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Performance Evaluation in Bank Branch with Two-Stage DEA Model

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Abstract. Data Envelopment Analysis (DEA) has been applied in many studies in the banking sector. Conventional DEA models consider the system as a single-process black box. There are however a number of so-called network DEA approach that consider the system as composed by distinct processes or stages, each one with its own inputs and outputs and with intermediate flows among the stages. In this paper some of these approaches that have been applied to banking sector are reviewed and in particular applications of two-stage DEA to Iranian banking branches are presented and discussed. The conclusions of this research are that two-stage DEA models have a greater discrimination power than conventional, single-process DEA and since they allow a more fine-grained analysis their results are generally more valid and useful. The main drawback is the need for more detailed data (i.e. at the process level) and the greater complexity of the resulting models, especially if there are inputs or outputs that are shared among the processes.

Keywords: Data envelopment analysis, two-stage, network model, bank performance, efficiency.

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1. Introduction

The improvement of performance for public or private banks is an important way for any country's progress. Measuring and evaluating the operating efficiency of bank branches require analytic techniques that provide insights beyond those available from accounting ratio analysis. Banks have aggressively sought to improve their performance by improving cash management and marketing new services that attract additional funds. Evaluating the economic performance of banks, however, is a complicated process. Often a number of criteria such as profits, liquidity, asset quality, attitude toward risk, and management strategies must be considered. The changing nature of the banking industry has made such evaluations even more difficult, increasing the need for more flexible alternative forms of financial analysis. Therefore, evaluating the efficiency requires employing different approaches for determining the efficiency frontier. There are many researches in this field. Two competing methods for constructing frontiers are parametric and non-parametric methods. Data Envelopment Analysis (DEA) is a non-parametric mathematical tool for assessing the relative efficiency of homogeneous Decision Making Units (DMUs). DEA has been applied in many sectors (education, health care, finance, transportation, etc); in particular, there are many applications of DEA in banking sector. Most of these DEA studies in Iranian bank sectors consider the units under assessment as a single process and assume that this aggregate process consumes all the different inputs and produces all the different outputs (some of them perhaps undesirable). No modeling of the inner structure of the system is performed. No sub-process or stages are considered and intermediate products produced and consumed within the system. This black-box approach is the most common one in DEA. This paper describes a particular methodology called Two-stage Data Envelopment Analysis (DEA), that has been used previously to analyze the relative efficiencies of industrial firms, universities, hospitals, military operations, baseball players and, more recently, commercial banks. Data envelopment analysis (DEA) is an approach for measuring the relative efficiency of peer decision making units (DMUs) that have multiple inputs and outputs.

As discussed in many DEA studies, DMUs can have a two-stage structure where the first stage uses inputs to generate outputs that become the inputs to the second stage. The second stage thus utilizes these first-stage outputs to produce its own outputs. We call the first stage outputs intermediate measures. For example, banks use labor and assets to generate deposits which are in turn used to generate loan income (Chen and Zhu, 2004). Kao and Hwang (2008) consider a set of Taiwanese non-life insurance companies with a two-stage process of premium acquisition and profit generation. A closer examination of Kao and Hwang (2008)'s approach reveals that (i) their overall efficiency is defined as the product of efficiencies of the two stages, (ii) their models assume constant returns to scale (CRS), and (iii) their models assume that the weights (or multipliers) on the intermediate measures are the same for the two stages. In this paper, in section 2, literature review in banking sector is reviewed. In section 3, proposal model are presented and in section 4 the empirical study of these approaches are provided. Finally, in section 5, conclusions are drawn and further research outlined.

