Financial liberalization and banking efficiency: evidence from Turkey

Cevdet A. Denizer · Mustafa Dinc · Murat Tarimcilar

Abstract This paper examines the banking efficiency in a pre- and post-liberalization environment by drawing on the Turkish experience by using DEA. The paper also investigates the scale effect on efficiency. Our findings suggest that liberalization programs were followed by an observable decline in efficiency. Another finding of the study is that the Turkish banking system had a serious scale problem during the study period. The second part of our analysis relied on econometric methods and found that one major reason for such system-wide efficiency decline has been the growing macroeconomic instability of the Turkish economy in general and financial sector in particular.

Keywords Banking · Efficiency · Liberalization · Data envelopment analysis

JEL Classification C14 · C61 · G21 · G28

Starting in early 1980s a large number of countries liberalized their financial sectors through deregulation of interest rates and removal of entry restrictions in order to improve efficiency performance. After a decade or so, most of these countries liberalized their capital accounts, which in turn set the stage for financial integration process across national markets. Today, financial institutions face a fast-paced, dynamic, and competitive environment on a global scale. Such a competitive environment forced these institutions to examine their performance because their survival will, to a large extent, depend upon their productive efficiencies. Some earlier studies (Berger and Humphrey 1991; Berger et al. 1993a, b) showed that, particularly in banking sector, inefficiencies are more important than scale and scope issues. Hence, in response, firms have been trying to adapt and to adjust themselves to improve their productive efficiencies in this changing social and economic environment (Harker and Zenios 2000; Isik and Hassan 2002).

The impact of financial liberalization measures on bank efficiency has received a considerable attention in the literature. However, most of these studies focused on efficiency outcomes in industrialized countries (Wheelock and Wilson 1999; Kumbhakar et al. 2001; Pastor 2002: Sturm and Williams 2004) but only a limited number of studies have been undertaken in the context of mixed developing economies where deregulation and liberalization programs have been introduced (Bhattacharyya et al. 1997; Canhoto and Dermine 2003; Kwan 2003, Fries and Taci 2005). All these studies report that deregulation and liberalization had a major impact on productivity and efficiency increases in various industries and the banking sector in some Eastern and Central European countries, as well as China. Although the primary goal of liberalization and deregulation has been to improve efficiency, earlier results have been mixed, in particular the short-term effects of liberalization have been discouraging (Leightner and Lovell 1998;

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Harker and Zenios 2000). For example, Berg et al. (1991) found that in Norway during 1980–1989 the productivity of banks declined initially but eventually rose. Isik and Hassan (2002 2003) and Zaim (1995) reported efficiency gains in Turkish banks after the 1980 liberalization program. Leightner and Lovell (1998) investigated the Thai banking industry from both the bank and the government's perspective from 1989 to 1994. They found that the average Thai bank had a rapid productivity gain based on its own objectives, but that during this period productivity gains from the liberalization program could not help advancing the government objectives (overall economic growth). Korea launched a major financial liberalization program in the 1980s. Gilbert and Wilson (1998) examined Korean banking institutions between 1980 and 1994 and found that most Korean banks experienced efficiency gains during this period as government controls were lifted. On the other hand, it was found that in the U.S. (Humphrey and Pulley 1997) and in Spain (Grifell-Tatje and Lovell 1996) deregulation resulted in a decline in efficiency.[1] For a detailed review of international comparison of banking efficiency studies see Berger 2004.

While these studies have improved our understanding of the impact of financial liberalization programs on bank efficiency, the review of literature suggests that, at least in the context of developing countries, some important factors that may have affected reform outcomes are overlooked. First, all of the aforementioned studies investigate the efficiency after or during the deregulation period without covering the period before liberalization/deregulation programs. Extending the evaluation to before and after liberalization could show the real impact of liberalization programs on efficiency, but this has not yet been demonstrated (Harker and Zenios 2000). Second, many developing countries suffered from macroeconomic instabilities and in some cases banking crisis during the last twenty years. It is possible that volatile inflation and growth rates distorted the incentive structure for banks making resource allocation to achieve efficiency a much harder task.

In this paper, we focus on Turkey's financial liberalization experience[2] and analyze bank efficiency using data covering a 25-year period from 1970 to 1994,[3] which is expected to improve the chances of identifying the long-term policy implications and comparing efficiency before and after liberalization. At the same time, we consider the

impact of unstable macroeconomic environment on bank efficiency observed during the study period which may shed light on whether a stable operating environment is indeed a prerequisite for financial reforms to be effective and improve efficiency. To our knowledge, this has not done before for countries at the stage of development similar to Turkey's. For assessing bank efficiency, we use a non-parametric mathematical programming model, DEA, for each year from 1970 to 1994 to understand the efficiency of the sector before reforms and at the same time analyze whether the liberalization program improved the efficiency of the Turkish banks by function and by ownership. Our use of DEA significantly differs from earlier works in one important respect. We apply DEA methodology in two stages[4] to the banking sector to facilitate the investigation of both production and intermediation functions of the banks to determine the relationship of these two components of bank operations. It allows us to examine the banks' efficiency in separate dimensions without one biasing the other. Although these components are two discrete analyses, they complete a continuum in presenting a more comprehensive picture of the system. We rely on regression methods for assessing the impact of unstable macroeconomic environment on bank efficiency, which is presented in the second half of the paper after deriving DEA-based efficiency scores.

The organization of the paper is as follows: The next section discusses methodology and its strengths. A two-stage modeling framework is presented, which considers both roles in this section. The selected variables and reasoning behind the selection with the modeling framework are also discussed. Section 3 presents the findings and discussion. Section 4 considers the impact of the unstable macroeconomic environment on bank efficiency. We first summarize the evolution of key macro variables and then use econometric methods to analyze the linkages between bank efficiency scores and inflation and growth. Section 5 concludes.

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[1] Later, Grifell-Tatje and Lovell (1997) employed a different specification and reached to the opposite conclusion.

[2] Isik and Hassan (2002, 2003) provide a detailed review of Turkish financial system and liberalization program.

[3] Due to some changes in the banking regulations in Turkey after 1994 resulting from a heavy financial crises that significantly affected the banking practice, we did not include later years in our study.

[4] Multi-stage application of DEA is not new, although it is not used in the context of present study. See, for example, Pastor (1999, 2002) and Maudos and Pastor (2003) for multi-stage DEA application to banking efficiency. Pastor (1999) proposed a new sequential DEA procedure to break down the main indicator of banking risk into two components (internal and external) to get a risk-adjusted efficiency measurement. Pastor (2002) developed a three-stage sequential DEA technique applied to the decomposition of risk into its internal and external components to obtaine efficiency measures adjusted for risk and environment. Maudos and Pastor (2003) used a two-stage DEA model to analyze cost and profit efficiency and to compare in both commercial and savings banks of Spain. All these new applications enriched the results and provided additional information about banking efficiency.

1 Methodology, variable selection and application

This inquiry employs the non-parametric frontier approach[5] to estimate the relative efficiency of commercial banks in Turkey. This approach, also known as Data Envelopment Analysis (DEA), is a mathematical programming technique that measures the efficiency of a bank relative to a best-practice bank on the efficiency frontier. The assumption here is that if the bank being measured is operating in the same environment it should perform as well as the one on the frontier. We should note, however, in such efficiency measurement the frontier reflects the estimated performances of the best-practice banks in the sample rather than true efficient point. It should also be noted that the efficiency scores are based on the performance of banks and do not include other social cost and benefits (Berger 2004).

The Warwick Windows DEA software version 1.02 is utilized in this study to solve the models. CCR and BCC input oriented models have been executed for every year from 1970 to 1994 for commercial banks in Turkey. These models identify efficiency in two stages; the intermediate point is first obtained, and then the subsequent projection point is found by solving the second stage. Formulations of a simple DEA model and the models used in this study are presented in the Appendix A.

1.1 Variable selection

It is commonly acknowledged that the choice of variables in efficiency studies significantly affects the results. A number of studies present results that differ due to variable selection (Favore and Pappi 1995; Hunter and Timme 1995). There are, however, certain limitations on variable selection due to the reliability of the data. For example, the variables may present different information, although they carry the same label, or the same information may be reported under different labels. This variation stems from the lack of reporting standards in banking industry. On the other hand, the use of unnecessary variables clutters the analysis and makes it difficult to interpret for both parametric and non-parametric studies. The burden is on the study to tediously justify the selection process. Another important complication in bank efficiency studies that affects the variable selection and hence the results is the definition of a bank's function.

The role of a commercial bank is generally defined as collecting the savings of households and other agents to finance the investment needs of firms and consumption needs of individuals. Three approaches in the banking literature discuss the activities of banks: the production approach, the intermediation approach and the modern approach (Freixas and Rochet 1997). The first two approaches apply the traditional microeconomic theory of the firm to banking and differ only in the specification of banking activities. The third approach, which will not be discussed here, goes one step further, and incorporates some specific activities of banking into the classical theory, and hence modifies it.

