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Efficiency of Turkish banking: Two-stage network system. Variable returns to scale model

Hirofumi Fukuyama[a], Roman Matousek[b,*]

[a] *Faculty of Commerce, Fukuoka University, 8-19-1 Nanakuma, Jonan-Ku, Fukuoka 814-0180, Japan*
[b] *Centre for EMEA Banking, Finance and Economics, London Metropolitan Business School, London Metropolitan University, 84 Moorgate, London EC2M 6SQ, UK*

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A B S T R A C T

This study curries out a systematic analysis of the cost, technical and allocative efficiency of the Turkish banking system from 1991 to 2007, under the assumption of variable returns to scale. This unique dataset allows to analyse changes in bank efficiency before and after the financial crises. The applied estimation approach is based on a two-stage network model introduced by Fukuyama and Weber (2010), where in the first stage of production, banks use inputs to produce an intermediate output (deposits) that becomes an input to a second stage where final outputs are produced. We have found several interesting results. Our results show that bank efficiency reflected the state of the Turkish economy before and after crises in 1993–1994 and 2000–2001. Furthermore, there persists a gap between the best and worst performing banks. We could not confirm the hypothesis that foreign banks have higher efficiency scores as we saw in new EU countries.

1. Introduction

The ongoing accession negotiations with a potential inclusion of Turkey into the European Union (EU) structures have renewed the research interest on the Turkish banking system (Steinherr et al., 2004). It is well documented that information on bank efficiency and performance provide an additional important dimension about banks behavior to bank regulators. The need for this kind of

* Corresponding author.
E-mail address: r.matousek@londonmet.ac.uk (R. Matousek).

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information is even more pronounced in emerging market economies because of the inherent fragility of the banking systems. Furthermore evaluating efficiency and performance of Turkish banks is of particular interest due to a large number of legal, structural and institutional changes that have been made in last two decades (Isik and Hassan, 2002).

Recent empirical research on Turkish bank efficiency that includes Aysan and Ceyhan (2008), Ozkan-Gunay and Tektas (2006), Demir et al. (2005), Isik and Hassan (2002, 2003) among others motivates and guides our case study. We deploy an innovative two-stage network system introduced by Fukuyama and Weber (2010) to estimate cost, technical and allocative efficiency. This innovative methodological approach contributes to the current theoretical research on bank efficiency and fully discloses the fundamental shortcomings of the traditional Data Envelopment Analysis (DEA) approach. As we show in Section 4.2, the main shortcomings of the traditional DEA approach is that the production process is treated as a black-box, where only the inputs and outputs are used to estimate efficiency. However, some production processes have a network structure, i.e., there exists an intermediate output that is an input to another sub-process. Such a network structure, as we show in the study, is inherent in banking operational activities and should therefore be taken into the model. In fact, this is even more pronounced in banking systems that largely depends on primary deposits.

The paper makes four main contributions. Firstly, it provides a detailed overview about the main bottlenecks and challenges of the Turkish banking sector for the period of 1991–2007. Secondly, we compare results obtained from a two-stage network system with the traditional black-box DEA approach. This comparison will reveal if there exist the measurement biases between these two approaches. We estimate cost, technical and allocative efficiency under the assumption of variable returns to scale. Thirdly, a unique long dataset allows us to analyse the changes of bank efficiency during the banking crises, i.e., 1994 and 2001. Finally, an integral part of this analysis is the estimation of the sources of bank (in)efficiency by regressing the cost and technical efficiency scores on a set of financial variables by using a bootstrap approach introduced by Simar and Wilson (2007).

We expect that the applied innovative model shows that the traditional DEA approach biases the true level of bank efficiency and does not provide reliable information to policy makers – regulators. Further, we hypothesize that the successful restructuring process should be reflected in higher levels of bank efficiency as argued by Isik and Hassan (2003), Athanasoglou et al. (2008) among others. In addition, we assume that foreign banks will show higher efficiency compared to domestic banks. This hypothesis is based on anecdotal evidence from not only emerging (transition) economies, i.e., Fries and Taci (2005), Staikouras et al. (2008) but also developed economies, i.e., Sturm and Williams (2010). The imposed working hypotheses spring from broadly accepted principles that rapid and successful restructuring of banking sectors should be reflected in higher levels of bank efficiency. Furthermore, we expect that size, profitability, capitalization, net interest margin among other variables will be the main factors having the impact on bank efficiency levels as reported by Mester (1996), Isik and Hassan (2002, 2003), Athanasoglou et al. (2008) and Fethi and Pasiouras (2010).

The paper is structured as follows: Section 2 provides information about the Turkish banking system. Section 3 reviews current studies on the frontier cost function applied in transition economies and Turkey. A further section tackles the methodological concept of estimating cost efficiency in the banking industry. Section 5 defines the used variables and discusses results. Section 6 concludes.

2. Turkish banking sector – a brief overview

The Turkish economy and particularly its banking sector has undergone in last three decades very turbulent periods. The banking system was prevented from being competitive because of strict regulation in the 1970 and early 1980s. The government imposed strict licensing policy and interest rate ceilings. Such environment contributed to banking stability but it worsened the efficient allocation of credits, competitiveness and bank efficiency across the whole sector.

In the early 1980s, the Turkish government launched the liberalisation process that aimed to make free market mechanism functional in the Turkish economy including the financial and banking sector. The deregulation process of the financial market aimed at the removal of a protective umbrella to enhance competitiveness and efficient credit allocation. An increase in number of branches and employees reflected the rapid growth of the banking sector under the post-1980s policy environment.

Increased competition led to the rise of banking activities in terms of resources and placements. In this period, banks' funds were also used in capital markets operations, purchase of government debt securities and Treasury bonds, and in foreign exchange transactions. Banks' customers were offered new products and services such as consumer loans, credit cards, foreign exchange deposit accounts, leasing, factoring, forfeiting, automatic teller machines, point of sales terminals. The launched reforms led to a large number of new bank entries, both domestic and foreign, which in turn increased the competition in the banking sector and enhanced the banking activities in terms of resources and placements.

This rather uncontrolled liberalisation of the financial market went along with the gradual deterioration of macro- and micro-economic imbalances that eventually lead to currency and banking crises in 1994.[1] A direct consequence of the crisis was that the Turkish government had to introduce the full deposit insurance scheme in order to restore the confidence in the banking system. This measure caused the problem of moral hazard since commercial banks, unfortunately, adopted correct expectation about the government financial support and further bail out. A number of banks then reported the deterioration of assets quality in order to be bailed out or to receive capital injections from the government.

The second financial crisis culminated in 2001. The government together with IMF introduced systemic measures to restore the Turkish economy through the so-called Rehabilitation Programme. The Programme addressed the following priorities: Firstly, it sought to restructure three large state-owned commercial banks. Secondly, to restructure those banks that was taken over by the Savings and Deposits Insurance Fund. Further, to strengthen the financial position of private banks and last but not least important issue was to improve the regulatory and supervisory framework. The authorities therefore set the basic regulatory and supervisory framework, new operational guidelines and principles for banks' prudential behavior. In 2002, the Programme was revised in order to reflect the current economic issues. The persistent macroeconomic problem was hyperinflation. In 2002, the government had to introduce inflation accounting to reflect severely distorted financial reporting (Arsoy and Gucenme, 2009).

