

# Impact of Disinflation on Profitability: A Data Envelopment Analysis Approach for Turkish Commercial Banks

Eren Ayaz and S. Emre Alptekin

**Abstract**—Data Envelopment Analysis (DEA) analysis has been applied to the banking industry by a significant number of researchers. In this paper, the aim is to investigate the direct influence of inflation on banks' profitability. Doing so, the data of the period 1998-2003 when the inflation was relatively high is compared to the data of the period 2004-2008 when the inflation was higher. DEA's ability to evaluate several inputs and outputs at the same time and give efficiency scores to each decision making unit is used to evaluate banks' efficiencies. The results reveal which period is more profitable for commercial banks.

**Index Terms**—Data envelopment analysis, banking sector, efficiency

## I. INTRODUCTION

BANKS play a vital role in a country's economic development and growth. In addition to their large economic significance, the existence of an increasingly competitive market highlights the importance of evaluating the banks' performance in order to continuously improve their functions and monitor their financial condition [1]. When the case of Turkey is considered, we can observe that the major changes experienced in Turkish economy has altered the working environment of the Turkish banks. In this study, inflation will be the main point of interest and it will be used to determine the trends in the profitability of banks.

Before the 2001 crisis, high inflation ruled the Turkish economy. Due to huge governmental deficits, the state had been the most significant customer of the banks. Banks collected deposits through private, SME and commercial banking. They 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 50%.

After the 2001 crisis, inflation was taken under control. The state needed less financial assist. The new trend was capturing more private, SME and commercial customers. Banks had to sell loans in order to make profit and to survive. Moreover, risk rates of Turkish economy decreased and for this reason foreign banks began to enter to the

Turkish market. Profit margins declined, but loan volumes increased sharply. By this way, banks continued to keep their profitability. However, it is a great source of debate whether the pre-crisis period or the post-crisis period is more profitable for Turkish banks. According to our hypothesis, the banks should have used advantages of low inflation between 2004 and 2008. In this paper, our research question is: "Did the Turkish banks really experience higher rates of profitability in the lower inflation era?" For this purpose, we have employed Slacks Based Measure (SBM) of DEA and Malmquist Productivity Index to compare the two periods (1998-2003 and 2004-2008). In addition, we have evaluated banks' efficiencies with respect to correlations with bank size, ROA, ROE, age of bank, ownership, loan ratio, capital adequacy ratio, etc. and we have come up with policy recommendations depending on the correlations.

Data Envelopment Analysis (DEA) has been employed as the main methodology. DEA is a quite popular management tool which is used to evaluate the efficiency of a number of producers. A typical statistical approach is characterized as a central tendency approach and it evaluates producers relative to an average producer. In contrast, DEA compares each producer with only the *best* producers. For each producer, a set of inputs and a set of related outputs are taken. For instance, when the banking sector is in question, each bank has a certain number of tellers, a certain square footage of space, and a certain number of managers which can be characterized as inputs. The number of checks cashed and/or number of loan applications processed can be determined as the outputs. DEA approach aims at determining which of the banks are most efficient, and to point out specific inefficiencies of the other banks. In this research, DEA is used to observe multi-period changes with the Malmquist productivity index, a tool for measuring efficiency changes over time. Accordingly, effects of the inflation on the profitability of the banking system are identified.

The remaining part of the paper is structured as follows. Previous research in the related topic is represented in Section 2. Section 3 presents the main lines of the methodology. Section 4 gives the results of the application, before concluding the paper in Section 5.

## II. RELATED LITERATURE

In literature, many research have compared the dynamics and the characteristics of the banking sector. Burdisso et al. have handled the bank privatization process in Argentina

Eren Ayaz is student at the Graduate School of Science and Engineering of Galatasaray University, Istanbul, TURKEY. (e-mail: erenayaz@yahoo.com)

S. Emre Alptekin is with the Industrial Engineering Department, Galatasaray University, Ciragan Cad. No:36 34357 Ortakoy, Istanbul TURKEY (phone: +902122274480/401; fax:+902122595557; e-mail: ealptekin@gsu.edu.tr).

[2]. Similarly, Krueger and Tornell have studied on the restructuring period following the crisis in Mexico [3]. Bhattacharya et al. have reported better efficiency rates after liberalization of banks in India [4]. There are several works in literature that are not directly related to the deregulation, restructuring and privatization issues. Rather than comparing pre- and post-development periods, they inquire the efficiencies of unique periods. Berger and Humprey have assessed bank scale economies, mergers, concentration and efficiency of the US [5]. Berger et al. [6] and De Young and Whalen [7] have evaluated banks' efficiencies and performances.

