EFFECTS OF DISINFLATION ON BANKS IN TERMS OF PROFITABILITY: A NONPARAMETRIC STUDY ON TURKISH COMMERCIAL BANKS

(KÂRLILIK AÇISINDAN DEZENFLASYONUN BANKALAR ÜZERİNDEKİ ETKİLERİ: TÜRK TİCARİ BANKALARI İÇİN PARAMETRİK OLMAYAN BİR ÇALIŞMA)

by

Eren AYAZ, B.S.

Thesis

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

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in
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Banking sector is one of the main elements in the economic life of Turkey. It may drive huge developments for the country if managed well. In addition, it may also cause dire consequences if managed badly. Therefore, the regulations, monitoring institutions and the top managements' strategies have huge impacts on thousands of sector employees and moreover on the economy. In order to apply better strategies, bank managers can benefit from the studies in the literature. This paper has a look from a different perspective on the banking sector and its correlation with inflation.

I would like to thank Asst. Prof. Emre Alptekin for his valuable support during my study. In addition, I am thankful to my colleagues at Peppers and Rogers Group for their assistance during projects that we employed in the banking sector. Also I would like to thank Mr Anıl Akman who helped me gain significant banking consultancy experience at Fortis Bank and Yapı Kredi Bank.

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Eren AYAZ
September, 2010

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LIST OF SYMBOLS

DEA	: Data Envelopment Analysis
DMU	: Decision Making Unit
DEA-CCR	: Data Envelopment Analysis developed by Charnes, Cooper and Rhodes
SBM	: Slacks Based Measure
CRS	: Constant Returns to Scale
VRS	: Variable Returns to Scale
RTS	: Returns to Scale
DEA-BCC	: Data Envelopment Analysis developed by Banker, Charnes and Cooper
NIRS	: Non-Increasing Returns to Scale
DRS	: Decreasing Returns to Scale
NDRS	: Non-Decreasing Returns to Scale
NDI	: Non-Discretionary Inputs
IRS	: Increasing Returns to Scale
PKM	: Pareto – Koopmans Model
TE	: Technical Efficiency
PTE	: Pure Technical Efficiency
SE	: Scale Efficiency
AP	: Andersen and Petersen model
MPI	: Malmquist Productivity Index
FS	: Frontier Shift
TEC	: Technical Efficiency Change
SFA	: Stochastic Frontier Analysis
FX	: Foreign Exchange
CPI	: Consumer Price Index
BAT	: Turkish Banking Association
ROE	: Return on Equity
ROA	: Return on Assets

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ABSTRACT

There exist some Data Envelopment Analysis (DEA) studies on the Turkish banking system in the literature. They mostly evaluate the effects of economic crises on the whole banking industry. However, none of them directly inquire the differences between the high inflation period and the low inflation period. Since inflation dropped drastically after the 2001 liquidity crisis, Turkish banking sector is a very prominent setting to observe whether high inflation or disinflation period is more profitable for commercial banks. Between 1998 and 2003 inflation was high and Turkish banks worked with low loan ratios and they mostly fed government deficits via government bonds. On the contrary, as the inflation dropped, the Turkish banks increased their total loans per total assets ratios. Based on the information above, should the Turkish banking sector be more profitable with higher rates of inflation?

In this study, we aim to investigate which period is more profitable for commercial banks. For this purpose, we employ Slacks Based Measure of DEA and Malmquist Productivity Index to compare the two periods (1998-2003 and 2004-2008). In addition, we evaluate banks' efficiencies with respect to correlations with bank size, ROA, ROE, age of bank, ownership, loan ratio, capital adequacy ratio, etc. and we come up with policy recommendations depending on the correlations.

Keywords: banking sector, profitability, Data Envelopment Analysis, Slacks Based Measure, Malmquist Productivity Index

RESUME

Dans la littérature, il existe des travaux étudiant le système bancaire turc en utilisant l'Analyse d'Enveloppement des Données (DEA). Ces travaux évaluent en majorité les effets des crises économiques sur le secteur bancaire. Cependant, aucune des études réalisées auparavant n'interroge les différences entre la période d'inflation haute et la période d'inflation basse. A la suite de la crise de liquidité en 2001, l'inflation à baissée d'une façon rigide, pour cette raison, l'économie de Turquie peut être utilisée comme une très bonne source pour évaluer parmi l'inflation haute ou l'inflation basse laquelle a produit un milieu plus convenable au regard de la rentabilité des banques. Entre les années 1998-2003, lorsque l'inflation était basse la plupart des banques commerciales en Turquie en achetant des obligations et bons, préféraient les déficits de budget et de financement de l'état, avec ce choix elles tenaient faible les volumes des autres crédits. Par contre, avec la baisse de l'inflation les banques ont augmenté la proportion de leurs crédits totaux par rapport à leurs actifs totaux. A la lumières de ces informations, les banques turques ont-elles travaillé plus rentablement lors de la période d'inflation haute?

L'objectif de ce travail est d'examiner lequel des climats distinct, mentionné en haut, est plus rentable pour les banques. Pour cela, en utilisant le model SBM (Slacks Based Measure) de l'Analyse d'Enveloppement des Données (DEA) et l'Index de Productivité Malmquist, les périodes 1998-2003 et 2004-2008 ont été comparée. En supplément, le volume bancaire les corrélations avec les données comme les scores de rentabilité des banques, ROA, ROE, l'âge de la banque, la structure d'association, le volume de crédit, la proportion de suffisance de capital etc. ont été examiné et selon ces corrélations, certaines suggestions stratégiques sont faites aux banques.

Les mots clés: secteur bancaire, rentabilité, Analyse d'Enveloppement des Données, SBM, l'Index de Productivité Malmquist

ÖZET

Literatürde Veri Zarflama Analizi kullanılarak Türk bankacılık sisteminin incelendiği çalışmalar mevcuttur. Bu çalışmalar çoğunlukla ekonomik krizlerin bankacılık sektörü üzerindeki etkileri ile ilgilidir. Buna karşın, önceden yapılan çalışmaların hiçbiri enflasyonun yüksek olduğu zaman ile düşük olduğu zaman arasındaki farkları sorgulamamaktadır. 2001 yılındaki likidite krizinden sonraki dönemde enflasyonun sert bir biçimde düşmesi nedeniyle, yüksek enflasyon ile düşük enflasyondan hangisinin bankaların kârlılıkları açısından daha uygun bir ortam yarattığını değerlendirmek için Türkiye ekonomisi çok iyi bir kaynak olarak kullanılabilir. 1998-2003 yılları arasında, enflasyonun yüksek olduğu dönemde Türkiye'deki ticari bankalar çoğunlukla tahvil ve bono alarak devletin bütçe ve finansman açıklarını kapatmayı tercih ederek diğer kredi hacimlerini düşük tutmuşlardır. Diğer taraftan, enflasyonun düşmesiyle birlikte, bankalar toplam kredilerinin toplam aktiflerine oranını artırmışlardır. Buna karşılık, operasyonel faaliyetler ve şubeleşme daha büyük önem kazanmıştır. Bu bilgilerin ışığında, Türk bankaları enflasyonun yüksek olduğu dönemde daha kârlı mı çalışmışlardır?

Bu çalışmanın amacı bahsedilen iki farklı ortamdan hangisinin bankalar açısından daha kârlı olduğunun incelenmesidir. Bunun için Veri Zarflama Analizi'nin SBM modeli ve Malmquist Üretkenlik Endeksi kullanılarak 1998-2003 ve 2004-2008 dönemleri karşılaştırılmıştır. Buna ek olarak, bankaların kârlılık skorlarının banka büyüklüğü, ROA, ROE, bankanın yaşı, ortaklık yapısı, kredi hacmi, sermaye yeterlilik oranı, vb. verilerle olan korelasyonları incelenmiş ve bu korelasyonlara bağlı olarak bankalara bazı stratejik tavsiyelerde bulunulmuştur.

Anahtar kelimeler: bankacılık sektörü, kârlılık, Veri Zarflama Analizi, SBM, Malmquist Üretkenlik Endeksi

1 INTRODUCTION

There exist many debates on the issue of Turkish economy since it has been a highly fluctuating economy. Banks are the major elements of an economy and therefore Turkish banking system has also been a controversial subject like the Turkish economy. As a matter of fact, in the literature there are many studies that evaluate Turkish economy and Turkish banking sector through many aspects. In this study, inflation is handled as the main driver of the banking system. Thanks to the major changes that are experienced just after the liquidity crisis in 2001, banks are extremely affected by the disinflation period.

Before the 2001 crisis Turkey had experienced many crises for some decades. During these decades high inflation ruled the economy and this situation determined the working style of the Turkish banks. Due to huge governmental budget deficits, the state had been the most significant customer of the banks. Banks collected deposits through individual, SME and commercial banking and used these funds for purchasing government bonds. Loans per assets ratios were quite low in this high inflation period. On the other hand, government bonds per assets ratios were over fifty percent.

After the 2001 crisis, inflation was taken under control and this altered the working environment of the Turkish banks. The new trend was capturing more individual, SME and commercial customers. Banks have had to sell loans in order to have profit and to survive. Besides, risk rates of Turkish economy decreased and for this reason foreign banks began to enter the Turkish market. In this new era, banks had to market and sell more aggressively. Profit margins declined but loan volumes increased sharply. By this way, banks continued to keep their profitability again. However, it is a great source of debate whether the pre-crisis period or the post-crisis period is more profitable for the Turkish banks. According to our hypothesis, the banks should have used advantages of

low inflation between 2004 and 2008. Did the Turkish banks really experience higher rates of profitability in the lower inflation era? This will be tested throughout the paper and the findings will lead us to a conclusion about the question.

In order to reach the findings, Data Envelopment Analysis (DEA) will be employed in this study. There are several types of DEA and these will be handled in the 3rd part of the paper. Based on the data of 2008, banks' performances will be evaluated. For this purpose, several inputs (such as number of branches, number of employees, expenses, etc.) and several outputs (such as net profit, loans, revenues, etc.) will be used. The analyses will be based on different DEA approaches, meaning that several different input – output combinations will be used. After assessing one-year data, DEA will be used to observe multi-period changes with the Malmquist productivity index. By this way, effects of the inflation on the profitability of the banking system will be identified.

The structure of the study is as follows: Section 2 is about banking sector and DEA studies in the literature. Section 3 identifies the DEA and MPI methodologies in details. Section 4 is the application part in which the findings and comments will be introduced and finally section 5 is the conclusion part.

2 BANKING AND DEA STUDIES IN THE LITERATURE

There exist studies that evaluate the effects of significant developments such as deregulation, restructuring and privatization. These studies basically compare the dynamics and the characteristics of the banking sector before and after these developments. For instance, Burdisso et al. (1998) handle the bank privatization process in Argentina. Similarly, Krueger and Tornell (1999) study on the restructuring period following the crisis in Mexico. Shyu (1998) and Leightner and Lovell (1998) claimed that deregulation led to increasing bank efficiencies in Taiwanese and Thai cases, respectively. Bhattacharya et al. (1997) reported better efficiency rates after liberalization of banks in India. According to Gilbert and Wilson (1998), deregulation and privatization provided higher productivity in Korean case. However, banking sector efficiencies do not necessarily increase after deregulation. For instance, based on what Bauer et al. (1993) and Elyasiani and Mehdian (1995) reported, US bank efficiencies did not change after deregulation. Furthermore, according to Humphrey (1993), Grabowski et al. (1994), Humphrey and Pulley (1997) and Wheelock and Wilson (1999), bank efficiencies decreased in the US following the deregulation period. Similarly, Lozano (1995) and Khumbakar et al. (2001) found out that deregulation of Spanish banking system led to decline of efficiencies.

There are some studies that are not directly related to the deregulation, restructuring and privatization issues. Rather than comparing pre- and post-development periods, these studies inquire the efficiencies of unique periods. For example, Berger and Humphrey (1994) assess bank scale economies, mergers, concentration, and efficiency of the US. Berger et al. (1998) and De Young and Whalen (1994) evaluated banks' efficiencies and performances.

For evaluating efficiencies, the impacts of economical developments, researchers and academicians have benefitted from some methodologies. These quantitative methods could be categorized as parametric and nonparametric studies. Although these two methods follow highly distinct ways of evaluating, they have mostly reached the same or similar conclusions. Berger and Humprey (1997) analyzed the findings of 130 efficiency studies and they assert that parametric and nonparametric methods provide parallel results. As an example of parametric studies, Dietsch and Lozano-Vivas (2000) studied on the environmental factors that determine banking sector's efficiencies with Distribution Free Approach that is a parametric method. Ozkan-Gunay (1997) measures the cost efficiency for Turkish commercial banks using the stochastic frontier approach. Kohers et al. (2000) use the Stochastic Frontier Approach in order to examine the influence of bank efficiencies on the market assessment of bank holding company mergers.

Nonparametric analyses are used more than the parametric approaches. For instance, Haslem et al. (1999) studied on the banking sector of the US with DEA and determined the most important inputs and outputs for bank managers. Staub et al. (2010) evaluated the Brazilian banking sector with the data up to 2007 with DEA and found out that Brazilian banks have lower efficiency levels than the European and US banks. In addition, depending on the correlations, state banks are more efficient than the private and foreign banks in the Brazilian case. Lin et al. (2009) benefit from DEA for a slightly different purpose and they assess the efficiencies of the branches for a Taiwanese bank.

Nonparametric analyses have also been used for assessing Turkish banking sector. In particular, Jackson et al. (1998) calculated efficiencies of Turkish commercial banks between 1992 and 1996 by using DEA and MPI. They concluded that foreign and privately owned banks are managed more efficiently than the state banks and that the crisis in 1994 affected bank efficiencies negatively. Secondly, Isik and Hassan (2002) handled the Turkish banking sector via nonparametric approach based on the data between 1988 and 1996. Thirdly, Isik and Hassan (2003) studied on the effects of the

crisis of 1994 on the efficiencies of Turkish banks. They benefitted from DEA and MPI with the 1988-1996 data, again.

Turker Kaya and Dogan (2005) evaluated the disinflation period by using DEA and Malmquist index and they argue that the banking sector experienced an increase in efficiencies due to the technological changes. However, they did not have the opportunity to study with ample data since their data consist of only 2002, 2003 and 2004. Similarly, Basti (2005) handled the same issue and concluded that crisis in 2001 had negative consequences on the banking sector but the sector has gotten rid of the negative effects of the crisis later. In addition, it is asserted in the study that the efficiency decrease after the crisis was caused by the downward technological frontier shift.

Ozkan-Gunay and Tektas (2006) utilizes DEA method for investigating the Turkish commercial banks depending on the data of 1990 to 2001. Yildirim (2002) also evaluates Turkish banking system with the data from 1988 to 1999. It compares banks' efficiencies with the other concepts like asset quality and bank size. Finally, Aysan and Ceyhan (2008) studied on Turkish banks by using DEA and MPI with the data from 1990 to 2006. However, state banks are excluded in this study. Moreover, mostly correlations between efficiencies and the other factors such as number of branches, bank size, ROE and ROA are emphasized. Mercan et al. (2003) have a comprehensive study that uses DEA on Turkish banking sector with the data of 1989-1999. The efficiency changes over years and the effects of scale size and ownership structures are interpreted based on the DEA findings in this study.

Malmquist Productivity Index (MPI) is a tool that is complementary to the Data Envelopment Analysis. While DEA deals with single period data, MPI measures the fluctuations between periods. By this way, it provides dynamic characteristics to DEA. Malmquist productivity index has been used by Alam and Semenick (2001) to observe efficiencies of large US banks. Berg et al. (1992) use the Malmquist Indices of Productivity to handle growth of Norwegian banks. Casu et al. (2004) evaluate the European banking system of 1994-2000 with MPI and they conclude that the efficiency

changes have mostly occurred because of the technological changes. Drake (2001) also studied on the banks of the UK with MPI.

This study aims to use DEA approach to assess commercial banks' efficiencies in Turkish banking sector. There are several reasons that distinguish this study from the others. First, this study is to use the latest data up to 2008. Secondly, its main purpose is to accomplish a direct comparison of high inflation period with the disinflation period. In order to do that, Malmquist productivity index will be employed and rather than comparing only the subsequent years, each and every year from the two different periods will be compared. This will provide the best comparison of the two different periods. There has been no other study that aims to investigate this particular comparison. As mentioned above, with the disinflation period, Turkish banks' practical working style has changed. They tend to sell much more loans instead of buying government bonds. With the low inflation, people demanded much more loans and due to lower budget deficits, the government began to sell fewer bonds. The last decade of the Turkish economy has a great scenario for this analysis and this makes the Turkish banks a great source of observation. Literature lacks a study that compares the inflation period and the disinflation period and this study is to fill this gap.

Another property that makes this study differ from others is that in addition to DEA-CCR and DEA-BCC, slacks based measure (SBM) of DEA will also be utilized. This new method is one of the latest versions of DEA and for the first time SBM will be complemented with Malmquist Productivity Index. Additionally, correlations between efficiencies and the other factors such as bank size, bank's age, loan ratios, capital adequacy ratio, ratio of loans under follow-up, etc. will be presented.

Turkish banking industry has a long and highly fluctuating history and this makes it a great source for many observations and analyses. During 1980s and 1990s, many developments such as liberalization in the banking sector had occurred worldwide. In these periods, many banking products and varieties have begun to be introduced to the financial markets. In addition, financial and nonfinancial sectors began to come closer to each other [28]. As a result, productivity of banks began to be crucial for bank

managers and decision makers. Unlike 1970s, governments' ownership of banks began to decrease and the rate of private banks began to increase significantly. Privatization began to be handled immensely by the government [38]. In the past, the majority of the world capital belonged to developed countries and a flow of capital towards developing countries emerged [39]. According to Akkurt et al. (1992), liberalization was initiated in this period. In parallel with liberalization, the market began to be more competitive and Turkish banking sector began to integrate with the world economy [41]. This situation caused activation of money and trade. By this way, import and export became more attractive and foreign trade deficits began to increase sharply for the countries which consume more than they produce. At the beginning liberalization was launched for making the economy more stable but reversely it caused an instable economy [42].

Due to the basic problem mentioned above, attempts to maintain stability could not succeed during 1990s. This resulted in an highly fluctuating economy, unstable interest rates and foreign exchange rates. Unbearable budget deficits, high risk perception of foreign investors were the other main problems during this period and some panic demands to foreign currencies brought about currency crises [43].

Turkish economy experienced several crises during 1990s. These crises happened in 1991 (economy was affected negatively by the Gulf War), 1994 (the government applied devaluation), 1997 (due to the Far Eastern crisis) and 1998 (related to Russian economical crisis). While observing the Turkish banking sector of 1990s, it is not difficult to see that Turkish banks were used as a resource for financing government's deficits. This was mainly accomplished by government bonds. Thus, Turkish banks were away from their primary mission which is intermediation. Rather than providing financial power for new investments and projects of private sector and individuals, banks were the suppliers of government due to the poorly managed fiscal policies [44].

In the high inflation period Turkish banks worked with high profit margins since they spent less time for marketing and selling individual and SME loans. The government bonds were easy and highly profitable financial instruments. Uncertainties due to the high inflation prevented banks from making long term plans. Also because of the high

levels of risks, sector could hardly find long term funds. Banks avoided long term loans such as mortgage loans. Besides, banks did not struggle for introducing new alternative products to the market [45].

These crises were followed by the 2001 crisis that had many causes [33]. Liquidity crisis of 2001 can be defined as the most serious crisis of the republic era [44] and therefore it should be taken into consideration in depth. As a matter of fact, there exist many studies on this issue in the literature. In addition to the malfunctioning of banks, lack of capital and political inconsistencies led to the crisis, as well. Following the crisis, "Restructuring program for Turkish banking sector" was declared in May of 2001 for the first time. Within the scope of this program, costs of banks were handled and tried to decrease. Number of branches and employees were revised and interactions between the branches were enlarged. Automation of transactions was accomplished and structures of the banks were tried to be more efficient. The problematic Turkish banks did not only improve their operational functions, but they also undertook financial restructurings. In particular, they struggled to strengthen their capital structure, to improve assets, to increase profitability, to reduce financial risks. These revisions had positive impacts on the financial performances of banks [46]. According to the foreign banking sector crisis, Dziobek and Pazarbasioglu (1997) and Garcia (1997) claim that the best way to restore the sector is to combine the financial and operational improvements. Before the 2001 crisis, the Turkish banking sector utilized high profit margins since they could easily finance the government due to the huge budget deficits.

With the help of the new economic program that was initiated in 2001, noteworthy steps were undertaken in terms of maintaining the macroeconomic consistency. Turkish economy grew during 14 quarters and most importantly inflation was reduced significantly. These developments made positive impacts on the financial capacity of Turkish banks. The sector that had negative growth rate following the 2001 crisis grew 81% in terms of Turkish Liras and 94% in terms of US Dollars between 2001 and 2004. In parallel with these, rather than financing the huge government's budget deficits via government bonds, Turkish banks began to increase their loan activities. Loans per assets ratio increased from 20% (2001) up to 32% (2004). Conversion rate from

deposits to loans also increased from 31% (2001) to 52% (2004). All these ratios prove that banks began to deal with intermediation duties more than they did before 2001 [28].

The table and figure below shows that 2001 - 2004 period is a milestone for inflation in Turkish economy.

Table 2.1 Yearly inflation rates

(website of TUIK and Central Bank of Turkey)

Year	CPI
1994	125.89%
1995	78.11%
1996	75.72%
1997	101.62%
1998	65.90%
1999	68.88%
2000	35.92%
2001	73.16%
2002	26.38%
2003	16.22%
2004	9.30%
2005	7.70%
2006	9.70%
2007	8.40%
2008	10.10%
2009	6.50%
2010	6.50% (estimated)
2011	5.50% (estimated)

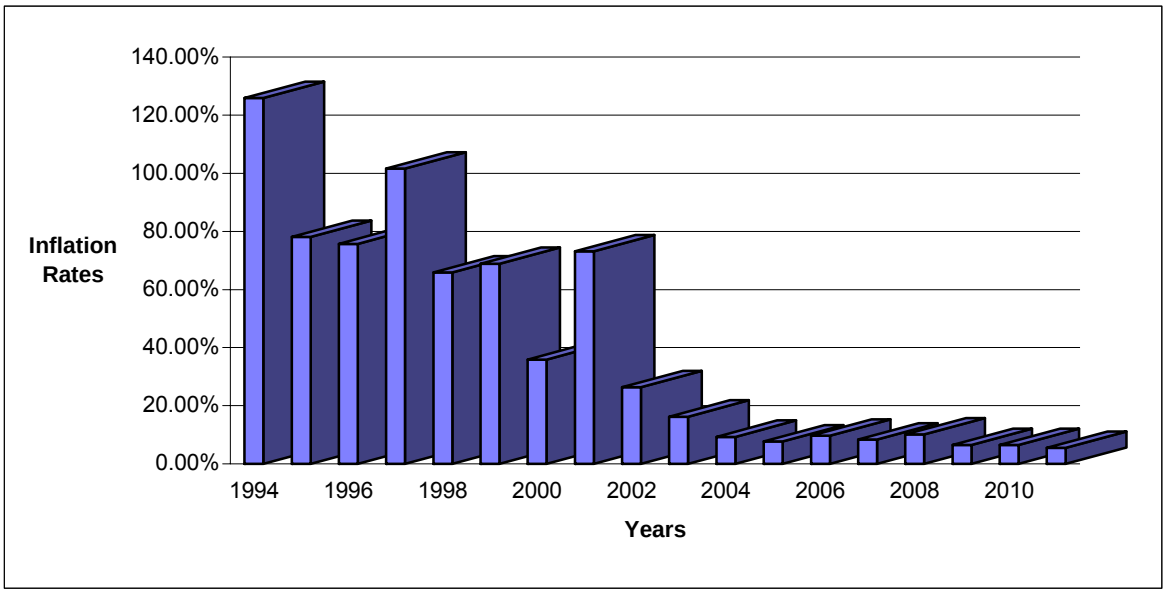

Figure 2.1 Yearly Inflation Rates

(website of TUIK and Central Bank of Turkey)

Individual and SME loans began to be more attractive due to the lower interest rates. Individuals began to benefit from mortgage loans that have payback options during more than 10 years. With the stabilization of foreign exchanges (FX), FX loans began to be utilized more. As a result, the new disinflation period created a new working environment for the Turkish banks [49].

The table below proves that after the 2001 crisis new economic program led to a sharp increase in total loans / total assets ratio:

Table 2.2 Total Loans per Total Assets Ratio for Banks in Turkey

source: Turkish Banking Association (TBA)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Whole Turkish Banking Sector	38.3	30.1	32.9	21.9	26.5	28.0	33.7	38.6	45.0	50.0	52.0

Similarly, the figure below shows that loan ratios have increased for all types of banks between 1998 and 2008:

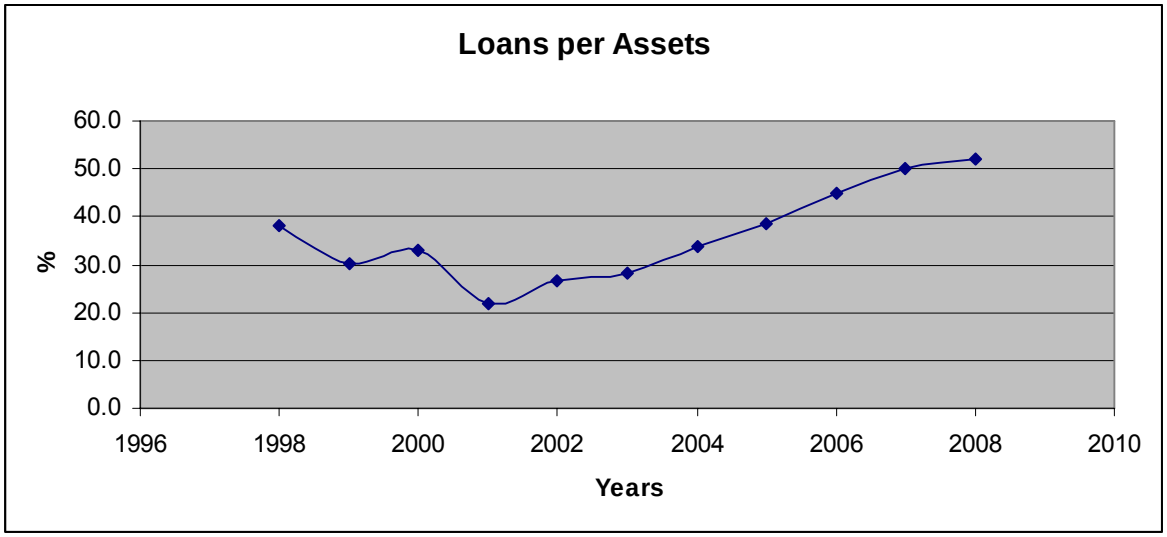

Figure 2.2 Sketch of Total Loans / Total Assets between 1998 – 2008

source: Turkish Banking Association (TBA)

By observing the figure above, it is quite easy to guess that government deficits have decreased in the same period and therefore banks gradually escaped from feeding the government. However, at the same time they partially lost a huge and loyal customer. In parallel with the loans per assets ratio, during the 1998 – 2008 period, conversion of deposits to loans ratio also improved. The ratios based on each bank and year can be seen in the table below:

Table 2.3 Total Loans per Total Deposits ratio for Banks in Turkey

source: Turkish Banking Association (TBA)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Whole Turkish Banking Sector	58.4	44.9	49.9	31.8	39.6	43.5	52.3	60.4	69.7	78.6	80.9

The graph below shows that banks have begun to do their intermediation functions after the 2001 crisis:

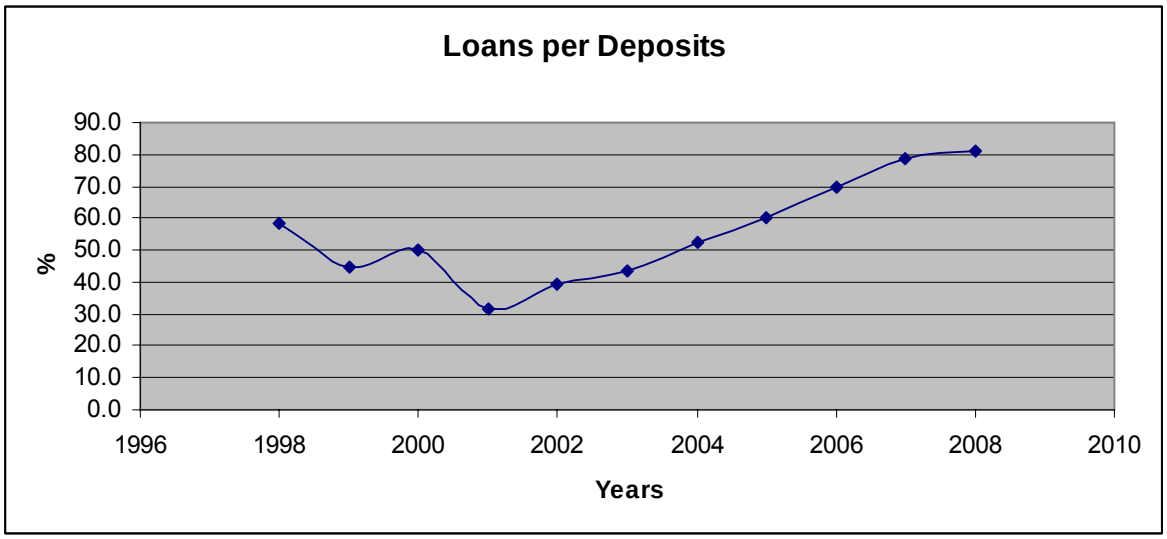

Figure 2.3 Sketch of Total Loans / Total Deposits between 1998 – 2008

source: Turkish Banking Association (TBA)

3 EVALUATION OF PERFORMANCE VIA DATA ENVELOPMENT ANALYSIS

Assessment of performance has been a crucial issue not only for academicians, but also for private industry managers. Indeed, in today's economy, the complexity of concepts and the number of factors that influences the working mechanisms bring about sophisticated evaluation tools for performance measurement. Professionals have been using some simple ratios for the resources that have been consumed and yields that have been maintained. Below are some examples of financial ratios for performance evaluations used by private sector companies [50]:

$$\frac{\text{Profits before tax}}{\text{Current liabilities}}, \qquad \frac{\text{Working capital}}{\text{Total assets}}, \qquad \frac{\text{Total liabilities}}{\text{Net capital}}$$

In addition to the financial ratios above, researchers have also been benefitting from some ratios such as [50]:

$$\frac{\text{Number of students}}{\text{Number of academicians}}, \frac{\text{Maintenance cost}}{\text{1 km of roadway}},$$

$$\frac{\text{Annual revenue from in-patient of hospitals}}{\text{Annual number of in-patient cases}},$$

$$\frac{\text{Revenue support for public passenger transport}}{\text{1000 population}}$$

These ratios are the basic indicators in many areas and industries. However, they are able to be beneficial to some limited extent for managers and performance evaluators

since they basically function with only one input and only one output. At this point, more complicated performance measurement tools have been needed for more complex systems that have more than one inputs and/or outputs.