Programme's measures targeted on the resilience of the economy against external shocks, dropping the inflation, reducing the public sector's debts, ensuring financial discipline, completion of financial reforms, and reinforcement of banking system. The appropriately defined policy targets and their implementation contributed to the stabilisation of the Turkish economy including the financial markets during 2002–2007. The imposed task of the rehabilitation Programme was materialised and economic performance improved in consideration with the fundamental macro-indicators. A stable and high rate of economic growth was achieved, and inflation was kept under control.

The successful implementation of the Programme was also reflected within the banking sector. Private banks increased their capital that eroded during the crisis. Those banks that failed to underwrite new capital had to merge with other banks or were transferred to the Savings Deposit Insurance Fund (SDIF). State-owned banks were restructured and recapitalized. Non-performing loans that were on the balance sheets of the state-owned banks were settled against government debt securities, and financial structures of these banks were strengthened. At the same time, banking supervisory and regulatory agency gained higher autonomy with the accountability for the systemic banking stability. Laws and regulations regarding banks' activities were revised in 2005 and converged to the internationally recognized principles.

3. A brief literature review

Firstly, we overview research studies that have tackled bank efficiency in Turkey.[2] Secondly, we outline and summarise recent development in the theoretical and applied DEA techniques.

[1] This situation was similar to the financial crisis in the South-east Asia in the late 1990s where domestic financial institutions had a large exposure in foreign currencies.

[2] The transition economies display a number of similarities with the Turkish banking sector and provide therefore useful information for comparative analyses. See, for example, Fries and Taci (2005), Staikouras et al. (2008), Matousek and Sarantis (2009) among others.

3.1. Empirical research on bank efficiency in Turkey

Empirical research on bank efficiency in Turkey has been rather limited compared to transition economies or EU countries. Onis (1995) and Ertugrul and Zaim (1999) were among the first to investigate the impact of financial liberalisation on the efficiency of Turkish banks by applying the DEA approach. The main finding of their studies was that financial liberalisation that took place in the late 1980s had positive effect on bank efficiency.

Isik and Hassan (2002) presented a comprehensive study on the efficiency of Turkish banks over the period 1988–1996. They used a non-parametric and parametric approach for the estimation. Their results showed that the main source of inefficiency in Turkish banking was due to technical inefficiency rather than allocative inefficiency caused by diseconomies of scale. They concluded that foreign banks operating in Turkey are significantly more efficient than their domestic peers. Isik and Hassan (2003) then applied non-parametric approach to investigate the impact of ownership and market structure, control and governance on bank efficiency in Turkey. They used only three years of observations – 1988, 1992 and 1996. They confirmed their previous results that foreign banks outperform domestic banks.

Kasman (2002) used a three input–three output Fourier-flexible cost function specification to investigate cost efficiency, scale economies, and technological progress in the Turkish banking system over the period 1988–1998. Results of the study validated the imposed hypothesis that the Turkish banking system had a significant inefficiency problem during the analysed period. The annual inefficiency average decreased over the sample period. Kasman argued that commercial banks in the sector operated more inefficiently than their US and European counterparts. The results also suggested the existence of significant economies of scale across the sample. The study did not confirm diseconomies of scale for larger banks.

Denizer et al. (2007) examined bank efficiency in a pre- and post-liberalisation environment by applying DEA. The dataset spanned from 1970 to 1994. The study concluded that liberalisation programmes were followed by a decline in bank efficiency. The second part of their research showed that the decline in efficiency was closely related with macroeconomic instability. A recent study by Ozkan-Gunay and Tektas (2006) then focused on the analysis of bank efficiency before and after crises period. The sample includes nonpublic commercial banks between 1990 and 2001. They found a gradual decline in bank efficiency over the period. Thus, they confirmed that the crises in 1994 and the late 1990s had the negative impact of bank efficiency. To our best knowledge there is no recent study that covers the period of 1990–2007.

3.2. Recent research on bank efficiency using DEA

Next, we review and summarise the main trends and directions of both theoretical and applied research on bank efficiency that use the DEA approach. The advantage of deploying the non-parametric DEA instead of the parametric method is that it facilitates the computation of multiple input and output production correspondences (Seiford and Zhu, 1999). Generally, there are two types of measures in the DEA; radial and non-radial. Radial measures are represented by CCR (Charnes et al., 1978) and BCC (Banker et al., 1984) models.

However, radial measures of efficiency overestimate technical efficiency when there are nonzero slacks in the constraints defining the piece-wise linear technology as discussed by Fukuyama and Weber (2009). Chen et al. (2010) and Fukuyama and Weber (2010) advanced recent research in banks efficiency by constructing alternative efficiency measures that account for intermediate products.

Fukuyama and Weber (2009) introduced the directional distance function technology into the slacks-based model (SBM) to develop a generalized measure of technical inefficiency. Their model accounts for slack input and output constraints. This new measure has been referred to as the directional slacks-based inefficiency (SBI) measure. Färe and Grosskopf (2010) also proposed a generalization of the SBM measure based on the directional distance function. The optimization problem of this measure is based on the sum of directional distance function and can tell how many excess inputs have been employed and how many or few outputs have been produced.

Chen et al. (2010) suggested an alternative approach for determining two-stage system-based projections for inefficient Decision Making Units (DMUs) within a Kao and Hwang (2008) framework. This approach provides frontier projections for inefficient DMUs, i.e., yields a set of optimal intermediate products that locate on the efficient frontier. Fukuyama and Weber (2010) employed this framework to construct two-stage production technology and developed a directional slacks-based inefficiency measurement approach with bad outputs.

The directional slacks-based measure may be considered a weighted additive model, in which case we need to determine unknown weights in empirical applications and the choice of weights will affect the optimal solutions. Hence, we need a justification for selecting appropriate weights. Although SBI (NSBI) has a similar problem regarding the choice of directions, we can directly compare the relative sizes of SBI (NSBI) and Chambers et al.'s (1996, 1998) directional distance function once we have decided a common directional vector. In this case, the deviation between the two can be quantified by directional inefficiency bias as will be defined in the next section. Furthermore, if we choose an observed input and output vector under evaluation as the directional vector, the computed inefficiency score indicates the total amount of average input inefficiency and average output inefficiency, and therefore can be thought of as a black-box (network) generalization of Tone's (2001) slack-based measure and Pastor et al.'s (1999) enhanced Russell measure.