In literature there are several works that have made use of DEA method for assessing Turkish banking sector. Işık and Hassan [8] studied the effects of the 1994 crises on the efficiencies of Turkish banks. They have used Malmquist productivity index to complement DEA. Özkan Günay and Tektaş [9] have utilized DEA for investigating the Turkish commercial banks depending on the data of 1990 to 2001. Mercan et al. have done a comprehensive study that uses DEA on Turkish banking sector with the data of 1989-1999 [10].

There are several reasons that differentiate our work from these ones. First, our work considers more recent data. Second, our main purpose is to accomplish a direct comparison of the high inflation period with the disinflation period. We compare each year from two different periods, rather than comparing only the subsequent years. As mentioned above, with the disinflation period, Turkish banks' working style has practically changed. They have sold much more loans instead of buying government bonds. With the low inflation, people have demanded much more loans and due to lower budget deficits, the government have 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. As far as we know, literature lacks this type of study that compares the inflation period and the disinflation period and this study is to fill this gap.

### III. DATA ENVELOPMENT ANALYSIS

Evaluation 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 influence the working mechanisms bring about sophisticated evaluation tools for performance measurement. Professionals have been using some simple ratios, some of which are given below [11]:

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

These ratios are the basic indicators in many industries; however they are beneficial to some limited extent for managers and performance evaluators, since they operate with only one input and one output. The systems with more than one input and output necessitate more sophisticated performance measurement tools.

The initial approach to assess multiple inputs and outputs has been accomplished by Farrell [12]. Charnes et al. came up with the idea of the first version of Data Envelopment Analysis [13]. In this method, a set of elements, named Decision Making Units (DMU), are compared with each other and the most effective ones form an upper boundary frontier. The other DMUs were scored based on their distances apart from the frontier. The selection of the DMUs is critical for the analyses and the following conditions should be provided when determining the inputs, outputs and DMUs [14]:

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.

This methodology has been a milestone for performance measurement and DEA has become a commonly used method for using in private and public sector. The first version of the DEA method has been named as DEA-CCR on behalf on its introducers, Charnes, Cooper and Rhodes [14]. The most important functionality of the model is its ability to evaluate several inputs and outputs at the same time and give efficiency scores to each DMU. Later, Banker et al. have come with the idea of a DEA model with "variable returns to scale" [15]. This has been another milestone and this methodology has been named based on its founders: Banker, Charnes and Cooper (DEA-BCC). The next form of DEA has been the Russell Measure that has been developed by Fare and Lovell [16] and later revised by Pastor et al. [17]. The next step has been the "additive model" or "Pareto – Koopmans (PK) model" that has been a non-radial model. The contribution of the model has been the usage of slacks ( $s^+$ ,  $s^-$ ), in other words input excesses and output shortfalls, in the objective function. Doing so, the model has depended on the amount of essential decreasing in the inputs or the amount of essential increasing in the outputs.

Since the objective function of the PK model was only dealing with the opportunities of improvements of inputs and outputs, it was not giving efficiency scores for DMUs. In order to overcome this deficiency, the smooth transition from the conventional DEA methods to Slack Based Measure (SBM) is done [18]. To extend the investigation on influence from slacks to Malmquist productivity index (MPI), Chen [19] has proposed a non-radial MPI, which is able to eliminate possible inefficiency represented by the non-zero slacks to measure the productivity change to three Chinese major industries.

In calculating MPI, the DEA is used as a measure of "relative efficiencies". Therefore, when a DMU in time  $t$  is plugged into the data set of time  $t+1$ , it is not possible to observe the real changes accurately since there is a frontier shift. 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 model measures the performance of  $DMU_o$  at time  $t$  with respect to

the efficiency frontier at time  $t+1$ :

$$D_0^{t+1}(x_0^t, y_0^t) = \min \rho_{in} = 1 - \frac{1}{m} \sum_{i=1}^m \frac{s_i^-}{x_{i0}^t}$$

subject to

$$x_0^t = X^{t+1} \lambda + s^+$$

$$y_0^t = Y^{t+1} \lambda - s^-$$

$$\lambda, s^-, s^+ \geq 0$$
(1)

with  $x$  represents inputs and  $y$  represents outputs. Based on this model, MPI, frontier shift and technological efficiency change values can be calculated. If these values exceed 1, it represents an improvement and the opposite means a decrease in the efficiency. If the value is equal to 1, it means no change has occurred.