The initial approach to assess multiple inputs and outputs was accomplished by Farrell (1957). Charnes et al. (1978) came up with the idea of the first version of Data Envelopment Analysis (DEA). In this method, a set of elements, named Decision Making Units (DMU), were compared and the most efficient ones were to form an upper boundary frontier. The other DMUs were scored based on their distances apart from the frontier. By this way, mathematical programming was used to compare a set of DMUs and score them based on their productivities. The selection of the DMUs is critical for the analyses and one should take the followings into account when determining the inputs, outputs and DMUs to study on [53]:

1. All input-output data should be available and positive for all DMUs.
2. The inputs, outputs and DMUs chosen should be in the area of interest of the interpreter.
3. Different inputs and outputs do not necessarily have to be in the same unit of measurement. For instance, one input can be in km and the other can be a financial data.

This was a milestone for performance measurement and DEA method has been commonly used in private sector and public sector, as well. The first version of the DEA model was named as DEA-CCR on behalf on its introducers, Charnes, Cooper and Rhodes.

The most important functionality of the model was its ability to evaluate several inputs and outputs at the same time and give efficiency scores to each DMU according to amounts of inputs and outputs. By this way, the method was designed to find out the relative efficiencies.

3.1 DEA - CCR Method

This model consists of n DMUs and each DMU_j, (j = 1,. . .,n) uses m inputs x_{ij} (i = 1, ..., m) and produces s outputs y_{rj} (r = 1, ..., s). The goal is to maximize the ratio of output to input shown below [52]:

$$\max Z = \frac{\sum_r u_r y_{rj}}{\sum_i v_i x_{ij}} \tag{3.1}$$

s.t. $\frac{\sum_r u_r y_{rj}}{\sum_i v_i x_{ij}} \leq 1$ for all j,

v_i u_r , v_i non-negative for all r, i.

In order to overcome non-linearity, the first constraint is revised as;

$$\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \leq 0 \tag{3.2}$$

Besides that, change of variables is applied and the model shows up as follows:

$$\begin{aligned} &\max Z = \sum_r \mu_r y_{ro} \\ &st \\ &\sum_i v_i x_{io} = 1 \\ &\sum_r \mu_r y_{rj} - \sum_i v_i x_{ij} \leq 0, \forall j \\ &\mu_r, v_i \geq 0, \text{ for all r, j.} \end{aligned} \tag{3.3}$$

By duality, the below model is derived from the primal CCR model [52]. In many cases dual model is used since it has fewer constraints than the primal model.

$$\begin{aligned}
&\min \theta \\
&\text{subject to} \\
&\sum_{j=1}^{n} x_{ij}\lambda_j \le \theta x_{io} \quad i = 1,2,...,m; \\
&\sum_{j=1}^{n} y_{rj}\lambda_j \ge y_{ro} \quad r = 1,2,...,s; \\
&\lambda_j \ge 0 \qquad\qquad j = 1,2,...,n.
\end{aligned} \tag{3.4}$$

Note that running the above models, both primal and dual, is not ample to find out efficiency scores for all DMUs and one need to run the models once more for each DMU. By duality, the objective functions would yield the same result in both models ($Z^* = \theta^*$). For the dual part, assume that a DMU_o is evaluated and the objective function is found as $\theta^* = 1$ (technically efficient DMU). This means that all λs should be equal to zero, except λ of DMU_o.

$$\begin{aligned}
&\lambda_k^* = 1 \\
&\lambda_k^* = \lambda_o^* \\
&\lambda_j^* = 0 \text{ for all other js.}
\end{aligned} \tag{3.5}$$

The "efficient" DMUs with $\theta^* = 1$ form the efficiency frontier. The other DMUs, that obtain optimal objective function value between zero and one ($0 < \theta^* < 1$), are assessed as "inefficient". By the way, there is also a distinction between efficient DMUs [54]. Efficient DMUs are mostly "technical efficient", but in some cases "weakly efficient" DMUs may occur. This situation is experienced due to non-zero slacks of weakly efficient DMUs. In other words, these weakly efficient DMUs still have some area of improvement, meaning that they can still decrease their inputs and/or increase their

outputs in order to be technical efficient. This analysis is accomplished by slacks analysis or by Slacks Based Measure (SBM) that are to be handled in this text, later on.

All data of the above models spans among a space and that space is defined as "production possibility set".

$$T = \left\{ (X,Y) \middle| X \geq \sum_j \lambda_j X_j, Y \leq \sum_j \lambda_j Y_j, \lambda_j \geq 0 \right\}$$

It is to be noted that (3.4) is focused not on outputs but on inputs. Therefore, it can be defined as input oriented DEA-CCR method [54]. This definition implies that this linear program basically deals with the improvement opportunities of only inputs. Actually, this input-oriented version is the one that has been commonly used in the analyses. However, there exists another version called output-oriented DEA-CCR model:

$$\begin{aligned} &\max \phi \\ &\text{subject to} \\ &\sum_{j=1}^{n} x_{ij}\lambda_j \leq x_{io} \quad i = 1,2,...,m; \\ &\sum_{j=1}^{n} y_{rj}\lambda_j \geq \phi y_{io} \quad r = 1,2,...,s; \\ &\lambda_j \geq 0 \qquad\qquad j = 1,2,...,n; \end{aligned} \tag{3.6}$$

The above model is called "envelopment model". This model mainly focuses on the production of DMUs and rate them basically regarding their yields (=outputs). The dual of the output-oriented envelopment model is introduced as follows [54]:

$$\min q = \sum_{i=1}^{m} v_i x_{io}$$
subject to
$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geq 0 \qquad (3.7)$$
$$\sum_{r=1}^{s} \mu_r y_{ro} = 1$$
$$\mu_r, v_i \geq 0$$

(3.7) is also called output-oriented "multiplier" model of DEA-CCR.

Up to now, it is assumed that all inputs are under the control of the decision makers. However, especially in real life, it is hard or even impossible to handle some inputs in some circumstances. DEA – CCR has also a solution for this tough situation. The below CCR model distinguishes the discretionary and non-discretionary inputs [54]:

$$\min \theta$$
subject to
$$\sum_{j=1}^{n} x_{ij}\lambda_j \leq \theta x_{io} \qquad i \in I_D;$$
$$\sum_{j=1}^{n} x_{ij}\lambda_j \leq x_{io} \qquad i \in I_N; \qquad (3.8)$$
$$\sum_{j=1}^{n} y_{rj}\lambda_j \geq y_{ro} \qquad r = 1,2,...,s;$$
$$\lambda_j \geq 0 \qquad j = 1,2,...,n.$$

Here, I_D is the set of discretionary inputs while I_N is the set of non-discretionary inputs.

3.2 DEA - BCC Method

The first version of DEA, which is DEA-CCR, has been handled so far. In this step, "constant returns to scale" (CRS) was accepted and the next development of DEA was on the issue of returns to scale (RTS). Banker et al. [55] came up with the idea of a DEA model with "variable returns to scale" (VRS). This was another milestone and was named based on its founders: Banker, Charnes and Cooper: DEA-BCC.

Actually, what Banker et al. [55] did was just adding a simple variable to the initial model. With this adjustment the input-oriented BCC model existed as such:

$$
\begin{aligned}
&\max e = [\sum_r u_r y_{ro} - u_o] / \sum_i v_i x_{io} \\
&\text{subject to} \\
&\sum_r u_r y_{rj} - u_o - \sum_i v_i x_{ij} \le 0, \qquad j = 1, 2, ..., n; \\
&u_r, v_i \ge 0, \qquad \forall i, r \\
&u_o \text{ unrestricted in sign}
\end{aligned}
\tag{3.9}
$$

On the dual model, Banker et al. just added a convexity constraint to the basic DEA-CCR model:

$$
\begin{aligned}
&\min \theta \\
&\text{subject to} \\
&\sum_{j=1}^{n} x_{ij} \lambda_j \le \theta x_{io} \qquad i = 1, 2, ..., m; \\
&\sum_{j=1}^{n} y_{rj} \lambda_j \ge y_{ro} \qquad r = 1, 2, ..., s; \\
&\sum_{j=1}^{n} \lambda_j = 1 \\
&\lambda_j \ge 0 \qquad j = 1, 2, ..., n.
\end{aligned}
\tag{3.10}
$$

The distinction between CRS and VRS models could be better depicted via graphical illustration. Suppose that there exist seven DMUs (from A to G) with one input and one output for each. Figure 3.1 sketches their location on the graph. The x coordinate is the input and the y coordinate is the output. For the models with one input and one output, the efficiency frontier is quite simple. In this particular example, CRS is applied so the only one efficient DMU is *B*. The dashed line resembles the efficiency frontier. The other DMUs take efficiency score between zero and one based on their distance from the frontier.

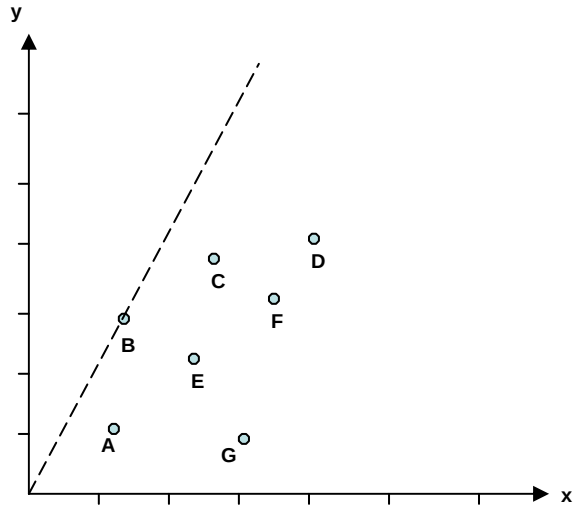

Figure 3.1 Sketch of CRS DEA model with one input and one output [56]

On the other side, Figure 3.2 shows a sketch of VRS DEA version of the above example. Again, the dashed line resembles the efficiency frontier and this time it passes through A, B, C and D. These four points are rated as 1 (efficient) while the others take efficiency scores between zero and one. When RTS of the model is altered, all DMUs' efficiency scores change except B. For instance, A, C and D are determined as efficient in one analysis and inefficient in the other analysis. Thus, one can conclude that the issue of RTS directly determines the results of the analyses.

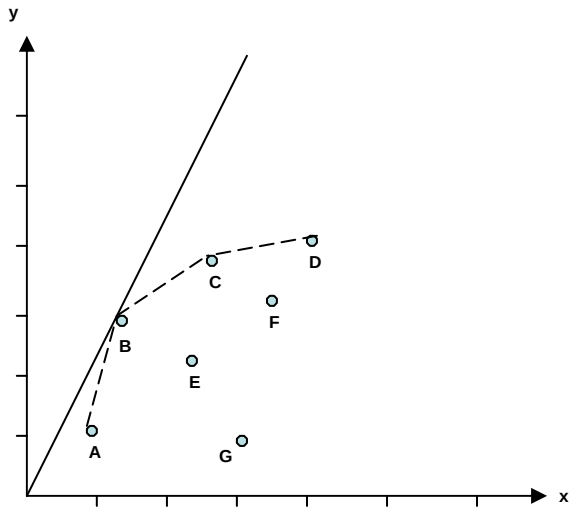

Figure 3.2 Sketch of VRS DEA model with one input and one output [56]

In addition to the CRS and VRS, there also exist non-increasing returns to scale (or decreasing returns to scale; DRS = NIRS) and non-decreasing returns to scale (or increasing returns to scale; IRS = NDRS) [57]. The convexity constraints of NIRS and NDRS for the dual DEA-BCC model are given below, respectively:

$$\sum_{j=1}^{n} \lambda_j \leq 1 \tag{3.11}$$

$$\sum_{j=1}^{n} \lambda_j \geq 1 \tag{3.12}$$

3.3 Russell Measure

The next form of DEA is Russell Measure that was developed by Fare and Novell [58] and later revised by Pastor et al. [59]:

$$\min R_o = [\sum_i (\theta_i / m) / \sum_r (\varphi_r / s)]$$

subject to

$$\begin{aligned} &\sum_j \lambda_j x_{ij} \le \theta_i x_{io}, \qquad i = 1,2,...,m; \\ &\sum_j \lambda_j y_{rj} \ge \varphi_r y_{ro}, \qquad r = 1,2,...,s; \\ &\sum_j \lambda_j = 1 \\ &\lambda_j \ge 0, \quad 0 \le \theta_i \le 1, \quad \varphi_r \ge 1, \quad \text{all i,j,r.} \end{aligned} \tag{3.13}$$

3.4 Additive Method

DEA-CCR and DEA-BCC models are radial measure models and the subsequent development of DEA was once more undertaken by Charnes et al. [60]. The next step was "additive model" or "Pareto – Koopmans (PK) model" that was a non-radial model. What the new model contributed to the literature was using slacks (s^+, s^-), in other words input excesses and output shortfalls, in the objective function. By this way, the model depended on the amount of essential decreasing in the inputs or the amount of essential increasing in the outputs. The additive model is as follows:

$$\max P_o = \sum_i s_i^- + \sum_r s_r^+$$

subject to

$$\begin{aligned}
&\sum_j \lambda_j x_{ij} + s_i^- = x_{io,} && i = 1,2,...,m; \\
&\sum_j \lambda_j y_{rj} - s_i^+ = y_{ro,} && r = 1,2,...,s; \\
&\sum_j \lambda_j = 1 \\
&\lambda_j, s_i^-, s_i^+ \geq 0, && \forall j,i,r.
\end{aligned} \tag{3.14}$$

(3.14) is a VRS model since it includes the convexity constraint. By excluding this constraint, one can transform it into CRS model. For a DMU_o if the optimal slack variables take value of zero, it means that DMU_o is additive-efficient or PK-efficient.

3.5 Slacks Based Measure (SBM)

Since the objective function of the PK model only dealt with the opportunities of improvements of inputs and outputs, it was not able to give efficiency scores for DMUs. Therefore, in order to overcome this handicap, the smooth transition from the conventional DEA methods to Slacks Based Measure (SBM) began and the first step of this transition was the use of the objective function below [60]:

$$Q_o = \delta\left(\sum_i s_i^- / x_{io} + \sum_r s_r^+ / y_{ro}\right) \tag{3.15}$$

The division of slack values by inputs and outputs provided the inputs and outputs to be unit invariant. In other words, scale size was not an issue for DEA applications any more. Nevertheless, the problem with (3.15) was that it would not give appropriate efficiency scores for DMUs to be analyzed. By transformation of it into $(1\text{-}Q_o)$ provided it to obtain efficiency scores [61]. However, later on, it was found out that (1-

Q_o) could cause negative efficiency values in some cases [62]. To get rid of these problems, a new objective function was proposed [63]:

$$\max R_o = \frac{1}{s+r}[\sum_i s_i^- / x_{io} + \sum_r s_r^+ /(y_{ro} + s_r^+)]$$

subject to

$$\sum_j \lambda_j x_{ij} + s_i^- = x_{io}, \qquad i = 1,2,...,m; \tag{3.16}$$

$$\sum_j \lambda_j y_{rj} - s_i^+ = y_{ro}, \qquad r = 1,2,...,s;$$

$$\sum_j \lambda_j = 1$$

$$\lambda_j, s_i^-, s_r^+ \geq 0, \qquad \forall j, i, r.$$

The new model proposed by Green et al. [63] gave efficiency scores between [0,1] and it was unit invariant, as well. However, non-linearity of the model caused difficult calculations. In addition to those, Russell (1985, 1988), Tone (1993, 1997), Pastor (1995, 1996), Lovell and Pastor (1995), Torgensen et al. (1996), Cooper and Pastor (1997), Cooper and Tone (1997) and Thrall (1997) also studied on the slacks based models.

Tone (2001) transformed the model (3.16) into a new form:

$$\min \rho = \frac{1 - \frac{1}{m}\sum_i s_i^- / x_{io}}{1 + \frac{1}{s}\sum_r s_r^+ / y_{ro}}$$

subject to (3.17)

$$\sum_j \lambda_j x_{ij} + s_i^- = x_{io}, \qquad i = 1, 2, ..., m;$$

$$\sum_j \lambda_j y_{rj} - s_i^+ = y_{ro}, \qquad r = 1, 2, ..., s;$$

$$\sum_j \lambda_j = 1$$

$$\lambda_j, s_i^-, s_r^+ \geq 0, \qquad \forall j, i, r.$$

Like the other models of DEA, such as CCR and BCC, SBM model is unit variant, meaning that inputs and outputs may have different kinds of units. Besides that, in DEA applications, each inefficient DMU receives an efficiency score totally based on its reference set that includes one or more of the technical efficient DMUs. SBM model also works in this sense. When data of n DMUs are analyzed by SBM, each DMU's reference set can also be found. This situation basically means that an inefficient DMU faces the efficient DMUs in its reference set as its benchmarks and that the manager of this inefficient DMU should set his goals based on the numerical values of the reference set.

For the SBM model, (3.17), it is assumed that all input data are positive [53]. If one of the input data is equal to zero ($x_{io} = 0$), the term (s_i^-/x_{io}) should be removed from the objective function. On the other side, if negative output occurs, that negative value of output should be revised as a very small positive data.

Another property of the model is that SBM is monotone decreasing in each input and output slack. To clarify, an increase of the value of a slack (either s_i^- or s_i^+) will lead to a monotone decrease in the value of the objective function.

Moreover, the objective function value is doubtlessly in between zero and one. In order to prove that, one can see that input excesses cannot exceed the values of inputs theoretically ($s_i^- < x_{io}$). Thus, the below inequality holds:

$$0 \leq \frac{\sum_i s_i^- / x_{io}}{m} \leq 1 \tag{3.18}$$

Conversely, the same inequality is not true for the denominator of the objective function since output shortfalls are able to be higher that corresponding output values. However, still the same ratio cannot be negative:

$$0 \leq \frac{\sum_r s_r^+ / y_{ro}}{s} \tag{3.19}$$

According to the two inequalities above, one can easily observe that the objective function value is in between zero and one. $(0 \leq \rho \leq 1)$ Besides that, ρ can only be 1 if all slacks are equal to zero.

The objective function of SBM can be written as follows [75]:

$$\rho = \left(\frac{1}{m} \sum_{i=1}^{m} \frac{x_{io} - s_i^-}{x_{io}} \right) \left(\frac{1}{s} \sum_{r=1}^{s} \frac{y_{ro} + s_r^+}{y_{ro}} \right) \tag{3.20}$$

It is possible to see that the first part of the above function is the average proportional reduction rate and it simply measures the input inefficiencies. Likewise, in the second part of the function, the ratio is used to obtain average proportional rate of output expansion. More simply, again, it measures the output inefficiencies. As a result, the objective function is a measure of input and output inefficiencies.

One of the biggest problems with the basic SBM model (3.17) is its non-linearity. To overcome this shortcoming, it is possible to apply the Charnes – Cooper transformation [76]. For that purpose, both numerator and denominator of the objective function of (3.17) are multiplied by a scalar (t > 0). Then, the denominator is transferred to the constraints. This prevents the model from being non-linear and it reaches the new model shown below:

$$
\begin{aligned}
&\min \tau = t - \frac{1}{m}\sum_{i=1}^{m} ts_i^- / x_{io} \\
&\text{subject to} \\
&1 = t + \frac{1}{s}\sum_{r=1}^{s} ts_r^+ / y_{ro} \\
&x_o = X\lambda + s^- \\
&y_o = Y\lambda - s^+ \\
&\lambda, s^-, s^+ \geq 0 \qquad t > 0
\end{aligned}
\tag{3.21}
$$

At this point, the changes below are applied to the model:

$$S^- = ts \ , \qquad S^+ = ts^+, \qquad \Lambda = t\lambda$$

Finally, the model is transformed into (3.22):

$$\min \tau = t - \frac{1}{m}\sum_{i=1}^{m} S_i^- / x_{io}$$

subject to

$$1 = t + \frac{1}{s}\sum_{r=1}^{s} S_r^+ / y_{ro} \qquad (3.22)$$

$$tx_o = X\Lambda + S^-$$

$$ty_o = Y\Lambda - S^+$$

$$\Lambda, S^-, S^+ \geq 0 \qquad t > 0$$

Based on the above model, the optimal solution is (τ^*, t^*, Λ^*, S^{-*}, S^{+*}). If $\tau^* = 1$ and S^{-*}, S^{+*} slack values are equal to zero, DMU_o is efficient, meaning that there exist neither input excess nor output shortfalls. Otherwise, DMU_o is evaluated as inefficient [75]. The decision makers should set their targets depending on the amounts of non-zero slacks and this application is called SBM – projection. They must aim at decreasing their inputs as much as their input excesses and increasing their outputs as much as their output shortfalls shown as below:

$$x_o \leftarrow x_o - s^{-*},$$

$$y_o \leftarrow y_o + s^{+*}$$

The next issue of the analysis is determining the reference – set for inefficient DMUs. When the model is run for a DMU_o, each λ_i that is larger than zero forms the reference – set (R_o) for DMU_o.

$$R_o = \left\{ j \middle| \lambda_j^* > 0 \right\} \qquad (j \in \{1, 2, ..., n\}). \qquad (3.23)$$

The reference – set issue of SBM is significant in the sense that each inefficient DMU's score totally depends on its reference – set. For instance, if one decreases the inputs and/or increases the outputs of a technical efficient DMU, that efficient DMU becomes even more efficient (its efficiency score cannot exceed 1, though). In addition, the efficiency frontier also changes. However, if that efficient DMU is not in the reference – set of an inefficient DMU_o, the efficiency score of DMU_o remains the same. By this way, SBM efficiency scores are not affected by statistical changes and by the extreme values among the data set, indeed.

The dual of the SBM model is given below:

$$\begin{aligned}
&\max \xi \\
&\text{subject to} \\
&\xi + vx_o - uy_o = 1, \\
&-vX + uY \le 0, \\
&v \ge \frac{1}{m}\left[1/x_o\right], \\
&u \ge \frac{\xi}{s}\left[1/y_o\right]
\end{aligned} \tag{3.24}$$

The first constraint is removed from the model:

$$\begin{aligned}
&\max uy_o - vx_o \\
&\text{subject to} \\
&-vX + uY \le 0, \\
&v \ge \frac{1}{m}\left[1/x_o\right], \\
&u \ge \frac{1 - vx_o + uy_o}{s}\left[1/y_o\right]
\end{aligned} \tag{3.25}$$

For the model (3.25), u and v vectors that are multiplied by outputs and inputs function as cost and price, respectively.

Note that as CCR has both input – oriented and output – oriented versions, SBM also has the same characteristics [53]. If the first constraint is extracted from (3.22), the model can be transformed to the input – oriented SBM model:

$$\begin{aligned}
&\min \rho_{in} = 1 - \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{io} \\
&\text{subject to} \\
&x_o = X\lambda + s^+ \\
&y_o = Y\lambda - s^+ \\
&\lambda, s^-, s^+ \geq 0
\end{aligned} \tag{3.26}$$

Again, the below inequality holds:

$$\rho_{in}^* \leq \theta_{CCR}^*$$

3.6 Exploring Inefficiencies

As a matter of fact, since DEA is a relative efficiency analysis method, technical efficient DMUs are rated as 1 (full score) and simply they do not have a benchmark to take as a sample. Reversely, inefficient DMUs deserve slightly more interest because the main causes for their inefficiencies may be crucial to know for improving. Moreover, the reason of the inefficiency of a working mechanism can be either the managers' fault or inappropriate situations. In order to find out the reason, it is possible to benefit from some ratios [53].

CCR models work with the assumption of constant returns to scale (CRS). In CCR models, the efficiency frontier is straightforward and optimal values are based on non-negative combinations of DMUs. CCR scores are named as "global technical efficiency". On the other hand, BCC assumes variable returns to scale (VRS) and this handles convex combinations of efficient DMUs. BCC scores are named as "local pure technical efficiency". If a DMU is rated as 1 (efficient) via CCR, no doubt, it would also be rated as efficient via BCC. However, the opposite is not necessarily true. This difference between CCR and BCC is related to the scale efficiency, meaning that the ratio of CCR and BCC for each DMU determines whether the DMU is operating with the best scale size. If DMU is efficient for both CCR and BCC calculations, one can conclude that DMU is working with the most productive scale size. The below ratio gives "scale efficiency":

$$SE = \frac{\theta^*_{CCR}}{\theta^*_{BCC}} \tag{3.27}$$

It is also possible to write the same equation as such:

[Technical Efficiency (TE)] = [Pure Technical Efficiency (PTE)] * [Scale Efficiency (SE)]

Here, scale efficiency cannot exceed one. If it is equal to 1, it means the DMU is working with the best scale size. Pure technical efficiency (PTE) is related to management faults while, scale efficiency (SE) is related to external situations.

Another efficiency concept is the "mix efficiency" and input – oriented SBM model is used for calculating mix efficiency. The below ratio gives the mix efficiency:

$$\text{Mix Efficiency} = \frac{\rho_{in}^{*}}{\theta_{CCR}^{*}} \tag{3.28}$$

When TE of (3.28) is divided into 2 parts like (3.27), the below equation holds:

ρ_{in}^{*} = [MIX] * [PTE] * [SE]

Note that for all the efficiency calculations it is recommended that the number of the DMUs should be more than twice of the sum of the inputs and outputs [77].

3.7 Super Efficiency

All DMUs are rated between 0 and 1 so far. Since more than one DMUs are needed to form the efficiency frontier, more than one DMUs are rated as efficient and take the value of 1. In addition, these efficient DMUs have no input excesses, no doubt. In this case, it is impossible to distinguish these efficient DMUs in terms of rankings. The concept of super efficiency comes into play in this situation. Super efficiency was first proposed by Andersen and Petersen (1993).

$$\begin{aligned}
&\min \theta \\
&\text{subject to} \\
&\sum_{j=1, j\neq o}^{n} x_{ij}\lambda_j \leq \theta x_{io} \quad i = 1, 2, ..., m; \\
&\sum_{j=1, j\neq o}^{n} y_{rj}\lambda_j \geq y_{ro} \quad r = 1, 2, ..., s; \\
&\lambda_j \geq 0 \qquad\qquad j = 1, 2, ..., n; j \neq o.
\end{aligned} \tag{3.29}$$

To interpret the model, the only difference is that DMU_o is excluded from the data set. The above model is also called as the AP model on behalf of the names of Andersen and Petersen. According to the results of the AP model, the efficient DMUs take value over 1 and the inefficient DMUs again take values between 0 and 1. Although the super-efficiency model is a great tool to distinguish efficient DMUs, it returns infeasible solutions very often, unfortunately [79-84].

3.8 Malmquist Productivity Index

Malmquist productivity index (MPI) is a tool for measuring efficiency changes over time. Adaptation of this index to data envelopment analysis is first proposed by Fare et al. (1992 and 1994) based on the studies of Caves et al. (1982). The index is named on behalf of Malmquist due to his studies [88]. Since the initiation of Malmquist productivity index there have been many studies on this issue and Malmquist and DEA have become like twin analyses that complement each other.