4. Methodology

4.1. Black-box (standard) cost efficiency

The x_{no} ($i=1, \ldots, N$) and y_{mo} ($m=1, \ldots, M$) represent, respectively, the input and output quantities for the DMU$_o$ ($o=1, \ldots, J$) to be evaluated. For DMU$_j$, $x_j=(x_{1j}, \ldots, x_{Nj})$, $j=1, \ldots, J$, and $y_j=(y_{1j}, \ldots, y_{Mj})$, $m=1, \ldots, M$, are an N-dimensional vector of inputs and an M-dimensional vector of outputs. $\boldsymbol{\lambda}$ is a J-dimensional vector of intensity variables and $\mathbf{0}=(0, \ldots, 0)$ is an appropriate dimensional vector of zeros. Throughout this paper, we assume all input and output quantities are positive. The black-box production possibility set is expressed as

$$T^B = \left\{ (\hat{x}, \hat{y}) \left| \sum_{j=1}^{J} \mathbf{x}_j \lambda_j \leq \hat{x};\ \sum_{j=1}^{J} \mathbf{y}_j \lambda_j \geq \hat{y};\ \sum_{j=1}^{J} \boldsymbol{\lambda}_j = 1; \quad \boldsymbol{\lambda} \geq 0 \right. \right\} \tag{1}$$

where the hat ($\hat{}$) above $\mathbf{x}$ indicates a vector of variables rather than observed values, and similarly for $\hat{\mathbf{y}}$. The convexity assumption $\sum_{j=1}^{J} \lambda_j = 1$ in (1) allows for variable returns to scale. Relative to (1), a black-box cost (standard) efficiency measure is denoted by

$$BC_o = \underset{\hat{\mathbf{x}}, \boldsymbol{\lambda}}{\text{minimize}} \left\{ \frac{\mathbf{c}\hat{\mathbf{x}}}{\cos t_o} \left| \sum_{j=1}^{J} \mathbf{x}_j \lambda_j \leq \hat{x};\ \sum_{j=1}^{J} \mathbf{y}_j \lambda_j \geq y_o;\ \ \sum_{j=1}^{J} \lambda_j = 1; \quad \boldsymbol{\lambda} \geq 0; \quad \hat{\mathbf{x}} \geq 0 \right. \right\} \tag{2}$$

and an (input-oriented) black-box technical efficiency measure is denoted by

$$BT_o = \underset{\theta, \lambda}{\text{minimize}} \left\{ \theta \left| \sum_{j=1}^{J} \mathbf{x}_j \lambda_j \leq \theta \mathbf{x}_o;\ \ \sum_{j=1}^{J} \mathbf{y}_j \lambda_j \geq \mathbf{y};\ \ \sum_{j=1}^{J} \lambda_j = 1; \quad \lambda \geq 0; \quad \theta: \text{ free} \right. \right\} \tag{3}$$

where c_n ($n=1, \ldots, N$) is the price of input n and the inner product, $\mathbf{cx}_o = c_1 x_{1o} + \cdots + c_N x_{No} = \cos t_o$, is the observed total cost for DMUo. Using (2) and (3), we can obtain the black-box allocative efficiency measure denoted by

$$BA_o = \frac{BC_o}{BT_o} \tag{4}$$

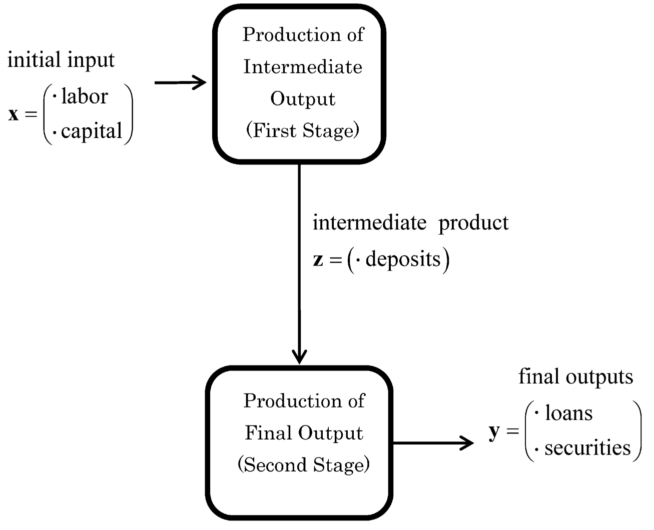

Fig. 1. Bank intermediation.

which can be written as the following black-box cost efficiency decomposition:

$$BC_o = BA_o \times BT_o \tag{5}$$

4.2. Network cost efficiency and network allocative efficiency

In the following section, we model a network structure as depicted in Fig. 1. For this, we modify (1) and define a two-stage network technology as

$$T = \left\{ (\hat{\mathbf{x}}, \hat{\mathbf{z}}, \hat{\mathbf{y}}) \left| \sum_{j=1}^{J} \mathbf{x}_j \lambda^1 \leq \hat{\mathbf{x}}; \quad \sum_{j=1}^{J} \mathbf{z}_j \lambda_j^1 \geq \hat{z}; \quad \sum_{j=1}^{J} \mathbf{z}_j \lambda_j^2 \leq \hat{\mathbf{z}}; \quad \sum_{j=1}^{J} \mathbf{y}_j \lambda_j^2 \geq \hat{\mathbf{y}}; \sum_{j=1}^{J} \lambda_j^1 = 1; \right. \right.$$
$$\left. \sum_{j=1}^{J} \lambda_j^2 = 1; \quad \hat{\mathbf{z}} : \text{free}; \quad \lambda^1 \geq 0; \quad \lambda^2 \geq 0 \right\} \tag{6}$$

where $\mathbf{z}$ is a Q-dimensional vector of intermediate products. The intermediate products are intermediate output at a first sage and are intermediate inputs at a second stage. Relative to (6), a network cost efficiency measure is gauged by

$$NC_o = \frac{\mathbf{c}\hat{\mathbf{x}}^*}{\cos t_o} = \underset{\hat{\mathbf{x}}, \hat{\mathbf{z}}, \ \lambda^1, \ \lambda^2}{\text{minimize}} \left\{ \frac{\mathbf{c}\hat{\mathbf{x}}}{\cos t_o} \left| \sum_{j=1}^{J} \mathbf{x}_j \lambda_j^1 \leq \hat{\mathbf{x}}; \quad \sum_{j=1}^{J} \mathbf{z}_j \lambda_j^1 \geq \hat{\mathbf{z}}; \quad \sum_{j=1}^{J} \mathbf{z}_j \lambda_j^2 \leq \hat{\mathbf{z}}; \quad \sum_{j=1}^{J} \mathbf{y}_j \lambda_j^2 \geq \mathbf{y}; \right. \right.$$
$$\left. \sum_{j=1}^{J} \lambda_j^1 = 1; \quad \sum_{j=1}^{J} \lambda_j^2 = 1; \qquad \hat{\mathbf{z}} : \text{free}; \quad \lambda^1 \geq 0; \quad \lambda^2 \geq 0 \right\} \tag{7}$$

For the treatment of intermediate products, we assume that intermediate products $\hat{\mathbf{z}}$ be endogenous due to the following reasons.