2. Literature Review

Major local Iranian banks continue to pursue all the opportunities available to enhance their competitiveness. Consequently, performance analysis in the banking industry has become part of their management practices. Top bank management wants to identify and eliminate the underlying causes of inefficiencies, thus helping their firms to gain competitive advantage, or, at least, meet the challenges from other banks. Therefore, it is critical to determine how to measure organizational performance in a multi-dimensional structure. In comparison with techniques of assessing organization performance, the method of data envelopment analysis (DEA) proposed by Charnes et al. (1978) is a better way to organize and analyze data since it allows efficiency to change over time and requires no prior assumption on the specification of the efficient frontier. Thus, DEA is an excellent approach for the performance analysis in banking industry in literature. Data envelopment analysis (DEA) is a non-parametric, linear programming technique to identify best practices of peer decision making units (DMUs) that use multiple inputs to generate multiple outputs. The efficiency score of any DMU is determined by comparison with the DMU located on the efficient frontier as a benchmark. DEA has been applied in many sectors such as education (Thanassoulis and Dunstan, 1994), forest management (Kao et al., 1993), insurance (Mahajan, 1991), library management (Hammond, 2002), life insurance companies (Cummins et al.,1999), transportation companies (Kerstens,1996), mutual funds (Basso and Funari, 2001), nursing (Nunamaker, 1983),airlines (Schefczyk, 1993),telecommunications (Uri, 2001), hospitals (Chilingerian and Sherman, 1990), transportation companies (Kerstens, 1996), hotels (Barros, 2005) etc. There are also many studies have used DEA to examine the performance of the banking industry. Drake and Howcroft (2002) assessed the relative efficiency of UK clearing bank branches using DEA method. This paper utilized the basic efficiency indices and extended the analysis by examining the relationship between size and efficiency, Aly, Grabowski, Pasurka, and Rangan (1990) evaluated the technical efficiency, scale efficiency, and allocative efficiency of 322 independent USA banks in 1986. Results indicated that 35In many real world scenarios, DMUs have a two-stage network process and due to this reason, DEA has been extended to examine the efficiency of two-stage processes, where all the outputs from the first stage are intermediate measures that make up the inputs to the second stage. Wang et al. (1997) present a two-stage process in the banking industry where the banks use inputs (to the first stage) of fixed assets, labor and information technology (IT) investments to generate deposits. The banks then use the deposits (intermediate measure) to generate loans and profits (as the outputs). Seiford and Zhu (1999) examined the performance of the top 55 US banks using a two-stage DEA approach. Results indicated that relatively large banks exhibit better performance on profitability, whereas smaller banks tend to perform better with respect to marketability. Kao and Hwang (2008) develop a different approach where the entire two-stage process can be decomposed into the product of the efficiencies of the two sub-processes. As a result, both the overall efficiency and each stage's efficiency are obtained. Sexton and Lewis (2003) propose a two-stage process for evaluating Major League Baseball performance.

Chilingerian and Sherman (2004) describe another two stage process in measuring physician care. Bhattacharya, Lovell, and Sahay (1997) used a two-stage DEA approach to examine the impact of liberalization on the efficiency of the Indian banking industry. In the first stage a technical efficiency score was calculated, whereas in the second stage a stochastic frontier analysis was used to attribute variation in efficiency scores to three sources: temporal, ownership and noise component. One of the drawbacks of traditional DEA models is the ignorance of intermediate measures or linking activities. To resolve this drawback, we apply relational network DEA proposed by Kao (2009) to construct a performance evaluation model for the Iranian bank. The proposed model provides not only an overall efficiency score of entire process but evaluates the individual stages.

3. Proposal Model

The performance of banks is aggregated from the efforts of different stages, but also relies on the bank as a whole. For example, the bank performance depends on the combination of marketability and profitability. Evaluating the efficiency of multiple inputs and outputs using a single process, as is the case in most DEA papers on bank performance evaluation, will be problematic because this single process evaluation ignores the efficiency of internal structure within the bank. Furthermore, the results cannot explain the relationships between the efficiency of each stage and the efficiency of the organization as a whole. To resolve the drawback mentioned above, we apply the two-stage network DEA model by Kao (2009) to construct a performance evaluation model, which aims to evaluate the bank based on efficiency of different stages. The bank can be viewed as an entity in which two inter-related operations are performed shown in Fig. 1. At the first stage, funds are collected from the customers in the form of deposits by consuming the bank resources such as fixed assets, number of employees, and IT budget. At the second stage, banks use the value of exchange deposits for investing other activities and loan benefits to get more profit (Wu et al., 2006, 2007; Wang et al., 1997).