Similar to DEA, Malmquist can also be applied to many issues in both private sector and public sector. For example, Lothgren and Tambour (1999) analyzed Swedish eye care services, Grifell-Tatje and Lovell (1996) evaluated the effect of deregulation on Spanish saving banks, Fulginiti and Perrin (1997) assessed the changes in agricultural productivity in 18 developing countries, Taskin and Zaim (1997) studied on an empirical investigation of the catch-up hypothesis for a group of high and low income countries, Madden and Savage (1999) handled the telecommunications productivity, technology catch-up and innovation in 74 countries, Maudos et al. (1999) worked on total factor productivity evolution in Organization for Economic Cooperation and Development (OECD) countries. There exist many more studies on Malmquist Productivity Index.

For calculating Malmquist productivity index, it must be noted that DEA is a measure of "relative efficiencies". Therefore, when a DMU of time *t* is plugged into the data set of time *t+1*, it is not possible to observe the real changes accurately since there exists a

frontier shift, as well. In order to get over this shortcoming, MPI is decomposed into two parts: technical efficiency change and the frontier shift of the whole data set. The below formulas are needed to define these concepts.

$$
\begin{aligned}
&D_o^t(x_o^t, y_o^t) = \min \theta \\
&\text{subject to} \\
&\sum_{j=1}^{n} x^t{}_{ij}\ \lambda_j \le \theta x^t{}_{io} \quad i = 1,2,...,m; \\
&\sum_{j=1}^{n} y^t{}_{rj} \lambda_j \ge y^t{}_{ro} \quad r = 1,2,...,s; \\
&\lambda_j \ge 0 \qquad\qquad j = 1,2,...,n.
\end{aligned}
\tag{3.30}
$$

To clarify, $D_o^t(x_o^t, y_o^t)$ is the efficiency score of DMU_o that is found by using input and output data of time *t*. In the same model, all data of time *t+1* could be used and in this case $D_o^{t+1}(x_o^{t+1}, y_o^{t+1})$ would be found. The next step is mixing the data of time *t* and *t+1*. The below model measures the performance of DMU_o of time *t+1* with respect to the efficiency frontier of time *t*:

$$
\begin{aligned}
&D_o^t(x_o^{t+1}, y_o^{t+1}) = \min \theta \\
&\text{subject to} \\
&\sum_{j=1}^{n} x^t{}_{ij}\ \lambda_j \le \theta x^{t+1}{}_{io} \quad i = 1,2,...,m; \\
&\sum_{j=1}^{n} y^t{}_{rj} \lambda_j \ge y^{t+1}{}_{ro} \quad r = 1,2,...,s; \\
&\lambda_j \ge 0 \qquad\qquad j = 1,2,...,n.
\end{aligned}
\tag{3.31}
$$

Likewise, the below model measures the performance of DMU_o of time *t* with respect to the efficiency frontier of time *t+1*:

$$D_o^{t+1}(x_o^t, y_o^t) = \min \theta$$
subject to
$$\sum_{j=1}^{n} x^{t+1}{}_{ij}\ \lambda_j \le \theta x^t{}_{io} \quad i = 1,2,...,m; \tag{3.32}$$
$$\sum_{j=1}^{n} y^{t+1}{}_{rj} \lambda_j \ge y^t{}_{ro} \quad r = 1,2,...,s;$$
$$\lambda_j \ge 0 \qquad j = 1,2,...,n.$$

These four optimal objective function values are ample to calculate the MPI and its components. The first component of MPI is the "frontier shift (FS)". In some sources, it is also named as "technological efficiency change" since it is assumed that all DMUs experience technological developments and these developments should have a positive impact on their efficiencies. Therefore, the effect of technological advancements must be distinguished from performances of decision makers. Frontier shift is presented below [85]:

$$FS_o = \left[\frac{D_o^t(x_o^{t+1}, y_o^{t+1})}{D_o^{t+1}(x_o^{t+1}, y_o^{t+1})} \frac{D_o^t(x_o^t, y_o^t)}{D_o^{t+1}(x_o^t, y_o^t)} \right]^{1/2} \tag{3.33}$$

Secondly, "technical efficiency change (TEC)", which is the other part of MPI, should be calculated.

$$TEC_o = \frac{D_o^{t+1}(x_o^{t+1}, y_o^{t+1})}{D_o^t(x_o^t, y_o^t)} \tag{3.34}$$

TEC is simply the comparison of the present DMU and the future DMU. When the two components are integrated, one can reach MPI as follows:

$$M_o = TEC_o \times FS_o = \frac{D_o^{t+1}(x_o^{t+1}, y_o^{t+1})}{D_o^t(x_o^t, y_o^t)} \left[\frac{D_o^t(x_o^{t+1}, y_o^{t+1})}{D_o^{t+1}(x_o^{t+1}, y_o^{t+1})} \frac{D_o^t(x_o^t, y_o^t)}{D_o^{t+1}(x_o^t, y_o^t)} \right]^{1/2} \tag{3.35}$$

$$M_o = \left[\frac{D_o^t(x_o^{t+1}, y_o^{t+1})}{D_o^t(x_o^t, y_o^t)} \frac{D_o^{t+1}(x_o^{t+1}, y_o^{t+1})}{D_o^{t+1}(x_o^t, y_o^t)} \right]^{1/2}$$

For MPI, FS and TEC if the value is larger than 1, it refers to a positive change; if the value is smaller than 1, it refers to a negative shift; and if the value is equal to 1, it means there has become no change between the two periods of DEA analysis.

MPI has mostly used with DEA-CCR. In this study a new form of MPI is employed. Instead of CCR, MPI can also be used with SBM as shown below:

$$D_o^t(x_o^t, y_o^t) = \min \rho_{in} = 1 - \frac{1}{m} \sum_{i=1}^{m} s_i^- / x_{io}^t$$

subject to

$$x_o^t = X^t \lambda + s^+ \tag{3.36}$$

$$y_o^t = Y^t \lambda - s^+$$

$$\lambda, s^-, s^+ \geq 0$$

Similar to the conventional MPI models, (3.33) consists of $D_o^t(x_o^t, y_o^t)$ that is the efficiency score of DMU_o in time *t*. In order to obtain $D_o^{t+1}(x_o^{t+1}, y_o^{t+1})$, data of time (t+1) should be plugged into the model. The next step is, again, the mixed periods. The below model measures the performance of DMU_o of time *t+1* with respect to the efficiency frontier of time *t*:

$$D_o^t(x_o^{t+1}, y_o^{t+1}) = \min \rho_{in} = 1 - \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{io}^{t+1}$$

subject to

$$x_o^{t+1} = X^t \lambda + s^+ \qquad (3.37)$$

$$y_o^{t+1} = Y^t \lambda - s^+$$

$$\lambda, s^-, s^+ \geq 0$$

Similarly, the below model measures the performance of DMU_o of time *t* with respect to the efficiency frontier of time *t+1*:

$$D_o^{t+1}(x_o^t, y_o^t) = \min \rho_{in} = 1 - \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{io}^t$$

subject to

$$x_o^t = X^{t+1} \lambda + s^+ \qquad (3.38)$$

$$y_o^t = Y^{t+1} \lambda - s^+$$

$$\lambda, s^-, s^+ \geq 0$$

Based on these models, MPI, frontier shift and technological efficiency change values can be calculated in the same way. Again, if these values exceed 1, it resembles an improvement and the opposite means a decline in the efficiency. If the value is equal to 1, it means no change has occurred.

In addition to the Malmquist productivity index, there are two more indices that basically accomplish the same function. These indices are Tornquist index and Fischer index [95]. However, these two indices deal with cost and price information and this is related to cost minimization and profit maximization. On the contrary, MPI is simple since it works only with amount information and it is non-parametric. Therefore,

according to Fukuyama (1995) and Isik (2001), MPI is more commonly used than the other two indexes.

3.9 Comparison of Nonparametric Analyses and DEA

Data envelopment is a nonparametric analysis method, meaning that there is no need to construct an equation or a utility function among inputs and outputs. Thus, all the inputs and outputs are independent from each other. Each DMU is considered kind of a black box and the best performing DMU is found and rated as efficient. However, there are also some parametric analysis methods that operate with an equation or a regression between the inputs and outputs. i.e. Stochastic Frontier Analysis (SFA), Cobb – Douglas loglinear forms, etc. SFA is the most basic parametric analysis method that is used to find efficiencies. Unlike DEA, SFA is an econometric method and it does not deal with mathematical programming [98]. Moreover, SFA works with a production function and this also includes an equation of inputs, outputs and an error part that is decomposed into two parts. One part of the error is related with statistical distortions and the other part is related to efficiency of DMUs. Based on Coelli et al. (1997) and Lan et al. (2003) the table below is structured and it summarizes the similarities and differences of the two methods:

Table 3.1 Comparison of SFA and DEA

	SFA	**DEA**
Consistency	Both DEA and SFA methods are efficiency frontier analyses, and are similar in that they determine a frontier and inefficiency based on that frontier.	
Characteristic	Parametric method	Non-Parametric method
Efficiency measurement	Technical efficiency, scale elasticity, scale efficiency, allocative efficiencies, technical change and TFP change	Technical efficiency, scale elasticity, scale efficiency, allocative efficiencies, congestion efficiencies, technical change and TFP change
Strengths	1. It does not assume that all firms are efficient in advance. 2. SFA makes accommodation for statistical noise such as random variables of weather, luck, machine breakdown and other events beyond the control of firms, and measures error. 3. It does not need to price information available. 4. It is capable to hypothesis test. 5. To estimate the best technical efficiencies of firm, rather than average technical efficiencies of firm.	1. It does not assume that all firms are efficient in advance. 2. It could handle efficiency measurement of multiple inputs and multiple outputs. 3. It does not need to price information available. 4. It does not need to assume function type and distribution type. 5. While sample size is small, it is compared with relative efficiency. 6. Both the CCR and BCC models have nature of unit invariance.
Weakness	1. It needs to assume functional form and distribution type in advance. 2. It needs enough samples to avoid lack of degree of freedom. 3. The assumed distribution type is sensitive to assessing efficiency scores.	1. It does not make accommodation for statistical noise such as measure error. 2. It is not capable to hypothesis test. 3. When the newly added DMU is an outlier, it could affect the efficiency measurement.
Application	It has applied to measure performance of profit organizations.	It has applied to assess performance of non-profit organizations or branches of firm.

4 APPLICATION OF DATA ENVELOPMENT ANALYSIS ON TURKISH BANKING INDUSTRY

4.1 DEA on a Single Period

Turkish banking industry has been a controversial issue because it has huge effects on the stability of Turkish economy. Many bankrupts and fluctuations have been experienced depending on the changes of the economy. In order to examine the performance of Turkish commercial banks, several versions of DEA are employed in this study.

First of all, there are 3 state banks, 11 Turkish based private banks, 1 monetary fund bank, 18 foreign banks and 13 development and investment banks in Turkey at the end of 2008. Here is the list of all banks in Turkey:

Table 4.1 List of All Banks in Turkey (2008)

source: Turkish Banking Association (TBA)

State Banks	**Turkish Based Private Banks**
Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	Adabank A.Ş.
Türkiye Halk Bankası A.Ş.	Akbank T.A.Ş.
Türkiye Vakıflar Bankası T.A.O.	Alternatif Bank A.Ş.
	Anadolubank A.Ş.
Monetary Fund Banks	Şekerbank T.A.Ş.
Birleşik Fon Bankası A.Ş.	Tekstil Bankası A.Ş.
	Turkish Bank A.Ş.
Foreign Banks	Türk Ekonomi Bankası A.Ş.
ABN AMRO Bank N.V.	Türkiye Garanti Bankası A.Ş.
Arap Türk Bankası A.Ş.	Türkiye İş Bankası A.Ş.
Bank Mellat	Yapı ve Kredi Bankası A.Ş.
Citibank A.Ş.	
Denizbank A.Ş.	**Development and Investment Banks**
Deutsche Bank A.Ş.	Aktif Yatırım Bankası A.Ş.
Eurobank Tekfen A.Ş.	Bank Pozitif Kredi ve Kalkınma Bankası A.Ş.
Finans Bank A.Ş.	Calyon Yatırım Bankası Türk A.Ş.
Fortis Bank A.Ş.	Diler Yatırım Bankası A.Ş.
Habib Bank Limited	GSD Yatırım Bankası A.Ş.
HSBC Bank A.Ş.	İller Bankası
ING Bank A.Ş.	İMKB Takas ve Saklama Bankası A.Ş.
JPMorgan Chase Bank N.A.	Merrill Lynch Yatırım Bank A.Ş.
Millennium Bank A.Ş.	Nurol Yatırım Bankası A.Ş.
Sociéte Générale (SA)	Taib Yatırım Bank A.Ş.
Turkland Bank A.Ş.	Türk Eximbank
Unicredit Banca di Roma S.p.A.	Türkiye Kalkınma Bankası A.Ş.
WestLB AG	Türkiye Sınai Kalkınma Bankası A.Ş.

Among these banks, 22 banks which have suitable number of branches and employees were chosen for the analyses. Moreover, since panel data of 1998-2008 is needed, the other banks were eliminated from the study.

The selection of the input output combination is crucial to maintain accurate and meaningful conclusions. We have benefitted from some papers in the literature. For

instance, Turker Kaya and Dogan (2005) analyzed the Turkish banking system based on three different approaches. The first approach that they used is the production approach in which they have opted employee costs, non-interest costs and number of employees per branch as the inputs and deposits and loans as the outputs. In this approach the banks are evaluated as production centers where mainly employees and physical assets are used to produce banking products such as deposits and loans. In the second approach of the same study, which is named as the intermediation approach, banks are assessed as institutions that are intermediary between investors and borrowers. In this sense, basically, liabilities are in the input side and the assets are in the output side. The inputs of the said paper are deposits, foreign funds, interest costs and non-interest costs while the outputs are loans and interest revenues. The third approach that is stated in the study of Turker Kaya and Dogan (2005) is the profit/revenue based approach in which the inputs are operating expenses and non-interest expenses and the outputs are interest revenue and non-interest revenue. We have accepted the approaches of this paper as a basis for our product and intermediation approaches with slight changes. At this point, by changing the number of inputs and outputs, we tested the rule of thumbs of DEA and assessed whether the sum of the number of inputs and the number of outputs are appropriate for the number of DMUs. Similarly, we have slightly changed the profit/revenue based approach to evaluate the profitability of the banks with respect to their scale. For this purpose, we have taken number of employees, number of branches and equity capital as the inputs and profit and revenue as the outputs in our profit based approach 1. For our second profit based approach we have taken the DEA study of Portela and Thanassoulis (2007). In this paper, there are several different approaches and one of them is the profit based approach in which the inputs are number of employees and the supply costs and the outputs are the current accounts, other resources, credit over bank and credit associates. Based on this approach, we imposed the Turkish balance sheet items and adapted the same approach to the Turkish data and by this way, we structured our second profit based approach with two inputs and six outputs. The reason for using more than one input output combinations for each approach is that we struggled to look from several distinct perspectives. For instance, in our first profit based approach, the outputs are directly net profits and total revenues and this combination shows us the pure impacts on the profitability. On the other hand,

secondly, we used six outputs in the second profit based approach and by this way, we had the opportunity to make a more comprehensive assessment on the profitabilities of the banks.

The suitable 22 Turkish commercial banks were evaluated with DEA through six different input-output combinations. These combinations are presented below.

Table 4.2 Input – Output Combinations

Approach	**Inputs**	**Outputs**
Production Approach 1	Number of employees	Deposits
	Number of branches	Loans
	Paid-in capital	
Production Approach 2	Employee expenses	Deposits
	Interest costs	Loans
	Paid-in capital	
Intermediation Approach 1	Deposits	Loans
	Interest costs	Gov. Bonds
	Employee expenses	Interest revenue
	Physical assets	
Intermediation Approach 2	Deposits	Loans
	Interest costs	Gov. Bonds
	Physical assets	
Profit Based Approach 1	Number of employees	Net profit
	Number of branches	Total revenue
	Equity capital	
Profit Based Approach 2	Number of employees	TL Deposits
	Non-interest costs	FX Deposits
		Loans
		Gov. Bonds
		Net Profit
		Income

Table 4.3 presents the input and output values for the “production approach 1” for the 22 banks:

Table 4.3 Input – Output Values for Production Approach 1

(Monetary values are in terms of millions of Turkish Liras)

	DMU	input1 # of employees	input2 # of branches	input3 paid-in capital	output1 deposits	output2 loans
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	21299	1269	2500	83883.435	30836.194
2	Türkiye İş Bankası A.Ş.	20924	1039	2756.585	63539.185	47610.332
3	Türkiye Garanti Bankası A.Ş.	16350	726	4200	52715.281	49907.407
4	Akbank T.A.Ş.	15127	868	3000	52181.947	44374.104
5	Yapı ve Kredi Bankası A.Ş.	14795	861	4347.051	41705.329	38672.952
6	Türkiye Vakıflar Bankası T.A.O.	9567	525	2500	37120.277	30502.299
7	Türkiye Halk Bankası A.Ş.	12467	622	1250	40271.114	25836.298
8	Finans Bank A.Ş.	9986	458	1500	15939.067	17878.045
9	Denizbank A.Ş.	7376	400	716.1	9999.213	12759.178
10	ING Bank A.Ş.	6357	366	1324.098	9997.729	11044.083
11	Türk Ekonomi Bankası A.Ş.	6400	336	1100	9271.747	8504.777
12	HSBC Bank A.Ş.	6853	335	652.29	9183.424	9723.783
13	Fortis Bank A.Ş.	5378	300	1050	5460.673	7238.078
14	Şekerbank T.A.Ş.	4089	250	400	5931.571	4799.814
15	Citibank A.Ş.	2315	56	33.753	4228.633	2512.889
16	Alternatif Bank A.Ş.	1006	46	300	2653.553	2370.575
17	Eurobank Tekfen A.Ş.	661	42	230	1795.524	1091.606
18	Anadolubank A.Ş.	1718	77	409.5	2086.935	1958.164
19	Tekstil Bankası A.Ş.	1410	60	420	1434.47	1606.119
20	Millennium Bank A.Ş.	320	18	202.535	986.008	883.815
21	Turkland Bank A.Ş.	457	25	170	577.887	594.796
22	Turkish Bank A.Ş.	292	26	80	413.34	201.734

DEA-CCR, DEA-BCC, CCR with discretionary inputs, Super-CCR, NIRS and NDRS are applied to the approach above and the results can be seen in Table 4.4. Note that input-3 is defined as nondiscretionary input for CCR NDI.

Table 4.4 CCR and BCC Efficiency Values for Production Approach 1

	DMU	CCR	CCR NDI	Super CCR	BCC	NIRS	NDRS
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	1.000	1.194	1.000	1.000	1.000
2	Türkiye İş Bankası A.Ş.	0.982	0.979	0.982	1.000	1.000	0.982
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.183	1.000	1.000	1.000
4	Akbank T.A.Ş.	1.000	1.000	1.066	1.000	1.000	1.000
5	Yapı ve Kredi Bankası A.Ş.	0.820	0.756	0.820	0.840	0.840	0.820
6	Türkiye Vakıflar Bankası T.A.O.	1.000	1.000	1.126	1.000	1.000	1.000
7	Türkiye Halk Bankası A.Ş.	1.000	1.000	1.122	1.000	1.000	1.000
8	Finans Bank A.Ş.	0.748	0.719	0.748	0.756	0.756	0.748
9	Denizbank A.Ş.	0.850	0.815	0.850	0.868	0.850	0.868
10	ING Bank A.Ş.	0.584	0.570	0.584	0.615	0.584	0.615
11	Türk Ekonomi Bankası A.Ş.	0.499	0.486	0.499	0.530	0.499	0.530
12	HSBC Bank A.Ş.	0.705	0.687	0.705	0.729	0.705	0.729
13	Fortis Bank A.Ş.	0.467	0.457	0.467	0.513	0.467	0.513
14	Şekerbank T.A.Ş.	0.574	0.530	0.574	0.643	0.574	0.643
15	Citibank A.Ş.	1.000	1.000	3.862	1.000	1.000	1.000
16	Alternatif Bank A.Ş.	0.798	0.740	0.798	0.950	0.798	0.950
17	Eurobank Tekfen A.Ş.	0.695	0.569	0.695	0.852	0.695	0.852
18	Anadolubank A.Ş.	0.388	0.383	0.388	0.542	0.388	0.542
19	Tekstil Bankası A.Ş.	0.389	0.361	0.389	0.524	0.389	0.524
20	Millennium Bank A.Ş.	0.866	0.672	0.866	1.000	0.866	1.000
21	Turkland Bank A.Ş.	0.409	0.356	0.409	0.869	0.409	0.869
22	Turkish Bank A.Ş.	0.361	0.265	0.361	1.000	0.361	1.000

The 1st, 3rd, 4th, 6th, 7th and 15th DMUs are rated as technical efficient according to CCR. At this point Super CCR distinguishes these efficient DMUs and it is found out that the 15th DMU is the best managed DMU with a score of 3.862. DEA-SBM (CRS), SBM (VRS), SBM (NIRS), SBM (NDRS) and reference sets based on SBM (CRS) results can be seen in Table 4.5:

Table 4.5 SBM (CRS) and Input Excess Values for Production Approach 1

	DMU	SBM (CRS)	References (based on SBM-CRS)	Input excesses based on SBM-CRS		
				Input 1	Input 2	Input 3
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000		0.000	0.000	0.000
2	Türkiye İş Bankası A.Ş.	0.979	4,7,15	765.436	28.030	0.000
3	Türkiye Garanti Bankası A.Ş.	1.000		0.000	0.000	0.000
4	Akbank T.A.Ş.	1.000		0.000	0.000	0.000
5	Yapı ve Kredi Bankası A.Ş.	0.756	3,6	2199.881	284.223	1104.195
6	Türkiye Vakıflar Bankası T.A.O.	1.000		0.000	0.000	0.000
7	Türkiye Halk Bankası A.Ş.	1.000		0.000	0.000	0.000
8	Finans Bank A.Ş.	0.719	3,4	4125.385	196.553	0.000
9	Denizbank A.Ş.	0.815	4,15	1456.940	143.051	0.000
10	ING Bank A.Ş.	0.570	3	2738.885	205.342	394.674
11	Türk Ekonomi Bankası A.Ş.	0.486	3,4	3581.747	200.197	424.158
12	HSBC Bank A.Ş.	0.687	4,15	3483.495	144.537	0.000
13	Fortis Bank A.Ş.	0.457	3	3006.757	194.708	440.873
14	Şekerbank T.A.Ş.	0.530	4,7	2346.473	152.724	89.925
15	Citibank A.Ş.	1.000		0.000	0.000	0.000
16	Alternatif Bank A.Ş.	0.740	3,6	242.378	9.035	102.545
17	Eurobank Tekfen A.Ş.	0.569	1,6	201.467	15.773	140.807
18	Anadolubank A.Ş.	0.383	3,6	1078.108	48.206	244.963
19	Tekstil Bankası A.Ş.	0.361	3	883.825	36.636	284.836
20	Millennium Bank A.Ş.	0.672	3,6	35.013	4.273	128.873
21	Turkland Bank A.Ş.	0.356	3	262.141	16.348	119.944
22	Turkish Bank A.Ş.	0.265	1,7	176.932	19.689	67.456

Table 4.6 shows the SBM (VRS), SBM (NIRS), SBM (NDRS), scale efficiency, pure technical efficiency and mix efficiency.

Table 4.6 SBM (VRS, NIRS, NDRS), SE, PTE and Mix Efficiency Values for Production Approach 1

	DMU	SBM (VRS)	SBM (NIRS)	SBM (NDRS)	Scale Eff	Pure Tech Eff	Mix Eff
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
2	Türkiye İş Bankası A.Ş.	1.000	1.000	0.979	0.982	1.000	0.996
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
4	Akbank T.A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
5	Yapı ve Kredi Bankası A.Ş.	0.758	0.756	0.758	0.976	0.840	0.922
6	Türkiye Vakıflar Bankası T.A.O.	1.000	1.000	1.000	1.000	1.000	1.000
7	Türkiye Halk Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
8	Finans Bank A.Ş.	0.736	0.719	0.736	0.990	0.756	0.961
9	Denizbank A.Ş.	0.815	0.815	0.815	0.979	0.868	0.959
10	ING Bank A.Ş.	0.601	0.570	0.601	0.949	0.615	0.976
11	Türk Ekonomi Bankası A.Ş.	0.522	0.486	0.522	0.940	0.530	0.975
12	HSBC Bank A.Ş.	0.693	0.687	0.693	0.966	0.729	0.975
13	Fortis Bank A.Ş.	0.499	0.457	0.499	0.911	0.513	0.979
14	Şekerbank T.A.Ş.	0.543	0.530	0.543	0.893	0.643	0.923
15	Citibank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
16	Alternatif Bank A.Ş.	0.933	0.740	0.933	0.840	0.950	0.928
17	Eurobank Tekfen A.Ş.	0.831	0.569	0.831	0.816	0.852	0.819
18	Anadolubank A.Ş.	0.512	0.383	0.512	0.715	0.542	0.988
19	Tekstil Bankası A.Ş.	0.497	0.361	0.497	0.743	0.524	0.928
20	Millennium Bank A.Ş.	1.000	0.672	1.000	0.866	1.000	0.776
21	Turkland Bank A.Ş.	0.805	0.356	0.805	0.470	0.869	0.871
22	Turkish Bank A.Ş.	1.000	0.265	1.000	0.361	1.000	0.733

Table 4.7 presents the input and output values for the “production approach 2” for the 22 banks:

Table 4.7 Input – Output Values for Production Approach 2

(Monetary values are in terms of millions of Turkish Liras)

	DMU	input1 employee expenses	input2 interest costs	input3 paid-in capital	output1 deposits	output2 loans
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	915.128	9265.832	2500	83883.435	30836.194
2	Türkiye İş Bankası A.Ş.	1251.804	6977.852	2756.585	63539.185	47610.332
3	Türkiye Garanti Bankası A.Ş.	962.916	6200.432	4200	52715.281	49907.407
4	Akbank T.A.Ş.	833.754	6212.528	3000	52181.947	44374.104
5	Yapı ve Kredi Bankası A.Ş.	873.717	4608.669	4347.051	41705.329	38672.952
6	Türkiye Vakıflar Bankası T.A.O.	557.063	4438.967	2500	37120.277	30502.299
7	Türkiye Halk Bankası A.Ş.	507.192	4666.693	1250	40271.114	25836.298
8	Finans Bank A.Ş.	464.599	2001.853	1500	15939.067	17878.045
9	Denizbank A.Ş.	372.885	1267.234	716.1	9999.213	12759.178
10	ING Bank A.Ş.	322.07	1396.591	1324.098	9997.729	11044.083
11	Türk Ekonomi Bankası A.Ş.	350.471	1261.604	1100	9271.747	8504.777
12	HSBC Bank A.Ş.	402.967	1059.048	652.29	9183.424	9723.783
13	Fortis Bank A.Ş.	296.034	923.985	1050	5460.673	7238.078
14	Şekerbank T.A.Ş.	203.73	695.01	400	5931.571	4799.814
15	Citibank A.Ş.	147.99	336.469	33.753	4228.633	2512.889
16	Alternatif Bank A.Ş.	59.59	251.98	300	2653.553	2370.575
17	Eurobank Tekfen A.Ş.	38.358	378.723	230	1795.524	1091.606
18	Anadolubank A.Ş.	89.388	258.471	409.5	2086.935	1958.164
19	Tekstil Bankası A.Ş.	82.238	262.142	420	1434.47	1606.119
20	Millennium Bank A.Ş.	26.984	65.43	202.535	986.008	883.815
21	Turkland Bank A.Ş.	35.721	71.539	170	577.887	594.796
22	Turkish Bank A.Ş.	14.076	41.484	80	413.34	201.734

DEA-CCR, DEA-BCC, CCR with discretionary inputs, Super-CCR, NIRS and NDRS are applied to the approach above and the results can be seen in Table 4.8. Note that input-2 and input-3 are defined as nondiscretionary inputs for CCR NDI.