In the production approach, banking activities are described as the production of services to depositors and borrowers. Traditional production factors, land, labor and capital, are used as inputs to produce desired outputs i.e. deposits and non-interest income. This approach suffers from a basic problem in terms of measurement of outputs. Is it the number of accounts, the number of operations on these accounts, or the dollar amounts when it comes to measuring deposits? We chose the generally accepted approach of using dollar amounts since it is the one that is least sensitive to random effect (Freixas and Rochet 1997).

The intermediation approach is in fact complementary to the production approach and describes the banking activities as transforming the money borrowed from depositors into the money lent to borrowers. This transformation activity originates from the different characteristics of deposits and loans. Deposits are typically divisible, liquid and riskless, while on the other hand loans are indivisible, illiquid and risky. In this approach, inputs are financial capital –the deposits collected and funds borrowed from financial markets, and outputs are measured by the volume of loans and investments outstanding (Freixas and Rochet 1997).

Banks were analyzed as production units in some earlier studies (Ferrier and Lovell 1990; Shaffnit et al. 1997; Zenios et al. 1999; Athanassopoulos and Giokas 2000), while others considered them as intermediary institutions (Barr et al. 1994; Athanassopoulos and Giokas 2000; Maudos and Pastor 2003; Casu et al. 2003). The importance of the definition of banking function is clear in determining the input and output variables for an efficiency study. Although it is obvious that the banks carry both functions, a choice has to be made for the definition of input and output variables for implementing an empirical study.

In light of these considerations, this study utilizes the production and intermediation approaches complementarily in the analysis of the efficiency of Turkish commercial banks. It is assumed that banking is a simultaneously occurring two-stage process. During the production stage banks collect deposits by using their resources, labor and capital; and in the intermediation stage they transform these deposits into loans and investments. This framework is employed to determine the application process as well as

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[5] Bauer et al. (1998) provide a detailed comparison of methods used in measuring the efficiency of financial institutions.

Labor and Capital $\xrightarrow{\text{Production}}$ Deposits $\xrightarrow{\text{Intermediation}}$ Loans and Investments
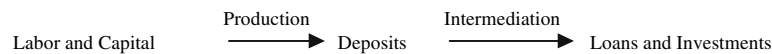
Fig. 1 Banking process

the selection of inputs and outputs for the analysis of efficiency. (Fig. 1)

This approach is particularly important in the analysis of performances of banks during transition from a strictly regulated banking system to much more liberalized system because the liberalization measures would lead to the entry of new banks and brokerage houses into the system, as in the Turkish case. Hence, the increased competition in the sector would force banks to take some steps in adapting to the new environment. From a purely profit seeking firm's point of view, this step could be focusing on collection of deposits by using less resources than its competitors and compensating its losses in the intermediation process or vice versa. The goal, depending on the gains from the each process, could be to accomplish some short-term objectives such as market share growth or introduction of a new financial product without any efficiency concern or to become leaner and more efficient. We should note that this approach could provide more information in the analysis of individual banks rather than the average efficiency of the whole system. Even though in the present study we analyzed individual banks in Turkey to obtain the efficiency scores of the system, we do not report these scores at the individual bank level. The below (Table 1) performance matrix shows that a bank may be in four different positions regarding its performance in the production and intermediation processes. It is obvious from the performance matrix that the most desirable position is the first row where a bank performs well in both the production and intermediation processes.

Following this framework, two major inputs were determined for both stages: **total own resources of the bank** (includes physical and financial capital) and **the total operational expenses** (includes personnel expenses, amortization and provision, and other expenses). Since these inputs are shared by both functionalities of the bank, it is necessary to allocate them to both stages of the analysis. There is, however, no readily available, recognized and accepted weight measure for such allocation. If data on the number and volume of the transactions for deposits and

loans were available, it would have been relatively straightforward to calculate these weights.

Given the lack of data for such an ideal allocation measure, our method of finding the best estimate for weights is based on the following reasoning. We should note that banks primarily fund themselves by attracting deposits. In this process these banks incur interest expenses on the volume of deposits they collect, which is emphasized by the production approach. It should also be noted that net interest expense associated with deposits is the largest as well as the most stable expense item in commercial banking. In the case of Turkish banking sector, the share of interest on deposits was around 60 percent of total interest and commission expenses during the 1970–1994 period and this percentage did not fluctuate much. Given the lack of any other option it seems to us that this is indeed a reasonable proxy for the weight of production. It would be, then, logical to argue that the rest of expenses are associated with intermediation function. Therefore, it is fair to assume that the definition of transactions through interest rates will more or less reflect each transaction's share.

The following proxy was developed and utilized in this analysis:

1 interest income $\equiv 1$ unit of intermediation transaction
1 interest expense $\equiv 1$ unit of production transaction

and

Interest income + interest expense $\equiv$
    Volume of Total transactions

hence

Weight of Production (WP)
$$\equiv \frac{\text{Interest Expenses}}{(\text{Interest Incomes} + \text{Interest Expenses})}$$
Weight of Intermediation (WI) $\equiv 1 - \text{WP}$

WP and WI are calculated for each bank for every year. These values, then, are used to weigh the total own resources of the bank and total operational expenses for production and intermediation functions.

Integrating the above defined weighting method with the inputs and outputs explained before, the following variables were employed for production and intermediation stages

Table 1 Performance matrix

	Production	Intermediation
Efficiency	+	+
	+	–
	–	–
	–	+

1.1.1 Production

Inputs:

Total own resources of the bank for production, (OR*WP)
Total operational expenses for production, (OE*WP)
The interests and fees paid by the bank.
 Outputs:

Total deposits,
Non-interest income.

1.1.2 Intermediation

Inputs:

Total own resources of the bank for intermediation, (OR*WI)
Total operational expenses for intermediation, (OE*WI)
Total deposits
 Outputs:

Total loans,
Banking income (interests, commissions and charges collected for banking).

Note that the number of branches owned by the banks is not used as an input although it is an important factor. The reason for this omission is that all input and output variables are normalized by dividing them by the number of branches for the given year.

All data used in this study come from the Banks Associations of Turkey.

1.2 Application

Within this framework, this study utilizes a two-stage DEA analysis. In the first stage, the relative efficiency of the production process of banking is assessed. In the second stage the efficiency of intermediation process of banking is examined.

Further, assuming that banks deal with only production (intermediation) activities we also run the same model by using the same variables for production (intermediation) without dividing total own resources and total operational expenses inputs to production and intermediation.[6]

The models presented in this paper test whether the financial liberalization program led to efficiency gains by deriving the average efficiency scores of the banking system over time. If the hypothesis holds, efficiency scores of the inefficient banks should move toward the efficiency frontier. In turn, the average efficiency score of the system

should increase for the years after the program is introduced. Hence, any increase in the average efficiency score would signal efficiency gains for that year. After determining efficiency scores of all operational banks individually for each year from 1970 to 1994,[7] the evolution of average efficiency scores of the banking system are considered. Combined with the percentage of efficient banks, these results provide useful information about the impact of liberalization on efficiency of the banking system.

2 Findings and discussion

The implementation of models discussed above produced four sets of efficiency scores for each year from 1970 to 1994. They are the total efficiency scores, which are generated by the CCR model and the technical efficiency scores, which are generated by the BCC models for both stages of banking process, production and intermediation.[8] These scores are presented as simple averages over banks under investigation for a given year. Although averaging the scores may cause loss of information, particularly the variation among individual banks, analyzing and reporting them all on an individual bank basis would require a separate study.

2.1 Average efficiency of Turkish commercial banking

The results of the BCC model for both production and intermediation processes of the banking system are presented in Fig. 2. From 1970 to 1994, the average relative efficiency of Turkish banking in terms of production process fluctuated significantly, ranging from an efficiency score of 86.56 in 1972 to a mere 50.61 in 1993. Prior to 1980, the production performance of the banking systems appeared to be relatively more stable than after liberalization, with an average efficiency ranging around just above 80. After liberalization, the relative efficiency of Turkish banking had a sharp decline in 1982, then increased its highest efficiency of 87.54 in 1985, and began to fluctuate after 1985. The results for the production process of banking as shown in Fig. 2 suggest that the annual average efficiency of the banking system as a whole followed a downward trend, which also suggests that the liberalization program did not fulfill its promise in terms of efficiency gains in the production process of banking.

Figure 2 also shows the results of BCC model for intermediation process. The Turkish banking system had relatively higher efficiency scores in intermediation than production, and similar to the production process, fluctu-

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[6] We would like to thank Allen Berger and anonymous referee for the suggestion.

[7] The number of banks under investigation ranged from 29 in 1976 and 1977 to 53 in 1990.

[8] Detailed results of each model are available from the authors.