The non-negativity constraints, $\hat{\mathbf{z}} \geq 0$, are not needed in (6) and (7) because they are redundant in view of the restrictions, $\sum_{j=1}^{J} \mathbf{z}_j\lambda_j^1 \geq \hat{\mathbf{z}};\quad \sum_{j=1}^{J} \mathbf{z}_j\lambda_j^2 \leq \hat{\mathbf{z}};$. The dual form of (7) is

$$\underset{\mathbf{v},\mathbf{w}^1,\mathbf{w}^2,\mathbf{u}}{\text{maximize}} \left\{ \mathbf{u}\mathbf{y}_o + \alpha^1 + \alpha^2 \,\middle|\, -\mathbf{v}\mathbf{x}_j + \mathbf{w}\mathbf{z}_j + \alpha^1 \leq 0,\ j = 1, \ldots, J;\ -\mathbf{w}\mathbf{z}_j + \mathbf{u}\mathbf{y}_j + \alpha^2 \leq 0,\ j = 1, \ldots, J; \right.$$
$$\left. \mathbf{v} \leq \frac{\mathbf{c}}{\cos t_o};\ -\mathbf{w}^1 + \mathbf{w}^2 = 0;\ \mathbf{v} \geq 0;\ \mathbf{w}^1 \geq 0;\ \mathbf{w}^2 \geq 0;\ \mathbf{u} \geq 0;\ \alpha^1 : \text{free};\ \alpha^2 : \text{free}. \right\} \tag{8}$$

As Chen et al. (2010) argue in an input-oriented radial technical efficiency setting, we treat $\hat{\mathbf{z}}$ as free variables rather than nonnegative variables. This treatment yields the equality constraints $\mathbf{w}^1 - \mathbf{w}^2 = 0$ in (8), rather than the non-negativity constraints $\mathbf{w}^1 - \mathbf{w}^2 \geq 0$. This adjustment will not cause any changes in the optimal objective values of (7) and (8). The condition $\mathbf{w}^1 - \mathbf{w}^2 = 0$ implies that the shadow prices of intermediate products are the same in both first and second stages. This is consistent to Kao and Hwang's (2008) two-stage technical efficiency measure. Note that the measures by Kao and Hwang (2008) and Chen et al. (2010) are constructed under the assumption of constant returns to scale. In contrast, we adopt the variable returns to scale specification.

As a consequence of treating the intermediate products as endogenous variables, the projected point based on (7) will be located on the efficient frontier, i.e., $NC_o = 1$ for the network cost efficiency projection $(\mathbf{x}_o^*, \hat{\mathbf{z}}^*)$ given a fixed level of $\mathbf{y}_o$. Hence, a DMU must be a frontier point for both divisions if $\hat{\mathbf{z}}^*$ is an optimal solution to (7). This fact justifies the treatment of intermediate products as in (6)–(8).

Regarding the relationship between the black-box measure and the network measure, we have $NC_o \leq BC_o$ because intensity variables can be changed more freely in (7) than (2). Furthermore, if $\lambda_j^{1*} = \lambda_j^{2*}\,(\forall j)$, then $NC_o = BC_o$. Exploiting this relationship, we define a cost efficiency measurement bias index as

$$CostBias = \frac{NC_o}{BC_o} \leq 1 \tag{9}$$

The cost efficiency measurement bias occurs when we completely ignore a two-stage structure in the measurement when such a network structure exists. That is, the cost efficiency measurement bias arises when an analyst focuses on initial inputs and final outputs by ignoring intermediate products. Using this relationship, we obtain the following decomposition:

$$NC_o = CostBias \times BC_o \tag{10}$$

which states that network cost efficiency consists of cost efficiency measurement bias and black-box cost efficiency multiplicatively.

The (whole-system) network technical efficiency measure for DMUo is obtained by

$$NT_o = \underset{\theta,\hat{\mathbf{z}},\lambda^1,\lambda^2}{\text{minimize}} \left\{ \theta \,\middle|\, \sum_{j=1}^{J} \mathbf{x}_j\lambda_j^1 \leq \theta\mathbf{x}_o;\quad \sum_{j=1}^{J} \mathbf{z}_j\lambda_j^1 \geq \hat{\mathbf{z}};\quad \sum_{j=1}^{J} \mathbf{z}_j\lambda_j^2 \leq \hat{\mathbf{z}};\quad \sum_{j=1}^{J} \mathbf{y}_j\lambda_j^2 \geq \mathbf{y}_o; \right.$$
$$\left. \sum_{j=1}^{J} \lambda_j^1 = 1;\quad \sum_{j=1}^{J} \lambda_j^2 = 1;\quad \lambda^1 \geq 0;\quad \lambda^2 \geq 0;\quad \theta : \text{free};\quad \hat{\mathbf{z}} : \text{free}. \right\} \tag{11}$$

Noticing that the relationship $NT_o \leq BTo$, we define a technical efficiency measurement bias by

$$TechBias = \frac{NT_o}{BT_o} \tag{12}$$

which can be interpreted similarly as the cost efficiency measurement bias (9). The corresponding decomposition to (12) is

$$NT_o = TechBias \times BT_o \tag{13}$$

which states that the network technical efficiency is a multiplicative composite of Technical efficiency measurement bias and black-box technical efficiency.

Noting $NC_o \le NT_o$ and hence comparing (11) and (7), we obtain the network allocative efficiency measure as

$$NA_o = \frac{NC_o}{NT_o} \tag{14}$$

Similar to the black-box version, the network measures can be interpreted. Each bank is efficient if the value of a measure is unity. If the value is less than unity, a DMU is inefficient. Rearranging (14), network cost efficiency is decomposed into the product of network allocative efficiency and network technical efficiency:

$$NC_o = NA_o \times NT_o \tag{15}$$

Dividing both sides of (5) by (10), we obtain

$$\frac{NC_o}{BC_o} = \frac{NA_o}{BA_o} \times \frac{NT_o}{BT_o} \quad \text{or} \quad CostBias = AllocBias \times TechBias \tag{16}$$

where cost efficiency measurement bias = $CostBias = NC_o/BC_o$; technical efficiency measurement bias = $TechBias = NT_o/BT_o$; allocative technical efficiency measurement bias = $AllocBias = NA_o/BA_o$.

The relation (16) can be used to identify the major cause of cost efficiency measurement bias.

In our empirical example we consider banks that use only two initial variable inputs: labor and capital (see Fig. 1). We are interested in comparing the ratio of actual labor costs to actual capital costs and the ratio of cost efficient labor costs to cost efficient capital costs that corresponds with cost efficiency. If multiple solutions to (7) exist, there may be more than one ratio of labor to capital costs that minimize total network costs. So as to examine the relative size of overspending on labor, we denote a labor-capital cost mix index as

$$mix = \frac{\text{labor cost}}{\text{capital cost}} = \frac{c_1 x_1}{c_2 x_2} \tag{17}$$