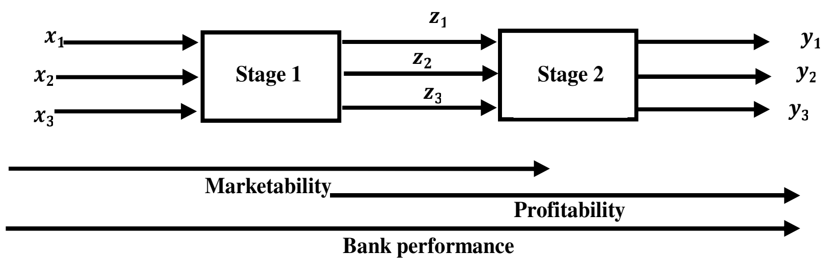

Fig 1. Two-stage network performance evaluation model for bank

This study aims to evaluate the efficiency of "marketability" and "profitability" stages and overall organization, and furthermore, to discover the relative contributions of efficiency of each stages to the overall performance of the bank.
In the phase of "marketability", the model aims to measure the ability of bank to transform fixed assets, employee and IT budget into deposits, non-operational income, and commission. Therefore, this research uses fixed assets (x_1), No. of employees (x_2), and IT budget (x_3) as inputs, and uses deposits (z_1), non-operational income (z_2), and commission (z_3) as intermediate outputs to measure the marketability of the bank.
In the phase of "profitability", we measure the ability to transform deposits, non-operational income, and commission into profit, loan benefit, and net income for the bank. We use the intermediate outputs from the "marketability" as inputs and the profit (y_1), fraction of loan recovered (y_2), and net income (y_3) as outputs to measure the "profitability" of bank. Finally, "bank performance" represents the overall performance of the bank.
The proposed network performance evaluation model for banks is described by the following linear program:

$$E_0^c entralized = Max \sum_{(r=1)}^{s} u_{ro} \tag{1.0}$$

Subject to

$$\sum_{(i=1)}^{m} v_i x_{io} = 1 \tag{1.1}$$

$$\sum_{(r=1)}^{s} u_r y_{rj} - \sum_{(i=1)}^{m} v_i x_i j \leqslant 0 \qquad j = 1, ..., n \tag{1.2}$$

$$\sum_{(d=1)}^{D} w_d z_{dj} - \sum_{(i=1)}^{m} v_i x_{ij} \leqslant 0 \qquad j = 1, ..., n \tag{1.3}$$

$$\sum_{(r=1)}^{s} u_r y_{rj} - \sum_{(d=1)}^{D} w_d z_{dj} \leqslant 0 \qquad j = 1, ..., n \tag{1.4}$$

$$v_i \geqslant 0, i = 1, ..., m; \quad u_r \geqslant 0, r = 1, ..., s; \quad w_d \geqslant 0, d = 1, ..., D \tag{1.5}$$

Where v_i, u_r, and w_d are the unknown non-negative weights. Let $X \in R^m$ denote a (1*m) vector of inputs, and $Y \in R^s$ denote a (1*s) vector of outputs, and $Z \in R^D$ denote a (1*D) vector of intermediate inputs/outputs variable.
Note that Eq. (1.2) is redundant in Kao and Hwang's (2008) model, since Eq. (1.3) and (1.4) imply Eq. (1.2). Model (1) provides the overall efficiency of the "marketability" and "profitability" stages.
The dual format of above model can be formulated as follows:

$$E_0^c entralized = Min\theta \tag{2.0}$$

$$\sum_{(j=1)}^{n} \lambda_j x_{ij} + s_i^- = \theta x_{io} \quad i = 1, ..., m \tag{2.1}$$

$$\sum_{(j=1)}^{n} (\lambda_j - \mu_j) z_{dj} - s_{Id}^+ = 0 \quad d = 1, ..., D \tag{2.2}$$

$$\sum_{(j=1)}^{n} \mu_j y_{rj} - s_r^+ = y_{ro} \quad r = 1, ..., s \tag{2.3}$$

$$\lambda_j, \mu_j, s_i^-, s_{Id}^+, s_r^+ \geqslant 0 \quad j = 1, ..., n \tag{2.4}$$

Eq. (1.1) represents the resource of oth DMU put into network process for marketability. Eq. (1.2) corresponds to the overall efficiency of each DMU. Eq. (1.3) represents stage1, which uses fixed assets, No. of employees, and IT budget as inputs and deposits, non-operational

income, and commission as the intermediate outputs to measure the marketability efficiency. Eq. (1.4) represents stage2, which uses the intermediate outputs from stage1 as an inputs and profits, loans, and net income as an output to measure the profitability efficiency. The overall performance of oth DMU could be formulated as Eq. (1.0), representing the objective function set by oth DMU to maximize the profit and fraction of loan recovered.
Assume the model (1) yields a unique solution, we can obtain $E_o^{(1)}$ and $E_o^{(2)}$ as the efficiencies for the "marketability" and "profitability" stages, respectively. In following Eq. (3.0) and Eq. (3.1) the v_i^*, u_r^*,and w_d^* represent the optimal multipliers of the mathematical model proposed.