Fig. 2 (**a**) Average efficiency of Turkish banking (BCC), (**b**) Distribution of BCCp efficiency scores over the years, (**c**) Distribution of BCCi efficiency scores over the years
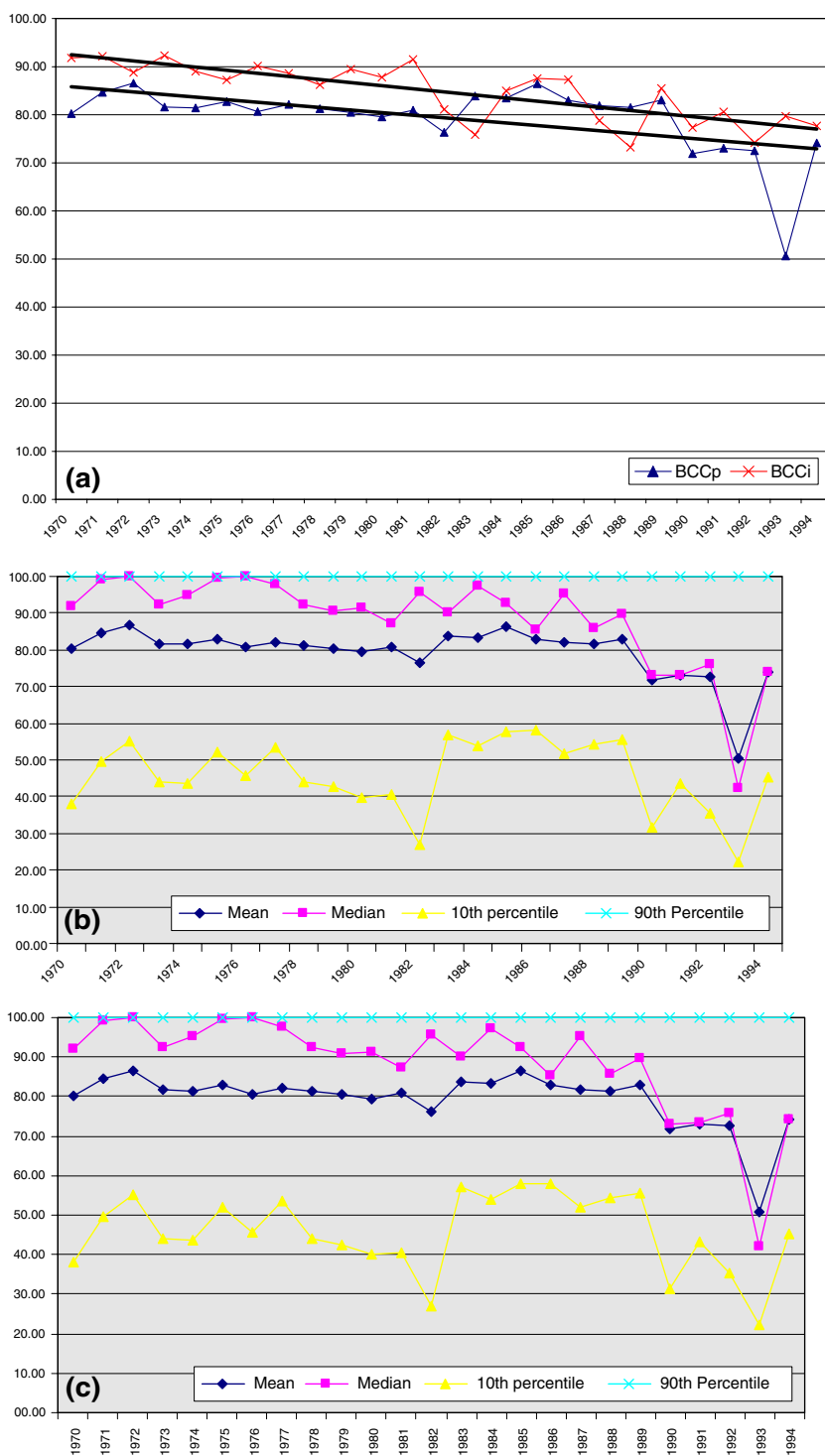
ated from a high of 92.15 percent to a low of 73.22 percent. This suggests that the banking system performed relatively well in its basic function: transforming deposits to loans. The slope of the trend lines for intermediation and production, which are similar, is another indicator of poor efficiency performance of Turkish banks. A glance at Fig. 2 suggests that the performance of the Turkish bank-

ing system, in both functionalities, began declining after 1978, although there was a short recovery period from 1981 to 1985.

We have also plotted means and medians together and compared the results.[9] The distribution of the efficiency

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[9] Graphs are available from the authors for interested readers.

scores for both the production and the intermediation processes show that there is an accumulation of efficient banks in earlier years with some banks scoring low and pulling the mean down. The distribution became more symmetric in later years; however the degree of variation remained relatively similar.

Along with the time series plot of average efficiency scores we run a two-sample t-test to shed some additional light on the findings. The average efficiency scores of the banks before and after the liberalization make up the samples and we then test the hypothesis of equality of the means of two groups. The methodology is the same straightforward two-sample t-test widely used for all the other analysis. The significant p-values indicate that the means of the two samples are not equal to each other regardless of the sampling errors. The p-values are corrected for those comparisons that have unequal variances. We relied on the Bartlett's F-ratio test to test the equality of variances. For those with significant violation of normality assumption we used a nonparametric test, namely Wilcoxen Rank Test. The results of these test demonstrated that the average efficiency declined after 1980 for both production and intermediation processes, which were statistically significant at acceptable levels for both functions.

We should note that these scores do not include scale (in)efficiency, therefore to understand the real impact of liberalization on efficiency it is imperative to review the scale effect. A comparison of the results of CCR and BCC models reveals that the scale problems of the system had an impact on the downward efficiency trend for both functions. One may speculatively interpret this observation as an encouraging sign for liberalization. More technically, this may mean that if the Turkish banking system had operated at the optimum scale, the liberalization program would have had an even greater positive impact on the efficiency of banks.

2.2 Scale efficiency

Although commercial banks are quite similar with respect to their organizational structure, goals and objectives, they vary significantly in size and production level. Even after normalizing the data, this suggests that the scale of banks plays an important role in their relative efficiency or inefficiency. The original CCR model of Charnes et al. (1978) considers both technical and scale efficiency and include inefficiencies resulting from sub-optimal scale size of DMUs. The BCC model, introduced by Banker et al. (1984), separates technical efficiency and scale efficiency. The efficiency scores obtained from CCR model for inefficient units will be lower than the scores obtained from BCC model, although ranking of the units will be the same. Indeed, they showed that the CCR efficiency measure

could be regarded as the product of a technical efficiency measure and a scale efficiency measure (Banker and Thrall 1992). BCC modified the original CCR formulation by adding a convexity constraint for the production possibility set to estimate not only technical efficiency, but also returns to scale (Banker et al. 1984; Banker and Thrall 1992).

Given that the CCR efficiency score is a product of technical and scale efficiency, and BCC measures pure technical efficiency, then the ratio of the efficiency scores $S_k = \frac{q_{k,CCR}}{q_{k,BCC}}$ yields a measure of the relative scale efficiency of bank k. If $S = 1$ it is said that bank k is operating at the most efficient scale size. If it is less than unity, this means there is scale inefficiency for bank k. Thus, $(1-S)$ represents the relative scale inefficiency of a bank (Banker et al. 1984, 1996; Banker and Thrall 1992). The units that are CCR efficient will also be scale efficient, since scale was already factored in the CCR model. The units that are BCC efficient, but inefficient based on the CCR model, have a scale inefficiency. Since they were technically efficient, all of the inefficiencies picked up by CCR are due to scale. This could serve as a useful diagnostic tool for decision makers and bank directors. Once technical and scale efficiency are isolated, the next step is to determine the share of the overall inefficiency that is attributable to technical inefficiency and scale inefficiency.

Following the above discussion, the overall scale efficiency of Turkish banking system is calculated by using the CCR to BCC ratio. The results are presented in Fig. 3. Recall that the higher the value of S, the lower the scale problem of the system. The scale efficiency scores of the Turkish banking system ranged from 75 to 93 for the production process and from 81 to 96 for the intermediation process over the period examined (see Fig. 3). This means that the Turkish banking system suffered from 7 percent to 25 percent efficiency loss in the production process and from 4 percent to 20 percent in the intermediation due to scale problems.

2.3 Average efficiency by ownership

The number of commercial banks in Turkey remained constant before 1980, at 30 (with the exception of 1976 and 1977 when it was 29). The number of banks increased steadily after 1980 reaching 53 in 1990. All of these banks were commercial banks, but their ownership structure was different: some were state banks, some were privately owned, and others were owned by foreign financial institutions. Since they operated in the same environment, we included all of them in the analysis. However, it should be kept in mind that each one of these groups might have responded to the liberalization program differently.