#### IV. APPLICATION ON TURKISH BANKING INDUSTRY

There are 3 state banks, 11 Turkish based private banks, a monetary fund bank, 18 foreign banks and 13 development and investment banks in Turkey at the end of 2008. 22 of these banks which have suitable number of branches and employees were chosen. These banks are 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 Turkey in the banking sector nearly all customers have at least one account in these banks 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.

TABLE I  
INPUT OUTPUT COMBINATIONS

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

When using DEA, the selection of the input output combination is crucial to maintain accurate and meaningful conclusions. We have benefitted from some papers in the literature and have identified 6 different input-output

combinations that are commonly used (Table 1). The chosen 22 banks were evaluated with DEA using SBM applied to the profit-based approach 1 in a single period (2008) as the aim was to evaluate the profitability of the banks.

The correlations presented in Table II can be interpreted as follows. First of all, ROA and ROE are the basic banking profitability indicators that are commonly used, which are highly correlated with the SBM scores (0.7046 and 0.7606). These results enable us to make the assumption that high SBM scores are indicators of high profitability for the banks chosen. The correlation value of age (0.5546) 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). Turkish based and state based banks have higher profitability scores according to the positive correlation values (0.4741 and 0.3127). Average employee cost has a negative correlation (-0.297) with SBM scores. Obviously, recruiting employees with higher salaries is not a beneficial strategy for banks. Marketing and selling consumer loans are of benefit for the banks according to the correlation value of consumer loans per total loans (0.2937). Therefore, if a commercial bank sets a certain marketing budget for advertisements, especially consumer loans should be emphasized for higher profitability. The conversion rate of deposits to the loans (total loans per total deposits) is negatively correlated with the SBM efficiency scores (-0.3002). Thus, collecting high amounts of deposits is also crucial for the commercial banks in Turkey. The negative correlation (-0.4178) 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 obtain revenue from other customer services such as transaction fees, foreign exchange trading, stock exchange commission, etc. The correlation value of loans under follow-up per total loans (0.2369) can be interpreted in terms of risk management. The commercial bank acts usually in a conservative manner due to the high level of fear for the bad loans. However, the efficiency scores and correlation values show that taking more risk could result in higher profitability. In parallel with the loans under follow-up, the correlation of capital adequacy rate (-0.4906) also supports that higher risk means higher profitability.

TABLE II  
CORRELATIONS AMONG SBM EFFICIENCY SCORES AND BANKING DATA FOR 22 BANKS

Banking Data	Correlations
ROA	0.7046
ROE	0.7606
Age	0.5546
Turkish based	0.4741
State based	0.3127
Average employee cost	-0.2970
Market share	0.6800
Total loans / Total assets	-0.0137
Consumer loans / Total loans	0.2937
Total loans / Total deposits	-0.3002
Loans under follow-up / Total loans	0.2369
Interest revenue / Total revenue	-0.4178
Capital adequacy rate	-0.4906

Turkish banking sector has been evaluated for a single period (2008) so far. In this stage, we have analyzed the fluctuations caused due to inflation observed in the

economy. Our analysis includes 10 years (1998-2008), but 2001 data is not included because of too many negative data. Since the area of concern is profitability, input-output combination is selected according to the profit-based approach 2. 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. Yearly inflation rates of Turkish economy are represented in Fig. 1. We can see the sharp decrease of the inflation rate on 2004.

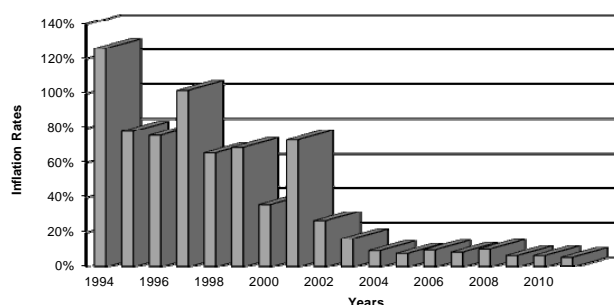


Fig.1. Yearly inflation rates

The SBM efficiency scores obtained are presented in Table III. Among the 22 commercial banks in Turkey, Akbank 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 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.