To calculate the relative amount of labor and capital we gauge two more LP problems. One is the following maximization program:

$$\underset{\hat{\mathbf{x}},\hat{\mathbf{z}},\lambda^1,\lambda^2}{\text{maximize}} \left\{ \hat{x}_2 \left| \sum_{n=1}^{N} \frac{c_n \hat{x}_n}{\cos t_o} = NC_o; \ \sum_{j=1}^{J} \mathbf{x}_j \lambda_j^1 \le \hat{\mathbf{x}}; \ \sum_{j=1}^{J} \mathbf{z}_j \lambda_j^1 \ge \hat{\mathbf{z}}; \ \sum_{j=1}^{J} \mathbf{z}_j \lambda_j^2 \le \hat{\mathbf{z}}; \ \sum_{j=1}^{J} \mathbf{y}_j \lambda_j^2 \ge y_o; \right. \right.$$
$$\left. \hat{\mathbf{x}} \ge 0; \ \sum_{j=1}^{J} \lambda_j^1 = 1; \ \sum_{j=1}^{J} \lambda_j^2 = 1; \ \lambda^1 \ge 0; \ \lambda^2 \ge 0; \ \hat{\mathbf{z}} : \text{free.} \right\} \tag{18}$$

where $NC_o = \mathbf{c}\hat{\mathbf{x}}^*$ is the optimal objective value in (7). Now let the double star (**) indicate the solution to (18). Since problem (18) gives the maximal second input, $\hat{x}_2^{**}$, we can obtain the optimal labor-capital cost mix index as $lower\_mix = c_1\hat{x}_1^{**}/c_2\hat{x}_2^{**}$ which gives a lower mix estimate. We obtain an upper mix index $upper\_mix$ to the mix index by replacing the objective function $\hat{x}_2$ by $\hat{x}_1$ in (18).

4.3. Determinants of bank efficiency

There is well-established empirical research that shows that independent variables that characterizes financial aspects of banks are important determinants of bank efficiency (Mester, 1996; Fethi and Pasiouras, 2010). Empirical studies have used a two-step approach to estimate the determinants of bank efficiency levels. In the first step, the efficiency scores are estimated and then the estimated scores are in the second stage regressed on a set of the defined independent variable, e.g., Isik and Hassan (2003), Carvallo and Kasman (2005), Staikouras et al. (2008) among others.

Simar and Wilson (2007) argued that efficiency scores generated by DEA are statistically dependent on each other and applying them in a second step regression may violate the model assumption. A fundamental shortcoming is the fact that the DEA efficiency score is a relative efficiency index and not an absolute efficiency index. Furthermore, conventional inference methods are inconsistent in the second step because of complicated and unknown serial correlations among estimated efficiency scores and environmental variables. They proposed a procedure – bootstrapped truncated regression – which overcomes these problems and enables consistent inference in the second step regression.

Thus, we follow this methodological approach and apply the algorithm presented in Simar and Wilson (2007, pp. 41–42).

i. Calculate the DEA network cost efficiency score $N\hat{C}_o$ for each bank, using the linear programming problem in (7):

$$N\hat{C}_o = \underset{\hat{\mathbf{x}},\hat{\mathbf{z}},\lambda^1,\lambda^2}{\text{minimize}} \left\{ \frac{\mathbf{c}\hat{\mathbf{x}}}{\cos t_o} \middle| \sum_{j=1}^{J} \mathbf{x}_j\lambda_j^1 \le \hat{\mathbf{x}};\quad \sum_{j=1}^{J} \mathbf{z}_j\lambda_j^1 \ge \hat{\mathbf{z}};\quad \sum_{j=1}^{J} \mathbf{z}_j\lambda_j^2 \le \hat{\mathbf{z}};\quad \sum_{j=1}^{J} \mathbf{y}_j\lambda_j^2 \ge \mathbf{y}; \right.$$
$$\left. \sum_{j=1}^{J}\lambda_j^1 = 1;\quad \sum_{j=1}^{J}\lambda_j^2 = 1;\quad \hat{\mathbf{z}}: \text{free};\quad \lambda^1 \ge 0;\quad \lambda^2 \ge 0. \right\} \quad \text{for } o = 1, \ldots, J.$$

ii. Use the maximum likelihood method to estimate the truncated regression of $N\hat{C}_o$ on $\mathbf{r}_o$, to provide estimates $\hat{\beta}$ of β and an estimate $\hat{\sigma}_\varepsilon$ of σ_ε, where $\mathbf{r}_o$ is a vector of independent variables.

iii. For each bank $o = 1, \ldots, J$, repeat the next four steps (1–4) L times to yield a set of bootstrap estimates $A = \left\{(\hat{\beta}^*,\ \hat{\sigma}_\varepsilon^*)_b\right\}_{b=1}^{L}$.
   1. Draw ε_i from the $N(0, \hat{\sigma}_\varepsilon^2)$ distribution with left truncation at $(1 - \hat{\beta}\mathbf{r}_o)$.
   2. Compute $NC_o^* = \hat{\beta}\mathbf{r}_o + \varepsilon_o$.
   3. The maximum likelihood method is used to estimate the truncated regression of NC_o^* on $\mathbf{r}_o$, yielding estimates $(\hat{\beta}^*, \hat{\sigma}_\varepsilon^*)$.

iv. Use the bootstrap results to construct confidence intervals.

In addition to the above bootstrap procedure for network cost efficiency, we carries out a similar bootstrap procedure for network technical efficiency (11).

5. Data and empirical results

5.1. Data and variables

The sample includes 25 commercial banks that operated in Turkey from 1991 to 2007 (see Appendix Table A1). The source of our database is the Banks Association of Turkey. The database covers more representative sample and the time period is longer than from BankScope database.

High inflationary environment in Turkey could distort comparativeness of our results over the analysed period. In particular, hyperinflation during the period of 2002–2004. During this period inflation accounting was adopted and it could cause difficulties to provide an unbiased comparison of the results.[3] Arsoy and Gucenme (2009) provided a thorough analysis of inflation accounting in Turkey. In order to minimise biases of our results inputs and outputs are denominated in US dollars. The denomination of variables in US dollars instead of using the domestic currency helps to control for the adverse impact of the inflation on the real magnitudes. Isik and Hassan (2003) correctly argued that the expression of bank variables in US dollars means direct adjustment of the variables for inflation. The use of variables denominated in US dollars is common in the case studies for Turkey (Isik and Hassan, 2002, 2003; Ozkan-Gunay and Tektas, 2006).

[3] We thank the anonymous referee for pointing out the issue of inflationary accounting in Turkey and possible distortions of a comparative analysis over the analysed period.

Table 1
Descriptive statistics of the employed variables (Mil $US).

	Employees	Capital	Deposits	Securities	Loans
Mean	4787.73	575.18	3642.06	1686.75	2085.62
Max	40,125.00	9146.78	58,871.53	40,177.23	32,103.76
Min	18.00	−320.13	0.14	0.01	0.01
Std	7397.86	1260.39	7290.24	4544.05	4352.73

Berger and Humphrey (1992) showed that studies on bank efficiency use the following three approaches for estimating bank efficiency: the asset, user cost, and value-added methods. Berger and Humphrey (1997) suggested the intermediation approach is best suited for evaluating bank efficiency, whereas the production approach is appropriate for evaluating the efficiency of bank branches. Nevertheless, there is a long lasting dispute whether deposits should be considered as inputs or outputs in efficiency models. This controversy is given by the fact that deposits have both input and output characteristics. However, a large number of empirical studies from emerging countries advocate that deposits should be treated as an input since they are intermediated into loans and securities (Isik and Hassan, 2003; Yildirim, 2002).