The results of the BCC model for production process are presented in Fig. 4. The state owned banks had their lowest

Fig. 3 Scale efficiency of
Turkish banking system
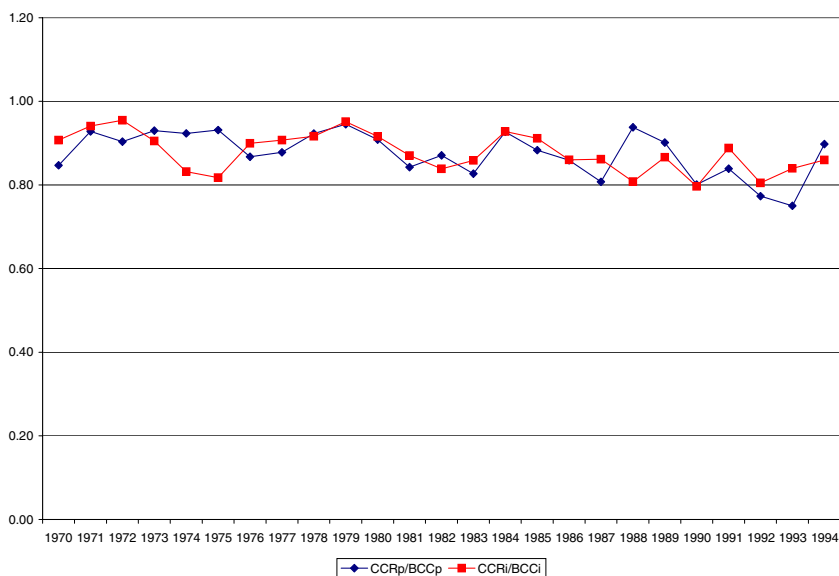
Fig. 4 Efficiency of Turkish
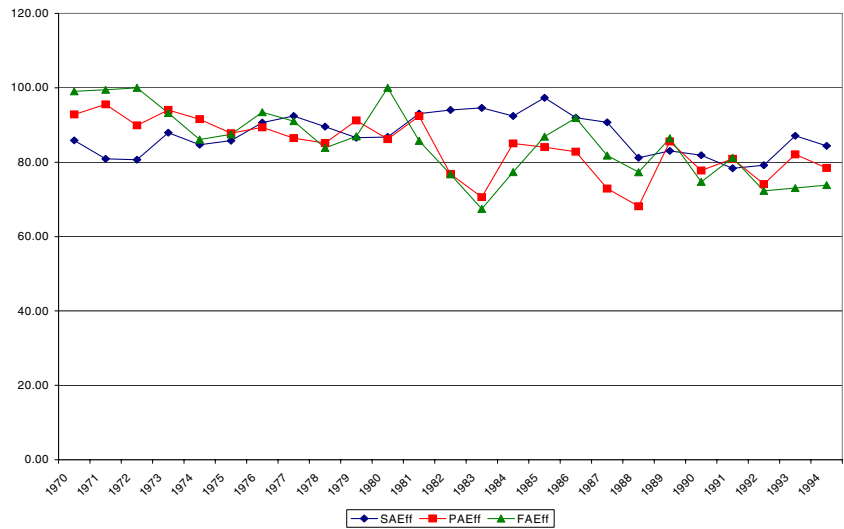banks by ownership for
production function (BCCp)
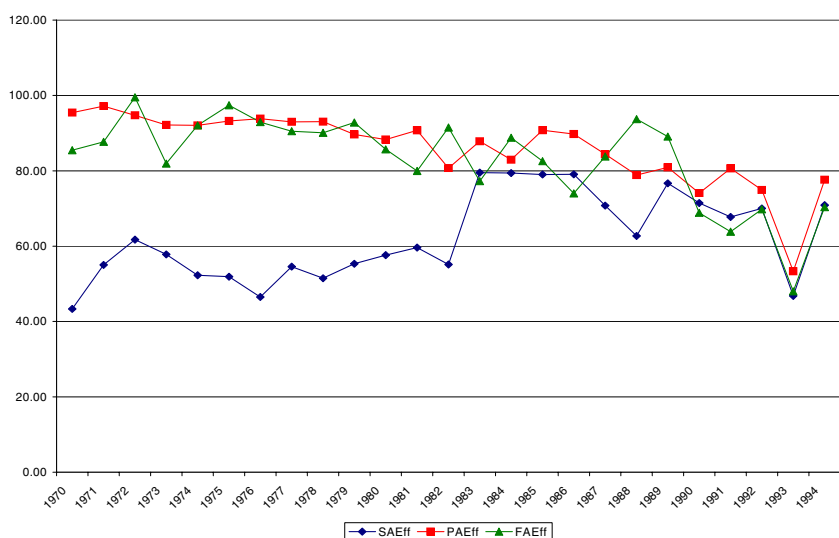
efficiency scores in 1970, 1976 and 1993, 43.32, 46.49 and
46.79, respectively. Other groups had their lowest efficiency
scores in 1993 (private banks, 53.32 and foreign owned
banks, 47.99). The highest score for state-owned banks is
79.50 in 1983, for private banks 97.16 in 1971, and for
foreign owned banks 99.50 in 1972. Prior to 1980, state
owned banks performed poorly, whereas privately owned
banks had a relatively better and stable performance during
the same period. Foreign-owned banks fluctuated, but out-
performed state banks and, in some years, even private
banks. The efficiency scores of all groups somewhat con-
verged after 1980, though all fluctuate wildly. One interest-
ing result was that, after liberalization, they all follow a
similar fluctuating pattern, which indicates that banks were
responding to economic changes similarly, although state

owned banks seem to have improved their technical capacity
in production process after liberalization program.

In terms of the intermediation process, state banks seem
to have performed better than private and foreign banks
after the liberalization, although there was no clear domi-
nance of state banks (Fig. 5). Private banks, on the other
hand, remained the poorest performing group until 1992.
The efficiency scores for all groups in this category fol-
lowed a similar trend; particularly after 1984. Another
important outcome of the BCC model for intermediation
process is that the efficiency scores of all groups became
closer to each other, suggesting that these groups had dif-
ferent scale efficiencies during the study period. The rela-
tive stabilization in the efficiencies after 1990 should also
be noted.

Fig. 5 Efficiency of Turkish banks by ownership for intermediation function (BCCi)

The scale efficiency scores of Turkish banking by ownership are presented in Figs. 6 and 7 for both the production and intermediation processes. The scale efficiency of state and private banks in the production process follow a similar pattern, and their scores are relatively close to each other during the early years. However the scale efficiency in production function became unstable after 1980 particularly for the state-owned banks. Foreign-owned banks, on the other hand, operated at a relatively better scale size, and hence have better scores most of the time.

Another important finding of this analysis is that scale efficiency scores of all groups are relatively stable for the years prior to the liberalization program, but after 1980 they started fluctuating, indicating worsening of scale problems. In terms of the intermediation process, state banks and foreign banks operated at a better scale level than their private counterparts, and had relatively steady scale efficiency until 1987. The figures for private banks

vary over the same period. All groups experienced a small decline in scale efficiency after 1985. These results confirm that Turkish banking system, particularly after the liberalization program, had a serious scale problem. This would suggest that banks neither were able to reallocate their labor and capital nor to adopt new processes to maximize efficiency with the resources they possessed.
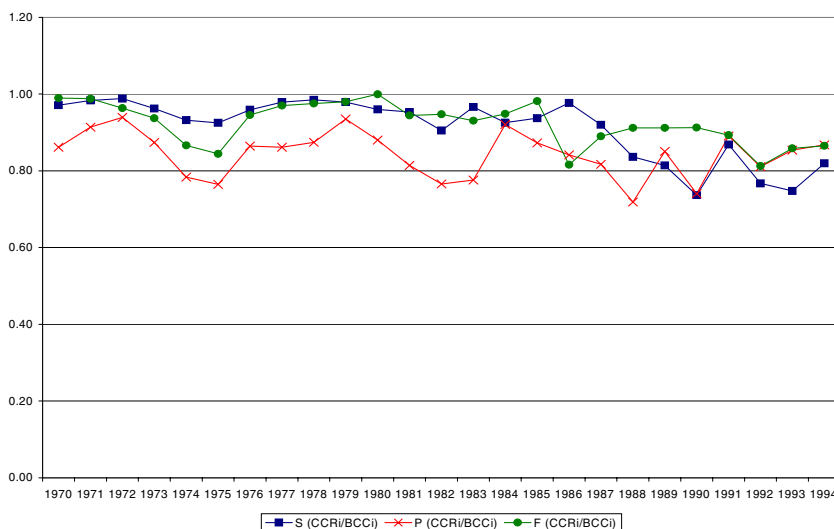
2.4 Percentage of efficient banks