$$E_o^{(1)centralized} = {}^{\sum_{(d=1)}^{D} w_d^* z_{do}}/_{\sum_{(i=1)}^{m} v_i^* x_{io}} = \sum_{(d=1)}^{D} w_d^* z_{do} \quad (3.0)$$

$$E_o^{(2)cenralized} = {}^{\sum_{(r=1)}^{s} u_r^* y_{ro}} /_{\sum_{d=1}^{D} w_d^* z_{do}} \quad (3.1)$$

If we denote the optimal value of model (1) as $E_o^{centralized}, E_o^{centralized}$ yields as follows:

$$E_o^c entralized = E_o^{(1)centralized} . E_o^{(2)centralized} \quad (3.2)$$

As noted in Kao and Hwang (2008), optimal multipliers from model (1) may not be unique. They proposed deriving the maximum achievable value of$E_o^{(1)}$ or $E_o^{(2)}$. Kao and Hwang's (2008) model can also be used to test whether $E_o^{(1)}$ and $E_o^{(2)}$, obtained from model (1), are unique (Liang et.al 2008). The maximum achievable value of $E_o^{(1)}$ can be calculated as follows:

$$E_o^{(1)+} = Max \sum_{d=1}^{D} w_d z_{do} \quad (4.0)$$

Subject to

$$\sum_{i=1}^{m} v_i x_{io} = 1 \quad (4.1)$$

$$\sum_{r=1}^{s} u_r y_{ro} = E_o^c entralized \quad (4.2)$$

$$\sum_{d=1}^{D} w_d z_{dj} - \sum_{i=1}^{m} v_i x_{ij} \leqslant 0 j = 1, ..., n \tag{4.3}$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{d=1}^{D} w_d z_{dj} \leqslant 0 j = 1, ..., n \tag{4.4}$$

$$v_i \geqslant 0, i = 1, ..., m; \quad u_r \geqslant 0, r = 1, ..., s; \quad w_d \geqslant 0, d = 1, ..., D \tag{4.5}$$

So, according to above model (3), the minimum of $E_o^{(2)-}$ is yielded as follows:

$$E_o^{(2)-} = {}^{E_o^c entralized} / {}_{E_o^{(1)+}} \tag{4.6}$$

And the maximum value of $E_o^{(2)+}$ can be determined by the following linear program:

$$E_o^{(2)+} = Max \sum_{r=1}^{s} u_r y_{ro} \tag{5.0}$$

Subject to

$$\sum_{d=1}^{D} w_d z_{do} = 1 \tag{5.1}$$

$$\sum_{r=1}^{s} u_r y_{ro} - E_o^c entralized. \sum_{i=1}^{m} v_i x_{io} = 0 \tag{5.2}$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{d=1}^{D} w_d z_{dj} \leqslant 0 j = 1, ..., n \tag{5.3}$$

$$\sum_{d=1}^{D} w_d z_{dj} - \sum_{i=1}^{m} v_i x_{ij} \leqslant 0 j = 1, ..., n \tag{5.4}$$

$$v_i \geqslant 0, \ \ i = 1, ..., m; \ \ u_r \geqslant 0, r = 1, ..., s; \ \ w_d \geqslant 0, d = 1, ..., D \tag{5.5}$$

The minimum of $E_o^{(1)-}$ is also calculated as follow:

$$E_0^{(1)-} = {}^{E_0^c entralized} / {}_{E_0^{(2)+}} \qquad (5.6)$$

Note that

$E_o^{(1)-} = E_o^{(1)+}$ if and only if $E_o^{(2)-} = E_o^{(2)+}$.

Note also if $E_o^{(1)-} = E_o^{(1)+} or E_o^{(2)-} = E_o^{(2)+}$,

then

$E_o^{(1)centralized}$ and $E_o^{(2)centralized}$ are uniquely determined by model (1). If $E_o^{(1)-} \neq E_o^{(1)+}$ or $E_o^{(2)-} \neq E_o^{(2)+}$, (Liang et.al 2008) develop a procedure to gain an alternative decomposition of $E_o^{(1)centralized}$ and $E_o^{(2)centralized}$. The aim of performance decomposition is to understand the relative contribution of "marketability" and "profitability" to overall bank performance. According to the decomposition results, bank managers could improve the components with a weaker contribution to enhance the overall performance of the bank. When compared with the conventional DEA model, we find that the two-stage network DEA model is more stringent. The evaluation results of two-stage network DEA model could provide managerial insights for increasing efficiency.