In similar spirit Fukuyama and Weber (2010) argued that a network two-stage DEA approach where deposits are treated as an intermediate output of a first stage of production and then they become an input in the production of loans and securities seems to be an appropriate alternative to the intermediation approach.

This notion is particularly attractive in the case of banking systems that are largely dependent on deposits. In our case the ratio of total deposits to total assets was on the average 57 per cent over the sample period. Furthermore, Turkish banks raised only 5 per cent funds measured to total assets through an interbank market. This indicates significant dependence on primary deposits and may justify the use of a network DEA.

Thus, the variables used in our model are as follows. The input vector includes: (i) labor, the number of employees and (ii) capital, the book value of premises and fixed assets. We further assume that banks then produce two outputs: (i) loans and (ii) securities. Finally, we include intermediate output: total deposits. Table 1 displays the summary statistics for all variables used in the model.

5.2. The empirical results

5.2.1. Measurement bias: network efficiency vs black-box efficiency

In this section, we compare the efficiency scores obtained from the two-stage network model and standard black-box DEA approach. We quantify the measurement biases as we discussed in Section 4.2, Eq. (16). The comparison helps to answer the imposed research questions whether the network efficiency approach provides more reliable results by analyzing the cause of cost efficiency measurement bias. In other words, if the bias is due to technical or allocative efficiency bias.

Table 2 reveals the measurement biases for the whole sample, domestic and foreign banks. Our results clearly indicate that the measurement bias comes from technical efficiency. The allocative efficiency measurement bias is smaller and for some years of our analysis is even equal to one. In other words, the estimation confirms that the black-box model, in the case of an internal structure, biases the technical efficiency measurement more than the allocative efficiency measurement. Thus, incorporating the network model is more important for technical efficiency than for allocative efficiency. The average allocative efficiency measurement bias for all banks is just 0.94 compared with technical efficiency measurement bias that is on average 0.76. Whether we use a network or black-box framework, it appears to have significant effects on the estimated values of cost and technical efficiency.

These results unambiguously confirm that the two-stage network model is appropriate in our case study and the results obtained by using a ‘simple’ black-box approach are biased. As we discuss later, Table 3 shows the differences of efficiency levels for both estimation techniques, i.e., network cost efficiency and black-box cost efficiency. As we see the levels differs substantially.

Table 2
Measurement bias.

	All banks			Domestic banks			Foreign banks		
	CostBias	*TechBias*	*AllocBias*	*CostBiass*	*TechBias*	*AllocBias*	*CostBiass*	*TechBias*	*AllocBias*
1991	0.717	0.708	0.927	0.803	0.753	0.962	0.375	0.493	0.808
1992	0.639	0.633	0.982	0.636	0.631	1	0.38	0.455	0.865
1993	0.482	0.529	0.925	0.492	0.551	0.91	0.424	0.425	0.975
1994	0.839	0.861	0.982	0.847	0.838	1.013	0.821	0.914	0.886
1995	0.758	0.814	0.906	0.746	0.829	0.896	0.803	0.787	0.959
1996	0.846	0.896	0.966	0.821	0.875	0.964	0.956	0.986	0.968
1997	0.795	0.843	0.971	0.754	0.819	0.955	0.952	0.907	1.049
1998	0.765	0.84	0.929	0.712	0.818	0.904	0.833	0.829	1
1999	0.615	0.701	0.986	0.566	0.69	0.956	0.868	0.814	1.082
2000	0.667	0.79	0.871	0.583	0.738	0.837	0.968	0.973	1
2001	0.756	0.806	0.945	0.75	0.795	0.946	0.753	0.825	0.937
2002	0.758	0.808	0.949	0.747	0.8	0.935	0.787	0.795	1.011
2003	0.773	0.808	0.952	0.771	0.805	0.964	0.797	0.821	0.937
2004	0.696	0.753	0.926	0.704	0.747	0.952	0.694	0.779	0.913
2005	0.738	0.771	0.988	0.778	0.808	1	0.583	0.653	1
2006	0.633	0.722	0.916	0.672	0.775	0.916	0.532	0.606	0.942
2007	0.563	0.668	0.856	0.613	0.760	0.840	0.500	0.543	0.867
Mean	0.708	0.762	0.940	0.706	0.767	0.938	0.707	0.741	0.953
Median	0.738	0.790	0.945	0.746	0.795	0.952	0.787	0.795	0.959
Max	0.846	0.896	0.988	0.847	0.875	1.000	0.968	0.986	1.000
Min	0.482	0.529	0.856	0.492	0.551	0.837	0.375	0.425	0.808

5.2.2. Cost, technical and allocative efficiency

Next, we analyse the cost, technical and allocative efficiency levels by the two-stage network model. In Table 3, we report bank efficiency levels for all banks over the period 1991–2007. The cost efficiency level declined from 1991 to 1993 by 11 percentage points. This decline was caused by the rapid

Table 3
Efficiency scores – all banks.

	NC	BC	NT	BT	NA	BA
1991	0.40	0.64	0.56	0.80	0.72	0.78
1992	0.35	0.55	0.41	0.64	0.83	0.84
1993	0.29	0.59	0.37	0.69	0.78	0.84
1994	0.51	0.61	0.65	0.75	0.76	0.78
1995	0.46	0.61	0.64	0.79	0.69	0.77
1996	0.57	0.67	0.70	0.78	0.82	0.85
1997	0.51	0.64	0.61	0.73	0.84	0.87
1998	0.54	0.71	0.63	0.75	0.88	0.95
1999	0.31	0.50	0.39	0.55	0.87	0.89
2000	0.41	0.61	0.53	0.67	0.80	0.91
2001	0.59	0.79	0.69	0.85	0.87	0.92
2002	0.59	0.78	0.67	0.83	0.88	0.93
2003	0.53	0.69	0.64	0.79	0.82	0.86
2004	0.51	0.73	0.63	0.84	0.80	0.86
2005	0.47	0.63	0.57	0.74	0.82	0.83
2006	0.40	0.63	0.52	0.72	0.78	0.85
2007	0.36	0.63	0.49	0.73	0.73	0.85
Mean	0.46	0.64	0.57	0.74	0.81	0.86
Median	0.40	0.65	0.52	0.81	0.86	0.92
Min	0.01	0.02	0.09	0.02	0.13	0.28
Max	1	1	1	1	1	1

Note – NC: network cost efficiency; BC: black-box cost efficiency; NT: network technical efficiency; BT: black-box technical efficiency; NA: network allocative efficiency; BA: black-box allocative efficiency.

Table 4
Efficiency scores – domestic banks.