There is a possibility that the decline of average efficiency scores may be due to a few very inefficient banks rather than an overall trend. The percentage of efficient banks in a given year and their time series trend prompt an analysis of this hypothesis. Figure 8 displays that the percentage of efficient banks decreased after liberalization for both production and intermediation processes. The percentage of efficient banks, particularly for intermediation function, significantly fluctuated during the study period. This means
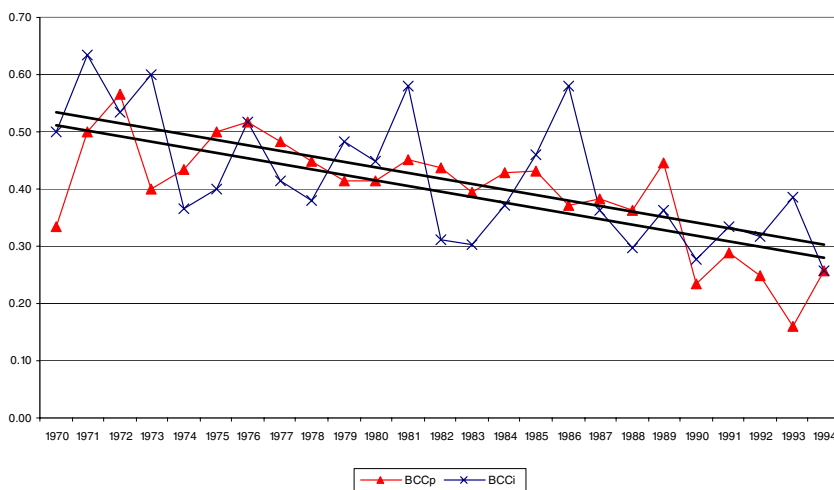
Fig. 6 Scale efficiency of Turkish banking system by ownership (production)
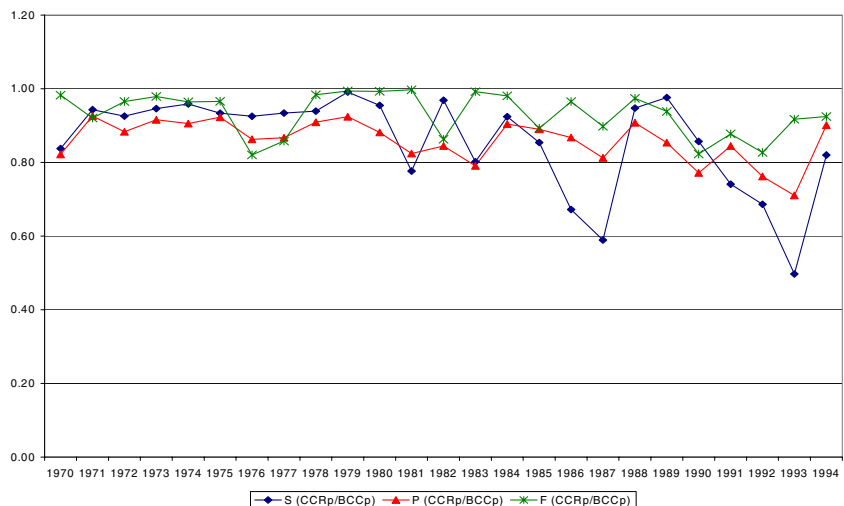
Fig. 7 Scale efficiency of Turkish banking system by ownership (intermediation)

Fig. 8 Percentages of efficient banks (BCC)

that some of these efficient banks had been on the frontier for very few years and could not sustained their performances. These results confirm the earlier findings that the policy change did not bring about the intended results, at least in terms of increasing efficiency.
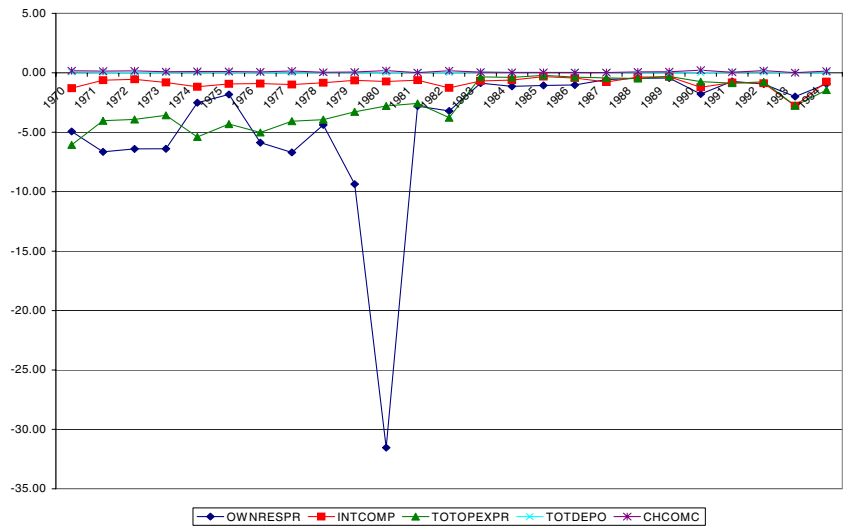
2.5 Sources of inefficiency

One of the strengths of DEA is its ability to provide information about sources of inefficiency in both the input and output sides. This information is extremely useful for managers in improving organizational performance. We have already established the fact that Turkish banking sector struggled with serious scale problems, which, in turn, negatively affected the efficiency of the industry. Even after the scale effect has been removed, the banking sector still suffered high technical inefficiency. This indicates an excess use of resources, output shortfalls, or some combination of the two. Figures 9 and 10 display the

sources of inefficiency for production and intermediation processes without the scale effect, respectively. The upper part of the figures represents output shortfalls and the lower part represents excess use of inputs.
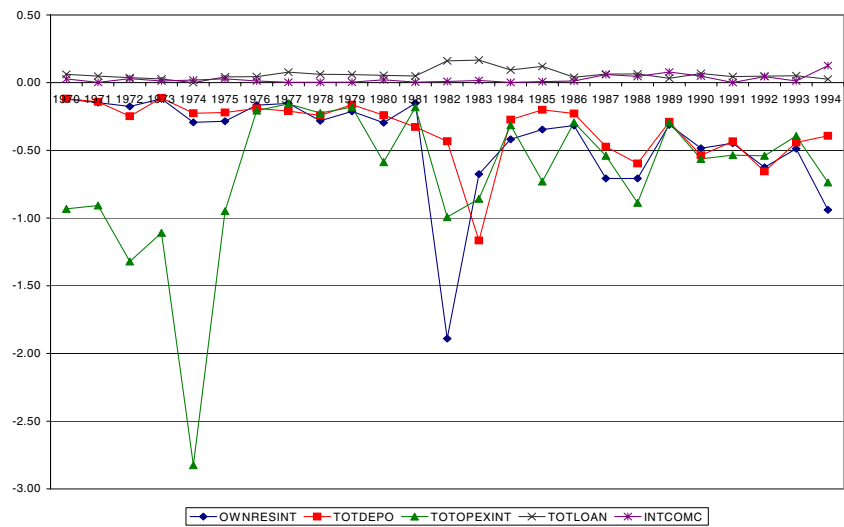
Figure 9 shows that, on average, Turkish commercial banks used excessive amounts of resources for all their inputs over the study period. Looking at the lower portion of the Figure, one can observe that until 1982 there was a stable, although not fully efficient, utilization of the input variable ''interest and commissions paid''. During the same period the utilization of own resources and operating expenses were extremely weak and very erratic. Shortly after the policy is introduced, however, the input usage efficiency became more stable but still with significant variations particularly after 1990s.

On the output side, the results show that banks performed relatively well in collecting deposits throughout the study period. However, their non-interest income output varied somewhat within a shortfall range of 0.1 percent to

Fig. 9 Sources of inefficiency
(BCCp)

Fig. 10 Sources of inefficiency
(BCCi)

22 percent, mostly in the moderate inefficiency zone. These findings suggest that, on average, Turkish commercial banks could have reduced all of their inputs and, at the same time, they could have produced more in terms of deposits and income.

A similar trend is apparent in the intermediation process, with relatively smaller inefficiencies on the input side. In terms of outputs, Turkish banks performed significantly better in the collection of interest income, while displaying poor efficiency in transforming deposits into loans. Similar to the production process, Turkish banks could have performed better at both ends of the intermediation process.

2.6 Further discussion of results

The question now is what happens if we assume that the only role of a commercial bank is the production of services to depositors and borrowers by using traditional production factors, land, labor and capital to produce desired outputs i.e. deposits and non-interest income. We run a BCC model from 1970 to 1994 to compare the results of this approach with the above discussed production approach. This comparison is presented in Fig. 11.

As seen in the figure, the results of both approaches followed a very similar pattern with a downward trend. With the exception of few years the average efficiency scores for production without allocation were a little higher than the scores with allocation ranging from 0.01 percent to 21 percent. During the study period the difference between efficiency scores of these approaches was, on average, 2.45 point. These findings suggest that both approaches provide meaningful results and can be used in the analysis of banking efficiency.