4. Empirical Study

Based on the proposal model which described above, we apply the two-stage network DEA model to evaluate the performance of Iranian bank in 2010. In this study, Iranian bank is comprised of 37 branches divided into "marketability" and "profitability" stages. At the first stage, this research uses fixed assets (x_1), No. of employees (x_2), and IT budget (x_3) as inputs, and uses deposits (z_1), non-operational income (z_2), and commission (z_3) as intermediate outputs to measure the marketability of the bank, and at the second stage, we use the intermediate outputs from the "marketability" as input and the profit (y_1), fraction of loan recovered (y_2), and net income (y_3) as outputs to measure the "profitability" of bank. Based on proposed model and using WINQSB package, the overall performance of each bank was obtained (relied on model (1)), and the maximum achievable value of first stage and the minimum value of second stage are determined by model (4) (see Table 1). From the calculation of performance decomposition using model (4), we obtained the optimal multipliers and the relative contribution of each stage to the overall performance of the bank. Decomposition results are shown in Table 1.

According to the dual format of the proposed model (model 2), and in respect to inefficient DMUs, slack/surplus variable analysis realizes the status of input resource application and finds inefficiency source and improves the extent of corresponding attribute value (see Table 2). The results of table 2 provide the bank management with a direction for resource reallocation. Take DMU 19 with worst overall efficiency for example. The improvable spaces of this DMU's input items are (0, 0.417868, and 0), and the improvable spaces of its output items are (9673737400, 12076484.2, and 0). Efficiency will improve for DMU 19 when the No. of employee (x_2) has to decrease by 0.417868 units, profit (y_1) has to increase by 9673737400 units, and non-operational income (y_2) has to increase by 12076484.2 units.

Based on CCR model the result obtained that the 22nd DMU is more efficient than others. Regarding the marketability stage, DMU 13, DMU 16, DMU 21, DMU 22, and DMU 23 are performed efficiently. Only DMU 27 is performed efficiently for the profitability stage. The results revealed that, in average, very few banks have efficiently transformed their resources into deposits, non-operational incomes, and net incomes, and that overall, profitability stage are more efficient than marketability stage.