Table 4.8 CCR and BCC Efficiency Values for Production Approach 2

	DMU	CCR	CCR NDI	Super CCR	BCC	NIRS	NDRS
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	1.000	1.154	1.000	1.000	1.000
2	Türkiye İş Bankası A.Ş.	0.992	0.962	0.992	1.000	1.000	0.992
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.056	1.000	1.000	1.000
4	Akbank T.A.Ş.	1.000	1.000	1.039	1.000	1.000	1.000
5	Yapı ve Kredi Bankası A.Ş.	0.966	0.919	0.966	1.000	1.000	0.966
6	Türkiye Vakıflar Bankası T.A.O.	1.000	1.000	1.034	1.000	1.000	1.000
7	Türkiye Halk Bankası A.Ş.	1.000	1.000	1.313	1.000	1.000	1.000
8	Finans Bank A.Ş.	0.965	0.908	Infeasible	0.974	0.974	0.965
9	Denizbank A.Ş.	1.000	1.000	1.180	1.000	1.000	1.000
10	ING Bank A.Ş.	0.845	0.658	0.845	0.861	0.861	0.845
11	Türk Ekonomi Bankası A.Ş.	0.727	0.443	0.727	0.775	0.775	0.727
12	HSBC Bank A.Ş.	0.942	0.677	0.942	0.985	0.985	0.942
13	Fortis Bank A.Ş.	0.723	0.468	0.723	0.767	0.767	0.723
14	Şekerbank T.A.Ş.	0.823	0.446	0.823	0.830	0.830	0.823
15	Citibank A.Ş.	1.000	1.000	3.862	1.000	1.000	1.000
16	Alternatif Bank A.Ş.	1.000	1.000	1.018	1.000	1.000	1.000
17	Eurobank Tekfen A.Ş.	0.580	0.580	0.580	0.813	0.580	0.813
18	Anadolubank A.Ş.	0.693	0.414	0.693	0.734	0.734	0.693
19	Tekstil Bankası A.Ş.	0.555	0.357	0.555	0.561	0.555	0.561
20	Millennium Bank A.Ş.	1.000	1.000	1.435	1.000	1.000	1.000
21	Turkland Bank A.Ş.	0.664	0.336	0.664	0.832	0.664	0.832
22	Turkish Bank A.Ş.	0.755	0.431	0.755	1.000	0.755	1.000

The 1st, 3rd, 4th, 6th, 7th, 9th, 15th, 16th and 20th DMUs are rated as technical efficient according to CCR. At this point Super CCR distinguishes these efficient DMUs and it is found out that the 15th DMU is the best managed DMU with a score of 3.862. The 8th DMU's Super efficiency score is not available because the model yields infeasible solution. DEA-SBM (CRS), SBM (VRS), SBM (NIRS), SBM (NDRS) and reference sets based on SBM (CRS) results can be seen in Table 4.9:

Table 4.9 SBM (CRS) and Input Excess Values for Production Approach 2

	DMU	SBM (CRS)	References (based on SBM-CRS)	Input excesses based on SBM-CRS		
				Input 1	Input 2	Input 3
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000		0.000	0.000	0.000
2	Türkiye İş Bankası A.Ş.	0.975	4,7,9,15	0.000	0.000	210.573
3	Türkiye Garanti Bankası A.Ş.	1.000		0.000	0.000	0.000
4	Akbank T.A.Ş.	1.000		0.000	0.000	0.000
5	Yapı ve Kredi Bankası A.Ş.	0.931	3,15,16	52.910	0.000	641.514
6	Türkiye Vakıflar Bankası T.A.O.	1.000		0.000	0.000	0.000
7	Türkiye Halk Bankası A.Ş.	1.000		0.000	0.000	0.000
8	Finans Bank A.Ş.	0.904	4,9	0.000	0.551	432.915
9	Denizbank A.Ş.	1.000		0.000	0.000	0.000
10	ING Bank A.Ş.	0.758	4,9	35.027	160.450	664.955
11	Türk Ekonomi Bankası A.Ş.	0.633	4,9	171.266	146.565	546.372
12	HSBC Bank A.Ş.	0.842	9,15	67.216	33.176	180.768
13	Fortis Bank A.Ş.	0.626	9	84.502	205.103	643.768
14	Şekerbank T.A.Ş.	0.731	7,9,15	83.928	0.000	157.574
15	Citibank A.Ş.	1.000		0.000	0.000	0.000
16	Alternatif Bank A.Ş.	1.000		0.000	0.000	0.000
17	Eurobank Tekfen A.Ş.	0.456	1,7	16.115	171.848	174.540
18	Anadolubank A.Ş.	0.586	4,9	46.855	6.701	283.431
19	Tekstil Bankası A.Ş.	0.473	4,9	39.976	84.393	324.712
20	Millennium Bank A.Ş.	1.000		0.000	0.000	0.000
21	Turkland Bank A.Ş.	0.535	3,9	22.410	2.248	125.125
22	Turkish Bank A.Ş.	0.564	1,7,15	5.951	0.000	70.788

Table 4.10 shows the SBM (VRS), SBM (NIRS), SBM (NDRS), scale efficiency, pure technical efficiency and mix efficiency.

Table 4.10 SBM (VRS, NIRS, NDRS), SE, PTE and Mix Efficiency Values for Production Approach 2

	DMU	SBM (VRS)	SBM (NIRS)	SBM (NDRS)	Scale Eff	Pure Tech Eff	Mix Eff
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
2	Türkiye İş Bankası A.Ş.	1.000	1.000	0.975	0.992	1.000	0.983
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
4	Akbank T.A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
5	Yapı ve Kredi Bankası A.Ş.	1.000	1.000	0.931	0.966	1.000	0.964
6	Türkiye Vakıflar Bankası T.A.O.	1.000	1.000	1.000	1.000	1.000	1.000
7	Türkiye Halk Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
8	Finans Bank A.Ş.	0.912	0.912	0.904	0.990	0.974	0.936
9	Denizbank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
10	ING Bank A.Ş.	0.768	0.758	0.768	0.981	0.861	0.897
11	Türk Ekonomi Bankası A.Ş.	0.652	0.633	0.652	0.938	0.775	0.871
12	HSBC Bank A.Ş.	0.848	0.848	0.842	0.956	0.985	0.894
13	Fortis Bank A.Ş.	0.644	0.626	0.644	0.943	0.767	0.867
14	Şekerbank T.A.Ş.	0.750	0.731	0.750	0.991	0.830	0.889
15	Citibank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
16	Alternatif Bank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
17	Eurobank Tekfen A.Ş.	0.624	0.456	0.624	0.713	0.813	0.786
18	Anadolubank A.Ş.	0.662	0.586	0.662	0.944	0.734	0.846
19	Tekstil Bankası A.Ş.	0.556	0.473	0.556	0.989	0.561	0.852
20	Millennium Bank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
21	Turkland Bank A.Ş.	0.754	0.535	0.754	0.797	0.832	0.806
22	Turkish Bank A.Ş.	1.000	0.564	1.000	0.755	1.000	0.747

Table 4.11 presents the input and output values for the “intermediation approach 1” for the 22 banks:

Table 4.11 Input – Output Values for Intermediation Approach 1
(monetary values are in terms of millions of Turkish Liras)

	DMU	input1 deposits	input2 interest costs	input3 employee expenses	input4 physical assets	output 1 loans	output 2 bonds	output 3 interest income
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	83883.435	9265.832	915.128	1491.551	30836.194	58521.823	13368.109
2	Türkiye İş Bankası A.Ş.	63539.185	6977.852	1251.804	5048.327	47610.332	25164.189	10596.147
3	Türkiye Garanti Bankası A.Ş.	52715.281	6200.432	962.916	2021.597	49907.407	25698.336	9378.392
4	Akbank T.A.Ş.	52181.947	6212.528	833.754	1763.465	44374.104	27066.066	9700.358
5	Yapı ve Kredi Bankası A.Ş.	41705.329	4608.669	873.717	4240.949	38672.952	13183.169	7023.786
6	Türkiye Vakıflar Bankası T.A.O.	37120.277	4438.967	557.063	1554.813	30502.299	11500.03	6413.658
7	Türkiye Halk Bankası A.Ş.	40271.114	4666.693	507.192	1385.32	25836.298	18333.549	6792.931
8	Finans Bank A.Ş.	15939.067	2001.853	464.599	771.138	17878.045	5275.231	3709.241
9	Denizbank A.Ş.	9999.213	1267.234	372.885	610.509	12759.178	2944.747	2362.657
10	ING Bank A.Ş.	9997.729	1396.591	322.07	252.343	11044.083	3191.075	2208.567
11	Türk Ekonomi Bankası A.Ş.	9271.747	1261.604	350.471	330.901	8504.777	2186.042	1965.791
12	HSBC Bank A.Ş.	9183.424	1059.048	402.967	391.976	9723.783	1120.418	2235.379
13	Fortis Bank A.Ş.	5460.673	923.985	296.034	373.281	7238.078	2494.84	1627.272
14	Şekerbank T.A.Ş.	5931.571	695.01	203.73	278.543	4799.814	2313.548	1321.601
15	Citibank A.Ş.	4228.633	336.469	147.99	44.29	2512.889	1066.327	757.291
16	Alternatif Bank A.Ş.	2653.553	251.98	59.59	59.99	2370.575	309.339	448.961
17	Eurobank Tekfen A.Ş.	1795.524	378.723	38.358	164.355	1091.606	1779.722	457.703
18	Anadolubank A.Ş.	2086.935	258.471	89.388	92.153	1958.164	733.29	473.259
19	Tekstil Bankası A.Ş.	1434.47	262.142	82.238	123.935	1606.119	393.544	422.616
20	Millennium Bank A.Ş.	986.008	65.43	26.984	9.034	883.815	39.063	113.634
21	Turkland Bank A.Ş.	577.887	71.539	35.721	19.276	594.796	101.862	123.047
22	Turkish Bank A.Ş.	413.34	41.484	14.076	39.851	201.734	105.479	70.781

DEA-CCR, DEA-BCC, CCR with discretionary inputs, Super-CCR, NIRS and NDRS are applied to the approach above and the results can be seen in Table 4.12. Note that input-1 and input-2 are defined as nondiscretionary inputs for CCR NDI.

Table 4.12 CCR and BCC Efficiency Values for Intermediation Approach 1

	DMU	CCR	CCR NDI	Super CCR	BCC	NIRS	NDRS
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	1.000	2.487	1.000	1.000	1.000
2	Türkiye İş Bankası A.Ş.	0.910	0.714	0.910	1.000	1.000	0.714
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.064	1.000	1.000	1.000
4	Akbank T.A.Ş.	1.000	1.000	1.077	1.000	1.000	1.000
5	Yapı ve Kredi Bankası A.Ş.	0.967	0.904	0.967	1.000	1.000	0.904
6	Türkiye Vakıflar Bankası T.A.O.	1.000	1.000	1.029	1.000	1.000	1.000
7	Türkiye Halk Bankası A.Ş.	1.000	1.000	1.068	1.000	1.000	1.000
8	Finans Bank A.Ş.	1.000	1.000	1.067	1.000	1.000	1.000
9	Denizbank A.Ş.	1.000	1.000	1.120	1.000	1.000	1.000
10	ING Bank A.Ş.	1.000	1.000	1.235	1.000	1.000	1.000
11	Türk Ekonomi Bankası A.Ş.	0.897	0.747	0.897	0.752	0.747	0.752
12	HSBC Bank A.Ş.	1.000	1.000	1.083	1.000	1.000	1.000
13	Fortis Bank A.Ş.	1.000	1.000	1.179	1.000	1.000	1.000
14	Şekerbank T.A.Ş.	1.000	1.000	1.020	1.000	1.000	1.000
15	Citibank A.Ş.	1.000	1.000	1.504	1.000	1.000	1.000
16	Alternatif Bank A.Ş.	1.000	1.000	1.060	1.000	1.000	1.000
17	Eurobank Tekfen A.Ş.	1.000	1.000	1.472	1.000	1.000	1.000
18	Anadolubank A.Ş.	0.968	0.839	0.968	0.963	0.839	0.963
19	Tekstil Bankası A.Ş.	0.989	0.901	0.989	1.000	0.901	1.000
20	Millennium Bank A.Ş.	1.000	1.000	1.795	1.000	1.000	1.000
21	Turkland Bank A.Ş.	0.952	0.770	0.952	1.000	0.770	1.000
22	Turkish Bank A.Ş.	0.839	0.539	Infeasible	1.000	0.539	1.000

Totally 15 DMUs out of 22 are rated as technical efficient according to CCR. This approaches shows that using too many inputs and outputs cause less meaningful scores. In order to overcome this shortcoming, more DMUs should be added to the analysis. At this point Super CCR distinguishes these efficient DMUs and it is found out that the 1st DMU is the best managed DMU with a score of 2.487. The 22nd DMU's Super efficiency score is not available because the model yields infeasible solution. DEA-SBM (CRS), SBM (VRS), SBM (NIRS), SBM (NDRS) and reference sets based on SBM (CRS) results can be seen in Table 4.13:

Table 4.13 SBM (CRS) and Input Excess Values for Intermediation Approach 1

	DMU	SBM (CRS)	References (based on SBM-CRS)	Input excesses based on SBM-CRS			
				Input 1	Input 2	Input 3	Input 4
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000		0.000	0.000	0.000	0.000
2	Türkiye İş Bankası A.Ş.	0.744	1,4	6198.237	171.606	347.703	3148.689
3	Türkiye Garanti Bankası A.Ş.	1.000		0.000	0.000	0.000	0.000
4	Akbank T.A.Ş.	1.000		0.000	0.000	0.000	0.000
5	Yapı ve Kredi Bankası A.Ş.	0.807	3,20	613.009	9.981	81.455	2798.680
6	Türkiye Vakıflar Bankası T.A.O.	1.000		0.000	0.000	0.000	0.000
7	Türkiye Halk Bankası A.Ş.	1.000		0.000	0.000	0.000	0.000
8	Finans Bank A.Ş.	1.000		0.000	0.000	0.000	0.000
9	Denizbank A.Ş.	1.000		0.000	0.000	0.000	0.000
10	ING Bank A.Ş.	1.000		0.000	0.000	0.000	0.000
11	Türk Ekonomi Bankası A.Ş.	0.855	10,15	0.000	84.888	46.305	125.977
12	HSBC Bank A.Ş.	1.000		0.000	0.000	0.000	0.000
13	Fortis Bank A.Ş.	1.000		0.000	0.000	0.000	0.000
14	Şekerbank T.A.Ş.	1.000		0.000	0.000	0.000	0.000
15	Citibank A.Ş.	1.000		0.000	0.000	0.000	0.000
16	Alternatif Bank A.Ş.	1.000		0.000	0.000	0.000	0.000
17	Eurobank Tekfen A.Ş.	1.000		0.000	0.000	0.000	0.000
18	Anadolubank A.Ş.	0.919	1,10,13,15	0.000	0.000	6.523	23.198
19	Tekstil Bankası A.Ş.	0.904	12,13	0.000	24.211	5.391	28.161
20	Millennium Bank A.Ş.	1.000		0.000	0.000	0.000	0.000
21	Turkland Bank A.Ş.	0.831	10,12,15,20	0.000	0.000	15.934	4.426
22	Turkish Bank A.Ş.	0.665	1,8	105.963	3.034	5.303	25.293

Table 4.14 shows the SBM (VRS), SBM (NIRS), SBM (NDRS), scale efficiency, pure technical efficiency and mix efficiency.

Table 4.14 SBM (VRS, NIRS, NDRS), SE, PTE and Mix Efficiency Values for Intermediation Approach 1

	DMU	SBM (VRS)	SBM (NIRS)	SBM (NDRS)	Scale Eff	Pure Tech Eff	Mix Eff
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
2	Türkiye İş Bankası A.Ş.	1.000	1.000	0.744	0.910	1.000	0.818
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
4	Akbank T.A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
5	Yapı ve Kredi Bankası A.Ş.	1.000	1.000	0.807	0.967	1.000	0.835
6	Türkiye Vakıflar Bankası T.A.O.	1.000	1.000	1.000	1.000	1.000	1.000
7	Türkiye Halk Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
8	Finans Bank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
9	Denizbank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
10	ING Bank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
11	Türk Ekonomi Bankası A.Ş.	0.858	0.858	0.855	1.193	0.752	0.953
12	HSBC Bank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
13	Fortis Bank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
14	Şekerbank T.A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
15	Citibank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
16	Alternatif Bank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
17	Eurobank Tekfen A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
18	Anadolubank A.Ş.	0.973	0.919	0.973	1.004	0.963	0.949
19	Tekstil Bankası A.Ş.	1.000	0.904	1.000	0.989	1.000	0.914
20	Millennium Bank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
21	Turkland Bank A.Ş.	1.000	0.831	1.000	0.952	1.000	0.873
22	Turkish Bank A.Ş.	1.000	0.665	1.000	0.839	1.000	0.792

Again, it is observed that 22 DMUs are not ample for 7 inputs and outputs and therefore the efficiency scores are mostly equal to 1.

Table 4.15 presents the input and output values for the “intermediation approach 2” for the 22 banks:

Table 4.15 Input – Output Values for Intermediation Approach 2
(monetary values are in terms of millions of Turkish Liras)

	DMU	input1 deposits	input2 interest costs	input3 physical assets	output1 loans	output2 bonds
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	83883.435	9265.832	1491.551	30836.194	58521.823
2	Türkiye İş Bankası A.Ş.	63539.185	6977.852	5048.327	47610.332	25164.189
3	Türkiye Garanti Bankası A.Ş.	52715.281	6200.432	2021.597	49907.407	25698.336
4	Akbank T.A.Ş.	52181.947	6212.528	1763.465	44374.104	27066.066
5	Yapı ve Kredi Bankası A.Ş.	41705.329	4608.669	4240.949	38672.952	13183.169
6	Türkiye Vakıflar Bankası T.A.O.	37120.277	4438.967	1554.813	30502.299	11500.03
7	Türkiye Halk Bankası A.Ş.	40271.114	4666.693	1385.32	25836.298	18333.549
8	Finans Bank A.Ş.	15939.067	2001.853	771.138	17878.045	5275.231
9	Denizbank A.Ş.	9999.213	1267.234	610.509	12759.178	2944.747
10	ING Bank A.Ş.	9997.729	1396.591	252.343	11044.083	3191.075
11	Türk Ekonomi Bankası A.Ş.	9271.747	1261.604	330.901	8504.777	2186.042
12	HSBC Bank A.Ş.	9183.424	1059.048	391.976	9723.783	1120.418
13	Fortis Bank A.Ş.	5460.673	923.985	373.281	7238.078	2494.84
14	Şekerbank T.A.Ş.	5931.571	695.01	278.543	4799.814	2313.548
15	Citibank A.Ş.	4228.633	336.469	44.29	2512.889	1066.327
16	Alternatif Bank A.Ş.	2653.553	251.98	59.99	2370.575	309.339
17	Eurobank Tekfen A.Ş.	1795.524	378.723	164.355	1091.606	1779.722
18	Anadolubank A.Ş.	2086.935	258.471	92.153	1958.164	733.29
19	Tekstil Bankası A.Ş.	1434.47	262.142	123.935	1606.119	393.544
20	Millennium Bank A.Ş.	986.008	65.43	9.034	883.815	39.063
21	Turkland Bank A.Ş.	577.887	71.539	19.276	594.796	101.862
22	Turkish Bank A.Ş.	413.34	41.484	39.851	201.734	105.479

DEA-CCR, DEA-BCC, CCR with discretionary inputs, Super-CCR, NIRS and NDRS are applied to the approach above and the results can be seen in Table 4.16. Note that input-1 and input-2 are defined as nondiscretionary input for CCR NDI.

Table 4.16 CCR and BCC Efficiency Values for Intermediation Approach 2

	DMU	CCR	CCR NDI	Super CCR	BCC	NIRS	NDRS
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	1.000	2.078	1.000	1.000	1.000
2	Türkiye İş Bankası A.Ş.	0.860	0.224	0.860	0.860	0.860	0.860
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.043	1.000	1.000	1.000
4	Akbank T.A.Ş.	1.000	1.000	1.004	1.000	1.000	1.000
5	Yapı ve Kredi Bankası A.Ş.	0.902	0.221	0.902	1.000	1.000	0.902
6	Türkiye Vakıflar Bankası T.A.O.	0.783	0.401	0.783	0.820	0.820	0.783
7	Türkiye Halk Bankası A.Ş.	0.827	0.491	0.827	0.828	0.827	0.828
8	Finans Bank A.Ş.	0.968	0.841	0.968	1.000	1.000	0.968
9	Denizbank A.Ş.	1.000	1.000	1.111	1.000	1.000	1.000
10	ING Bank A.Ş.	1.000	1.000	Infeasible	1.000	1.000	1.000
11	Türk Ekonomi Bankası A.Ş.	0.794	0.472	0.794	0.796	0.794	0.796
12	HSBC Bank A.Ş.	0.914	0.568	0.914	0.982	0.982	0.914
13	Fortis Bank A.Ş.	1.000	1.000	1.132	1.000	1.000	1.000
14	Şekerbank T.A.Ş.	0.837	0.412	0.837	0.857	0.837	0.857
15	Citibank A.Ş.	1.000	1.000	1.024	1.000	1.000	1.000
16	Alternatif Bank A.Ş.	0.879	0.525	0.879	0.972	0.972	0.879
17	Eurobank Tekfen A.Ş.	1.000	1.000	Infeasible	1.000	1.000	1.000
18	Anadolubank A.Ş.	0.872	0.492	0.872	0.918	0.872	0.918
19	Tekstil Bankası A.Ş.	0.845	0.326	0.873	0.921	0.845	0.921
20	Millennium Bank A.Ş.	1.000	1.000	1.781	1.000	1.000	1.000
21	Turkland Bank A.Ş.	0.917	0.582	0.917	1.000	0.917	1.000
22	Turkish Bank A.Ş.	0.609	0.100	0.609	1.000	0.609	1.000

The 1st, 3rd, 4th, 9th, 10th, 13th, 15th, 17th and 20th DMUs are rated as technical efficient according to CCR. At this point Super CCR distinguishes these efficient DMUs and it is found out that the 1st DMU is the best managed DMU with a score of 2.078. The 10th and 17th DMUs' Super efficiency scores are not available because the model yields infeasible solution. DEA-SBM (CRS), SBM (VRS), SBM (NIRS), SBM (NDRS) and reference sets based on SBM (CRS) results can be seen in Table 4.17:

Table 4.17 SBM (CRS) and Input Excess Values for Intermediation Approach 2

	DMU	SBM (CRS)	References (based on SBM-CRS)	Input excesses based on SBM-CRS		
				Input 1	Input 2	Input 3
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000		0.000	0.000	0.000
2	Türkiye İş Bankası A.Ş.	0.682	1,3	12469.691	980.136	3116.089
3	Türkiye Garanti Bankası A.Ş.	1.000		0.000	0.000	0.000
4	Akbank T.A.Ş.	1.000		0.000	0.000	0.000
5	Yapı ve Kredi Bankası A.Ş.	0.716	3,9	7313.247	394.275	2500.518
6	Türkiye Vakıflar Bankası T.A.O.	0.745	1,10	6476.922	291.153	815.256
7	Türkiye Halk Bankası A.Ş.	0.796	1,10	4621.659	223.928	622.591
8	Finans Bank A.Ş.	0.947	3,9,10,20	0.000	0.000	122.774
9	Denizbank A.Ş.	1.000		0.000	0.000	0.000
10	ING Bank A.Ş.	1.000		0.000	0.000	0.000
11	Türk Ekonomi Bankası A.Ş.	0.736	10,20	1339.520	244.243	150.577
12	HSBC Bank A.Ş.	0.845	9,20	0.000	212.362	103.882
13	Fortis Bank A.Ş.	1.000		0.000	0.000	0.000
14	Şekerbank T.A.Ş.	0.784	3,10	967.273	97.137	96.461
15	Citibank A.Ş.	1.000		0.000	0.000	0.000
16	Alternatif Bank A.Ş.	0.785	1,10,20	0.000	42.518	28.525
17	Eurobank Tekfen A.Ş.	1.000		0.000	0.000	0.000
18	Anadolubank A.Ş.	0.827	3,10	202.368	12.493	34.323
19	Tekstil Bankası A.Ş.	0.688	9,10,20	0.000	81.001	77.802
20	Millennium Bank A.Ş.	1.000		0.000	0.000	0.000
21	Turkland Bank A.Ş.	0.832	10,20	0.000	6.153	8.053
22	Turkish Bank A.Ş.	0.445	1,3	198.328	16.217	31.670

Table 4.18 shows the SBM (VRS), SBM (NIRS), SBM (NDRS), scale efficiency, pure technical efficiency and mix efficiency.

Table 4.18 SBM (VRS, NIRS, NDRS), SE, PTE and Mix Efficiency Values for Intermediation Approach 2

	DMU	SBM (VRS)	SBM (NIRS)	SBM (NDRS)	Scale Eff	Pure Tech Eff	Mix Eff
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
2	Türkiye İş Bankası A.Ş.	0.682	0.682	0.682	1.000	0.860	0.793
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
4	Akbank T.A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
5	Yapı ve Kredi Bankası A.Ş.	1.000	1.000	0.716	0.902	1.000	0.794
6	Türkiye Vakıflar Bankası T.A.O.	0.811	0.811	0.745	0.955	0.820	0.952
7	Türkiye Halk Bankası A.Ş.	0.805	0.805	0.796	0.998	0.828	0.963
8	Finans Bank A.Ş.	1.000	1.000	0.947	0.968	1.000	0.978
9	Denizbank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
10	ING Bank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
11	Türk Ekonomi Bankası A.Ş.	0.753	0.753	0.736	0.998	0.796	0.926
12	HSBC Bank A.Ş.	0.941	0.941	0.845	0.931	0.982	0.924
13	Fortis Bank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
14	Şekerbank T.A.Ş.	0.788	0.784	0.788	0.977	0.857	0.936
15	Citibank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
16	Alternatif Bank A.Ş.	0.907	0.907	0.785	0.904	0.972	0.893
17	Eurobank Tekfen A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
18	Anadolubank A.Ş.	0.858	0.827	0.858	0.950	0.918	0.949
19	Tekstil Bankası A.Ş.	0.720	0.688	0.720	0.917	0.921	0.814
20	Millennium Bank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
21	Turkland Bank A.Ş.	1.000	0.832	1.000	0.917	1.000	0.907
22	Turkish Bank A.Ş.	1.000	0.445	1.000	0.609	1.000	0.730

Table 4.19 presents the input and output values for the “profit based approach 1” for the 22 banks:

Table 4.19 Input – Output Values for Profit Based Approach 1

(Monetary values are in terms of millions of Turkish Liras)

	DMU	input1 # of employees	input2 # of branches	input3 equity capital	output1 net profit	output2 total income
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	21299	1269	7361.236	2134.259	4986.058
2	Türkiye İş Bankası A.Ş.	20924	1039	9449.011	1509.408	6231.541
3	Türkiye Garanti Bankası A.Ş.	16350	726	9469.074	1750.488	5270.824
4	Akbank T.A.Ş.	15127	868	11208.372	1704.553	5395.322
5	Yapı ve Kredi Bankası A.Ş.	14795	861	6853.047	1042.601	4245.838
6	Türkiye Vakıflar Bankası T.A.O.	9567	525	5670.999	753.198	2868.829
7	Türkiye Halk Bankası A.Ş.	12467	622	4288.827	1018.315	2704.911
8	Finans Bank A.Ş.	9986	458	2839.819	362.648	2122.435
9	Denizbank A.Ş.	7376	400	2034.14	278.09	1279.402
10	ING Bank A.Ş.	6357	366	1610.176	140.053	915.121
11	Türk Ekonomi Bankası A.Ş.	6400	336	1423.619	164.198	1027.203
12	HSBC Bank A.Ş.	6853	335	2268.926	249.686	1508.134
13	Fortis Bank A.Ş.	5378	300	1805.009	144.671	948.702
14	Şekerbank T.A.Ş.	4089	250	975.271	144.307	777.671
15	Citibank A.Ş.	2315	56	796.194	81.361	587.336
16	Alternatif Bank A.Ş.	1006	46	375.267	53.016	259.095
17	Eurobank Tekfen A.Ş.	661	42	272.563	12.367	115.719
18	Anadolubank A.Ş.	1718	77	509.124	86.852	265.532
19	Tekstil Bankası A.Ş.	1410	60	449.827	12.579	185.255
20	Millennium Bank A.Ş.	320	18	147.281	2.865	54.976
21	Turkland Bank A.Ş.	457	25	207.302	0.836	66.862
22	Turkish Bank A.Ş.	292	26	145.496	10.01	43.138

DEA-CCR, DEA-BCC, CCR with discretionary inputs, Super-CCR, NIRS and NDRS are applied to the approach above and the results can be seen in Table 4.20. Note that input-3 is defined as nondiscretionary input for CCR NDI.