In the same way, we run a BCC model from 1970 to 1994 assuming that the banking activities are about transforming the money borrowed from depositors into the

Fig. 11 Comparison of production approaches (with allocation vs. without allocation)
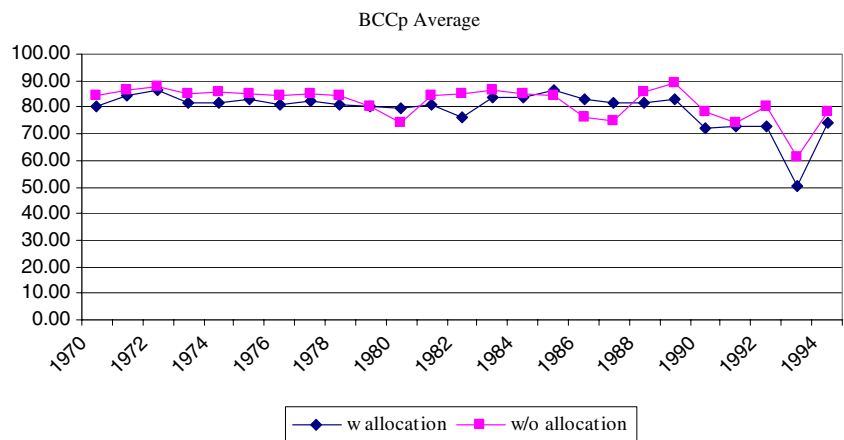
money lent to borrowers by using its financial capital (the deposits collected and funds borrowed from financial markets) and total operational expenses. We compared the results of this approach with the earlier discussed intermediation approach. This comparison is presented in Fig. 12.

As seen in the Fig. 12, the results of both approaches followed almost the same pattern and trend until 1985 and after that the efficiency scores for the intermediation without allocation approach were a little lower than the efficiency score of intermediation with allocation.

We have also compared the results of these two approaches by ownership. These results are presented in Annex B. Similar to the overall comparison of average efficiency scores; the results of these two approaches for all categories by ownership followed a quite similar pattern and the same trend with very small differences. These findings give a strong support to the idea that the proposed approach for separating production and intermediation functions of the banks is indeed a valid one and provides more information about the performances of the banks. These also validate the proposed method of separating

production and intermediation functions of the banks by using the ratio of interest income to the sum of interest income and expense as a proxy.

We should, however, note that all reported results are the average efficiency scores of the whole banking system for a given year and could cause loss of information; particularly the variation among individual banks in terms of the above discussed two different approaches.

Our findings suggest that there are two patterns irrespective of models or the functional form employed. The first pattern is that during 1981–1984, the first four years of the post-liberalization period, efficiency in the banking sector has somewhat improved in both functions. As noted by Atiyas and Ersel (1994), the liberalization measures led to the entry of new banks, and numerous brokerage houses, which increased competition in the sector. This forced banks to be more efficient, which is probably reflected in the results. However, a financial crisis took place in 1982, which caused many brokerage houses exit the system. It may be the case that the deterioration of efficiency measures after 1984 was related to banks reestablishing themselves as the dominant players in financial markets in

Fig. 12 Comparison of intermediation approaches (with allocation vs. without allocation)
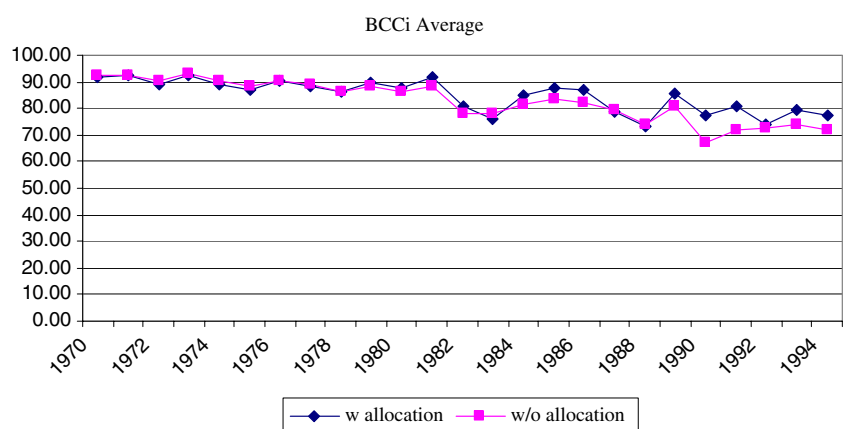
Turkey and regaining their market power. In fact, a number of studies showed that, even after the reform program, banks still have market power in Turkey (Aydogan 1992; Denizer 1997)

The second pattern is related to the efficiency differences between public and private banks. In both the production and intermediation processes, public banks seem to perform better or at least as well as their private and foreign counterparts, which may seem surprising. However, a number of factors probably explain this. Public banks have always enjoyed the benefits of state support and public confidence with respect to safety of deposits. The deposits of public banks increased after the 1982 crisis in particular, which may explain the efficiency jump of public banks in production process in 1982.

Another noteworthy aspect of the public ownership of banks is related to credit. Due to political pressures, public banks issue loans more easily than private banks, which have the effect of increasing of their output and making them appear more efficient. However, this may not be the case on a risk-adjusted basis as public banks carry large amounts of non-performing loans and if adjustments to their outputs were made to reflect these loan losses, public banks might actually be much less efficient than private banks. The lack of detailed data on the duty losses of public banks due to subsidized loans to favored sectors prevents the in-depth examination of this hypothesis. It was always known in Turkey that the size of public banks' bad loan portfolio was very large. In fact, after the financial crisis in November 2000 and February 2001, it was disclosed that the stock of non-performing loans were in excess of US$20 billion, or 10 percent of GDP which were accumulated during the 1980s and 1990s, which reflect the extent of political intervention in public banks.

3 Macroeconomic factors and efficiency

The fact that efficiency scores, irrespective of models or the functional form employed, exhibits a negative trend for all banks during the study period could be an indication of the impact of some common factors on bank efficiency. In the context of Turkey, the first obvious suspect is the macroeconomic, or the operating environment for the banking system. As noted earlier, during the entire study period the rate of inflation has been high and variable and economic growth patterns remained volatile. As shown in Fig. 11, inflation steadily rose from 9 percent in 1970 to about 85 percent by 1980. Despite repeated stabilization efforts, lack of credible fiscal adjustment during the 1980s and 1990s led to sustained increases in the level of prices and inflation averaged about 65 percent in the 1990s. Moreover, due to stop-go nature of stabilization attempts, the volatility of inflation has been high as shown in Fig. 11. Under these circumstances economic growth has also been erratic and Turkey's output performance during the study period has been characterized by boom-bust cycles (Fig. 13).

It is natural to expect that such volatile environment affected banks' performance in Turkey. In fact, a number of studies have shown that high and variable inflation negatively impacted the development of financial sector. (Uygur 1993; Denizer et al. 2000). In particular, it was shown that commercial banks reduced their lending and share of credit as the percentage of total bank assets declined over time. In fact, the share of liquid assets, including treasury securities, in total bank assets increased from about 20 percent in 1970 to almost 37 percent of total in 1998 as government securities were the most attractive instrument; yields averaged between 15 and 20 percent in dollar terms due to high inflation and uncertainty and banks

Fig. 13 Inflation rate and GDP growth rate of Turkey
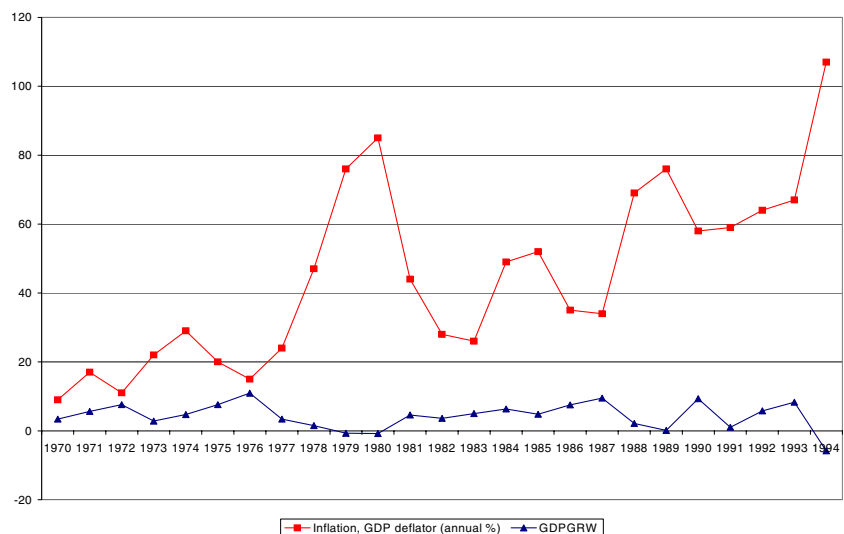
were enjoying easy profits especially after 1989 (World Bank 2000). The end result is that this situation did not provide strong incentives to banks to be efficient and they did not reallocate their labor and capital as much as expected after the 1980 reforms. This may explain the serious scale problem we discussed earlier since high yields on government securities enabled banks to maintain their over extended branch networks and high levels of employment.[10]