DMUs	Network efficiency	Stage efficiency		Reference set for the marketability stage	Reference set for the profitability stage	Value of λ	Value of μ
Bank	Bank performance $(E_j^{centralized})$	Marketability $(E_j^{(1)+})$	Profitability $(E_j^{(2)-})$				
DMU(1)	0.463	0.583	0.794	13,21,23	27	0.0818,0.3877,0.1062	2.0043
DMU(2)	0.384	0.46	0.834	13,21,23	27	0.0568,0.3699,0.0185	1.5923
DMU(3)	0.436	0.707	0.617	13,21,23	27	0.011,0.2901,0.0905	1.2532
DMU(4)	0.211	0.371	0.569	13,21,23	27	0.02,0.2308,0.0466	0.9957
DMU(5)	0.223	0.532	0.419	13,21,23	27	0.0194,0.206,0.0381	0.8884
DMU(6)	0.45	0.8	0.563	13,21	27	,0.0956,0.4301	1.9399
DMU(7)	0.321	0.676	0.475	13,21	27	0.0627,0.2534	1.1717
DMU(8)	0.352	0.44	0.8	13,21,22	27	0.0384,0.1959,0.0307	0.9399
DMU(9)	0.165	0.29	0.57	13,21	27	0.0397,0.1789	0.8069
DMU(10)	0.294	0.55	0.534	16,21,23	27	0.0127,0.2542,0.102	1.1288
DMU(11)	0.132	0.328	0.402	13,21,23	27	0.025,0.1615,0.0076	0.6953
DMU(12)	0.185	0.404	0.458	13,21	27	0.0797,0.0715	0.6094
DMU(13)	0.5	1	0.5	13	27	0.4992	2.2446
DMU(14)	0.334	0.595	0.561	13,21	27	0.0669,0.2761	1.2704
DMU(15)	0.383	0.53	0.723	13,21,22	27	0.0343,0.0612,0.1824	0.8412
DMU(16)	0.568	1	0.568	16,21,23	27	0.2347,0.0639,0.0411	0.8155
DMU(17)	0.17	0.384	0.443	13,21	27	0.0306,0.1491	0.6609
DMU(18)	0.396	0.695	0.57	13,21,22	26	0.0215,0.5616,0.0319	1.3485
DMU(19)	0.089	0.843	0.106	16,21,23	27	0.0012,0.0579,0.0231	0.2532
DMU(20)	0.334	0.587	0.569	16,21,23	27	0.1204,0.1891,0.0833	1.0944
DMU(21)	0.506	1	0.506	13,21,22	27	0.0608,0.323,0.0316	1.4893
DMU(22)	0.775	1	0.775	13,22	27	0.0639,0.4944	1.5665
DMU(23)	0.741	1	0.741	13,21,23	27	0.053,0.3877,0.0434	1.6695
DMU(24)	0.215	0.288	0.746	13,21,23	27	0.031,0.2183,0.0167	0.9399
DMU(25)	0.28	0.324	0.864	16,21,23	27	0.0678,0.2577,0.1071	1.2704
DMU(26)	0.307	0.321	0.957	16,23	18,27	0.1002,0.5309	0.3677, 0.747
DMU(27)	0.445	0.445	1	13,21,22	27	0.0408,0.032,0.2722	1
DMU(28)	0.22	0.343	0.642	13,21	27	0.0789,0.2424	1.206
DMU(29)	0.179	0.492	0.364	13,21	27	0.0537,0.15	0.7682
DMU(30)	0.229	0.368	0.622	13,21,23	27	0.0118,0.2666,0.0793	1.1515
DMU(31)	0.262	0.511	0.513	13,21	27	0.0764,0.2933	1.3734
DMU(32)	0.24	0.395	0.609	13,21	27	0.1025,0.1731	1.0687
DMU(33)	0.359	0.502	0.716	13,21	27	0.1338,0.1599	1.1631
DMU(34)	0.461	0.584	0.789	13,21,23	27	0.0376,0.4596,0.0977	1.9828
DMU(35)	0.19	0.296	0.642	16,21,23	27	0.049,0.1883,0.0782	0.927
DMU(36)	0.25	0.345	0.726	13,21,23	27	0.017,0.2149,0.0469	0.927
DMU(37)	0.3	0.474	0.633	13,21,23	27	0.0025,0.4019,0.1544	1.7382

Table 1. Performance measure of the 37 Iranian bank branches in 2010.

