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Multi-Component Efficiency with Shared Resources in Commercial Banks

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Abstract In the most utilization of Data Envelopment Analysis (DEA), available models yield efficiency score corresponding to each Decision Making Unit (DMU). Indeed, in classical models, a DMU had its own input and outputs, and these data had direct effect on the corresponding unit. But in the model we're examining, some inputs are used for some components in common, and the whole components are used to make some outputs. However, in most of real cases, efficiency is a function of various shared resources in decision making units. In this article, the efficiency four Banks in six periods has been examined and indices in question. This article includes debt ratio, flow of capital resources ratio, average period of collection check of banks and capital efficiency. So the components of capital structure, profitability and growth have been known like the components that use the specific and common indices. At last, the relative efficiency of units has been calculated financially. In this article to calculate the efficiency of a decision making unit four components have been used until the specific efficiency of single component has been determined individually, and its efficiency without the effect of other indices have been found. Finally, the aggregate efficiency of all components has been recognized. In this method we focus on finding the inefficient components in an efficient DMU, and also we can exactly determine which of the inefficient components makes a DMU inefficient. To continue, the preface of data envelopment analysis, ratios and methods used in banking and the models of multi components efficiency with shared resource will be presented. Finally, performing of this model will be discussed in Iranian banks.

Keywords Data Envelopment Analysis, Multi Component Efficiency, Performance Evaluation, Bank, Shared Resource.

1 Preface

Public trust to the bank is its main assets. Missing people's trust may lead that the investors withdraw their money from a bank, so the liquidity will be put under pressure.

It's impossible that a bank which earns money less than that of parallel groups, compete with them. The weak operation of a bank may appoint it to earn more by granting risky loans or presenting services based on wage that creditable banks avoid to do. Moreover, the bank may try to decrease its expenses by using force on workers or delaying the essential optional expenses in some aspects like education, mechanism, appliance due to loss reserves covering loans. Competition based economy to maintain quality services in long-term, a bank must

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provide services in low prices and it should be capable to invest on staff machinery equipment. And the issue is that the share of certain support services is spent. The main role of a bank is to receive funds from deposit and stock and invest them in assets with high interest leading to revenue with interest rate. Moreover, these banks provide financial services based on payments that lead to commission income. For achieving this goal, the bank should invest the resources in order to employ staff and support loans. This issue requires a suitable management to avoid optimization of expenses. Bank managers in a competitive market face compensating factors that decisions can affect the features and performance of their banks such as supervising on profit, maximizing income without interest, controlling operational expenses and investing for accessing competitive advantage. In previous works in literature for performance evaluation in expect of provision displayed strategies and measures, relative efficiency of proficiency by simple operational ratios have been used, for example, every person's transactions or by financial ratios like deposit to loan or return assets.

In the strategies of industrial engineering, relative efficiency evaluation, partial management of staff operation and optimization of work process or system usage are assessed separately. Now, the used sources and the quality of productions, in addition to profit, can be assessed jointly because the main goal of assessing operational relative efficiency of a bank, in a competitive environment, is not only ranking according to insight but also obtaining manageable standards in order to improve performance. DEA was used for relative performance evaluation of decision making units, using mathematical planning. The phrase, relative is for efficiency obtained by comparing units together. One of the advantages of this way is that DEA estimates production function. [1]. Data envelopment analysis was established in 1987 by Charnes and et al. [2] this technique has been changed to one of the ways of scientific management for performance evaluation. The CCR model was innovated by Charnes and et al. [2] and some year later, banker and et al. developed the model BCC. These two models are of the underlying DEA models.

DEA models examine the relative efficiency of a DMU from the ratio of weighted outputs to the weighted inputs.

Indeed, relative influences which are affected by these DMUs, which are located onto the efficient frontier. [3].As it was addressed in the literature one general solution for controlling weight is cone-ratio. [4] It means that the values should limit for weight of inputs and outputs as closed cones. Our first task in developing a model, based on DEA, is to choose a model which suits the nature of that organization and issue. For example, in evaluating an organization with different DMUs, which compete with each other, due to the use of similar resources, and resources which are competitive with similar sources, the best model is variable return to scale which was developed by banker and et al. [5] and was known as BCC. Here, our main model for performance evaluation is BCC model. In classical models of DEA, a standard amount of efficiency for decision making units was obtained, so in most cases, the efficiency of a DMU with sources therefore classification of in some component is necessary.

Indeed, decision making units have different components in order to achieve the goal of organization. It should be noted that there are common and special inputs in components that can receive common and specific outputs by using and processing these inputs. In these cases, we have to obtain the efficiency of a DMU in different components.