Table 4.20 CCR and BCC Efficiency Values for Profit Based Approach 1

	DMU	CCR	CCR NDI	Super CCR	BCC	NIRS	NDRS
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	1.000	1.224	1.000	1.000	1.000
2	Türkiye İş Bankası A.Ş.	1.000	1.000	1.046	1.000	1.000	1.000
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.228	1.000	1.000	1.000
4	Akbank T.A.Ş.	1.000	1.000	1.106	1.000	1.000	1.000
5	Yapı ve Kredi Bankası A.Ş.	0.956	0.936	0.956	0.938	0.936	0.938
6	Türkiye Vakıflar Bankası T.A.O.	0.918	0.871	0.918	0.877	0.871	0.877
7	Türkiye Halk Bankası A.Ş.	0.947	0.882	0.947	0.891	0.882	0.891
8	Finans Bank A.Ş.	0.979	0.914	0.979	1.000	1.000	0.914
9	Denizbank A.Ş.	0.828	0.570	0.828	0.583	0.570	0.583
10	ING Bank A.Ş.	0.723	0.449	0.723	0.465	0.449	0.465
11	Türk Ekonomi Bankası A.Ş.	0.912	0.616	Infeasible	0.650	0.650	0.616
12	HSBC Bank A.Ş.	0.901	0.748	0.901	0.756	0.748	0.756
13	Fortis Bank A.Ş.	0.712	0.525	0.712	0.544	0.525	0.544
14	Şekerbank T.A.Ş.	1.000	1.000	1.073	1.000	1.000	1.000
15	Citibank A.Ş.	1.000	1.000	1.445	1.000	1.000	1.000
16	Alternatif Bank A.Ş.	0.980	0.934	Infeasible	1.000	0.934	1.000
17	Eurobank Tekfen A.Ş.	0.621	0.491	0.621	0.739	0.491	0.739
18	Anadolubank A.Ş.	0.743	0.478	0.743	0.780	0.478	0.780
19	Tekstil Bankası A.Ş.	0.550	0.416	0.550	0.535	0.416	0.535
20	Millennium Bank A.Ş.	0.573	0.486	0.573	1.000	0.486	1.000
21	Turkland Bank A.Ş.	0.491	0.419	0.491	0.781	0.419	0.781
22	Turkish Bank A.Ş.	0.481	0.414	0.481	1.000	0.414	1.000

The 1st, 2nd, 3rd, 4th, 9th, 14th and 15th DMUs are rated as technical efficient according to CCR. At this point Super CCR distinguishes these efficient DMUs and it is found out that the 15th DMU is the best managed DMU with a score of 1.445. The 11th and 16th DMUs' Super efficiency scores are not available because the model yields infeasible solution. DEA-SBM (CRS), SBM (VRS), SBM (NIRS), SBM (NDRS) and reference sets based on SBM (CRS) results can be seen in Table 4.21:

Table 4.21 SBM (CRS) and Input Excess Values for Profit Based Approach 1

	DMU	SBM (CRS)	References (based on SBM-CRS)	Input excesses based on SBM-CRS		
				Input 1	Input 2	Input 3
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000		0.000	0.000	0.000
2	Türkiye İş Bankası A.Ş.	1.000		0.000	0.000	0.000
3	Türkiye Garanti Bankası A.Ş.	1.000		0.000	0.000	0.000
4	Akbank T.A.Ş.	1.000		0.000	0.000	0.000
5	Yapı ve Kredi Bankası A.Ş.	0.858	3,15	30.780	356.657	62.339
6	Türkiye Vakıflar Bankası T.A.O.	0.845	3,15	0.000	163.578	867.913
7	Türkiye Halk Bankası A.Ş.	0.904	1,3,15	2112.469	73.130	0.000
8	Finans Bank A.Ş.	0.892	1,14,15	854.138	108.802	0.000
9	Denizbank A.Ş.	0.650	3,15	2770.620	255.927	70.061
10	ING Bank A.Ş.	0.531	3,15	2807.644	275.838	339.377
11	Türk Ekonomi Bankası A.Ş.	0.647	1,3,15	2391.052	229.931	0.000
12	HSBC Bank A.Ş.	0.746	3,15	1085.469	182.277	131.636
13	Fortis Bank A.Ş.	0.575	3,15	1696.137	206.643	488.765
14	Şekerbank T.A.Ş.	1.000		0.000	0.000	0.000
15	Citibank A.Ş.	1.000		0.000	0.000	0.000
16	Alternatif Bank A.Ş.	0.887	1,3,15	14.978	14.886	0.000
17	Eurobank Tekfen A.Ş.	0.509	15	204.891	30.967	115.694
18	Anadolubank A.Ş.	0.628	3,15	888.541	40.718	35.131
19	Tekstil Bankası A.Ş.	0.457	15	679.813	42.337	198.695
20	Millennium Bank A.Ş.	0.491	15	103.311	12.758	72.755
21	Turkland Bank A.Ş.	0.423	15	193.462	18.625	116.664
22	Turkish Bank A.Ş.	0.393	3,15	139.467	21.003	77.830

Table 4.22 shows the SBM (VRS), SBM (NIRS), SBM (NDRS), scale efficiency, pure technical efficiency and mix efficiency.

Table 4.22 SBM (VRS, NIRS, NDRS), SE, PTE and Mix Efficiency Values for Profit Based Approach 1

	DMU	SBM (VRS)	SBM (NIRS)	SBM (NDRS)	Scale Eff	Pure Tech Eff	Mix Eff
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
2	Türkiye İş Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
4	Akbank T.A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
5	Yapı ve Kredi Bankası A.Ş.	0.899	0.899	0.858	1.019	0.938	0.898
6	Türkiye Vakıflar Bankası T.A.O.	0.857	0.857	0.845	1.047	0.877	0.920
7	Türkiye Halk Bankası A.Ş.	0.907	0.904	0.907	1.063	0.891	0.955
8	Finans Bank A.Ş.	1.000	1.000	0.892	0.979	1.000	0.912
9	Denizbank A.Ş.	0.662	0.662	0.650	1.421	0.583	0.785
10	ING Bank A.Ş.	0.550	0.550	0.531	1.554	0.465	0.735
11	Türk Ekonomi Bankası A.Ş.	0.702	0.702	0.647	1.403	0.650	0.710
12	HSBC Bank A.Ş.	0.800	0.800	0.746	1.191	0.756	0.829
13	Fortis Bank A.Ş.	0.599	0.599	0.575	1.308	0.544	0.808
14	Şekerbank T.A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
15	Citibank A.Ş.	1.000	1.000	1.000	1.000	1.000	1.000
16	Alternatif Bank A.Ş.	1.000	0.887	1.000	0.980	1.000	0.906
17	Eurobank Tekfen A.Ş.	0.725	0.509	0.725	0.840	0.739	0.820
18	Anadolubank A.Ş.	0.803	0.628	0.803	0.952	0.780	0.846
19	Tekstil Bankası A.Ş.	0.570	0.457	0.570	1.028	0.535	0.830
20	Millennium Bank A.Ş.	1.000	0.491	1.000	0.573	1.000	0.857
21	Turkland Bank A.Ş.	0.777	0.423	0.777	0.628	0.781	0.862
22	Turkish Bank A.Ş.	1.000	0.393	1.000	0.481	1.000	0.818

5 distinct input-output approaches are presented so far. The next step is evaluating the findings in the light of some correlations. The below table includes data for the 22 commercial banks:

Table 4.23 Data (1) to be correlated with SBM efficiency rates

	DMU	SBM	ROA	ROE	Age	Turkish based	State based	Average employee cost
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	2.04	28.99	145	1	1	2.50
2	Türkiye İş Bankası A.Ş.	1.000	1.55	15.97	84	1	0	3.26
3	Türkiye Garanti Bankası A.Ş.	1.000	1.97	18.49	62	1	0	3.19
4	Akbank T.A.Ş.	1.000	1.99	15.21	60	1	0	2.99
5	Yapı ve Kredi Bankası A.Ş.	0.858	1.64	15.21	64	1	0	3.20
6	Türkiye Vakıflar Bankası T.A.O.	0.845	1.44	13.28	54	1	1	3.32
7	Türkiye Halk Bankası A.Ş.	0.904	1.99	23.74	70	1	1	2.40
8	Finans Bank A.Ş.	0.892	1.36	12.77	21	0	0	2.53
9	Denizbank A.Ş.	0.650	1.45	13.67	11	0	0	2.75
10	ING Bank A.Ş.	0.531	0.85	8.70	24	0	0	2.74
11	Türk Ekonomi Bankası A.Ş.	0.647	1.11	11.53	81	0	0	2.99
12	HSBC Bank A.Ş.	0.746	1.70	11.00	18	0	0	3.21
13	Fortis Bank A.Ş.	0.575	1.21	8.01	44	0	0	3.03
14	Şekerbank T.A.Ş.	1.000	1.79	14.80	55	0	0	2.75
15	Citibank A.Ş.	1.000	1.49	10.22	28	0	0	3.47
16	Alternatif Bank A.Ş.	0.887	1.42	14.13	16	1	0	3.23
17	Eurobank Tekfen A.Ş.	0.509	0.36	4.54	16	0	0	3.20
18	Anadolubank A.Ş.	0.628	2.57	17.06	12	1	0	2.82
19	Tekstil Bankası A.Ş.	0.457	0.43	2.80	22	1	0	3.16
20	Millennium Bank A.Ş.	0.491	0.24	1.95	24	0	0	4.59
21	Turkland Bank A.Ş.	0.423	0.08	0.40	17	0	0	4.29
22	Turkish Bank A.Ş.	0.393	1.22	6.88	26	0	0	2.61

Table 4.24 Data (2) to be correlated with SBM efficiency rates

	DMU	Market share (total assets) %	Total loans / Total assets %	Consumer loans / Total loans %	Total loans / total deposits %	Loans under followup / Total loans %	Interest revenue / total revenue %	Capital adequacy ratio (CAR) %
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	14.79	29.53	43.10	36.76	1.96	77.36	20.08
2	Türkiye İş Bankası A.Ş.	13.82	48.81	29.66	74.93	4.61	41.15	15.19
3	Türkiye Garanti Bankası A.Ş.	12.60	56.11	32.72	94.67	2.48	52.35	16.14
4	Akbank T.A.Ş.	12.13	51.81	32.40	85.04	2.57	46.14	18.20
5	Yapı ve Kredi Bankası A.Ş.	9.03	60.69	34.88	92.73	4.43	47.97	15.75
6	Türkiye Vakıflar Bankası T.A.O.	7.39	58.44	28.29	82.17	4.77	55.26	14.30
7	Türkiye Halk Bankası A.Ş.	7.24	50.56	21.18	64.16	4.84	69.62	14.49
8	Finans Bank A.Ş.	3.76	67.28	50.38	112.16	3.69	58.91	16.05
9	Denizbank A.Ş.	2.72	66.37	32.72	127.60	3.20	75.39	17.18
10	ING Bank A.Ş.	2.34	66.92	33.49	110.47	2.43	82.33	13.76
11	Türk Ekonomi Bankası A.Ş.	2.09	57.71	19.45	91.73	2.37	58.78	17.65
12	HSBC Bank A.Ş.	2.08	66.17	56.46	105.88	5.33	62.21	15.36
13	Fortis Bank A.Ş.	1.69	60.75	40.08	132.55	5.38	66.53	14.78
14	Şekerbank T.A.Ş.	1.14	59.69	16.09	80.92	4.92	68.00	14.70
15	Citibank A.Ş.	0.77	46.10	50.93	59.43	10.36	52.50	17.85
16	Alternatif Bank A.Ş.	0.53	63.30	0.57	89.34	5.44	57.13	14.11
17	Eurobank Tekfen A.Ş.	0.49	31.36	1.53	60.80	6.96	51.32	17.89
18	Anadolubank A.Ş.	0.48	57.87	24.41	93.83	2.25	74.26	18.46
19	Tekstil Bankası A.Ş.	0.42	54.39	15.02	111.97	3.32	63.45	17.94
20	Millennium Bank A.Ş.	0.17	73.25	64.58	89.64	1.23	85.31	22.34
21	Turkland Bank A.Ş.	0.14	58.28	1.13	102.93	2.60	69.87	21.87
22	Turkish Bank A.Ş.	0.12	24.51	1.51	48.81	4.40	56.88	34.49

Depending on the above data the below correlation values are maintained. SBM refers to the profit based approach 1 because the aim is to compare the banking data with the profitability of the banks.

Table 4.25 Correlations between SBM efficiency scores and banking data for 22 banks

Banking Data	**SBM**
ROA	0.704645
ROE	0.760646
Age	0.554668
Turkish based	0.470171
State based	0.312737
Average employee cost	-0.29704
Market share	0.680074
Total loans / Total assets	-0.01375
Consumer loans / Total loans	0.293767
Total loans / Total deposits	-0.30028
Loans under follow up / Total loans	0.236974
Interest revenue / Total revenue	-0.41787
CAR	-0.49065

The above correlation values are crucial to interpret the SBM scores. First of all, ROA and ROE are the basic banking profitability indicators that are commonly used in the sector. No surprise, they are highly correlated with the SBM scores (0.704 and 0.760). This is kind of a proof that our SBM scores reflect profitability of the 22 banks, indeed. The second data is about the ages of the banks. The banks' ages range between 11 and 145. The correlation value of 0.554 shows that long-established banks have a greater advantage in terms of profitability. Similarly, the correlation of market shares is also quite high (0.68). Age and market shares are also highly correlated between each other (0.786). In this case, one can conclude that old banks have a longer history and they have well organized their operations, technology, infrastructure and processes. By this way, they use their own capacity better and obtain higher profitability. On the other hand, smaller and more recently established banks still have to improve their organizations and processes. They are not able to use their facilities or they could not form their client base, yet.

Turkish based and state based banks have higher profitability scores according to the positive correlation values (0.47 and 0.31). It could be basically thought that state banks are not competitive, they have too much complicated processes and they do not

work efficiently but reversely, due to the high governmental deposits and high thrust of public opinion they can easily form a loyal customer base. Especially, Ziraat Bankası benefits from an extremely high deposit that is around 83.8 billions Turkish Liras in 2008 and is the first by far. Unlike the inspiring profitability of the state banks in 2008, the bad scenario of pre-crisis period for the state banks will be introduced throughout the paper.

Average employee cost has a negative correlation (-0.297) with SBM scores. Obviously, cutting employee expenses or recruiting employees with lower salaries provides a surplus to the budget. Holding too qualified employees with higher salaries is not a beneficial strategy for the 22 commercial banks.

Total loans per total assets ratio has a correlation that is around zero (-0.01375). This can be interpreted as the loan ratio is not an important strategic issue for the commercial banks. However, this strategy should differ for different kinds of banks and this will be handled later in the paper.

Marketing and selling consumer loans are of benefit of the banks according to the mid-high correlation value of consumer loans per total loans (0.293767). Therefore, if a commercial bank sets a certain marketing budget for advertisements, especially consumer loans should be emphasized for higher profitability. Similarly, consumer loans should cross-sold with the other loan products.

The conversion rate of deposits to the loans (total loans per total deposits) is negatively correlated with the SBM efficiency scores (-0.30028). Thus, collecting high amounts of deposits is also crucial for the commercial banks in Turkey.

The negative correlation (-0.41787) of interest revenue per total revenue shows that selling loans is not the only way to obtain profitability. In addition to the interest revenue, banks should maintain revenue from the other customer services such as transaction fees, foreign exchange (FX) trading, stock exchange commissions, etc.

The correlation value of loans under follow-up per total loans (0.236974) is extremely meaningful in terms of risk management. The commercial banks act in an extremely conservative manner due to the high level of fear for the bad loans. However, our efficiency scores and correlation values show that taking more risk is the best strategy for higher profitability. In parallel with the loans under follow-up, the correlation of capital adequacy rate (CAR) (-0.49065) also proves that higher risk means higher profitability. Thus, banks should set their CAR at 8% that is the minimum allowed rate by the regulatory institution.

The above correlation values and their interpretations are about all the 22 banks. However, these 22 banks can be categorized into two groups as primary banks and secondary banks on the issue of customer loyalty. In other words, there are three state banks and four private banks (İş Bankası, Akbank, Garanti and Yapı Kredi) and in the banking sector it is well known that nearly all customers have at least one account and they execute basic banking transactions through these banks (credit cards, salary payments, rental payments, money transfers, etc.). Therefore, these 7 banks can be defined as 'primary' banks. The rest of the banks are relatively smaller banks that can be defined as secondary banks and they should be more competitive to acquire higher shares from the market. The secondary banks' correlations are evaluated distinctly.

Table 4.26 Correlations between SBM efficiency scores and banking data for the 15 secondary banks

Banking Data	**SBM**
ROA	0.590771
ROE	0.696084
Age	0.183853
Turkish based	0.005021
State based	N/A
Average employee cost	-0.265054
Market share	0.356089
Total loans / Total assets	0.261290
Consumer loans / Total loans	0.279340
Total loans / Total deposits	-0.080719
Loans under followup / Total loans	0.517225
Interest revenue / Total revenue	-0.315213
CAR	-0.536201

Once again, ROA and ROE have highly positive correlation values (0.590771 and 0.696084) with the SBM scores for the secondary banks. Similarly, age has a positive but smaller correlation (0.183853). Being Turkish based is not important at all according to the correlation value (0.005021). Since there exist no state banks among 15 secondary banks, the correlation of state based banks is not available. The correlation of average employee cost (-0.265054) is nearly the same with the correlation of all banks (-0.29704) and once more we can conclude as commercial banks should not recruit employees with high salaries. Market share is again an important factor for the banks due to the positive correlation value (0.356089).

The ratio of total loans per total assets deserves slightly more interest because its correlation value for the all 22 banks (-0.01375) is around zero while the correlation for the secondary banks is positive (0.261290). This situation implies that primary banks take the advantage of earning profit through transaction fees and other revenues. On the other side, according to the positive correlation, among the secondary banks those who sell more loans are more profitable. Thus, for a secondary bank that is not highly profitable, the short term goal should be increasing loans instead of selling government

bonds and the long term goal should be structuring the customer base and becoming a primary bank.

Similar to the 22 banks case, again, consumer loans are profitable loan products for the secondary banks according to the positive correlation value (0.279340). Total loans per total deposits ratio is not crucial according to the correlation value (-0.080719) that is close to zero. The correlation of interest revenue per total revenue (-0.315213) shows that operational revenues, fees, commissions, FX trading revenues are more important for also the 15 secondary banks.

Based on the correlations of loans under follow-up per total loans (0.236974) and CAR (-0.49065), we concluded that banks should take much more risk in order to acquire more profits. According to the same correlation values (0.517225 and -0.536201 respectively) taking more risks is even more important for the secondary banks. Hence, secondary banks should decrease their capital adequacy ratios for improved profitability.

Banking sector has been evaluated in a single period (2008) so far. From now on, each of ten years will be analyzed and fluctuations of the sector will be interpreted. Our analysis includes ten years (1998-2008) but 2001 data will not be included due to too many negative data. Since profitability is the area of concern in the paper, input-output combination is selected according to the profit based approach. Besides, in order to overcome the effect of inflation on the monetary values, each year's data is adjusted to the 2008 by multiplying by inflation.

We have used the profit based approach 1 so far. From now on, we will be using profit based approach 2. Note that for the all ten years, the monetary values are in terms of millions of TL. Below are the inputs, outputs and SBM scores of the year 1998:

Table 4.27 Input and output data of year 1998

source: Turkish Banking Association (TBA)

DMU	input1 # of employees	input2 non-interest costs - adjusted	output1 TL Deposit - adjusted	output2 FX Deposit - adjusted	output3 Loans - adjusted	output4 Gov. Bonds - adjusted	output5 net profit - adjusted	output6 total income - adjusted	SBM
Ziraat	36460	3595.371	26549.046	15326.741	7554.143	6382.986	283.709	5690.675	1.000
İş Bankası	14827	2534.181	2920.671	14641.439	15464.379	3617.348	1831.797	6902.247	0.764
Garanti	7748	2530.155	2485.672	12837.327	14824.699	8889.903	2085.543	7990.525	1.000
Akbank	7911	1658.326	4271.982	12157.042	11715.223	7258.517	2683.045	11515.721	1.000
YKB	12029	2806.773	4672.464	19595.713	19580.718	5247.718	1670.460	7289.442	1.000
Vakıfbank	9450	1814.877	2178.278	7283.517	10659.144	5160.785	1010.768	3651.378	0.785
Halkbank	14559	1723.742	13193.583	5356.328	3691.658	2869.816	199.068	3719.505	1.000
Finans Bank	1536	505.377	29.434	1607.769	1773.363	2058.360	472.107	3192.774	1.000
Denizbank	584	148.403	22.004	689.532	436.396	35.494	42.259	474.466	0.698
ING Bank	362	73.103	0.746	173.349	466.209	110.346	122.277	737.187	1.000
TEB	1275	323.541	154.490	1801.454	1182.057	1042.873	144.593	1008.206	0.839
HSBC	2018	798.468	357.897	2816.263	3597.743	3834.095	473.910	4237.613	1.000
Fortis	1384	877.333	57.173	1331.612	1332.466	2353.836	341.139	2271.229	0.771
Şekerbank	3188	316.085	1278.330	1150.399	1756.484	686.549	41.093	433.806	0.784
Citibank	454	1227.299	10.100	490.532	869.917	229.017	190.350	2920.373	1.000
Alternatif Bank	654	302.351	72.236	744.305	901.575	556.965	74.730	1446.283	0.945
Eurobank Tekfen	667	1652.225	384.782	239.117	535.028	101.683	0.518	1210.474	0.602
Anadolubank	213	40.971	15.673	195.990	130.954	32.593	14.900	127.836	0.625
Tekstil Bankası	955	207.731	56.251	448.503	1068.795	569.668	192.818	1149.938	0.757
Millennium Bank	302	42.219	36.809	77.591	66.324	53.689	5.613	135.659	0.354
Turkland Bank	319	51.587	12.839	86.281	98.592	95.107	40.443	159.290	0.428
Turkish Bank	251	27.251	40.510	131.754	47.222	44.822	6.345	45.120	0.501

According to the SBM efficiency scores in the above table, there are 9 efficient DMUs among the 22 commercial banks. Millenium Bank is the least efficient bank with a profitability score of 0.354.

Table 4.28 Input and output data of year 1999

source: Turkish Banking Association (TBA)

DMU	input1 # of employees	input2 non-interest costs - adjusted	output1 TL Deposit - adjusted	output2 FX Deposit - adjusted	output3 Loans - adjusted	output4 Gov. Bonds - adjusted	output5 net profit - adjusted	output6 total income - adjusted	SBM
Ziraat	37705	3894.816	39002.322	13877.348	7491.329	6933.354	328.262	8543.919	0.813
İş Bankası	15867	3456.343	4770.968	15743.524	13316.571	7246.326	2053.867	11230.194	0.646
Garanti	7597	3136.376	1791.670	15498.104	13952.925	12255.955	1874.986	3060.530	1.000
Akbank	8383	1990.639	5353.222	13712.090	11252.300	10475.408	2601.929	11375.790	1.000
YKB	12523	3472.516	4950.920	22278.572	18938.692	8456.182	2243.087	9156.092	1.000
Vakıfbank	9182	2201.891	2920.049	7357.558	8612.190	9794.874	700.654	1315.850	0.838
Halkbank	14843	1694.167	20736.491	6100.997	4119.544	3537.101	720.733	5078.758	1.000
Finans Bank	2029	599.506	39.815	2467.357	1933.409	1869.437	536.931	5676.270	1.000
Denizbank	714	177.934	14.277	1714.998	869.189	104.711	87.026	577.678	1.000
ING Bank	400	99.423	3.383	237.011	399.074	153.556	83.741	758.783	0.813
TEB	1405	511.050	63.572	2060.961	941.881	688.126	158.443	1269.784	0.601
HSBC	2556	1200.597	59.927	4299.684	4228.888	4906.635	880.680	10580.584	1.000
Fortis	1627	529.503	50.725	1796.336	837.277	1577.558	452.218	2079.234	0.781
Şekerbank	3158	313.674	623.573	1708.493	1231.962	326.260	78.175	498.743	0.505
Citibank	679	428.143	33.898	694.443	517.661	463.005	229.876	2229.791	0.827
Alternatif Bank	678	441.022	71.000	1882.332	1236.457	977.896	277.055	2583.893	1.000
Eurobank Tekfen	653	271.024	366.933	864.956	832.937	43.002	-263.873	1874.585	1.000
Anadolubank	356	51.493	88.489	697.842	369.581	101.090	36.154	240.141	1.000
Tekstil Bankası	1012	245.894	94.430	840.766	1264.561	302.323	210.337	1309.223	0.923
Millennium Bank	343	54.607	60.908	174.779	127.724	61.831	4.724	200.816	0.436
Turkland Bank	408	72.545	17.758	163.444	128.704	57.778	11.188	217.741	0.312
Turkish Bank	226	28.611	33.621	304.799	32.632	68.802	6.015	54.566	0.796

According to the SBM efficiency scores in the above table, there are 10 efficient DMUs among the 22 commercial banks. Turkland Bank is the least efficient bank with a profitability score of 0.312.

Table 4.29 Input and output data of year 2000

source: Turkish Banking Association (TBA)

DMU	input1 # of employees	input2 non-interest costs - adjusted	output1 TL Deposit - adjusted	output2 FX Deposit - adjusted	output3 Loans - adjusted	output4 Gov. Bonds - adjusted	output5 net profit - adjusted	output6 total income - adjusted	SBM
Ziraat	36576	5812.130	25768.031	11705.973	5111.578	4323.637	351.099	9182.770	0.622
İş Bankası	16133	3250.858	4877.875	14978.152	14114.291	3486.429	1236.687	12149.275	0.648
Garanti	6414	3614.481	2474.042	11878.534	14603.424	4772.983	1092.841	10313.956	1.000
Akbank	8244	1963.922	4839.366	12791.497	12727.191	3122.105	1662.734	14939.135	1.000
YKB	12786	3754.935	4036.283	17721.281	19080.682	5085.689	1333.953	7395.900	0.897
Vakıfbank	8590	2062.959	1860.347	6350.138	10477.744	2121.439	242.733	2458.349	0.787
Halkbank	15025	1545.643	15194.062	5060.811	2592.919	2788.238	22.482	3135.708	1.000
Finans Bank	2324	1074.104	89.020	2385.342	2798.449	503.355	343.622	4928.269	0.784
Denizbank	956	261.034	13.501	1214.432	967.040	248.022	22.192	716.386	0.747
ING Bank	386	139.791	9.107	239.868	373.407	29.789	0.017	548.959	0.597
TEB	1358	914.096	56.733	1729.827	1124.421	18.355	112.789	1457.576	0.550
HSBC	4225	4348.026	2647.422	2598.082	6447.427	4869.489	0.017	5074.414	1.000
Fortis	1586	899.544	45.221	1516.918	1331.054	984.640	342.190	1591.657	1.000
Şekerbank	3029	384.038	847.200	1499.183	1396.643	217.468	9.920	456.949	0.520
Citibank	849	428.824	78.799	661.724	634.291	129.697	144.998	1233.644	0.623
Alternatif Bank	738	530.362	43.160	1112.009	1239.388	442.078	54.120	3054.591	1.000
Eurobank Tekfen	629	301.218	282.495	614.620	550.391	255.517	0.017	79.975	0.682
Anadolubank	742	146.764	326.918	1130.571	570.343	202.573	14.749	415.279	1.000
Tekstil Bankası	1033	304.997	84.316	1080.816	772.746	8.009	86.721	1145.577	0.604
Millennium Bank	320	68.874	226.899	111.536	170.756	19.661	0.017	84.892	0.697
Turkland Bank	332	76.767	26.586	125.008	160.033	43.387	0.174	182.946	0.340
Turkish Bank	200	30.210	61.790	98.059	17.014	42.826	21.994	103.363	0.726

According to the SBM efficiency scores in the above table, there are 7 efficient DMUs among the 22 commercial banks. Turkland Bank is the least efficient bank with a profitability score of 0.340.

Table 4.30 Input and output data of year 2002

source: Turkish Banking Association (TBA)

DMU	input1 # of employees	input2 non-interest costs - adjusted	output1 TL Deposit - adjusted	output2 FX Deposit - adjusted	output3 Loans - adjusted	output4 Gov. Bonds - adjusted	output5 net profit - adjusted	output6 total income - adjusted	SBM
Ziraat	23330	3151.393	24831.707	18468.105	9794.762	38042.143	321.348	7889.264	0.974
İş Bankası	14873	2183.985	7523.244	22282.870	14874.704	3078.733	639.049	3681.645	0.812
Garanti	7407	1493.608	4050.782	17692.094	11634.392	10309.347	253.045	2054.080	1.000
Akbank	9011	1686.892	6224.063	24141.812	12917.772	1387.860	1409.307	5403.568	1.000
YKB	13692	2583.686	5804.128	24347.405	19669.928	4330.942	1958.009	5289.691	1.000
Vakıfbank	7600	1293.480	1314.377	10827.037	6967.185	2683.920	629.353	1772.060	0.663
Halkbank	9228	1168.148	10677.791	6907.118	2480.391	27304.435	1220.706	4587.102	1.000
Finans Bank	2811	406.795	1000.772	4594.382	3564.881	1722.359	387.411	968.322	1.000
Denizbank	2860	266.199	1200.666	3569.363	1724.933	275.606	35.516	481.460	1.000
ING Bank	3590	458.733	1999.147	2803.758	2209.617	1387.042	76.914	522.018	0.723
TEB	1673	232.805	336.292	2612.348	1648.679	75.163	38.065	418.165	0.780
HSBC	3525	426.870	307.297	3183.803	2903.065	717.777	61.780	1079.611	0.725
Fortis	2735	550.021	619.287	3244.427	2552.986	0.097	168.476	969.492	0.623
Şekerbank	2948	305.739	550.337	2653.565	1014.243	1774.584	21.266	354.644	0.561
Citibank	1064	291.717	203.418	1634.400	994.744	0.097	67.187	583.978	0.770
Alternatif Bank	486	176.494	332.023	1101.506	617.453	769.295	20.817	6.396	1.000
Eurobank Tekfen	654	82.858	118.748	33.639	272.238	190.375	34.877	134.333	0.423
Anadolubank	826	104.852	303.685	1476.319	678.394	1038.085	34.899	161.288	1.000
Tekstil Bankası	840	115.352	130.447	1267.934	662.589	718.671	120.223	180.656	1.000
Millennium Bank	97	13.886	2.329	2.033	0.230	9.663	0.479	12.780	0.250
Turkland Bank	179	27.129	19.059	106.089	122.972	21.819	4.789	53.360	0.555
Turkish Bank	183	24.282	110.411	205.104	22.524	0.097	5.270	53.124	0.713

According to the SBM efficiency scores in the above table, there are 9 efficient DMUs among the 22 commercial banks. Millenium Bank is the least efficient bank with a profitability score of 0.250.