Our main goal is to compare the high inflation period (1998-2003) with the disinflation period (2004-2008) in terms of profitability. We have taken a deeper look by distinctly comparing the two five year periods. For this purpose, we have followed two types of procedures. First, we have collected each five years' data so that two sets are formed. Then, SBM DEA and MPI are applied to compare the two sets. By this way, data for time (t) and time (t+1) will be compared. The results are presented in Table IV. The geometric mean (1.810) of all the MPIs is 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 have followed to accurately compare the two distinct periods is to compare each of the years from the two different sets. For this purpose, we have applied SBM DEA and MPI for every combination of two selected years from the two sets. In total 25 analyses have been made. As a result of the all calculations, the below table is obtained (Table V). The MPIs in table V are significant. Each year of the second period (disinflation period) is much better than each year of the first period (inflation period). This means that banks are able to obtain higher profitability in a lower inflation environment. The same finding is obtained using two different ways.

TABLE III  
SBM EFFICIENCY SCORES OF 1998-2008

DMU	1998	1999	2000	2002	2003	2004	2005	2006	2007	2008	G.M.	S.D.
1 Citibank	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 Akbank	0.600	0.532	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.892	0.184
3 Finans Bank	0.603	0.598	0.821	0.964	0.811	0.675	0.805	1.000	0.670	0.892	0.772	0.144
4 Alternatif	0.378	1.000	1.000	0.322	1.000	0.780	0.552	0.790	0.720	0.887	0.695	0.252
5 Garanti Bankası	0.564	0.477	0.655	0.421	0.562	0.855	0.758	0.956	1.000	1.000	0.694	0.220
6 HSBC Bank	0.444	1.000	0.338	0.456	0.680	0.742	0.716	0.866	0.710	0.746	0.639	0.202
7 Vakıfbank	0.448	0.212	0.171	0.799	1.000	1.000	0.700	1.000	0.816	0.845	0.602	0.315
8 Yapı Kredi	0.304	0.390	0.380	1.000	0.418	0.508	0.608	0.920	1.000	0.858	0.584	0.278
9 Fortis Bank	0.539	0.566	1.000	0.596	0.544	0.590	0.462	0.564	0.494	0.575	0.580	0.149
10 Eurobank Tekfen	1.000	1.000	1.000	0.583	0.501	0.371	0.329	0.481	0.428	0.509	0.572	0.272
11 Tekstilbank	1.000	0.589	0.541	1.000	0.473	0.479	0.381	0.417	0.417	0.457	0.542	0.232
12 İş Bankası	0.289	0.263	0.311	0.368	0.563	0.691	0.606	0.743	0.803	1.000	0.511	0.251
13 TEB	0.368	0.332	0.488	0.429	0.547	0.539	0.493	0.630	0.556	0.647	0.493	0.103
14 ING Bank	0.634	0.467	0.308	0.293	0.461	0.524	0.791	0.466	0.439	0.531	0.473	0.146
15 Ziraat Bankası	0.058	0.079	0.210	0.530	0.731	0.867	1.000	1.000	0.717	1.000	0.433	0.380
16 Şekerbank	0.059	0.080	0.064	1.000	1.000	1.000	1.000	1.000	0.608	1.000	0.423	0.440
17 Anadolubank	0.148	0.239	0.223	0.547	0.554	0.621	0.480	0.548	0.505	0.628	0.407	0.177
18 Halkbank	0.071	0.165	0.091	1.000	0.752	0.524	0.517	0.703	0.641	0.904	0.393	0.331
19 Denizbank	0.178	0.253	0.188	0.291	0.490	0.480	0.501	0.645	0.542	0.650	0.382	0.180
20 Turkland Bank	0.278	0.122	0.139	0.453	0.549	0.504	0.408	0.476	0.345	0.423	0.333	0.148
21 Turkish Bank	0.120	0.086	1.000	0.373	0.414	0.369	0.270	0.320	0.234	0.393	0.293	0.252
22 Millennium Bank	0.103	0.148	0.336	0.242	0.138	0.312	0.453	0.338	0.481	0.491	0.268	0.144
<b>Geometric Mean</b>	0.303	0.324	0.384	0.558	0.595	0.620	0.589	0.677	0.602	0.714		
<b>S. D.</b>	0.302	0.320	0.353	0.287	0.239	0.221	0.229	0.243	0.225	0.220		

TABLE IV  
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
... ..	...	...	...	...	...
105 2003 – Alternatif Bank A.Ş.	0.802	1.000	0.882	0.818	1.159
106 2003 – Eurobank Tefen A.Ş.	1.000	1.000	0.787	0.645	1.105
107 2003 – Tekstil Bankası A.Ş.	0.858	0.983	0.486	0.744	0.865
108 2003 – Millenium 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
<b>Geometric Mean</b>					<b>1.810</b>

TABLE V  
MALMQUIST PRODUCTIVITY INDICES FOR EACH COMBINATION OF YEARS

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

#### V. CONCLUSION

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. In this paper, we have investigated the question of: “Were the Turkish banks more profitable between 1998 and 2003 or between 2004 and 2008?” 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.