Given these concerns, we investigate whether the efficiency scores were affected by the high and variable inflation and the volatility of economic growth by using an econometric model. This is because in DEA applications there might be some environmental factors exogenous to DMUs under investigation and beyond their control and hence could not be included in the model. To address this issue we followed the framework of Lovell et al. (1994); Andersen and Petersen (1993); Rhodes and Southwick (1989); Ray (1991) and Haynes et al. (2000). Lovell et al. (1994) raised the issue of skewness of DEA scores, and argued that DEA scores are bounded between zero and unity, hence the application of ordinary least squares regression analysis may not be an appropriate estimation technique. They suggested a simple logarithmic transformation in the form of:

$$\ln Y = \beta X + \varepsilon$$

In this analysis, to test the impact of environmental factors on banking efficiency two most important macroeconomic variables, GDP growth rate and inflation (GDP deflator) are used as independent variables. Following Lovell et al. (1994) the model employed is as follows:

$$\ln \text{EFFC}_t = \alpha + \beta_1 \text{GDPGR}_t + \beta_2 \text{INFGDP}_t + \text{AR}(1) + \text{AR}(2) + \varepsilon$$

where EFFC is average efficiency score for time t. GDPGR is the GDP growth rate for time t, and INFGDP is the GDP

deflator for the given year. AR(1) and AR(2) are the first and second-order autoregressive terms.[11]

Results of this model for production (EFFC_p) and intermediation (EFFC_i) stages are presented in Table 2. Since the scale problem was already recognized and discussed earlier, in the econometric formulation the results of BCC model were utilized. As seen in Table 2, the sign of inflation coefficient in both models is as expected; inflation had a negative impact on banking efficiency. It seems that the unstable character of inflation distorted asset/liability choices of banks. It may also be the case that true values of assets and liabilities may become blurred in a high inflation environment increasing the uncertainty and the risk banks faced triggering wrong management decisions. Another indirect impact of high inflation on banks seems to be the disintermediation process caused by government bonds increasingly making a larger portion of assets in bank balance sheets. This seems to have negatively affected the resource mobilization and allocation process, which in turn could have reduced bank efficiency.

The negative sign of GDP growth coefficient in both models may seem somewhat counterintuitive, but similar to the inflation the growth of the economy has not been stable in Turkey during the study period, ranging from –6 percent to 11 percent as shown in Fig. 11. This large fluctuation intensified the uncertainty and risks. Further, it is widely acknowledged that economic growth encourages banks to expand their portfolios beyond their capacities that would be sustainable in the long run. It was confirmed by empirical studies that lending booms lead to financial vulnerability by contributing to an endogenous decline in the quality of banks' assets (Tornell 1999; Keeton 1999) and our results are consistent with these findings. While bank loans in Turkey did not grow as rapidly as in some other countries and the share of loans never exceeded half of bank assets after liberalization, the fact that we obtain a negative link between efficiency scores and economic growth would suggest that the quality of loans were not high. This would imply even when the rate of credit growth was not as high as in other countries, the Turkish banks would allocate funds efficiently. This finding reinforces our argument that the banks would have difficulty about their

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[10] As noted at the outset a key objective of the 1980 reforms was to raise efficiency of the banking system. Prior to 1980 banks were engaged in non-price competition as interest rates on deposits and loans were controlled which led to the expansion of bank branch networks. Following the 1980 reforms, which lifted interest rate controls and other restrictions on financial intermediation there was a slowdown in branch expansion. This situation did not last long and after mid-1980s banks started to expand their branch networks again as they were making easy profits from government securities. Bank employment never declined. The fact that banking sector restructuring started after the November 2000 and February 2001 crises and the introduction of a major stabilization program seems to confirm our interpretation of the sources of inefficiency and the scale problem: as long as they made easy profits banks would not restructure to increase their efficiency.

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[11] A common problem in time series analysis is the serial correlation where the residuals are correlated with their own lagged values. We have tested the specified model for serial correlation by using the Durbin–Watson test and found that the model has serial correlation problem. We employed the simplest and most widely used model, the first (and second)-order autoregressive model to deal with serial correlation issue. We should note that when employing an AR model, the estimated coefficients, coefficient standard errors, and t-statistics may be interpreted in the usual manner, but if one is interested in the results involving residuals should be careful because they differ from those computed in OLS settings, which is not the case in present study.

Table 2 Regression results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent variable: Ln(BCCi)				
C	4.615026	0.042470	108.6657	0.0000
INFGDP	–0.002924	0.000622	–4.699191	0.0002
GDPGRW	–0.010896	0.003959	–2.752297	0.0131
AR(1)	0.290932	0.205521	1.415583	0.1740
AR(2)	–0.521006	0.207903	–2.506002	0.0220
R-squared	0.410723			
F-statistic	3.136476			
Prob. (F-statistic)	0.040239			
Durbin–Watson stat	2.101377			
Dependent variable: Ln(BCCp)				
C	4.581684	0.082529	55.51577	0.0000
INFGDP	–0.002994	0.001206	–2.483407	0.0220
GDPGRW	–0.016810	0.006657	–2.525249	0.0201
AR(1)	0.266232	0.230189	1.156579	0.2611
R-squared	0.383787			
F-statistic	4.152104			
Prob (F-statistic)	0.019341			
Durbin–Watson stat	2.011600			

portfolio selection decisions in unstable macroeconomic environments and this may lower the quality of their assets. This, in turn, would reduce interest income and possibly increase interest expenses, which may force loan write-offs, all having a negative impact on bank efficiency.

4 Conclusion

This study analyzed the levels of efficiency covering long periods of time before and after financial liberalization and assessed whether financial liberalization policies led to efficiency increases in the core processes of commercial banks in Turkey. The study also investigated the unstable macro environment characterized by high and variable inflation and erratic growth patterns had an impact on bank efficiency in Turkey between 1970–1994. Our analysis suggests that the total efficiency scores by functionality or ownership, the percentage of efficient banks, and the sources of inefficiency suggest that the liberalization did not provide the anticipated efficiency gains. None of the efficiency scores displayed consistent increases after the introduction of the policy. For all measures, the scores became less stable with a wide range of dispersion during the study period. Between the two functions of the banks, intermediation reacted somewhat more favorably to the new policy. The expected result that the opening up of financial markets would have motivated management to use its resources more efficiently, which would have been reflected positively in efficiency measures, did not materialize.

During the study period in general and post-liberalization period in particular, Turkish commercial banking suffered a serious scale problem. The fact that removing the scale effect somewhat improved the efficiency trend for both functions, although never attained a positive slope may be seen as an encouraging sign for liberalization. In other words, this may be interpreted that if the Turkish banking system had operated at the optimum scale, the liberalization program would have had an even greater positive impact on the efficiency of banks.

Further, the findings of the study suggest that the Turkish commercial banks utilized their resources poorly. On average, Turkish commercial banks could have reduced all of their inputs and, at the same time, they could have produced more in terms of deposits and income.

Another unexpected result is the lack of a difference in efficiency between the state-owned and privately owned banks. Due to their relatively smaller size and more dynamic structure, privately owned and foreign-owned banks were expected to react better to liberalization. The findings of this study generally do not support that assumption. However, we should note that public banks often issue loans not on the basis of commercial criteria but on political grounds, which makes them appear to be producing more output (loans) than private banks with a given amount of resources. While lack of data prevented us further analyzing this issue, as a result of recent financial crisis in Turkey it was disclosed that public banks indeed carry a very large non-performing loans, which confirms our point. If adjustments could be made to public banks' balance

sheets to reflect these loan losses, private banks would be more efficient.

Further, by assuming that banks deal with only production (intermediation) activities we also run the same model by using the same variables for production (intermediation) without dividing total own resources and total operational expenses inputs to production and intermediation. The efficiency scores for the intermediation and production without allocation approach were compared to the efficiency score with allocation. The results of these two approaches for all categories including by ownership followed a similar pattern and the same trend with very small differences. These findings give a strong support to the idea that the proposed approach for separating production and intermediation functions of the banks is indeed a valid one and provides more information about the performances of the banks. These also validate the proposed method of separating production and intermediation functions of the banks by using the ratio of interest income to the sum of interest income and expense as a proxy.

Finally we considered whether the high and variable inflation and unstable growth patterns affected bank efficiency. Our results show that volatile inflation and growth rates have reduced bank efficiency in Turkey. This is an expected result and suggests that environmental factors are important determinants of banking firm efficiency, and that the effectiveness of financial reforms in developing countries would also depend on establishing a stable macroeconomic environment. Another important finding is that in the case of Turkey the scale problem may have been caused and exacerbated by the unstable macro economic environment. In this connection, we identified two key factors, namely the volatility of growth and inflation that made short term scale adjustment more difficult to achieve, and the second, the easy profits from lending to government at high interest rates, which did not provide incentives to move towards optimal scale.