	NC	BC	NT	BT	NA	BA
1991	0.53	0.66	0.61	0.81	0.76	0.79
1992	0.35	0.55	0.41	0.65	0.85	0.85
1993	0.31	0.63	0.38	0.69	0.81	0.89
1994	0.50	0.59	0.62	0.74	0.78	0.77
1995	0.44	0.59	0.63	0.76	0.69	0.77
1996	0.55	0.67	0.70	0.80	0.80	0.83
1997	0.49	0.65	0.59	0.72	0.84	0.88
1998	0.52	0.73	0.63	0.77	0.85	0.94
1999	0.30	0.53	0.40	0.58	0.86	0.90
2000	0.35	0.60	0.48	0.65	0.77	0.92
2001	0.60	0.80	0.70	0.88	0.87	0.92
2002	0.59	0.79	0.68	0.85	0.87	0.93
2003	0.54	0.70	0.66	0.82	0.81	0.84
2004	0.50	0.71	0.62	0.83	0.80	0.84
2005	0.49	0.63	0.59	0.73	0.83	0.83
2006	0.41	0.61	0.55	0.71	0.76	0.83
2007	0.38	0.62	0.57	0.75	0.68	0.81
Mean	0.46	0.65	0.58	0.75	0.80	0.86
Median	0.41	0.65	0.57	0.82	0.85	0.92
Max	1.00	1.00	1.00	1.00	1.00	1.00
Min	0.01	0.02	0.01	0.02	0.13	0.29

Note – NC: network cost efficiency; BC: black-box cost efficiency; NT: network technical efficiency; BT: black-box technical efficiency; NA: network allocative efficiency; BA: black-box allocative efficiency.

worsening of technical efficiency that dropped by 19 percentage points. On the other hand, the results obtained from the black-box DEA are in sharp contrast with the network model when the drop of cost and technical efficiency was 5 and 11 percentage points respectively. These low efficiency levels for period of 1991–1993 reflect the deterioration of the Turkish economy including the financial markets.

Bank efficiency levels then improved in 1994 as the Turkish government injected capital and bailed out the banking sector and this trend continued till 1998. The cost efficiency levels varied from 46 to 57 per cent. However, the new wave of financial crises interrupted this positive trend in 1999 and 2000.

If our results are linked with the economic development then it is obvious that the Rehabilitation Programme introduced in May 2001 had a positive impact on bank efficiency. Interestingly, the bank efficiency level improved in the peak of the crisis, i.e., in 2001. We observe the similar pattern during the crisis in 1994. Although results for the high inflation period of 2002–2004 may not be fully compatible with the results for the period before 2002 and after 2005, we may yet see a gradual decline in bank efficiency levels.

Overall, the decline in the cost efficiency level was caused by technical efficiency, rather than allocative efficiency. The results confirm that the efficiency scores estimated by using the standard DEA are substantially higher that those obtained by our network model. The results obtained from the traditional DEA would give incorrect signals to policy makers. Thus, the reported level using the black-box efficiency measurements do not show so alarming picture about the bank inefficiency levels in 1991 and 2000. Although we do not present the results for individual banks we found that the gap between the best performing banks and banks with the lowest efficiency scores in terms of cost efficiency was on the average 70 percentage points.

Tables 4 and 5 then present the results for domestic and foreign banks.[4] The average cost efficiency scores for domestic banks are just marginally higher. The cost efficiency level was 46

[4] Foreign banks are defined as banks that have more than 50 per cent of their capital held by foreign investors.

Table 5
Efficiency scores – foreign banks.

	NC	BC	NT	BT	NA	BA
1991	0.21	0.56	0.37	0.75	0.59	0.73
1992	0.19	0.50	0.30	0.66	0.64	0.74
1993	0.28	0.66	0.34	0.80	0.79	0.81
1994	0.55	0.67	0.74	0.81	0.70	0.79
1995	0.53	0.66	0.70	0.89	0.71	0.74
1996	0.65	0.68	0.71	0.72	0.90	0.93
1997	0.60	0.63	0.68	0.75	0.85	0.81
1998	0.55	0.66	0.58	0.70	0.94	0.94
1999	0.33	0.38	0.35	0.43	0.92	0.85
2000	0.61	0.63	0.71	0.73	0.89	0.89
2001	0.58	0.77	0.66	0.80	0.89	0.95
2002	0.59	0.75	0.62	0.78	0.95	0.94
2003	0.51	0.64	0.55	0.67	0.89	0.95
2004	0.50	0.72	0.60	0.77	0.84	0.92
2005	0.35	0.60	0.47	0.72	0.81	0.81
2006	0.33	0.62	0.43	0.71	0.81	0.86
2007	0.32	0.64	0.38	0.70	0.78	0.90
Mean	0.44	0.64	0.52	0.73	0.83	0.86
Median	0.37	0.65	0.43	0.75	0.87	0.94
Max	1.00	1.00	1.00	1.00	1.00	1.00
Min	0.06	0.14	0.08	0.18	0.31	0.34

Note – NC: network cost efficiency; BC: black-box cost efficiency; NT: network technical efficiency; BT: black-box technical efficiency; NA: network allocative efficiency; BA: black-box allocative efficiency.

and 44 per cent for domestic and foreign banks respectively.[5] Surprisingly, the reported cost efficiency scores in the late 1990s are only marginally different. It is worth to note that foreign banks were less affected by the consolidation and restructuring process than domestic banks in terms of efficiency levels. Further, the average score of technical efficiency was higher by 6 percentage points compared with foreign banks. Finally, the gap between the technical efficiency levels calculated by network and DEA models is 18 and 21 percentage points for domestic and foreign banks respectively.

It is rather surprising that bank efficiency deteriorated in 2003, i.e., two years after the Restructuring Programme was introduced. Further the cost efficiency scores were only 0.36 and 0.30 for domestic and foreign banks respectively in 2007. One of the possible explanations is that the Banking and Regulation and Supervision Agency (BRSA) introduced comprehensive provisions for strengthening banking regulation. In particular, BRSA shed light on effective risk management and its implementation. Banks were forced to fully implement Basel II Capital framework by 2007. This finding will require a further investigation once more recent data are available.

5.2.3. Regression model – determinants of efficiency

As we explained in Section 4.2.3, we also investigate the determinants of bank efficiency by applying the bootstrap model. The selection of the variables reflects other studies that analysed determinants of bank efficiency, Mester (1996), Isik and Hassan (2003), Casu and Girardone (2004) among others.[6] We selected the following regression specification:

$$NC_o = f(\mathrm{NIM, NNIM, MSL, MSD, ROA, BRANCH, TIME, DUMMY, AGE, CAPEQ}) \quad (19)$$

The set of independent variables in our model includes: net interest margin (NIM) that is defined as net interest income to total deposits and net non-interest income margin (NNIM) that is defined as net non-interest income to total assets. These two variables control for management quality. We

[5] The applied ANOVA test did support the hypothesis that the mean values are different between domestic and foreign banks.
[6] Mester (1996) applied 14 variables.

Table 6
Truncated bootstrap regression.

Variable	Cost efficiency		Technical efficiency	
	Coefficient	Std error	Coefficient	Std error
Constant	0.5515***	0.0882	0.5016***	0.0865
NIM	−0.0865***	0.0343	−0.0652	0.0425
NNIM	0.7135**	0.0882	0.5671*	0.3131
MSL	1.1107***	0.5744	3.4264***	0.8534
MSD	0.2033	0.6194	0.3171	0.9099
ROA	0.7958*	0.4506	−0.6001	0.5029
BRANCH	−0.0358***	0.0134	−0.0515***	0.01382
TIME	−0.0007*	0.0004	0.0004	0.0005
Dummy	0.0014	0.0036	0.0022	0.01382
AGE	−0.0003	0.0080	0.0001	0.0007
CAPEQ	0.1645	0.1903	0.0398	0.1831

NIM: net interest margin, NNIM; net non-interest margin, MS: market share on loan market, MSD: market share on deposit market, ROA: returns on assets; Branch: number of bank offices; Dummy: foreign banks vs domestic banks; Time: the analysed year; AGE: the number of years of bank operation; CAPEQ: capital to total equity.