Table 4.31 Input and output data of year 2003

source: Turkish Banking Association (TBA)

DMU	input1 # of employees	input2 non-interest costs - adjusted	output1 TL Deposit - adjusted	output2 FX Deposit - adjusted	output3 Loans - adjusted	output4 Gov. Bonds - adjusted	output5 net profit - adjusted	output6 total income - adjusted	SBM
Ziraat	22138	2394.753	24426.685	14039.919	8945.241	32222.982	1744.796	7348.902	0.968
İş Bankası	15550	2375.825	8927.194	17261.527	13957.071	1558.038	688.338	4564.474	0.772
Garanti	8145	1408.543	4755.139	13615.158	11177.931	7384.320	490.504	2024.234	1.000
Akbank	9964	1904.140	7204.841	19350.471	14182.159	1048.948	2154.827	6089.860	1.000
YKB	13796	2125.147	6095.061	17863.572	17571.491	4246.210	399.593	2641.666	1.000
Vakıfbank	7341	1122.873	1708.571	8810.536	7670.549	1432.628	377.416	2120.284	0.817
Halkbank	8515	917.954	9691.986	5648.623	4097.410	19891.917	790.471	3201.565	1.000
Finans Bank	3923	610.486	972.445	3740.187	4283.822	1526.122	249.033	1141.372	0.845
Denizbank	3240	296.614	1100.828	2776.680	2471.086	140.238	154.164	556.601	0.860
ING Bank	3919	483.226	2310.662	2325.167	3547.567	1529.137	102.685	655.157	0.915
TEB	1849	204.328	452.790	2021.980	1899.907	139.585	82.811	365.287	1.000
HSBC	3477	619.870	174.226	2917.756	2973.797	0.076	154.108	1051.989	0.620
Fortis	3404	490.381	1192.454	2453.002	3312.415	22.809	279.262	781.572	0.786
Şekerbank	3000	270.830	1016.598	1720.795	1205.508	1282.607	96.337	436.849	0.540
Citibank	1167	247.486	108.789	822.000	975.902	0.076	61.954	419.649	0.559
Alternatif Bank	482	156.214	127.189	686.537	639.718	529.222	20.308	202.124	1.000
Eurobank Tekfen	563	66.742	137.549	296.482	266.550	162.472	12.433	101.035	0.469
Anadolubank	983	91.725	390.668	1322.734	819.134	740.657	26.329	160.251	1.000
Tekstil Bankası	908	95.771	114.100	897.246	831.579	0.076	10.266	139.649	0.898
Millennium Bank	200	39.434	21.846	60.759	5.543	7.646	0.574	11.556	0.156
Turkland Bank	208	22.947	45.217	130.156	183.709	31.989	5.743	47.680	0.840
Turkish Bank	180	20.006	124.903	157.030	22.900	0.076	8.165	39.458	0.826

According to the SBM efficiency scores in the above table, there are 7 efficient DMUs among the 22 commercial banks. Millenium Bank is the least efficient bank with a profitability score of 0.156.

Table 4.32 Input and output data of year 2004

source: Turkish Banking Association (TBA)

DMU	input1 # of employees	input2 non-interest costs - adjusted	output1 TL Deposit - adjusted	output2 FX Deposit - adjusted	output3 Loans - adjusted	output4 Gov. Bonds - adjusted	output5 net profit - adjusted	output6 total income - adjusted	SBM
Ziraat	21172	1913.888	31035.308	14860.487	12787.552	34179.169	2142.653	6430.991	1.000
İş Bankası	16055	2122.803	9924.632	17573.455	17430.321	443.100	889.522	5194.104	0.771
Garanti	9128	1518.081	5292.905	13463.237	14700.022	5047.325	630.687	3008.574	1.000
Akbank	10413	1607.790	7469.879	17120.353	18112.533	451.276	1428.554	4832.615	1.000
YKB	14148	2038.972	7186.710	16981.668	19580.129	4722.309	64.208	3071.124	0.882
Vakıfbank	7150	1010.760	2599.472	8285.347	11285.397	772.570	873.386	2521.575	0.963
Halkbank	11145	736.603	12478.301	7431.853	6075.701	23454.656	738.716	2300.819	1.000
Finans Bank	5464	532.156	1948.359	3851.422	7266.081	0.439	268.149	1067.877	1.000
Denizbank	4344	410.864	1275.106	3492.734	3679.741	51.011	171.773	673.881	0.644
ING Bank	4199	422.019	2941.898	2641.921	4876.655	558.766	161.217	717.145	0.998
TEB	2131	220.708	572.986	2107.158	2218.322	91.617	47.314	363.712	0.752
HSBC	3652	586.149	631.614	3353.119	4929.491	0.439	151.329	1031.742	0.761
Fortis	3843	532.546	1656.652	2308.560	4295.868	598.726	150.020	832.608	0.704
Şekerbank	3334	302.047	1050.932	1544.284	1821.207	682.293	115.310	612.148	0.548
Citibank	1351	265.750	184.877	950.039	1135.985	0.439	40.399	412.930	0.588
Alternatif Bank	547	78.731	131.666	541.202	817.210	246.673	7.187	152.482	0.970
Eurobank Tekfen	578	52.594	149.104	309.392	324.206	93.411	7.028	66.384	0.466
Anadolubank	1036	93.323	490.697	1023.889	1012.175	596.585	60.423	185.349	1.000
Tekstil Bankası	938	86.884	182.007	698.371	1035.456	0.439	5.984	125.984	0.848
Millennium Bank	215	55.930	94.080	128.365	126.539	0.439	0.192	26.576	0.340
Turkland Bank	226	23.751	57.342	166.205	226.817	43.865	6.875	41.717	0.747
Turkish Bank	188	18.882	122.802	118.657	60.182	0.439	1.925	31.299	0.620

According to the SBM efficiency scores in the above table, there are 6 efficient DMUs among the 22 commercial banks. Millenium Bank is the least efficient bank with a profitability score of 0.340.

Table 4.33 Input and output data of year 2005

source: Turkish Banking Association (TBA)

DMU	input1 # of employees	input2 non-interest costs - adjusted	output1 TL Deposit - adjusted	output2 FX Deposit - adjusted	output3 Loans - adjusted	output4 Gov. Bonds - adjusted	output5 net profit - adjusted	output6 total income - adjusted	SBM
Ziraat	20373	1631.173	33050.788	13334.939	17193.835	27467.204	2307.997	5278.621	1.000
İş Bankası	17111	2129.679	12737.079	17937.020	26574.597	405.398	1223.885	5534.196	0.846
Garanti	10523	1732.037	8351.076	13934.260	21691.676	3074.933	907.249	3498.203	0.955
Akbank	11186	1698.102	13735.831	16033.002	28311.619	412.879	1842.041	4746.210	1.000
YKB	13801	4966.280	9950.711	15418.211	23675.911	9869.394	0.277	3540.284	1.000
Vakıfbank	7164	937.047	4692.065	8193.450	15246.953	462.039	685.399	2458.199	0.919
Halkbank	10509	897.338	13739.620	5725.245	7964.259	17243.012	681.041	2003.366	1.000
Finans Bank	6499	670.099	2967.771	3574.614	9753.722	0.447	448.814	1480.767	0.733
Denizbank	5059	480.461	2041.686	3316.583	5838.902	44.738	257.057	858.613	0.594
ING Bank	4585	496.099	3667.445	2519.690	6522.690	167.183	394.198	834.786	0.718
TEB	2619	253.289	557.052	2692.375	3763.558	0.447	100.814	413.287	1.000
HSBC	4180	616.046	1825.265	3169.693	6556.900	0.447	304.110	1165.204	0.667
Fortis	4048	576.949	1965.842	1835.434	4437.166	436.312	103.564	735.571	0.475
Şekerbank	3405	319.793	1324.312	1167.325	1453.089	243.036	47.425	593.136	0.542
Citibank	1529	251.061	341.665	1126.353	1445.301	0.447	145.908	503.361	0.747
Alternatif Bank	602	65.429	169.533	546.066	1124.800	215.686	26.594	127.277	1.000
Eurobank Tekfen	575	53.662	277.564	253.051	396.493	92.343	2.771	59.791	0.440
Anadolubank	1199	111.159	678.689	801.935	1212.161	510.361	50.624	180.956	0.716
Tekstil Bankası	1112	85.379	289.369	743.836	1546.209	0.447	12.980	119.907	1.000
Millennium Bank	260	50.833	103.101	420.213	424.951	0.447	0.277	39.683	1.000
Turkland Bank	272	29.458	110.894	15.620	325.795	0.447	9.703	42.532	0.568
Turkish Bank	192	18.768	126.356	114.800	112.339	0.447	5.018	24.048	0.577

According to the SBM efficiency scores in the above table, there are 8 efficient DMUs among the 22 commercial banks. Eurobank Tekfen is the least efficient bank with a profitability score of 0.440.

Table 4.34 Input and output data of year 2006

source: Turkish Banking Association (TBA)

DMU	input1 # of employees	input2 non-interest costs - adjusted	output1 TL Deposit - adjusted	output2 FX Deposit - adjusted	output3 Loans - adjusted	output4 Gov. Bonds - adjusted	output5 net profit - adjusted	output6 total income - adjusted	SBM
Ziraat	20684	1682.907	35777.752	14738.634	20657.167	20286.480	2497.213	5216.964	1.000
İş Bankası	18729	2209.364	16376.574	20490.911	35458.391	0.301	1319.024	5229.502	0.872
Garanti	11907	1742.164	10840.018	18263.017	32523.780	5492.493	1264.853	3709.756	1.000
Akbank	12333	1875.618	15566.078	17166.548	33696.817	0.301	1902.865	4690.858	1.000
YKB	13478	2376.009	11533.284	17451.438	26760.760	18883.550	609.128	3623.981	1.000
Vakıfbank	7679	1112.247	7050.613	8444.707	21456.083	57.544	915.323	2712.790	1.000
Halkbank	10860	859.942	14129.138	8621.677	13848.387	13407.313	1026.827	2428.515	1.000
Finans Bank	7751	895.725	3812.561	6046.550	13288.372	0.301	881.125	2323.216	0.931
Denizbank	5528	558.590	2401.932	4693.951	8115.902	52.560	328.614	1040.293	0.698
ING Bank	5403	488.645	4794.781	3409.390	8703.016	113.734	124.365	717.456	0.866
TEB	3565	353.496	1869.381	3494.836	5887.990	0.301	125.693	556.333	0.766
HSBC	5018	744.482	1952.032	4288.731	8947.429	0.301	333.696	1248.759	0.662
Fortis	4335	598.838	1754.999	2244.636	5756.225	520.495	89.677	771.267	0.522
Şekerbank	3368	308.094	1423.159	1428.550	2372.606	139.750	61.837	578.727	0.604
Citibank	2228	306.759	593.224	1963.652	2101.469	0.301	71.486	491.868	0.640
Alternatif Bank	680	78.297	445.991	631.002	1598.174	30.101	35.263	162.570	1.000
Eurobank Tekfen	567	52.539	378.650	411.444	685.874	45.907	14.729	79.667	0.664
Anadolubank	1331	121.116	805.723	1002.254	1638.539	771.819	57.073	211.175	0.721
Tekstil Bankası	1313	100.267	401.644	800.049	2013.438	0.301	17.918	154.325	0.812
Millennium Bank	315	66.496	123.013	887.641	754.950	0.301	0.685	37.092	1.000
Turkland Bank	266	33.554	190.428	164.473	363.884	0.301	0.685	36.591	0.580
Turkish Bank	218	20.210	165.248	164.951	151.577	0.301	6.851	29.434	0.664

According to the SBM efficiency scores in the above table, there are 8 efficient DMUs among the 22 commercial banks. Fortis Bank is the least efficient bank with a profitability score of 0.522.

Table 4.35 Input and output data of year 2007

source: Turkish Banking Association (TBA)

DMU	input1 # of employees	input2 non-interest costs - adjusted	output1 TL Deposit - adjusted	output2 FX Deposit - adjusted	output3 Loans - adjusted	output4 Gov. Bonds - adjusted	output5 net profit - adjusted	output6 total income - adjusted	SBM
Ziraat	20872	1620.243	40018.205	13152.657	23418.881	15019.283	2548.583	5105.768	1.000
İş Bankası	19414	2334.983	19924.909	18524.226	36834.148	2119.646	1844.759	6368.422	0.917
Garanti	14517	1976.578	13490.136	19866.056	40344.188	4275.041	2510.128	5347.557	1.000
Akbank	13513	1838.775	17975.900	16783.625	40125.109	0.280	2161.815	5286.669	1.000
YKB	14249	2961.883	12194.299	13845.834	30903.627	13054.597	768.757	4347.828	1.000
Vakıfbank	8700	1078.115	7441.367	6799.671	25441.483	1600.376	1117.279	2841.277	1.000
Halkbank	11484	918.899	14556.510	9245.925	19643.249	7628.563	1226.046	2685.254	1.000
Finans Bank	9061	963.361	4966.051	5838.890	15365.065	0.280	599.155	1951.164	0.645
Denizbank	6634	621.158	3209.338	3879.815	11279.032	42.714	228.995	1039.842	0.687
ING Bank	5922	527.831	4924.278	3274.890	9225.548	58.926	146.646	772.716	0.706
TEB	5141	499.270	2175.289	3548.717	7441.039	0.280	141.230	753.186	0.590
HSBC	5733	794.268	2521.428	4443.008	10130.463	0.280	394.728	1383.839	0.614
Fortis	5041	612.440	2251.056	2328.197	5992.453	339.736	162.687	869.597	0.482
Şekerbank	3824	349.915	1914.608	1528.916	3918.045	89.620	133.181	707.931	0.593
Citibank	2349	344.366	946.579	1560.319	2116.267	0.280	179.361	634.062	0.665
Alternatif Bank	868	76.839	417.493	1053.575	2020.184	27.963	68.639	197.840	1.000
Eurobank Tekfen	549	59.956	460.804	575.073	955.801	1042.381	20.052	100.850	1.000
Anadolubank	1724	125.229	886.470	938.952	1912.478	429.765	78.649	241.669	0.610
Tekstil Bankası	1547	119.948	517.395	877.756	2257.946	0.280	46.023	187.779	0.659
Millennium Bank	300	52.805	78.675	745.212	798.044	0.280	0.065	51.824	1.000
Turkland Bank	390	35.044	183.200	125.124	454.093	0.280	0.653	41.472	0.487
Turkish Bank	272	22.132	195.631	144.133	139.862	0.280	1.634	24.976	0.544

According to the SBM efficiency scores in the above table, there are 9 efficient DMUs among the 22 commercial banks. Fortis Bank is the least efficient bank with a profitability score of 0.482.

Table 4.36 Input and output data of year 2008

source: Turkish Banking Association (TBA)

DMU	input1 # of employees	input2 non-interest costs - adjusted	output1 TL Deposit - adjusted	output2 FX Deposit - adjusted	output3 Loans - adjusted	output4 Gov. Bonds - adjusted	output5 net profit - adjusted	output6 total income - adjusted	SBM
Ziraat	21299	1724.53	45587.754	15313.809	30836.194	48787.2	2134.259	4986.058	1.000
İş Bankası	20924	2819.538	25739.216	22156.269	47610.332	3461.854	1509.408	6231.541	0.876
Garanti	16350	2542.39	18238.882	22465.592	49907.407	7617.297	1750.488	5270.824	1.000
Akbank	15127	2187.262	20225.349	20458.169	44374.104	20560.583	1704.553	5395.322	1.000
YKB	14795	2358.59	15777.211	16601.725	38672.952	11529.009	1042.601	4245.838	0.826
Vakıfbank	9567	1319.172	8702.906	11142.152	30502.299	3471.338	753.198	2868.829	1.000
Halkbank	12467	1002.236	16622.191	12882.449	25836.298	15858.882	1018.315	2704.911	1.000
Finans Bank	9986	1106.224	7259.922	5119.24	17878.045	2669.056	362.648	2122.435	0.696
Denizbank	7376	687.914	4004.139	3923.086	12759.178	660.613	278.09	1279.402	0.690
ING Bank	6357	596.026	5159.433	3143.639	11044.083	51.982	140.053	915.121	0.727
TEB	6400	701.015	3475.708	3596.025	8504.777	797.771	164.198	1027.203	0.524
HSBC	6853	921.512	3492.156	4534.97	9723.783	0.29764	249.686	1508.134	0.640
Fortis	5378	640.68	2218.074	2068.158	7238.078	297.711	144.671	948.702	0.547
Şekerbank	4089	427.546	2807.073	1836.579	4799.814	1398.881	144.307	777.671	0.635
Citibank	2315	349.18	958.664	1643.1	2512.889	0.29764	81.361	587.336	0.697
Alternatif Bank	1006	123.278	969.229	1187.963	2370.575	189.271	53.016	259.095	0.916
Eurobank Tekfen	661	78.059	576.336	600.155	1091.606	971.55	12.367	115.719	0.803
Anadolubank	1718	134.811	1077.853	797.05	1958.164	680.169	86.852	265.532	0.621
Tekstil Bankası	1410	127.145	723.848	546.529	1606.119	364.068	12.579	185.255	0.499
Millennium Bank	320	50.371	197.301	521.65	883.815	0.29764	2.865	54.976	1.000
Turkland Bank	457	58.713	243.118	245.206	594.796	29.764	0.836	66.862	0.458
Turkish Bank	292	26.004	157.722	206.676	201.734	0.29764	10.01	43.138	0.651

According to the SBM efficiency scores in the above table, there are 6 efficient DMUs among the 22 commercial banks. Turkland Bank is the least efficient bank with a profitability score of 0.458.

Table 4.37 SBM Efficiency Scores of 1998-2008

		1998	1999	2000	2002	2003	2004	2005	2006	2007	2008	G.M.	S.D.
1	Akbank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	**1.000**	**0.000**
2	Garanti	1.000	1.000	1.000	1.000	1.000	1.000	0.955	1.000	1.000	1.000	**0.995**	**0.014**
3	Halkbank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.947	**0.995**	**0.017**
4	Alternatif Bank	0.945	1.000	1.000	1.000	1.000	0.970	1.000	1.000	1.000	0.980	**0.989**	**0.019**
5	YKB	1.000	1.000	0.897	1.000	1.000	0.882	1.000	1.000	1.000	0.956	**0.972**	**0.047**
6	Ziraat	1.000	0.813	0.622	0.974	0.968	1.000	1.000	1.000	1.000	1.000	**0.929**	**0.125**
7	Finans Bank	1.000	1.000	0.784	1.000	0.845	1.000	0.733	0.931	0.645	0.979	**0.882**	**0.132**
8	Vakıfbank	0.785	0.838	0.787	0.663	0.817	0.963	0.919	1.000	1.000	0.918	**0.862**	**0.109**
9	Anadolubank	0.625	1.000	1.000	1.000	1.000	1.000	0.716	0.721	0.610	0.743	**0.825**	**0.172**
10	İş Bankası	0.764	0.646	0.648	0.812	0.772	0.771	0.846	0.872	0.917	1.000	**0.798**	**0.111**
11	ING Bank	1.000	0.813	0.597	0.723	0.915	0.998	0.718	0.866	0.706	0.723	**0.796**	**0.135**
12	Tekstil Bankası	0.757	0.923	0.604	1.000	0.898	0.848	1.000	0.812	0.659	0.550	**0.790**	**0.160**
13	HSBC	1.000	1.000	1.000	0.725	0.620	0.761	0.667	0.662	0.614	0.901	**0.780**	**0.164**
14	Denizbank	0.698	1.000	0.747	1.000	0.860	0.644	0.594	0.698	0.687	0.828	**0.764**	**0.142**
15	TEB	0.839	0.601	0.550	0.780	1.000	0.752	1.000	0.766	0.590	0.912	**0.763**	**0.163**
16	Citibank	1.000	0.827	0.623	0.770	0.559	0.588	0.747	0.640	0.665	1.000	**0.727**	**0.159**
17	Fortis	0.771	0.781	1.000	0.623	0.786	0.704	0.475	0.522	0.482	0.712	**0.668**	**0.164**
18	Turkish Bank	0.501	0.796	0.726	0.713	0.826	0.620	0.577	0.664	0.544	0.481	**0.634**	**0.120**
19	Eurobank Tekfen	0.602	1.000	0.682	0.423	0.469	0.466	0.440	0.664	1.000	0.621	**0.608**	**0.213**
20	Şekerbank	0.784	0.505	0.520	0.561	0.540	0.548	0.542	0.604	0.593	1.000	**0.606**	**0.155**
21	Turkland Bank	0.428	0.312	0.340	0.555	0.840	0.747	0.568	0.580	0.487	0.491	**0.512**	**0.165**
22	Millennium Bank	0.354	0.436	0.697	0.250	0.156	0.340	1.000	1.000	1.000	0.573	**0.491**	**0.327**
	Geometric Mean	**0.772**	**0.797**	**0.744**	**0.751**	**0.756**	**0.762**	**0.759**	**0.792**	**0.746**	**0.802**		

Among the 22 commercial banks in Turkey, Akbankbank is the most efficient one over the ten-year period by achieving the top score for every year. Garanti also seems to be the bank that is well adopted to the new working environment. Halkbank is rated as efficient nine times and the geometric average makes it the third most profitable bank throughout the ten years. Smaller secondary banks such as Eurobank Tekfen, Turkland Bank, Şekerbank and Millenium Bank are the least profitable banks. They probably experience difficulties for forming their customer base. In addition, they have less public awareness and less trust than the larger banks.

When comparing the three basic categories (state banks, primary banks and secondary banks), primary banks benefit from a huge customer base and they have the efficiency score of 0.941 in average. Next, state banks have an average of 0.929 and secondary banks' average score is 0.722 for the whole period. Depending on the standard

deviations, Akbank, Garanti and Halkbank are the most consistent ones while Millenium Bank and Eurobank Tekfen have the highest fluctuations.

4.2 Comparison of the Inflation Period and the Disinflation Period

Our main goal is to compare the high inflation period (1998-2003) with the disinflation period (2004-2008) in terms of profitability. For this purpose, we must have a deeper look by distinctly comparing the two five-year periods. At this point, we will follow two types of procedures. First, we will collect each five-year's data so that we will obtain to sets. Then, we will apply SBM DEA and MPI to compare the two sets. By this way, data for time (t) and time (t+1) will be compared.

Table 4.38 Malmquist Productivity Indices for the two five-year periods

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+5},y^{t+5})$	$D^{t+5}(x^{t+5},y^{t+5})$	$D^{t+5}(x^t,y^t)$	MPI
1	1998 - Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.022	0.849	1.000	0.663	7.594
2	1998 - Türkiye İş Bankası A.Ş.	0.041	1.000	0.771	0.965	4.417
3	1998 - Türkiye Garanti Bankası A.Ş.	0.061	1.000	0.859	0.821	4.128
4	1998 - Akbank T.A.Ş.	0.070	1.000	1.000	0.891	3.995
5	1998 - Yapı ve Kredi Bankası A.Ş.	0.044	1.000	0.692	0.878	4.217
6	1998 - Türkiye Vakıflar Bankası T.A.O.	0.061	1.000	0.837	0.865	3.981
7	1998 - Türkiye Halk Bankası A.Ş.	0.050	0.771	1.000	0.800	4.386
8	1998 - Finans Bank A.Ş.	0.309	0.962	0.613	0.777	1.566
9	1998 - Denizbank A.Ş.	0.818	0.921	0.577	0.869	0.865
10	1998 - ING Bank A.Ş.	1.000	1.000	0.564	0.891	0.795
11	1998 - Türk Ekonomi Bankası A.Ş.	0.406	0.985	0.644	0.862	1.347
12	1998 - HSBC Bank A.Ş.	0.223	0.998	0.616	0.790	1.867
13	1998 - Fortis Bank A.Ş.	0.293	0.904	0.525	0.721	1.499
14	1998 - Şekerbank T.A.Ş.	0.253	0.618	0.548	0.600	1.494
15	1998 - Citibank A.Ş.	0.538	0.552	0.588	0.683	0.940
16	1998 - Alternatif Bank A.Ş.	0.656	1.000	0.686	0.774	1.162
17	1998 - Eurobank Tekfen A.Ş.	0.525	0.595	0.421	0.687	0.834
18	1998 - Anadolubank A.Ş.	1.000	0.892	0.793	0.933	0.870
19	1998 - Tekstil Bankası A.Ş.	0.574	0.919	0.557	0.863	1.017
20	1998 - Millennium Bank A.Ş.	1.000	0.419	0.294	1.000	0.351
21	1998 - Turkland Bank A.Ş.	1.000	0.989	0.558	0.981	0.750
22	1998 - Turkish Bank A.Ş.	1.000	0.660	0.546	0.654	0.742
23	1999 - Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.021	0.821	1.000	0.795	7.029
24	1999 - Türkiye İş Bankası A.Ş.	0.035	1.000	0.815	0.898	5.125
25	1999 - Türkiye Garanti Bankası A.Ş.	0.059	1.000	0.811	0.769	4.240
26	1999 - Akbank T.A.Ş.	0.063	0.992	1.000	0.868	4.251
27	1999 - Yapı ve Kredi Bankası A.Ş.	0.040	1.000	0.515	0.834	3.929
28	1999 - Türkiye Vakıflar Bankası T.A.O.	0.057	1.000	0.867	0.678	4.715
29	1999 - Türkiye Halk Bankası A.Ş.	0.050	0.907	0.754	0.988	3.714
30	1999 - Finans Bank A.Ş.	0.242	0.942	0.659	0.807	1.783
31	1999 - Denizbank A.Ş.	0.729	0.942	0.557	0.872	0.908
32	1999 - ING Bank A.Ş.	0.975	0.923	0.601	0.846	0.820
33	1999 - Türk Ekonomi Bankası A.Ş.	0.328	0.948	0.710	0.805	1.597
34	1999 - HSBC Bank A.Ş.	0.169	1.000	0.649	0.742	2.277
35	1999 - Fortis Bank A.Ş.	0.293	0.872	0.443	0.787	1.295
36	1999 - Şekerbank T.A.Ş.	0.255	0.561	0.510	0.628	1.336
37	1999 - Citibank A.Ş.	0.598	0.692	0.688	0.733	1.043
38	1999 - Alternatif Bank A.Ş.	0.595	1.000	0.734	0.738	1.293
39	1999 - Eurobank Tekfen A.Ş.	0.674	0.853	0.391	0.791	0.791
40	1999 - Anadolubank A.Ş.	1.000	0.952	0.560	1.000	0.730
41	1999 - Tekstil Bankası A.Ş.	0.519	0.884	0.634	0.853	1.125
42	1999 - Millennium Bank A.Ş.	1.000	1.000	0.670	0.988	0.824
43	1999 - Turkland Bank A.Ş.	1.000	1.000	0.454	0.955	0.690
44	1999 - Turkish Bank A.Ş.	1.000	0.828	0.507	0.881	0.690
45	2000 - Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.017	0.819	1.000	0.717	8.154
46	2000 - Türkiye İş Bankası A.Ş.	0.035	1.000	0.831	0.920	5.077

