53%	14.41%	13.31%
Turkish Is Bank	1.88%	1.50%	14.57%	13.42%
Yapi Kredi Bank	1.57%	2.15%	11.35%	18.50%
Turkish Bank	0.16%	0.00%	0.93%	0.03%
Fibabanka	1.17%	0.66%	11.95%	8.81%
Tekstil Bank	0.73%	1.14%	4.68%	7.30%
Anadolu Bank	2.63%	1.23%	14.32%	8.76%
Arab Turk Bank	2.14%	1.48%	14.22%	10.73%
Citibank	1.20%	1.40%	8.69%	8.28%
ING Bank	1.00%	0.52%	8.19%	5.16%
Turkland Bank	0.43%	0.35%	3.47%	2.67%
Finansbank	1.66%	1.11%	12.32%	9.60%
Deutsche Bank	8.03%	0.09%	20.22%	0.49%
HSBC Bank	0.71%	0.08%	5.93%	0.99%
Altertatif Bank	0.85%	0.73%	11.98%	12.82%
Burgan Bank	-0.03%	-0.60%	-0.19%	-6.99%
Denizbank	1.83%	0.76%	16.16%	9.24%
Odea Bank	-0.54%	-0.85%	-3.81%	-10.29%
The Royal Bank of Scotland PLC.	4.09%	1.34%	9.29%	7.62%
Bank Mellat	6.20%	2.07%	13.90%	3.67%
Habib Bank Ltd.	2.42%	2.73%	4.03%	5.38%
JP Morgan Chase Bank National Association	11.26%	7.88%	17.29%	8.52%
Portigon A.G.	0.66%	N.A.	1.05%	N.A.
Societe Generale S.A.	1.26%	0.49%	6.63%	5.16%
Average	2.11%	1.25%	10.23%	7.84%

Notes: * Author's calculations. ** *ROA* indicator has been calculated as percentage of "net profit after taxes / total assets". *** *ROE* indicator has been calculated as percentage of "net profit after taxes / equity capital".

Table 11. ROA and ROE figures for Turkish development and investment banks in 2012-2013

Development & investment banks	*ROA*		*ROE*	
	2012	2013	2012	2013
Turkish İller Bank	2.31%	2.22%	3.13%	3.21%
Turkish Eximbank	1.43%	0.99%	6.02%	6.30%
Turkish Development Bank	1.52%	1.03%	7.56%	6.06%
Turkish Industrial Development Bank *(TSKB)*	2.99%	2.53%	17.50%	17.30%
Istanbul Settlement and Custody Bank Inc. (Takasbank)	1.50%	1.46%	16.64%	13.86%
Diler Investment Bank	2.94%	3.83%	3.63%	5.35%
GSD Investment Bank	5.44%	3.83%	7.58%	5.88%
Nurol Investment Bank	1.31%	-0.27%	3.11%	-1.47%
Aktif Investment Bank	2.34%	1.86%	19.65%	12.01%
Bankpozitif Credit and Development Bank	1.28%	1.03%	4.74%	4.70%
Merrill Lynch Investment Bank	1.90%	0.68%	35.37%	2.30%
TAIB Investment Bank	-7.66%	-18.14%	-9.05%	-18.66%
Standard Chartered Investment Bank Turk	-6.54%	3.35%	-7.19%	3.79%
Average	0.83%	0.34%	8.36%	4.66%

Notes: * Author's calculations. ** *ROA* indicator has been calculated as percentage of "net profit after taxes / total assets". *** *ROE* indicator has been calculated as percentage of "net profit after taxes / equity capital".

Conclusion

Measuring the financial efficiencies of the banks has played a significant role in quantitative finance literature. Turkish banking and finance sector is a promising emerging market within the global economy. In particular, asset size of the Turkish banking sector has achieved TL 1,732 billion as of December 2013 whereas total loans correspond to TL 1,047 billion and the profit of the sector TL 24,732 million with capital adequacy standard ratio as 15.3%.

In this respect, this empirical study covers the technical financial efficiency analyses of Turkish banks via DEA technique, a non-parametric and deterministic mathematical programing methodology for determining the efficient frontier which depends upon the selected input and output variables of the DMUs. Besides, fundamental bank performance indicators (*net interest income, non-interest income, ROA and ROE*) have also been analyzed for the Turkish banks in the related term.

Technical efficiency studies have carried out on the basis of operating and intermediation approaches for Turkish commercial, and development and investment banks for 2012-2013 data. However, empirical studies have revealed notable efficiency results for these banks. The empirical results revealed that Turkish banks demonstrated better financial efficiencies in terms of intermediation approach which corresponds to the *economic viability* perspective.

As there has been made structural reforms in Turkish banking sector in 2000, these reforms lead the Turkish banks indicate significant financial efficiencies in 2012-2013 period so that the *sustainability* of the sector has reached to reasonable level.

Surprisingly, the aforementioned Turkish banks have lower technical financial efficiencies in terms of operating approach. It is assumed the cost efficiency of the Turkish banks have slightly lower than the intermediation results. However, Turkish banks should also increase their technical efficiency scores in operating approach.

On the other side, commercial banks have demonstrated better technical financial efficiencies rather than development and investment banks which correspond to the development and investment banking *sub-sector* should increase the market capitalization within whole banking sector in the following years. This may depend on the progress in the real sector for the aforesaid period.

In addition, Turkish banks also require improvements in the input and output variables which have been analyzed in the empirical study. Particularly, development and investment banks require more improvement in intermediation approach whereas commercial banks need considerable amount of input and output improvement in operating approach.

Consequently, both financial efficiency analyses and selected bank performance indicators have revealed that Turkish banks have demonstrated significant financial technical efficiencies and bank performances for 2012-2013. In this regard, it can be concluded that Turkish banks should manage the financial inefficiencies and improve their input and output variables to the desired thresholds, in order to operate and intermediate under global market conditions.

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