Obtaining efficiency based on components is not a new idea. In literature this issue has been addressed. Fare and Grosskopf [6] have provided a model in multi stage models, in the case that outputs of a process are both outputs and inputs for letter process. It is noteworthy to mention that their approach can't be used for multi component efficiency with shared resources.

A model for computing the efficiency of a component which has shared resources has been provided by Cook and et al. [7]. Function productivity is a kind of internal and external indices. The most important part in relative efficiency and productivity is to recognize the best member of community since others can be compared with them.

2 Background

2.1 Data Envelopment Analysis

In performance evaluation each unit consumes multiple inputs to produce multiple outputs. Consider a set of n Decision Making Units for *DMUj*, $X_j = (x_{1j}, \dots, x_{mj})^T$ and $Y_j = (y_{1j}, \dots, y_{sj})^T$ denote the vector-columns of its m inputs and s outputs, respectively. The mathematical form of CCR model, which was introduced by Charnes et al. [2], for relative efficiency evaluation, is as following which provides assessments and targets with an input minimization orientation:

$$
\begin{aligned}
&Min \qquad \theta_p = -\varepsilon\left[\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right] \\
&s.t. \\
&\qquad -\sum_{i=1}^{n} \lambda_j x_{ij} - s_i^- + \theta x_{ip} = 0, \qquad i = 1, \dots, m, \\
&\qquad \sum_{i=1}^{n} \lambda_j y_{rj} + s_r^+ = y_{rj}, \qquad r = 1, \dots, s, \\
&\qquad \lambda_j, s_r^+, s_i^- \geq 0, \qquad for\ all\ i, j, r.
\end{aligned}
\tag{1}
$$

where ε > 0 is a non-Archimedean constant. The dual of (1) is as follows:

$$
\begin{aligned}
&Max \qquad \sum_{r=1}^{s} u_r\, y_{rp} \\
&s.t. \\
&\qquad \sum_{i=1}^{m} v_r x_{ij} = 1, \\
&\qquad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \qquad j = 1, \dots, n, \\
&\qquad u_r \geq \varepsilon, \qquad r = 1, \dots, s, \\
&\qquad v_i \geq \varepsilon, \qquad i = 1, \dots, m.
\end{aligned}
\tag{2}
$$

where u_r , $r = 1, \dots, s$, v_i, $i = 1, \dots, m$ are multipliers for outputs and inputs, respectively.

DMUp chooses the multipliers in order to maximize its relative efficiency, which means it is evaluated from optimistic point of view. It also should be noted that the nature of returns to scale is constant and the model provides a radial measure of efficiency.

2.2 A multi-component performance model

In real application issue it has happened so frequently that there exists some subunits within a DMU. In standard efficiency evaluation, relative efficiency of the DMU under assessment can be achieved. But those models are unable to provide efficiency of subunits. Jahanshahloo et al. [3] in their paper considered this issue and provided a model which can evaluate the efficiency of each subunit within a DMU.

In their paper they have Considered a set of n DMUs and let $(Y_k^{(1)}, Y_k^{(2)}, \dots, Y_k^{(b)})$ to be I_1, I_2, … I_b-dimensional vectors of dedicated outputs to each component transactions of and $(X_k^{(1)}, X_k^{(2)}, \dots, X_k^{(b)})$ to be I_1, I_2, … I_b-dimensional vectors of dedicated inputs to each components and $X_k^{(c)}$ a I_c-dimensional vector of shared inputs. As they have considered in their paper some portion α_i of the shared input $X_k^{(c)}$is allocated to the *i*th component. Also, *i*th component is involved in producing some portion β_i of the shared output $Y_k^{(c)}$.(Note that $\alpha_i \geq 0, \beta_i \geq 0 \; and \; \sum_{i=1}^{b} \alpha_i = \sum_{i=1}^{b} \beta_i = 1$ in proposed model α_i and β_i are decision variables which must be determined.

The provided model for efficiency evaluation, as presented in Jahanshahloo et al.[3] is as follows.