47	2000 - Türkiye Garanti Bankası A.Ş.	0.065	1.000	0.967	0.765	4.420
48	2000 - Akbank T.A.Ş.	0.064	1.000	1.000	0.858	4.261
49	2000 - Yapı ve Kredi Bankası A.Ş.	0.038	1.000	0.835	0.839	5.088
50	2000 - Türkiye Vakıflar Bankası T.A.O.	0.061	1.000	0.904	0.688	4.626
51	2000 - Türkiye Halk Bankası A.Ş.	0.053	0.805	0.913	0.764	4.276
52	2000 - Finans Bank A.Ş.	0.186	0.893	0.811	0.776	2.238
53	2000 - Denizbank A.Ş.	0.527	0.954	0.660	0.853	1.183
54	2000 - ING Bank A.Ş.	0.838	0.985	0.708	0.809	1.014
55	2000 - Türk Ekonomi Bankası A.Ş.	0.295	1.000	0.723	0.743	1.815
56	2000 - HSBC Bank A.Ş.	0.089	1.000	0.618	0.714	3.116
57	2000 - Fortis Bank A.Ş.	0.261	1.000	0.459	0.741	1.540
58	2000 - Şekerbank T.A.Ş.	0.232	0.840	0.518	0.578	1.800
59	2000 - Citibank A.Ş.	0.500	0.744	0.545	0.762	1.032
60	2000 - Alternatif Bank A.Ş.	0.537	1.000	0.830	0.736	1.449
61	2000 - Eurobank Tekfen A.Ş.	0.657	0.997	0.599	0.560	1.274
62	2000 - Anadolubank A.Ş.	0.768	0.940	0.638	0.924	0.919
63	2000 - Tekstil Bankası A.Ş.	0.475	0.901	0.682	0.841	1.240
64	2000 - Millennium Bank A.Ş.	1.000	1.000	1.000	0.685	1.209
65	2000 - Turkland Bank A.Ş.	1.000	1.000	0.504	0.888	0.753
66	2000 - Turkish Bank A.Ş.	1.000	0.975	0.626	1.000	0.782
67	2002 - Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.029	0.759	1.000	0.978	5.157
68	2002 - Türkiye İş Bankası A.Ş.	0.044	0.984	0.879	0.873	4.751
69	2002 - Türkiye Garanti Bankası A.Ş.	0.076	0.901	1.000	0.983	3.465
70	2002 - Akbank T.A.Ş.	0.065	0.921	1.000	0.927	3.918
71	2002 - Yapı ve Kredi Bankası A.Ş.	0.042	1.000	0.691	0.928	4.188
72	2002 - Türkiye Vakıflar Bankası T.A.O.	0.080	0.911	1.000	0.844	3.672
73	2002 - Türkiye Halk Bankası A.Ş.	0.076	0.746	1.000	0.888	3.319
74	2002 - Finans Bank A.Ş.	0.234	0.968	0.645	1.000	1.634
75	2002 - Denizbank A.Ş.	0.293	0.980	0.659	0.909	1.557
76	2002 - ING Bank A.Ş.	0.195	0.978	0.686	0.676	2.254
77	2002 - Türk Ekonomi Bankası A.Ş.	0.401	1.000	0.588	0.893	1.283
78	2002 - HSBC Bank A.Ş.	0.205	1.000	0.608	0.843	1.877
79	2002 - Fortis Bank A.Ş.	0.207	1.000	0.464	0.783	1.693
80	2002 - Şekerbank T.A.Ş.	0.267	0.969	0.567	0.753	1.654
81	2002 - Citibank A.Ş.	0.473	0.707	0.597	0.854	1.022
82	2002 - Alternatif Bank A.Ş.	0.768	0.794	1.000	0.837	1.112
83	2002 - Eurobank Tekfen A.Ş.	1.000	1.000	0.976	0.676	1.202
84	2002 - Anadolubank A.Ş.	0.851	0.818	0.573	1.000	0.742
85	2002 - Tekstil Bankası A.Ş.	0.804	0.894	0.641	1.000	0.845
86	2002 - Millennium Bank A.Ş.	1.000	1.000	1.000	0.535	1.367
87	2002 - Turkland Bank A.Ş.	1.000	0.981	0.485	0.771	0.786
88	2002 - Turkish Bank A.Ş.	1.000	0.902	0.510	0.827	0.745
89	2003 - Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.035	0.820	1.000	1.000	4.862
90	2003 - Türkiye İş Bankası A.Ş.	0.041	1.000	0.843	0.788	5.097
91	2003 - Türkiye Garanti Bankası A.Ş.	0.074	1.000	1.000	0.930	3.807
92	2003 - Akbank T.A.Ş.	0.058	1.000	1.000	0.924	4.318
93	2003 - Yapı ve Kredi Bankası A.Ş.	0.046	1.000	0.822	0.787	4.754
94	2003 - Türkiye Vakıflar Bankası T.A.O.	0.087	1.000	1.000	0.809	3.767
95	2003 - Türkiye Halk Bankası A.Ş.	0.090	0.825	1.000	0.917	3.155

96	2003 - Finans Bank A.Ş.	0.162	1.000	0.669	0.774	2.311
97	2003 - Denizbank A.Ş.	0.261	0.968	0.680	0.760	1.820
98	2003 - ING Bank A.Ş.	0.182	1.000	0.723	0.645	2.480
99	2003 - Türk Ekonomi Bankası A.Ş.	0.410	1.000	0.501	0.798	1.237
100	2003 - HSBC Bank A.Ş.	0.171	1.000	0.549	0.739	2.082
101	2003 - Fortis Bank A.Ş.	0.194	1.000	0.488	0.694	1.906
102	2003 - Şekerbank T.A.Ş.	0.285	1.000	0.572	0.675	1.725
103	2003 - Citibank A.Ş.	0.474	0.818	0.562	0.780	1.114
104	2003 - Alternatif Bank A.Ş.	0.802	1.000	0.882	0.818	1.159
105	2003 - Eurobank Tekfen A.Ş.	1.000	1.000	0.787	0.645	1.105
106	2003 - Anadolubank A.Ş.	0.837	0.840	0.577	0.951	0.781
107	2003 - Tekstil Bankası A.Ş.	0.858	0.983	0.486	0.744	0.865
108	2003 - Millennium Bank A.Ş.	1.000	1.000	0.928	0.432	1.466
109	2003 - Turkland Bank A.Ş.	1.000	1.000	0.447	0.738	0.778
110	2003 - Turkish Bank A.Ş.	1.000	0.960	0.586	0.780	0.849
	Geometric Mean					**1.810**

The geometric mean (1.810) of all the MPIs is tremendously meaningful. According to this value, the second period is much more profitable than the second period since the average MPI is quite above 1.

The second way that we will be following to accurately compare the two distinct periods is to compare each of the years from the two different sets. For this purpose, we will apply SBM DEA and MPI for every combination of two selected years from the two sets. Then, (5 x 5 = 25) analyses are to be made. The results of the MPIs can be found in the Appendix part. As a result of the all calculations, the below table is obtained.

Table 4.39 Malmquist Productivity Indices for each Combination of Years

	2004	**2005**	**2006**	**2007**	**2008**	**G.M.**
1998	1.054	1.088	1.091	1.072	1.056	1.072
1999	1.044	1.062	1.075	1.053	1.054	1.058
2000	1.095	1.126	1.152	1.132	1.115	1.124
2002	1.034	1.018	1.052	1.038	1.023	1.033
2003	1.130	1.124	1.180	1.164	1.141	1.147
G.M.	1.071	1.083	1.109	1.091	1.077	**1.086**

The MPIs in the above table are extremely significant. Each and every year of the second period (disinflation period) is much better than each and every year of the first period (inflation period). This means that banks are able to obtain higher profitability in a lower inflation environment. In addition, the two ways that we followed brought parallel results.

5 CONCLUSION

Banking sector deserve much interest of researchers. Especially, Turkish banking system can be evaluated from many different aspects since the Turkish economy and the banking system is highly fluctuating. With the crisis and bankrupts, many changes have occurred in the banking system over time. For instance, within the disinflation period the basic working styles and strategies have changed. The commercial banks have focused on marketing more loan products to individual and SME customers instead of purchasing government bonds. They have opened more branches and recruited marketing staff for the branches. In this new environment, the operational and employee expenses have increased sharply but loan volumes have also increased. New loan products have been launched.

According to our hypothesis, the banking sector should have been more advantageous in the low inflation period. Indeed, were the Turkish banks more profitable between 1998 and 2003 or between 2004 and 2008? In this study, this hypothesis has been tested and a quantitative evaluation of the Turkish banking sector is accomplished for the last decade. The adaptation of the Turkish banks to the new era has been inquired. Two periods that have completely opposite characteristics were compared by using Slacks Based Measure version of Data Envelopment Analysis. According to the results, the disinflation period (2004-2008) has created a more profitable environment for the banks than the inflation period (1998-2003). Hence, it has been found out that high inflation could cause problems, and create high risks for the whole economy and it also prevents profit opportunities for the commercial banks. In the high inflation period, the commercial banks located in Turkey benefitted from the state's budget deficits. By financing the state, they could capture high profit margins. However, due to lower loan volumes, they could not maintain as high profitability as they did in the disinflation period.

Secondly, the profitability scores were assessed depending on some correlations. According these correlations, older banks are more profitable since they have already formed their customer base and technological infrastructure. The banks that take more risks while imbursing loans also have higher profitability. Therefore, the commercial banks should keep their capital adequacy ratio close to the lower limit that is 8% and sell loans as much as they can. Surprisingly, the state banks are more profitable than the private banks since they can easily collect deposit from state institutions and from public with the help of high trust of people. Also Turkish banks are more profitable than the foreign capitalized banks. One of the most significant factors for high profitability is being a primary bank. The four big primary banks are much more profitable than the small sized banks. Finally, average employee expense has a negative correlation with the profitability scores, meaning that the commercial banks should recruit employees with lower salaries.

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APPENDIX

MPI of 1998 – 2004

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	0.716	1.000	0.521	1.172
2	Türkiye İş Bankası A.Ş.	0.764	0.970	0.771	0.928	1.028
3	Türkiye Garanti Bankası A.Ş.	1.000	0.981	1.000	0.736	1.154
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.823	1.103
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.920	0.882	0.813	0.999
6	Türkiye Vakıflar Bankası T.A.O.	0.785	0.837	0.963	0.798	1.134
7	Türkiye Halk Bankası A.Ş.	1.000	0.658	1.000	0.700	0.969
8	Finans Bank A.Ş.	1.000	0.791	1.000	0.669	1.088
9	Denizbank A.Ş.	0.698	0.753	0.644	0.802	0.930
10	ING Bank A.Ş.	1.000	0.986	0.998	0.856	1.072
11	Türk Ekonomi Bankası A.Ş.	0.839	0.748	0.752	0.739	0.952
12	HSBC Bank A.Ş.	1.000	0.883	0.761	0.667	1.004
13	Fortis Bank A.Ş.	0.771	0.857	0.704	0.576	1.166
14	Şekerbank T.A.Ş.	0.784	0.735	0.548	0.478	1.037
15	Citibank A.Ş.	1.000	0.565	0.588	0.525	0.795
16	Alternatif Bank A.Ş.	0.945	0.843	0.970	0.639	1.164
17	Eurobank Tekfen A.Ş.	0.602	0.683	0.466	0.530	0.998
18	Anadolubank A.Ş.	0.625	0.850	1.000	0.890	1.236
19	Tekstil Bankası A.Ş.	0.757	0.721	0.848	0.803	1.003
20	Millennium Bank A.Ş.	0.354	0.516	0.340	1.000	0.704
21	Turkland Bank A.Ş.	0.428	0.751	0.747	0.945	1.178
22	Turkish Bank A.Ş.	0.501	0.960	0.620	0.482	1.571
						1.054

MPI of 1998 – 2005

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	0.691	1.000	0.508	1.166
2	Türkiye İş Bankası A.Ş.	0.764	1.000	0.846	0.911	1.103
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	0.955	0.692	1.175
4	Akbank T.A.Ş.	1.000	0.862	1.000	0.756	1.068
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.879	1.000	0.790	1.055
6	Türkiye Vakıflar Bankası T.A.O.	0.785	0.990	0.919	0.823	1.186
7	Türkiye Halk Bankası A.Ş.	1.000	0.704	1.000	0.714	0.993
8	Finans Bank A.Ş.	1.000	0.815	0.733	0.642	0.965
9	Denizbank A.Ş.	0.698	0.815	0.594	0.796	0.933
10	ING Bank A.Ş.	1.000	0.871	0.718	0.840	0.863
11	Türk Ekonomi Bankası A.Ş.	0.839	0.731	1.000	0.715	1.104
12	HSBC Bank A.Ş.	1.000	0.872	0.667	0.652	0.945
13	Fortis Bank A.Ş.	0.771	0.883	0.475	0.567	0.979
14	Şekerbank T.A.Ş.	0.784	0.710	0.542	0.426	1.075
15	Citibank A.Ş.	1.000	0.706	0.747	0.523	1.003
16	Alternatif Bank A.Ş.	0.945	0.760	1.000	0.616	1.143
17	Eurobank Tekfen A.Ş.	0.602	0.810	0.440	0.529	1.058
18	Anadolubank A.Ş.	0.625	0.904	0.716	0.878	1.086
19	Tekstil Bankası A.Ş.	0.757	0.718	1.000	0.779	1.104
20	Millennium Bank A.Ş.	0.354	0.966	1.000	1.000	1.651
21	Turkland Bank A.Ş.	0.428	0.805	0.568	0.925	1.075
22	Turkish Bank A.Ş.	0.501	0.960	0.577	0.525	1.453
						1.088

MPI of 1998 – 2006

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	0.694	1.000	0.538	1.136
2	Türkiye İş Bankası A.Ş.	0.764	0.781	0.872	0.957	0.965
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	0.783	1.130
4	Akbank T.A.Ş.	1.000	0.863	1.000	0.903	0.977
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.920	1.000	0.825	1.056
6	Türkiye Vakıflar Bankası T.A.O.	0.785	0.845	1.000	0.921	1.081
7	Türkiye Halk Bankası A.Ş.	1.000	0.689	1.000	0.785	0.937
8	Finans Bank A.Ş.	1.000	0.884	0.931	0.714	1.074
9	Denizbank A.Ş.	0.698	0.838	0.698	0.801	1.022
10	ING Bank A.Ş.	1.000	0.931	0.866	0.890	0.952
11	Türk Ekonomi Bankası A.Ş.	0.839	0.887	0.766	0.735	1.049
12	HSBC Bank A.Ş.	1.000	0.856	0.662	0.726	0.884
13	Fortis Bank A.Ş.	0.771	0.847	0.522	0.639	0.947
14	Şekerbank T.A.Ş.	0.784	0.786	0.604	0.469	1.137
15	Citibank A.Ş.	1.000	0.789	0.640	0.522	0.983
16	Alternatif Bank A.Ş.	0.945	0.975	1.000	0.680	1.231
17	Eurobank Tekfen A.Ş.	0.602	0.961	0.664	0.531	1.411
18	Anadolubank A.Ş.	0.625	0.924	0.721	0.902	1.087
19	Tekstil Bankası A.Ş.	0.757	0.743	0.812	0.873	0.956
20	Millennium Bank A.Ş.	0.354	1.000	1.000	1.000	1.680
21	Turkland Bank A.Ş.	0.428	0.961	0.580	0.986	1.150
22	Turkish Bank A.Ş.	0.501	0.928	0.664	0.582	1.454
						1.091

MPI of 1998 – 2007

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	0.685	1.000	0.511	1.158
2	Türkiye İş Bankası A.Ş.	0.764	0.961	0.917	0.898	1.133
3	Türkiye Garanti Bankası A.Ş.	1.000	0.907	1.000	0.711	1.130
4	Akbank T.A.Ş.	1.000	0.825	1.000	0.800	1.015
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.996	1.000	0.795	1.119
6	Türkiye Vakıflar Bankası T.A.O.	0.785	0.851	1.000	0.930	1.079
7	Türkiye Halk Bankası A.Ş.	1.000	0.691	1.000	0.744	0.963
8	Finans Bank A.Ş.	1.000	0.907	0.645	0.680	0.928
9	Denizbank A.Ş.	0.698	0.859	0.687	0.768	1.049
10	ING Bank A.Ş.	1.000	0.921	0.706	0.837	0.882
11	Türk Ekonomi Bankası A.Ş.	0.839	0.828	0.590	0.756	0.878
12	HSBC Bank A.Ş.	1.000	0.860	0.614	0.658	0.896
13	Fortis Bank A.Ş.	0.771	0.838	0.482	0.589	0.943
14	Şekerbank T.A.Ş.	0.784	0.814	0.593	0.457	1.161
15	Citibank A.Ş.	1.000	0.803	0.665	0.525	1.009
16	Alternatif Bank A.Ş.	0.945	0.852	1.000	0.652	1.176
17	Eurobank Tekfen A.Ş.	0.602	0.760	1.000	0.527	1.547
18	Anadolubank A.Ş.	0.625	0.855	0.610	0.854	0.989
19	Tekstil Bankası A.Ş.	0.757	0.760	0.659	0.801	0.909
20	Millennium Bank A.Ş.	0.354	0.920	1.000	0.987	1.622
21	Turkland Bank A.Ş.	0.428	0.801	0.487	0.922	0.995
22	Turkish Bank A.Ş.	0.501	0.913	0.544	0.556	1.336
						1.072

MPI of 1998 – 2008

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	1.000	0.693	1.000	0.551	1.121
2	Türkiye İş Bankası A.Ş.	0.764	0.821	0.876	0.923	1.010
3	Türkiye Garanti Bankası A.Ş.	1.000	0.871	1.000	0.721	1.099
4	Akbank T.A.Ş.	1.000	0.845	1.000	0.845	1.000
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.880	0.826	0.810	0.947
6	Türkiye Vakıflar Bankası T.A.O.	0.785	0.829	1.000	0.876	1.097
7	Türkiye Halk Bankası A.Ş.	1.000	0.692	1.000	0.796	0.932
8	Finans Bank A.Ş.	1.000	0.993	0.696	0.720	0.980
9	Denizbank A.Ş.	0.698	0.891	0.690	0.785	1.060
10	ING Bank A.Ş.	1.000	0.950	0.727	0.858	0.897
11	Türk Ekonomi Bankası A.Ş.	0.839	0.856	0.524	0.790	0.822
12	HSBC Bank A.Ş.	1.000	0.880	0.640	0.636	0.941
13	Fortis Bank A.Ş.	0.771	0.822	0.547	0.596	0.990
14	Şekerbank T.A.Ş.	0.784	0.930	0.635	0.469	1.268
15	Citibank A.Ş.	1.000	0.869	0.697	0.527	1.072
16	Alternatif Bank A.Ş.	0.945	1.000	0.916	0.656	1.215
17	Eurobank Tekfen A.Ş.	0.602	0.782	0.803	0.529	1.403
18	Anadolubank A.Ş.	0.625	0.687	0.621	0.876	0.883
19	Tekstil Bankası A.Ş.	0.757	0.817	0.499	0.832	0.804
20	Millennium Bank A.Ş.	0.354	0.993	1.000	1.000	1.674
21	Turkland Bank A.Ş.	0.428	0.879	0.458	0.947	0.997
22	Turkish Bank A.Ş.	0.501	0.886	0.651	0.588	1.400
						1.056

MPI of 1999 – 2004

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.813	0.706	1.000	0.692	1.120
2	Türkiye İş Bankası A.Ş.	0.646	0.991	0.771	0.816	1.204
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	0.687	1.206
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.763	1.145
5	Yapı ve Kredi Bankası A.Ş.	1.000	1.000	0.882	0.748	1.086
6	Türkiye Vakıflar Bankası T.A.O.	0.838	0.940	0.963	0.632	1.307
7	Türkiye Halk Bankası A.Ş.	1.000	0.682	1.000	0.963	0.842
8	Finans Bank A.Ş.	1.000	0.853	1.000	0.698	1.106
9	Denizbank A.Ş.	1.000	0.838	0.644	0.801	0.821
10	ING Bank A.Ş.	0.813	0.894	0.998	0.783	1.184
11	Türk Ekonomi Bankası A.Ş.	0.601	0.866	0.752	0.686	1.256
12	HSBC Bank A.Ş.	1.000	1.000	0.761	0.658	1.076
13	Fortis Bank A.Ş.	0.781	0.996	0.704	0.679	1.150
14	Şekerbank T.A.Ş.	0.505	0.785	0.548	0.442	1.389
15	Citibank A.Ş.	0.827	0.670	0.588	0.602	0.890
16	Alternatif Bank A.Ş.	1.000	0.929	0.970	0.573	1.254
17	Eurobank Tekfen A.Ş.	1.000	0.762	0.466	0.685	0.720
18	Anadolubank A.Ş.	1.000	0.764	1.000	0.998	0.875
19	Tekstil Bankası A.Ş.	0.923	0.823	0.848	0.796	0.974
20	Millennium Bank A.Ş.	0.436	0.484	0.340	0.967	0.625
21	Turkland Bank A.Ş.	0.312	0.870	0.747	0.923	1.502
22	Turkish Bank A.Ş.	0.796	0.739	0.620	0.965	0.772
						1.044

MPI of 1999 – 2005

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.813	0.689	1.000	0.717	1.087
2	Türkiye İş Bankası A.Ş.	0.646	0.977	0.846	0.796	1.268
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	0.955	0.648	1.214
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.713	1.184
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.811	1.000	0.711	1.068
6	Türkiye Vakıflar Bankası T.A.O.	0.838	0.955	0.919	0.687	1.235
7	Türkiye Halk Bankası A.Ş.	1.000	0.680	1.000	1.000	0.824
8	Finans Bank A.Ş.	1.000	0.872	0.733	0.675	0.973
9	Denizbank A.Ş.	1.000	0.849	0.594	0.795	0.797
10	ING Bank A.Ş.	0.813	0.868	0.718	0.767	1.000
11	Türk Ekonomi Bankası A.Ş.	0.601	0.838	1.000	0.675	1.438
12	HSBC Bank A.Ş.	1.000	1.000	0.667	0.622	1.035
13	Fortis Bank A.Ş.	0.781	1.000	0.475	0.655	0.964
14	Şekerbank T.A.Ş.	0.505	0.670	0.542	0.499	1.201
15	Citibank A.Ş.	0.827	0.844	0.747	0.592	1.134
16	Alternatif Bank A.Ş.	1.000	0.821	1.000	0.594	1.176
17	Eurobank Tekfen A.Ş.	1.000	0.851	0.440	0.681	0.742
18	Anadolubank A.Ş.	1.000	0.805	0.716	0.989	0.764
19	Tekstil Bankası A.Ş.	0.923	0.777	1.000	0.783	1.036
20	Millennium Bank A.Ş.	0.436	1.000	1.000	0.952	1.551
21	Turkland Bank A.Ş.	0.312	0.894	0.568	0.911	1.337
22	Turkish Bank A.Ş.	0.796	0.881	0.577	1.000	0.800
						1.062

MPI of 1999 – 2006

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.813	0.702	1.000	0.760	1.066
2	Türkiye İş Bankası A.Ş.	0.646	0.967	0.872	0.817	1.264
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	0.734	1.167
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.879	1.067
5	Yapı ve Kredi Bankası A.Ş.	1.000	1.000	1.000	0.813	1.109
6	Türkiye Vakıflar Bankası T.A.O.	0.838	1.000	1.000	0.612	1.397
7	Türkiye Halk Bankası A.Ş.	1.000	0.717	1.000	1.000	0.847
8	Finans Bank A.Ş.	1.000	0.834	0.931	0.757	1.012
9	Denizbank A.Ş.	1.000	0.872	0.698	0.882	0.831
10	ING Bank A.Ş.	0.813	0.877	0.866	0.819	1.068
11	Türk Ekonomi Bankası A.Ş.	0.601	0.874	0.766	0.708	1.254
12	HSBC Bank A.Ş.	1.000	1.000	0.662	0.697	0.975
13	Fortis Bank A.Ş.	0.781	0.992	0.522	0.711	0.966
14	Şekerbank T.A.Ş.	0.505	0.840	0.604	0.533	1.373
15	Citibank A.Ş.	0.827	0.937	0.640	0.630	1.073
16	Alternatif Bank A.Ş.	1.000	0.938	1.000	0.636	1.215
17	Eurobank Tekfen A.Ş.	1.000	0.865	0.664	0.685	0.916
18	Anadolubank A.Ş.	1.000	0.717	0.721	1.000	0.719
19	Tekstil Bankası A.Ş.	0.923	0.779	0.812	0.769	0.944
20	Millennium Bank A.Ş.	0.436	1.000	1.000	0.987	1.523
21	Turkland Bank A.Ş.	0.312	0.980	0.580	0.935	1.396
22	Turkish Bank A.Ş.	0.796	0.867	0.664	0.900	0.896
						1.075

MPI of 1999 – 2007

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.813	0.683	1.000	0.710	1.087
2	Türkiye İş Bankası A.Ş.	0.646	0.905	0.917	0.855	1.225
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	0.638	1.252
4	Akbank T.A.Ş.	1.000	0.848	1.000	0.753	1.061
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.986	1.000	0.734	1.159
6	Türkiye Vakıflar Bankası T.A.O.	0.838	0.912	1.000	0.616	1.330
7	Türkiye Halk Bankası A.Ş.	1.000	0.720	1.000	1.000	0.849
8	Finans Bank A.Ş.	1.000	0.897	0.645	0.713	0.901
9	Denizbank A.Ş.	1.000	0.852	0.687	0.797	0.857
10	ING Bank A.Ş.	0.813	0.868	0.706	0.771	0.989
11	Türk Ekonomi Bankası A.Ş.	0.601	0.858	0.590	0.689	1.106
12	HSBC Bank A.Ş.	1.000	0.997	0.614	0.616	0.997
13	Fortis Bank A.Ş.	0.781	0.941	0.482	0.692	0.916
14	Şekerbank T.A.Ş.	0.505	0.846	0.593	0.502	1.408
15	Citibank A.Ş.	0.827	0.910	0.665	0.603	1.102
16	Alternatif Bank A.Ş.	1.000	0.835	1.000	0.590	1.190
17	Eurobank Tekfen A.Ş.	1.000	0.790	1.000	0.666	1.089
18	Anadolubank A.Ş.	1.000	0.730	0.610	1.000	0.668
19	Tekstil Bankası A.Ş.	0.923	0.786	0.659	0.780	0.848
20	Millennium Bank A.Ş.	0.436	1.000	1.000	0.928	1.572
21	Turkland Bank A.Ş.	0.312	0.838	0.487	0.883	1.218
22	Turkish Bank A.Ş.	0.796	0.832	0.544	0.876	0.806
						1.053

MPI of 1999 – 2008

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.813	0.703	1.000	0.778	1.054
2	Türkiye İş Bankası A.Ş.	0.646	1.000	0.876	0.832	1.277
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	0.654	1.236
4	Akbank T.A.Ş.	1.000	0.877	1.000	0.804	1.044
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.870	0.826	0.761	0.972
6	Türkiye Vakıflar Bankası T.A.O.	0.838	0.991	1.000	0.532	1.491
7	Türkiye Halk Bankası A.Ş.	1.000	0.767	1.000	1.000	0.876
8	Finans Bank A.Ş.	1.000	0.911	0.696	0.745	0.923
9	Denizbank A.Ş.	1.000	0.856	0.690	0.790	0.865
10	ING Bank A.Ş.	0.813	0.881	0.727	0.791	0.998
11	Türk Ekonomi Bankası A.Ş.	0.601	0.910	0.524	0.706	1.060
12	HSBC Bank A.Ş.	1.000	0.989	0.640	0.613	1.016
13	Fortis Bank A.Ş.	0.781	0.930	0.547	0.722	0.950
14	Şekerbank T.A.Ş.	0.505	0.849	0.635	0.544	1.402
15	Citibank A.Ş.	0.827	1.000	0.697	0.615	1.171
16	Alternatif Bank A.Ş.	1.000	0.968	0.916	0.607	1.209
17	Eurobank Tekfen A.Ş.	1.000	0.952	0.803	0.674	1.065
18	Anadolubank A.Ş.	1.000	0.781	0.621	1.000	0.697
19	Tekstil Bankası A.Ş.	0.923	0.810	0.499	0.798	0.740
20	Millennium Bank A.Ş.	0.436	1.000	1.000	0.954	1.550
21	Turkland Bank A.Ş.	0.312	0.971	0.458	0.907	1.254
22	Turkish Bank A.Ş.	0.796	0.842	0.651	1.000	0.830
						1.054