Moreover, 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 imbursement 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.

#### ACKNOWLEDGMENT

This research has been financially supported by Galatasaray University Research Fund.

#### REFERENCES

- [1] J.C. Paradi and H. Zhu, “A survey on bank branch efficiency and performance research with data envelopment analysis”, *Omega*, to be published, doi:10.1016/j.omega.2011.08.010.
- [2] T. Burdissio, L. D’Amato and A. Molinari, “The bank privatization process in Argentina: towards a more efficient banking system?”, Research Dev. Of the Banco Central de la Republica Argentina, Working Paper no.4, 1998.
- [3] A. Krueger and A. Tornell, “The role of bank restructuring in recovering from crises: Mexico 1995-98”, NBER Working Paper no. 7042, 1999.
- [4] A. Bhattacharya, C.A.K. Lovell and P. Sahay, “The impact of financial liberalization on the productive efficiency of Indian commercial banks”, *European Journal of Operational Research* 99, 1997, pp. 332-345.
- [5] A.N. Berger and D.B. Humphrey, “Bank scale economies, mergers, concentration, and efficiency: The US experience”, Finance and Economics Discussion Series, Washington DC, 1994.
- [6] A.N. Berger, S.M. Davies and M.J. Flannery, “Comparing market and supervisory assessments of bank performance: who knows what when?”, Federal Reserve: Finance and Economics Discussion Series Paper, 1998, pp. 1-43.
- [7] R. De Young and G. Whalen, “Banking industry consolidation: efficiency issues”, in Proc. Conference of the Jerome Levy Economics Institute, 1994.
- [8] I. Işık, M.K. Hassan, “Financial Disruption and Bank Productivity: The 1994 Experience of Turkish Bank”, *The Quarterly Review of Economics and Finance*, 2003, 43, pp. 291-320.

- [9] E.N. Özkan Günay, A. Tektaş, "Efficiency analysis of the Turkish banking sector in pre-crisis and crisis period: A DEA approach, *Contemporary Economic Policy*, 2006, 24 (3), pp. 418-431.
- [10] M. Mercan, A. Reisman, R. Yolalan and A.B. Emel, "The effect of scale and mode of ownership on the financial performance of the Turkish banking sector: results of a DEA-based analysis", *Socio-Economic Planning Sciences* 37, 2003, pp. 185-202.
- [11] M. Norman and B. Stoker, *Data Envelopment Analysis: The Assessment of Performance*. Wiley, 1991.
- [12] M.J. Farrell, The measurement of productive efficiency, *Journal of the Royal Statistical Society, Series A*, 1957, 120 (3), pp. 253-281.
- [13] A. Charnes, W.W. Cooper and E.L. Rhodes, "Measuring the efficiency of decision making units", *European Journal of Operational Research*, 1978, 2, pp. 429-444.
- [14] W.W. Cooper, L.M. Seiford and K. Tone, *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*. KAP 22, 2000.
- [15] R.D. Banker, A. Charnes and W.W. Cooper, "Some models for estimating technical and scale efficiencies in data envelopment analysis", *Management Science*, 1984, 30, pp. 1078-1092.
- [16] R.S. Fare and C.A.K. Lovell, "Measuring the technical efficiency of production", *Journal of Economic Theory*, 1978, 19, pp. 150-162.
- [17] J.T. Pastor, J.L. Ruiz and I. Sirvent, "An enhanced DEA Russell graph efficiency measure", *European Journal of Operational Research*, 1999, 115, pp. 596-607.
- [18] K. Tone, "A slacks-based measure of efficiency in data envelopment analysis", *European Journal of Operational Research*, 2001, 130, pp. 498-509.
- [19] Y. Chen, "A non-radial Malmquist productivity index with an illustrative application to Chinese major industries", *International Journal of Production Economics*, 2003, 83, pp. 27-35.