DMUs										
DMU(1)	0.463	0	2.193807	0	58556984900	985315961.8	0	0	525617694.757	0
DMU(2)	0.384	0	0	33.724739	73582151500	873221562.6	0	0	488790977.3	0
DMU(3)	0.436	0	0	4.398879	59894842200	623641215.3	0	0	418485425.8	0
DMU(4)	0.211	0	0	46.921376	42502697300	544370038	0	0	321396807	0
DMU(5)	0.223	0	0	73.31465	35195938200	489871103.6	0	0	284570089.5	0
DMU(6)	0.45	0	0	32.258446	76566602400	785280100.3	0	573941.6105	569140179	0
DMU(7)	0.321	0	0	79.179822	46104620800	632311500.3	0	518398.874	338136224	0
DMU(8)	0.352	540032.3	0	0	36225059200	467576085	0	0	261134905.7	0
DMU(9)	0.165	0	0	33.724739	28403739600	306556506	0	240685.1915	237699721.8	0
DMU(10)	0.294	0	0.104467	0	51250225800	617448154.6	0	0	371615058.1	0
DMU(11)	0.132	0	0.417868	0	17700881200	333186667.2	0	0	214264538	0
DMU(12)	0.185	0	0	35.191032	22229013600	243387286.6	0	1943995.778	120523802.6	0
DMU(13)	0.5	0	0	0	11989300000	1119086074	0	14385568.75	207568771.2	0
DMU(14)	0.334	0	0	58.65172	57219127600	616828848.5	0	536913.1195	368267174.7	0
DMU(15)	0.383	0	0.313401	0	4631044500	217995737.6	0	0	117175919.2	0
DMU(16)	0.568	0	6.894822	241.938345	28918300100	410599926.3	0	0	0	0
DMU(17)	0.17	0	0	107.039389	24698904000	351765849.4	0	129599.7185	194177237.6	0
DMU(18)	0.396	3780226	0	0	26036761300	0	988576042	0	438572726.2	0
DMU(19)	0.089	0	0.417868	0	9673737400	120764684.2	0	0	83697085.15	0
DMU(20)	0.334	0	0	85.044994	53514292000	592056605.6	0	0	231003955	0
DMU(21)	0.506	0	1.462538	0	75331657200	819961240.4	0	0	425181192.6	0
DMU(22)	0.775	25921550	7.835025	0	51867698400	842875565.1	0	0	100436502.2	0
DMU(23)	0.741	0	0	46.921376	94370395700	875698786.9	0	0	518921927.9	0
DMU(24)	0.215	0	0	43.98879	11526155200	518978489	0	0	291265856.3	0
DMU(25)	0.28	0	0	58.65172	39003685900	71220198.37	0	0	354875641	0
DMU(26)	0.307	0	0	362.174371	17495057000	0	235807129	0	241047605.2	0
DMU(27)	0.445	4860291	0	0	0	0	0	0	97088618.78	0
DMU(28)	0.22	0	0	30.792153	47339566000	95373135.21	0	1036797.748	331440457.2	0
DMU(29)	0.179	0	0	4.398879	35195938200	340618340	0	796112.5565	207568771.2	0
DMU(30)	0.229	0	0.522335	0	0	529506692.2	435336239	0	381658708.3	0
DMU(31)	0.262	50763035	0	0	49706544300	613732318.1	0	722055.5745	391702358.5	0
DMU(32)	0.24	0	0	234.60688	28300827500	302840669.6	0	2073595.496	254439138.9	0
DMU(33)	0.359	0	0	14.66293	59483193800	641601091.4	0	3054850.508	251091255.5	0
DMU(34)	0.461	0	0	156.893351	110939000000	1093075218	0	0	642793614	0
DMU(35)	0.19	0	0	85.044994	24698904000	359816828.3	0	0	257787022.3	0
DMU(36)	0.25	0	0	65.983185	32931872000	376538092.3	0	0	301309506.5	0
DMU(37)	0.3	0	0	271.264205	57322039700	838540422.6	0	0	592575362.9	0

Table 2. Inefficiency slacks and surplus from the network model.

5. Conclusion

This paper is the first application of relational network DEA proposed by kao (2009) to construct a network performance evaluation model for banking sector in Iran. The proposed model evaluates the performance of different network branches of Iranian bank. Comparing with previous branch studies, this two-dimensional efficiency analysis shows a significantly more comprehensive evaluation of bank branches performance, which is also likely to be better accepted by branch level management. The empirical study considers 37 bank branches in Iran which provides detailed results on overall efficiency and efficiency of each stage separately. In addition the ranking of the branches across their ability to marketing and making profit could be provided as benchmarks for branches to adopt in order to improve their performance. Generally, the present study may provide a starting point for further investigation and validation into the efficiency of Iranian bank sector .We hope that branches improve their overall performance through comprehensive performance evaluation which leads to an increase in competitiveness of banking sector in Iran. Conventional DEA models for measuring the efficiency of a system treat systems as a black-box, disregarding its internal structure .More reprehensive and informative results can be obtained if interactions of the component processes within the system are taken into account. Black-box DEA models estimate the efficiency of DMUs by assuming that inputs are used to produce only final outputs; in this paper we go into the black-box details and allow for a two-stage structure to produce where inputs in first stage produce intermediate outputs that are transformed in second stage of production to final outputs. We argue that a two-stage has superiority over traditional DEA if applied in a banking sector that largely depends on primary deposits.

References

[1] Barros, C. P., (2005a). Measuring efficiency in the hotel's: an illustrative example. Annals of Tourism Research, 32 (2), 456-477.

[2] Barros, C. P., (2005b). Evaluating the efficiency of small hotel chain with a

malmquist productivity index. International Journal of Tourism Research, 7 (3), 173-184.

[3] Basso, A., and Funari, S., (2001). A data envelopment analysis approach to measure the mutual fund performance. European Journal ofOperational Research, 135, 477-492.

[4] Bhattacharya, A., Lovell, C. A. K., and Sahay, P., (1997). 'The Impact of Liberalization on the Productive Efficiency of Indian Commercial Banks', European Journal of Operational Research, Vol., 98 (2), pp. 332-45.