Appendix A

Let us start with the relatively simple fractional programming formulation of DEA. Assume that there are n DMUs to be evaluated. Each consumes different amounts of i inputs and produces r different outputs, i.e. DMUj consumes x_{ij} amounts of input to produce y_{rj} amounts of output. It is assumed that these inputs, x_{ij}, and outputs, y_{rj}, are non-negative, and each DMU has at least one positive input and output value. The productivity of a DMU can then be written as:

$$h_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \tag{1}$$

In this formulation, v_i and u_r are the weights assigned to

each input and output. By using mathematical programming techniques, DEA optimally assigns the weights subject to the following constraints:

- The weights for each DMU are assigned subject to the constraint that no other DMU has an efficiency greater than 1 if it uses the same weights implying that efficient DMUs will have a ratio value of 1.
- The derived weights, u and v are not negative.

The objective function of DMUk is the ratio of the total weighted output divided by the total weighted input:

$$\text{Maximize } h_k = \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \tag{2}$$

$$\text{subject to } \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \quad \text{for } j = 1 \ldots n \tag{3}$$

$v_i \geq 0$ for i = 1.... m, and $u_r \geq 0$ for r = 1 ..... s

This is a simple presentation of a basic DEA model.

Charnes et al. (1978) employed the optimization method of mathematical programming to generalize the single output/input technical efficiency measure to the multiple output/multiple input case by constructing a single virtual output to single virtual input relative efficiency measure. This is the principal form of the DEA model and is known as the CCR ratio model.

The characteristics of the CCR ratio model is the reduction of the multiple output /multiple input situation, for each DMU, to a single virtual output and a single virtual input ratio. For a given DMU this ratio provides a measure of efficiency, which is a function of multipliers (Charnes et al. 1978). The objective is to find the largest sum of weighted outputs of DMUk while keeping the sum of its weighted inputs at the unit value, thereby forcing the ratio of the weighted output to the weighted input for any DMU to be less than or equal to one.

It is possible to create and estimate models that provide input-oriented or output-oriented projections for both constant returns to scale and variable returns to scale envelopments. An input-oriented model attempts to maximize the proportional decrease in input variables while remaining within the envelopment space. On the other hand an output-oriented model maximizes the proportional increase in the output variables while remaining within the envelopment space. Models utilized in this study are formulated as:

CCR First Stage

Max q

s.t. $\sum_j \lambda_j x_{ij} + s_i^- = (1 - w_i q) x_{ij_0}$ (4)

$\sum_j \lambda_j y_{rj} - s_i^+ = (1 - w_r q) y_{rj_0}$ (5)

$\lambda_i \geq 0;\ j = 1.... 50;\ q \geq 0;\ i = 1.... 4;\ r = 1.... 3$

where x_{ij} and y_{rj} are the ith input and rth output level for DMUj. λ_j is the weight of DMU in the facet for the evaluated DMU. w_i and w_r are priorities. s_i and s_r are slacks corresponding to input and output respectively (≥ 0). j_0 is the DMU being assessed. For input minimization model w_i is set equal to 100percent, while w_r is set equal to 0, implying that the input reduction is targeted while keeping output unchanged. For output maximization models, the reverse is true.

CCR Second Stage

$$\text{Max} \quad \sum_i F_i^- s_i^- + \sum_i F_r^+ s_r^+ \tag{6}$$
$$\text{s.t.} \quad \sum_j \lambda_j x_{ij} + s_i^- = (1 - w_i q) x_{ij_0} \tag{7}$$
$$\sum_j \lambda_j y_{rj} - s_i^+ = (1 - w_r q) y_{rj_0} \tag{8}$$

$\lambda_i \geq 0;\ j = 1.... 50;\ q \geq 0;\ i = 1.... 4;\ r = 1.... 3$

where F_i^- and F_r^+ are priorities. In this application, F_i^- is $\frac{1}{\bar{X}_i}$ where $\bar{X}_i$ is the mean value of x_{ij}, and F_r^+ is $\frac{1}{\bar{Y}_r}$, where $\bar{Y}_r$ is the mean value of y_{ij}.

Under input minimization and variable returns to scale conditions, Warwick Windows DEA software solves the following BCC models:

BCC First Stage
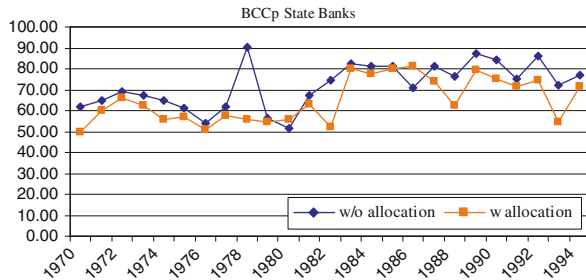
$$\text{Max} \quad q = \sum_r u_r y_{rj_0} + \Omega_1 - \Omega_2 \tag{9}$$
$$\text{s.t.} \quad \sum_r u_r y_{rj} - \sum_i v_i x_{ij} + \Omega_1 - \Omega_2 \leq 0 \tag{10}$$
$$\sum_i v_i x_{ij_0} = 1 \tag{11}$$

$u_r,\ v_i,\ \Omega_1,\ \Omega_2 \geq 0$

By letting q^* be the optimal value of q in the above model, the minimum and maximum limit of the Ω range is obtained by solving the second stage.
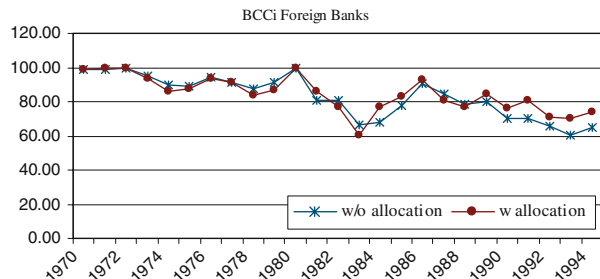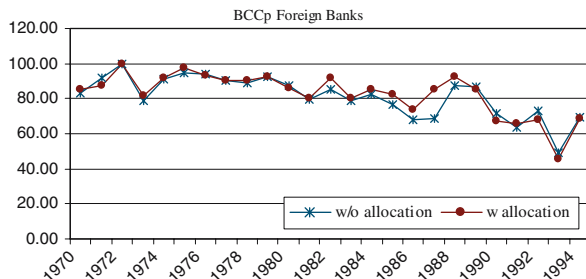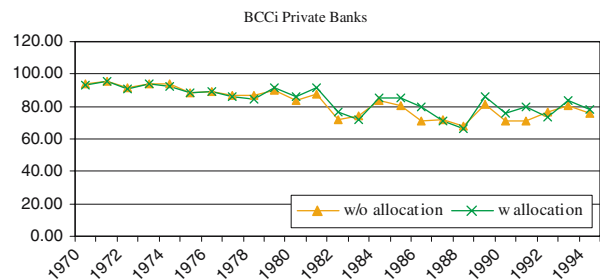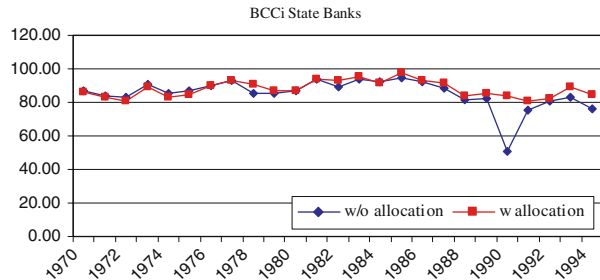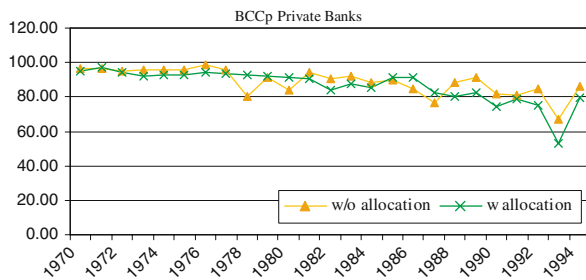
BCC Second Stage

$$\text{Min/Max} \quad \Omega_1 - \Omega_2 \tag{12}$$
$$\text{s.t.} \quad q^* = \sum_r u_r y_{rj_0} + \Omega_1 - \Omega_2 \tag{13}$$
$$\sum_r u_r y_{rj} - \sum_i v_i x_{ij} + \Omega_1 - \Omega_2 \leq 0 \tag{14}$$
$$\sum_i v_i x_{ij_0} = 1 \tag{15}$$

$u_r,\ v_i,\ \Omega_1,\ \Omega_2,\ \geq 0$

where u_r is the weight of the rth output and v_i is the weight of ith input for DMUj. Ω_1 and Ω_2 are the distance from frontier facet.

Annex B

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