MPI of 2000 – 2004

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.622	0.690	1.000	0.578	1.385
2	Türkiye İş Bankası A.Ş.	0.648	0.887	0.771	0.866	1.105
3	Türkiye Garanti Bankası A.Ş.	1.000	0.913	1.000	0.637	1.197
4	Akbank T.A.Ş.	1.000	0.824	1.000	0.794	1.019
5	Yapı ve Kredi Bankası A.Ş.	0.897	0.860	0.882	0.738	1.071
6	Türkiye Vakıflar Bankası T.A.O.	0.787	0.802	0.963	0.612	1.266
7	Türkiye Halk Bankası A.Ş.	1.000	0.639	1.000	0.648	0.993
8	Finans Bank A.Ş.	0.784	0.748	1.000	0.659	1.203
9	Denizbank A.Ş.	0.747	0.721	0.644	0.767	0.900
10	ING Bank A.Ş.	0.597	0.881	0.998	0.711	1.438
11	Türk Ekonomi Bankası A.Ş.	0.550	0.723	0.752	0.615	1.268
12	HSBC Bank A.Ş.	1.000	0.837	0.761	0.562	1.065
13	Fortis Bank A.Ş.	1.000	0.824	0.704	0.615	0.971
14	Şekerbank T.A.Ş.	0.520	0.725	0.548	0.367	1.443
15	Citibank A.Ş.	0.623	0.602	0.588	0.648	0.936
16	Alternatif Bank A.Ş.	1.000	0.821	0.970	0.611	1.141
17	Eurobank Tekfen A.Ş.	0.682	0.708	0.466	0.448	1.039
18	Anadolubank A.Ş.	1.000	0.783	1.000	0.866	0.951
19	Tekstil Bankası A.Ş.	0.604	0.694	0.848	0.761	1.131
20	Millennium Bank A.Ş.	0.697	0.499	0.340	0.535	0.675
21	Turkland Bank A.Ş.	0.340	0.742	0.747	0.826	1.405
22	Turkish Bank A.Ş.	0.726	0.875	0.620	0.988	0.870
						1.095

MPI of 2000 – 2005

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.622	0.668	1.000	0.590	1.349
2	Türkiye İş Bankası A.Ş.	0.648	0.925	0.846	0.852	1.191
3	Türkiye Garanti Bankası A.Ş.	1.000	0.991	0.955	0.625	1.230
4	Akbank T.A.Ş.	1.000	0.819	1.000	0.779	1.025
5	Yapı ve Kredi Bankası A.Ş.	0.897	1.000	1.000	0.733	1.234
6	Türkiye Vakıflar Bankası T.A.O.	0.787	0.775	0.919	0.579	1.250
7	Türkiye Halk Bankası A.Ş.	1.000	0.704	1.000	0.671	1.024
8	Finans Bank A.Ş.	0.784	0.792	0.733	0.654	1.065
9	Denizbank A.Ş.	0.747	0.763	0.594	0.756	0.896
10	ING Bank A.Ş.	0.597	0.927	0.718	0.707	1.255
11	Türk Ekonomi Bankası A.Ş.	0.550	0.703	1.000	0.613	1.445
12	HSBC Bank A.Ş.	1.000	0.837	0.667	0.551	1.006
13	Fortis Bank A.Ş.	1.000	0.850	0.475	0.606	0.816
14	Şekerbank T.A.Ş.	0.520	0.693	0.542	0.397	1.348
15	Citibank A.Ş.	0.623	0.750	0.747	0.644	1.182
16	Alternatif Bank A.Ş.	1.000	0.733	1.000	0.589	1.115
17	Eurobank Tekfen A.Ş.	0.682	0.791	0.440	0.513	0.998
18	Anadolubank A.Ş.	1.000	0.821	0.716	0.859	0.828
19	Tekstil Bankası A.Ş.	0.604	0.688	1.000	0.757	1.226
20	Millennium Bank A.Ş.	0.697	0.910	1.000	0.538	1.559
21	Turkland Bank A.Ş.	0.340	0.780	0.568	0.817	1.264
22	Turkish Bank A.Ş.	0.726	0.862	0.577	0.970	0.841
						1.126

MPI of 2000 – 2006

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.622	0.671	1.000	0.659	1.279
2	Türkiye İş Bankası A.Ş.	0.648	0.966	0.872	0.887	1.211
3	Türkiye Garanti Bankası A.Ş.	1.000	0.962	1.000	0.661	1.206
4	Akbank T.A.Ş.	1.000	0.819	1.000	0.813	1.004
5	Yapı ve Kredi Bankası A.Ş.	0.897	1.000	1.000	0.772	1.202
6	Türkiye Vakıflar Bankası T.A.O.	0.787	0.804	1.000	0.647	1.257
7	Türkiye Halk Bankası A.Ş.	1.000	0.666	1.000	0.706	0.971
8	Finans Bank A.Ş.	0.784	0.820	0.931	0.648	1.227
9	Denizbank A.Ş.	0.747	0.782	0.698	0.787	0.963
10	ING Bank A.Ş.	0.597	0.939	0.866	0.712	1.383
11	Türk Ekonomi Bankası A.Ş.	0.550	0.813	0.766	0.613	1.359
12	HSBC Bank A.Ş.	1.000	0.820	0.662	0.584	0.965
13	Fortis Bank A.Ş.	1.000	0.814	0.522	0.644	0.813
14	Şekerbank T.A.Ş.	0.520	0.766	0.604	0.443	1.417
15	Citibank A.Ş.	0.623	0.789	0.640	0.653	1.114
16	Alternatif Bank A.Ş.	1.000	0.881	1.000	0.618	1.195
17	Eurobank Tekfen A.Ş.	0.682	0.859	0.664	0.377	1.489
18	Anadolubank A.Ş.	1.000	0.834	0.721	0.912	0.812
19	Tekstil Bankası A.Ş.	0.604	0.704	0.812	0.758	1.118
20	Millennium Bank A.Ş.	0.697	0.943	1.000	0.603	1.499
21	Turkland Bank A.Ş.	0.340	0.917	0.580	0.834	1.370
22	Turkish Bank A.Ş.	0.726	0.893	0.664	1.000	0.904
						1.152

MPI of 2000 – 2007

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.622	0.663	1.000	0.617	1.313
2	Türkiye İş Bankası A.Ş.	0.648	0.752	0.917	0.838	1.128
3	Türkiye Garanti Bankası A.Ş.	1.000	0.974	1.000	0.631	1.242
4	Akbank T.A.Ş.	1.000	0.786	1.000	0.783	1.002
5	Yapı ve Kredi Bankası A.Ş.	0.897	1.000	1.000	0.731	1.235
6	Türkiye Vakıflar Bankası T.A.O.	0.787	0.966	1.000	0.612	1.416
7	Türkiye Halk Bankası A.Ş.	1.000	0.668	1.000	0.662	1.005
8	Finans Bank A.Ş.	0.784	0.830	0.645	0.647	1.028
9	Denizbank A.Ş.	0.747	0.791	0.687	0.749	0.985
10	ING Bank A.Ş.	0.597	0.916	0.706	0.688	1.255
11	Türk Ekonomi Bankası A.Ş.	0.550	0.773	0.590	0.602	1.174
12	HSBC Bank A.Ş.	1.000	0.828	0.614	0.589	0.929
13	Fortis Bank A.Ş.	1.000	0.810	0.482	0.615	0.796
14	Şekerbank T.A.Ş.	0.520	0.795	0.593	0.415	1.479
15	Citibank A.Ş.	0.623	0.811	0.665	0.635	1.168
16	Alternatif Bank A.Ş.	1.000	0.784	1.000	0.596	1.147
17	Eurobank Tekfen A.Ş.	0.682	0.943	1.000	0.380	1.907
18	Anadolubank A.Ş.	1.000	0.778	0.610	0.858	0.744
19	Tekstil Bankası A.Ş.	0.604	0.716	0.659	0.730	1.035
20	Millennium Bank A.Ş.	0.697	0.869	1.000	0.563	1.488
21	Turkland Bank A.Ş.	0.340	0.782	0.487	0.794	1.188
22	Turkish Bank A.Ş.	0.726	0.865	0.544	0.951	0.826
						1.132

MPI of 2000 – 2008

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.622	0.670	1.000	0.672	1.265
2	Türkiye İş Bankası A.Ş.	0.648	0.783	0.876	0.859	1.111
3	Türkiye Garanti Bankası A.Ş.	1.000	0.826	1.000	0.628	1.147
4	Akbank T.A.Ş.	1.000	0.803	1.000	0.823	0.988
5	Yapı ve Kredi Bankası A.Ş.	0.897	0.835	0.826	0.749	1.013
6	Türkiye Vakıflar Bankası T.A.O.	0.787	0.991	1.000	0.643	1.399
7	Türkiye Halk Bankası A.Ş.	1.000	0.669	1.000	0.723	0.962
8	Finans Bank A.Ş.	0.784	0.903	0.696	0.656	1.105
9	Denizbank A.Ş.	0.747	0.813	0.690	0.765	0.991
10	ING Bank A.Ş.	0.597	0.914	0.727	0.700	1.261
11	Türk Ekonomi Bankası A.Ş.	0.550	0.832	0.524	0.607	1.143
12	HSBC Bank A.Ş.	1.000	0.849	0.640	0.570	0.976
13	Fortis Bank A.Ş.	1.000	0.795	0.547	0.627	0.833
14	Şekerbank T.A.Ş.	0.520	0.880	0.635	0.453	1.541
15	Citibank A.Ş.	0.623	0.832	0.697	0.643	1.203
16	Alternatif Bank A.Ş.	1.000	0.982	0.916	0.606	1.219
17	Eurobank Tekfen A.Ş.	0.682	0.966	0.803	0.428	1.630
18	Anadolubank A.Ş.	1.000	0.827	0.621	0.885	0.762
19	Tekstil Bankası A.Ş.	0.604	0.798	0.499	0.745	0.941
20	Millennium Bank A.Ş.	0.697	0.916	1.000	0.622	1.454
21	Turkland Bank A.Ş.	0.340	0.850	0.458	0.813	1.187
22	Turkish Bank A.Ş.	0.726	0.807	0.651	0.979	0.860
						1.115

MPI of 2002 – 2004

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.974	0.846	1.000	0.826	1.025
2	Türkiye İş Bankası A.Ş.	0.812	0.905	0.771	0.960	0.947
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	0.761	1.146
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.900	1.054
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.998	0.882	0.878	1.001
6	Türkiye Vakıflar Bankası T.A.O.	0.663	0.973	0.963	0.873	1.272
7	Türkiye Halk Bankası A.Ş.	1.000	0.761	1.000	0.790	0.981
8	Finans Bank A.Ş.	1.000	0.836	1.000	0.949	0.939
9	Denizbank A.Ş.	1.000	0.788	0.644	1.000	0.712
10	ING Bank A.Ş.	0.723	0.847	0.998	0.598	1.398
11	Türk Ekonomi Bankası A.Ş.	0.780	0.849	0.752	1.000	0.904
12	HSBC Bank A.Ş.	0.725	0.998	0.761	0.765	1.170
13	Fortis Bank A.Ş.	0.623	0.904	0.704	0.675	1.230
14	Şekerbank T.A.Ş.	0.561	0.630	0.548	0.768	0.896
15	Citibank A.Ş.	0.770	0.566	0.588	0.782	0.743
16	Alternatif Bank A.Ş.	1.000	0.997	0.970	0.685	1.189
17	Eurobank Tekfen A.Ş.	0.423	0.596	0.466	0.513	1.130
18	Anadolubank A.Ş.	1.000	0.774	1.000	0.976	0.890
19	Tekstil Bankası A.Ş.	1.000	0.820	0.848	0.935	0.862
20	Millennium Bank A.Ş.	0.250	0.440	0.340	0.303	1.408
21	Turkland Bank A.Ş.	0.555	0.863	0.747	0.657	1.330
22	Turkish Bank A.Ş.	0.713	0.738	0.620	0.775	0.910
						1.034

MPI of 2002 – 2005

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.974	0.805	1.000	1.000	0.909
2	Türkiye İş Bankası A.Ş.	0.812	0.904	0.846	1.000	0.971
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	0.955	0.988	0.983
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.893	1.059
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.780	1.000	0.867	0.949
6	Türkiye Vakıflar Bankası T.A.O.	0.663	0.922	0.919	0.954	1.157
7	Türkiye Halk Bankası A.Ş.	1.000	0.828	1.000	0.816	1.007
8	Finans Bank A.Ş.	1.000	0.856	0.733	0.924	0.824
9	Denizbank A.Ş.	1.000	0.828	0.594	0.994	0.704
10	ING Bank A.Ş.	0.723	0.874	0.718	0.682	1.128
11	Türk Ekonomi Bankası A.Ş.	0.780	0.834	1.000	1.000	1.034
12	HSBC Bank A.Ş.	0.725	1.000	0.667	0.832	1.051
13	Fortis Bank A.Ş.	0.623	0.872	0.475	0.733	0.952
14	Şekerbank T.A.Ş.	0.561	0.605	0.542	0.914	0.800
15	Citibank A.Ş.	0.770	0.701	0.747	0.822	0.909
16	Alternatif Bank A.Ş.	1.000	0.866	1.000	0.785	1.051
17	Eurobank Tekfen A.Ş.	0.423	0.755	0.440	0.562	1.182
18	Anadolubank A.Ş.	1.000	0.821	0.716	1.000	0.767
19	Tekstil Bankası A.Ş.	1.000	0.720	1.000	0.890	0.899
20	Millennium Bank A.Ş.	0.250	1.000	1.000	0.330	3.484
21	Turkland Bank A.Ş.	0.555	0.874	0.568	0.714	1.119
22	Turkish Bank A.Ş.	0.713	0.799	0.577	0.838	0.878
						1.018

MPI of 2002 – 2006

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.974	0.798	1.000	1.000	0.905
2	Türkiye İş Bankası A.Ş.	0.812	0.908	0.872	0.894	1.044
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	0.973	1.014
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.993	1.003
5	Yapı ve Kredi Bankası A.Ş.	1.000	1.000	1.000	0.924	1.040
6	Türkiye Vakıflar Bankası T.A.O.	0.663	0.992	1.000	0.815	1.355
7	Türkiye Halk Bankası A.Ş.	1.000	0.809	1.000	0.937	0.929
8	Finans Bank A.Ş.	1.000	0.899	0.931	1.000	0.915
9	Denizbank A.Ş.	1.000	0.849	0.698	0.923	0.801
10	ING Bank A.Ş.	0.723	0.812	0.866	0.561	1.318
11	Türk Ekonomi Bankası A.Ş.	0.780	0.843	0.766	0.999	0.910
12	HSBC Bank A.Ş.	0.725	0.997	0.662	0.927	0.992
13	Fortis Bank A.Ş.	0.623	0.936	0.522	0.818	0.979
14	Şekerbank T.A.Ş.	0.561	0.747	0.604	0.706	1.068
15	Citibank A.Ş.	0.770	0.749	0.640	0.788	0.888
16	Alternatif Bank A.Ş.	1.000	0.898	1.000	0.760	1.087
17	Eurobank Tekfen A.Ş.	0.423	0.820	0.664	0.621	1.438
18	Anadolubank A.Ş.	1.000	0.819	0.721	1.000	0.769
19	Tekstil Bankası A.Ş.	1.000	0.710	0.812	1.000	0.759
20	Millennium Bank A.Ş.	0.250	0.978	1.000	0.367	3.264
21	Turkland Bank A.Ş.	0.555	0.936	0.580	0.798	1.107
22	Turkish Bank A.Ş.	0.713	0.751	0.664	0.843	0.911
						1.052

MPI of 2002 – 2007

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.974	0.778	1.000	0.882	0.952
2	Türkiye İş Bankası A.Ş.	0.812	0.876	0.917	0.859	1.073
3	Türkiye Garanti Bankası A.Ş.	1.000	0.970	1.000	0.812	1.093
4	Akbank T.A.Ş.	1.000	0.970	1.000	0.874	1.054
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.979	1.000	0.873	1.059
6	Türkiye Vakıflar Bankası T.A.O.	0.663	0.898	1.000	0.783	1.315
7	Türkiye Halk Bankası A.Ş.	1.000	0.785	1.000	0.895	0.937
8	Finans Bank A.Ş.	1.000	0.867	0.645	0.957	0.765
9	Denizbank A.Ş.	1.000	0.824	0.687	0.892	0.796
10	ING Bank A.Ş.	0.723	0.808	0.706	0.563	1.185
11	Türk Ekonomi Bankası A.Ş.	0.780	0.836	0.590	0.901	0.837
12	HSBC Bank A.Ş.	0.725	0.979	0.614	0.874	0.974
13	Fortis Bank A.Ş.	0.623	0.826	0.482	0.775	0.908
14	Şekerbank T.A.Ş.	0.561	0.816	0.593	0.664	1.140
15	Citibank A.Ş.	0.770	0.707	0.665	0.765	0.893
16	Alternatif Bank A.Ş.	1.000	0.750	1.000	0.663	1.064
17	Eurobank Tekfen A.Ş.	0.423	0.931	1.000	0.607	1.903
18	Anadolubank A.Ş.	1.000	0.751	0.610	1.000	0.677
19	Tekstil Bankası A.Ş.	1.000	0.768	0.659	0.961	0.726
20	Millennium Bank A.Ş.	0.250	0.979	1.000	0.348	3.358
21	Turkland Bank A.Ş.	0.555	0.810	0.487	0.746	0.976
22	Turkish Bank A.Ş.	0.713	0.742	0.544	0.814	0.834
						1.038

MPI of 2002 – 2008

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.974	0.819	1.000	0.967	0.933
2	Türkiye İş Bankası A.Ş.	0.812	0.966	0.876	1.000	1.021
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	0.853	1.083
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.886	1.062
5	Yapı ve Kredi Bankası A.Ş.	1.000	1.000	0.826	0.883	0.967
6	Türkiye Vakıflar Bankası T.A.O.	0.663	0.976	1.000	0.931	1.258
7	Türkiye Halk Bankası A.Ş.	1.000	0.815	1.000	0.832	0.990
8	Finans Bank A.Ş.	1.000	0.883	0.696	1.000	0.784
9	Denizbank A.Ş.	1.000	0.822	0.690	1.000	0.753
10	ING Bank A.Ş.	0.723	0.824	0.727	0.577	1.198
11	Türk Ekonomi Bankası A.Ş.	0.780	0.878	0.524	1.000	0.768
12	HSBC Bank A.Ş.	0.725	0.965	0.640	0.967	0.938
13	Fortis Bank A.Ş.	0.623	0.835	0.547	0.854	0.927
14	Şekerbank T.A.Ş.	0.561	0.861	0.635	0.737	1.150
15	Citibank A.Ş.	0.770	0.818	0.697	0.779	0.974
16	Alternatif Bank A.Ş.	1.000	0.923	0.916	0.678	1.117
17	Eurobank Tekfen A.Ş.	0.423	0.933	0.803	0.617	1.694
18	Anadolubank A.Ş.	1.000	0.773	0.621	1.000	0.693
19	Tekstil Bankası A.Ş.	1.000	0.812	0.499	1.000	0.636
20	Millennium Bank A.Ş.	0.250	1.000	1.000	0.371	3.284
21	Turkland Bank A.Ş.	0.555	0.944	0.458	0.817	0.976
22	Turkish Bank A.Ş.	0.713	0.744	0.651	0.862	0.888
						1.023

MPI of 2003 – 2004

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.968	0.952	1.000	0.948	1.019
2	Türkiye İş Bankası A.Ş.	0.772	1.000	0.771	0.707	1.189
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	0.916	1.045
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.897	1.056
5	Yapı ve Kredi Bankası A.Ş.	1.000	1.000	0.882	0.829	1.031
6	Türkiye Vakıflar Bankası T.A.O.	0.817	1.000	0.963	0.758	1.247
7	Türkiye Halk Bankası A.Ş.	1.000	0.847	1.000	0.807	1.025
8	Finans Bank A.Ş.	0.845	0.943	1.000	0.695	1.267
9	Denizbank A.Ş.	0.860	0.933	0.644	0.703	0.996
10	ING Bank A.Ş.	0.915	1.000	0.998	0.677	1.270
11	Türk Ekonomi Bankası A.Ş.	1.000	0.985	0.752	0.804	0.959
12	HSBC Bank A.Ş.	0.620	1.000	0.761	0.608	1.421
13	Fortis Bank A.Ş.	0.786	0.925	0.704	0.619	1.157
14	Şekerbank T.A.Ş.	0.540	0.622	0.548	0.535	1.087
15	Citibank A.Ş.	0.559	0.581	0.588	0.669	0.955
16	Alternatif Bank A.Ş.	1.000	1.000	0.970	0.715	1.165
17	Eurobank Tekfen A.Ş.	0.469	0.600	0.466	0.467	1.130
18	Anadolubank A.Ş.	1.000	0.896	1.000	1.000	0.947
19	Tekstil Bankası A.Ş.	0.898	0.919	0.848	0.740	1.083
20	Millennium Bank A.Ş.	0.156	0.423	0.340	0.169	2.337
21	Turkland Bank A.Ş.	0.840	0.989	0.747	0.636	1.176
22	Turkish Bank A.Ş.	0.826	0.726	0.620	0.741	0.857
						1.130

MPI of 2003 – 2005

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.968	0.885	1.000	0.910	1.003
2	Türkiye İş Bankası A.Ş.	0.772	1.000	0.846	0.788	1.179
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	0.955	1.000	0.977
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.887	1.062
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.740	1.000	0.963	0.877
6	Türkiye Vakıflar Bankası T.A.O.	0.817	1.000	0.919	0.872	1.136
7	Türkiye Halk Bankası A.Ş.	1.000	0.898	1.000	0.912	0.992
8	Finans Bank A.Ş.	0.845	0.931	0.733	0.741	1.044
9	Denizbank A.Ş.	0.860	0.935	0.594	0.800	0.898
10	ING Bank A.Ş.	0.915	0.965	0.718	0.551	1.173
11	Türk Ekonomi Bankası A.Ş.	1.000	0.948	1.000	0.961	0.993
12	HSBC Bank A.Ş.	0.620	1.000	0.667	0.660	1.277
13	Fortis Bank A.Ş.	0.786	0.888	0.475	0.556	0.982
14	Şekerbank T.A.Ş.	0.540	0.563	0.542	0.639	0.941
15	Citibank A.Ş.	0.559	0.715	0.747	0.727	1.146
16	Alternatif Bank A.Ş.	1.000	0.999	1.000	0.663	1.227
17	Eurobank Tekfen A.Ş.	0.469	0.858	0.440	0.511	1.255
18	Anadolubank A.Ş.	1.000	0.977	0.716	1.000	0.837
19	Tekstil Bankası A.Ş.	0.898	0.884	1.000	0.841	1.082
20	Millennium Bank A.Ş.	0.156	0.989	1.000	0.194	5.714
21	Turkland Bank A.Ş.	0.840	1.000	0.568	0.656	1.016
22	Turkish Bank A.Ş.	0.826	0.830	0.577	0.720	0.898
						1.124

MPI of 2003 – 2006

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.968	0.840	1.000	1.000	0.932
2	Türkiye İş Bankası A.Ş.	0.772	1.000	0.872	0.793	1.193
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	0.993	1.003
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.951	1.026
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.922	1.000	0.738	1.118
6	Türkiye Vakıflar Bankası T.A.O.	0.817	1.000	1.000	0.820	1.222
7	Türkiye Halk Bankası A.Ş.	1.000	0.894	1.000	0.883	1.006
8	Finans Bank A.Ş.	0.845	0.866	0.931	0.798	1.093
9	Denizbank A.Ş.	0.860	0.946	0.698	0.720	1.032
10	ING Bank A.Ş.	0.915	0.927	0.866	0.541	1.274
11	Türk Ekonomi Bankası A.Ş.	1.000	1.000	0.766	0.787	0.986
12	HSBC Bank A.Ş.	0.620	1.000	0.662	0.737	1.204
13	Fortis Bank A.Ş.	0.786	1.000	0.522	0.621	1.034
14	Şekerbank T.A.Ş.	0.540	0.846	0.604	0.585	1.272
15	Citibank A.Ş.	0.559	0.779	0.640	0.812	1.048
16	Alternatif Bank A.Ş.	1.000	1.000	1.000	0.771	1.139
17	Eurobank Tekfen A.Ş.	0.469	0.965	0.664	0.564	1.557
18	Anadolubank A.Ş.	1.000	0.963	0.721	0.914	0.871
19	Tekstil Bankası A.Ş.	0.898	0.901	0.812	0.694	1.084
20	Millennium Bank A.Ş.	0.156	0.953	1.000	0.166	6.076
21	Turkland Bank A.Ş.	0.840	1.000	0.580	0.729	0.973
22	Turkish Bank A.Ş.	0.826	0.975	0.664	0.714	1.047
						1.180

MPI of 2003 – 2007

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.968	0.848	1.000	0.992	0.940
2	Türkiye İş Bankası A.Ş.	0.772	0.969	0.917	0.760	1.230
3	Türkiye Garanti Bankası A.Ş.	1.000	0.983	1.000	0.886	1.054
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.856	1.081
5	Yapı ve Kredi Bankası A.Ş.	1.000	0.909	1.000	0.718	1.125
6	Türkiye Vakıflar Bankası T.A.O.	0.817	0.956	1.000	0.785	1.221
7	Türkiye Halk Bankası A.Ş.	1.000	0.810	1.000	1.000	0.900
8	Finans Bank A.Ş.	0.845	0.974	0.645	0.775	0.980
9	Denizbank A.Ş.	0.860	0.992	0.687	0.684	1.076
10	ING Bank A.Ş.	0.915	0.926	0.706	0.537	1.153
11	Türk Ekonomi Bankası A.Ş.	1.000	1.000	0.590	0.749	0.887
12	HSBC Bank A.Ş.	0.620	1.000	0.614	0.682	1.205
13	Fortis Bank A.Ş.	0.786	1.000	0.482	0.572	1.035
14	Şekerbank T.A.Ş.	0.540	0.978	0.593	0.577	1.364
15	Citibank A.Ş.	0.559	0.722	0.665	0.754	1.067
16	Alternatif Bank A.Ş.	1.000	0.884	1.000	0.700	1.123
17	Eurobank Tekfen A.Ş.	0.469	1.000	1.000	0.555	1.961
18	Anadolubank A.Ş.	1.000	0.847	0.610	0.912	0.753
19	Tekstil Bankası A.Ş.	0.898	0.893	0.659	0.659	0.998
20	Millennium Bank A.Ş.	0.156	1.000	1.000	0.159	6.350
21	Turkland Bank A.Ş.	0.840	0.972	0.487	0.687	0.906
22	Turkish Bank A.Ş.	0.826	0.902	0.544	0.695	0.924
						1.164

MPI of 2003 – 2008

	DMU	$D^t(x^t,y^t)$	$D^t(x^{t+1},y^{t+1})$	$D^{t+1}(x^{t+1},y^{t+1})$	$D^{t+1}(x^t,y^t)$	MPI
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	0.968	0.895	1.000	1.000	0.962
2	Türkiye İş Bankası A.Ş.	0.772	1.000	0.876	0.801	1.190
3	Türkiye Garanti Bankası A.Ş.	1.000	1.000	1.000	0.930	1.037
4	Akbank T.A.Ş.	1.000	1.000	1.000	0.878	1.067
5	Yapı ve Kredi Bankası A.Ş.	1.000	1.000	0.826	0.837	0.994
6	Türkiye Vakıflar Bankası T.A.O.	0.817	1.000	1.000	0.846	1.203
7	Türkiye Halk Bankası A.Ş.	1.000	0.920	1.000	0.876	1.025
8	Finans Bank A.Ş.	0.845	1.000	0.696	0.787	1.023
9	Denizbank A.Ş.	0.860	0.983	0.690	0.773	1.010
10	ING Bank A.Ş.	0.915	0.955	0.727	0.509	1.220
11	Türk Ekonomi Bankası A.Ş.	1.000	1.000	0.524	0.871	0.776
12	HSBC Bank A.Ş.	0.620	1.000	0.640	0.768	1.160
13	Fortis Bank A.Ş.	0.786	1.000	0.547	0.690	1.005
14	Şekerbank T.A.Ş.	0.540	1.000	0.635	0.547	1.467
15	Citibank A.Ş.	0.559	0.852	0.697	0.841	1.124
16	Alternatif Bank A.Ş.	1.000	1.000	0.916	0.723	1.126
17	Eurobank Tekfen A.Ş.	0.469	1.000	0.803	0.558	1.752
18	Anadolubank A.Ş.	1.000	0.883	0.621	1.000	0.741
19	Tekstil Bankası A.Ş.	0.898	0.968	0.499	0.791	0.825
20	Millennium Bank A.Ş.	0.156	1.000	1.000	0.182	5.938
21	Turkland Bank A.Ş.	0.840	1.000	0.458	0.743	0.857
22	Turkish Bank A.Ş.	0.826	0.960	0.651	0.735	1.015
						1.141

BIOGRAPHICAL SKETCH

Eren Ayaz was born in Erzurum on September 13, 1983. He studied in Bornova Anatolian High School, İzmir Science High School and Ege College respectively and graduated in 2001. He took his BS degree in Electrical and Electronics Engineering from Koç University with a full merit scholarship in 2006. His undergraduate thesis was a study on electrical circuit design of PSPICE in Matlab. He worked for Peppers and Rogers Group and took responsibilities in many management consultancy projects mostly in the banking sector. In addition, he has a one-year-experience with Voneks Consulting where he undertaken product profitability project and managed a project group in the head quarters of Fortis Bank. He presented the projects' deliverables to the top management of the bank. He also worked for the project management office in the IT department of Yapı Kredi Bankası. Currently, he is studying for the MS degree in Industrial Engineering in Galatasaray University under the supervision of Asst. Prof. Emre Alptekin.