[5] Charnes, A., Cooper, W. W., and Rhodes, E., (1978). Measuring the efficiency of decision making units. European Journal of Operational Research, 6 (2), 429-444.

[6] Chen, Y., and Ahu, J., Measuring information technology's indirect impact on firm performance. Information Technology & Management Journal, 5 (1-2), (2004), 9-22.

[7] Chilingerian, J., and Sherman, H., (1990). "Managing Physician Efficiency and Effectiveness in Providing Hospital Services." Health Services Management Research, 3 (1), 3-15.

[8] Yildirim, C., (2002). 'Evolution of banking efficiency within an unstable macroeconomic environment: The case of Turkish commercial banks'. Applied Economics, 34, 2289-2301.

[9] Drake, L., and Howcroft, J., (2002). "An Insight into the Size Efficiency of a UK Bank Branch Network", Managerial Finance, Vol., 28 (9), pp. 24-36.

[10] Elyasiani, E., and Mehdian, S. M., (1990). A Nonparametric Approach to Measurement of Efficiency and Technological Change: The Case of Large U. S. Commercial Banks, Journal of Financial Services Research, 4, 157-168.

[11] Kao, C., and Hwang, S. N., "Efficiency decomposition in two-stage data envelopment analysis: An application to non-life insurance companies in Taiwan", European Journal of Operational Research, 185 (2008), 418-429.

[12] Kao, C., and Hwang, S-N., Efficiency decomposition in two-stage data envelopment analysis: an application to non-life insurance companies in Taiwan, European Journal of Operational Research, (2008), 185 (1), 418-42.

[13] Kao, C., (2009). Efficiency decomposition in network data envelopment analysis: A relational model.Eur. J. Operat. Res., 192, 949-962. DOI: 10.1016/j.ejor.2007.10.008.

[14] Kao, C., and Hwang, S. N., "Efficiency decomposition in two-stage data envelopment analysis: An application to non-life insurance companies in Taiwan", European Journal of Operational Research, 185 (2008), 418-429.

[15] Kao, Ch., and Yang, Y. Ch., (1991). Measuring the efficiency of forest management. Forest Science, 37 (5), 1239-1252.

[16] Kerstens, K., (1996). Technical efficiency measurement and explanation of French urban transit companies. Transportation Research Part A: Policy and Practice, Volume, 30, Issue 6, pp. 431-452.

[17] Lozano, S., and Gutirrez, E., "Efficiency analysis and target setting of Spanish airports", Networks and Spatial Economics, (doi: 10.1007/s11067-008-9096-1).

[18] Mahajan, J., (1991). "Data Envelopment Analytic Model for Assessing the Relative Efficiency of the Selling Function". European Journal of Operational Research, 53, 189-205.

[19] Nunamaker, T. R., and Lewin, A. Y., (1983). "Measuring routine nursing service efficiency: A comparison of cost per patient day and data envelopment analysis models/comment." Health Services Research, 18 (2 (Part 1)), 183-208.

[20] Ping-wen, L., (2002). The Efficiency of Commercial Bank Mergers in Taiwan: An Envelopment Analysis. International Journal of Management, Vol. 19, Iss. 2, Part. 2, pp. 334-342.

[21] Schefczyk, M., (1993). Operational performance of airlines: an extension of traditional measurement paradigms. Strategic Management Journal, 14, 301-317.

[22] Sexton, T. R., and Lewis, H. F., (2003). Two-Stage DEA: An application to major league baseball. Journal ofProductivity Analysis, 19, 227-249.

[23] Thanassoulis, E., and Dunstan, P., (1993). "Guiding Schools to Improved Performance using Data Envelopment Analysis, An Illustration with data with data from a local education authority",Research paper, No. 94, Warwick Bussines School, 1-29.

[24] Uri, N., Technical efficiency, allocative efficiency, and the impact of incentive regulation in telecommunications in the United States, Structural Change and Economic Dynamics, 12 (2001), 59-73.

[25] Wang, H., (1997). Contingent Valuation of Environmental Resources: A Stochastic Perspective, Ph.D. Dissertation, Department of Environmental Sciences and Engineering, School ofPublic Health, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA.

[26] Wu, D., Yang, Z., and Liang, L., Using DEA-neural network approach to evaluate branch efficiency of a large Canadian bank. Expert Syst. Appl., (2006), 108-115.