* Significant at the 10 per cent level.
** Significant at the 5 per cent level.
*** Significant at the 1 per cent level.

also include variables that control for the market power, which are market share on deposit and loans (MSD and MSL). ROA (net income/total assets) is used as a proxy variable for banks' performance (e.g., Isik and Hassan, 2002). Since Turkish banks' business operations are very dependent on branch networks we include a number of branches – BRANCH. We assume that this variable is a suitable proxy for measuring not only the performance of a branch network but also service quality as discussed by Cook et al. (2000). To capture the dynamic of cost efficiency we apply time trend (TIME). A further important variable is the impact of ownership structure on the efficiency levels. We use dummy variables to distinguish between private and foreign ownership (DUMMY). Next, following Mester (1996) we include a variable bank's age (AGE) to test if bank efficiency depends on the years of operation in the market. We also include a variable CAPEQ defined as total capital to equity as a proxy for credit risk.

Table 6 reports the estimate of the selected variables. We also estimate determinants for technical efficiency. The coefficient of NIM is negative and statistically significant. This implies that Turkish banks with high margins utilize unnecessary many deposits to produce few loans and securities. In contrary, the sign of NNIM's coefficient is positive that may indicate that banks are more managerial efficient and control effectively non-interest income. This coefficient is also statistically significant in the case of technical efficiency. The coefficient of MSL is relatively high and statistically significant in both models. This finding may indirectly support the efficient market hypothesis. We may see that banks with superior production technology and/or managerial skills have lower costs, which results in the acquisition of larger market share over less efficient banks. However, we could not support this hypothesis in the case of MSD.

Further the positive and statistically significant coefficient of ROA corresponds with other empirical studies (Isik and Hassan, 2003; Casu et al., 2004). It indicates that more efficient banks also show higher performance. Thus, more efficient banks also perform better. The variable BRANCH has an expected negative sign and is in both models statistically significant. The negative sign of the coefficient reflects the common fact that a branch network is costly for banks. Yet, a branch network is particularly important in emerging markets since it may indirectly influence bank efficiency through the quality of provided services (Portela and Thanassoulis, 2007). We did not confirm that the ownership type has an impact on cost efficiency. This result shows the change of the period since Isik and Hassan (2003) found that foreign banks were more efficient. We could not support the 'quiet life' hypothesis since the coefficient is not statistically significant. We could not also confirm the learning by doing hypothesis since the variable is statistically insignificant.

6. Discussion and conclusions

The paper analyses the cost efficiency of the Turkish banks from 1991 to 2007. We apply an innovative two-stage network production technology approach (Fukuyama and Weber, 2010). We show that the accuracy and consistency of DEA results is improved by using this method. The results confirm that the traditional black-box DEA approach overestimates the efficiency scores. We argue that a two-stage network system is a superior to the traditional DEA if applied in a banking sector that largely depends on the primary deposits.

We found that the Turkish banks positively reacted to consolidation and restructuring process. It is evident that bank efficiency has gradually improved and the cost efficiency scores peaked immediately after the Restructuring Programme was introduced. Nevertheless, we found a gradual deterioration of bank efficiency from 2004 to 2007. This negative trend could be explained by the strict regulatory rules imposed by BRSA. Our efficiency levels are lower than those found by Ozkan-Gunay and Tektas (2006), who analysed only the period of 1990–2001. Nevertheless, we may confirm the deterioration of bank efficiency during the crisis period, i.e., 1991–2001.

We did not confirm that foreign banks are on the average more efficient than domestic banks as reported by Isik and Hassan (2003). This is also in contrast with other studies from emerging economies and particularly from transition countries Fries and Taci (2005), Staikouras et al. (2008). The results may partially be explained by the role and place of foreign banks in Turkey. The first significant activities of foreign banks started in the 1980s when the Turkish government tried to liberalise the banking sector. But neither before nor after that had the foreign banks an intention to expand and enter into retail banking and lending to SMEs. They engaged in trade financing and business with top “blue chip” corporate with a single or a few (mostly in three big cities) branches at most. It is only after the Restructuring programme of 2001 that they entered into retail banking and other services with wide branch network and employment. Hence, in terms of managerial skills and technological infrastructure, they have had negligible effects on commercial banks in Turkey. A further liberalisation reforms catalysed activities of private commercial Turkish banks that have become very advanced in that respect to the extent that they were at par with the EU’s commercial banks by the late 1990s. In recent years, domestic commercial banks are progressing well compared to new foreign banks in all aspects (managerial skills, technology, innovation, etc.).

We also obtained interesting results as for the determinants of bank efficiency. Firstly, our results indicate the increase in market shares within the deposit market contributes to bank efficiency. Secondly, ROA ratios may be considered as an appropriate proxy indicator that provides information not only about bank performance and indirectly about its efficiency. Thirdly, we found that branch network has a negative effect on efficiency growth. However, we assume that a branch network is an important element as for the quality of providing services and the size of the coefficient is only marginally reflected in terms of efficiency. We could not confirm that the age of a bank is an important factor for bank efficiency. This is in contrast what Isik and Hassan (2003) reported. In other words, we could not confirm the quiet life hypothesis.

Overall, the present study may provide a starting point for further investigation and validation into the efficiency of the Turkish bank sector. This strand of research can provide important information for policy makers as for the openness of the Turkish banking to new banks. Therefore, more investigation with alternative models can cross validate the present research.

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Appendix A.

See Table A1.

Table A1
List of currently operating banks in Turkey.

Rank	Bank	Ownership as end of 2007	Established
1	Ziraat	State-owned	1863
2	Isbank	Privately owned	1924
3	Akbank	Privately owned	1948
4	Garanti	Privately owned	1946
5	Yapi Kredi	Privately owned	1944
6	Vakifbank	State-owned	1954
7	Halkbank	State-owned	1938
8	Finansbank	Foreign	1987
9	Denizbank	Foreign	1997
10	HSBC	Foreign	1990
11	ING (previously OYAK)	Foreign	1984
12	T Ekonomi Bankasi	Privately owned	1927
13	Fortis (previously Disbank)	Foreign	1964
14	Sekerbank	Privately owned	1953
15	Citibank	Foreign	1980
16	Anadolubank	Privately owned	1996
17	Tekstilbank	Privately owned	1986
18	Tekfenbank (previously Bankekspres)	Foreign	1992
19	Alternatifbank	Privately owned	1992
20	ABN Amro	Foreign	1921
21	West LB	Foreign	1985
22	Turkishbank	Privately owned	1982
23	Turkland (previously MNG)	Foreign	1991
24	Arab-Turk	Foreign	1977
25	Adabank	Privately owned	1985

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