$$
\begin{aligned}
Max \quad & \sum_{i=1}^{b} \mu^{(i)^T} Y_k^{(i)} + \sum_{i=1}^{b} \mu^{(s_i)^T} (\beta_i Y_k^{(c)}) \\
s.t. \quad & \\
& \textstyle\sum_{i=1}^{b} V^{(i)^T} X_k^{(i)} + \sum_{i=1}^{b} V^{(s_i)^T} (\alpha_i X_k^{(c)}) = 1, \\
& \textstyle\sum_{i=1}^{b} \mu^{(i)^T} Y_j^{(i)} + \sum_{i=1}^{b} \mu^{(s_i)^T} (\beta_i Y_j^{(s_i)} - \sum_{i=1}^{b} V^{(i)^T} X_j^{(i)} + \sum_{i=1}^{b} V^{(s_i)^T} (\alpha_i X_j^{(c)}) \leq 1, \quad j \in Y_0 \\
& \mu^{(i)^T} Y_j^{(i)} + \mu^{(s_i)^T} (\beta_i Y_j^{(c)}) - V^{(i)^T} X_j^{(i)} + V^{(s_i)^T} \left(\alpha_i X_j^{(c)}\right) \leq 0, \quad i = 1, \dots, b, \quad j \in Y_0 \\
& \sum_{i=1}^{b} \alpha_i = 1, \qquad (3) \\
& \sum_{i=1}^{b} \beta_i = 1, \\
& \left(\mu^{(i)}, v^{(i)}, v^{(s_i)}, \mu^{(s_i)}, \right) \geq \varepsilon, \quad i = 1, \dots, b, \\
& \alpha_i, \beta_i \geq 0, \quad i = 1, \dots, b.
\end{aligned}
$$

Due to this fact that α_i and β_i are decision variables, this problem is clearly nonlinear. Now, by variable transformation such as $\bar{\mu}^{(s_i)} = \mu^{(s_i)} \beta_i; \; i = 1, \dots, b \quad and \; \bar{V}^{(s_i)} = V^{(s_i)}; i = 1, \dots b$ problem (4) reduces to the following form. For more details about this variable transformation see Jahanshahloo et al. [3].

$$
\begin{aligned}
Max \quad & \sum_{i=1}^{b} \mu^{(i)^T} Y_k^{(i)} + \sum_{i=1}^{b} \bar{\mu}^{(s_i)^T} Y_k^{(c)} \\
s.t. \quad & \\
& \sum_{i=1}^{b} V^{(i)^T} X_k^{(i)} + \sum_{i=1}^{b} \bar{V}^{(s_i)^T} X_k^{(c)} = 1, \\
& \sum_{i=1}^{b} \mu^{(i)^T} Y_j^{(i)} + \sum_{i=1}^{b} \bar{\mu}^{(s_i)^T} Y_j^{(s_i)} - \sum_{i=1}^{b} V^{(i)^T} X_j^{(i)} + \sum_{i=1}^{b} \bar{V}^{(s_i)^T} X_j^{(c)} \leq 1, \quad j \in Y_0 \\
& \mu^{(i)^T} Y_j^{(i)} + \mu^{(s_i)^T} (\beta_i Y_j^{(c)}) - V^{(i)^T} X_j^{(i)} + V^{(s_i)^T} (\alpha_i X_j^{(c)}) \leq 0 , \quad i = 1, \dots, b , \quad j \in Y_0 \qquad (4) \\
& (\mu^{(i)}, V^{(i)}) \geq \varepsilon, \quad i = 1, \dots, b, \\
& \bar{V}^{(s_i)} \geq \beta_i \varepsilon \quad i = 1, \dots, b, \\
& \mu^{(s_i)}, \geq \alpha_i \varepsilon, \quad i = 1, \dots, b.
\end{aligned}
$$

In evaluating relative efficiency in basic DEA models, it is proven that at least one DMU is efficient, but, using the above mentioned model, this is not true. That means this model provides absolute efficiency.

3 The performance of banks and their indices

From marketing point of view, banks provide services which reflect their commitments toward customer's needs and providing services with high quality. Performance evaluation has extensive aspect in attracting customers, cost management, financial mediation and quality service. The first notice of bank legislators is to assure the health security of depositors' money. After that, liquidity and high ratio of capital to assets are taken into consideration. Also Shareholders want to maximize their own investment efficiency. So in financial review, we can assess bank status in capital structure, profitability and growth.
Of course as the picture below depicts, liquidity is considerate between of three aspects.

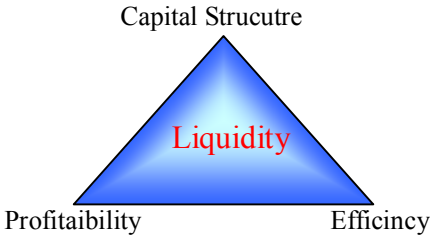

Fig. 1 Liquidity Relations

3.1 Financial Ratio

Financial ratio often divides into three components:

- ✓ Capital Structure,
- ✓ Profitability,
- ✓ Efficiency,

- ✓ Liquidity.

The unique features of bank operations have influenced us to pay attention in selecting these components and exploiting the ratio which is used in each of these groups.

In this section, a set of expressions and effective factors on bank systems will be examined.

3.1.1 Liquidity

In the common financial analysis, liquidity means the ability of the agency to undertake commitments in their expected time.

$$Current\ Ratio = \frac{Current\ assets}{Current\ liabilities} \tag{5}$$

This ratio shows the ability of a company to pay current debts in short term.

$$Quick\ Ratio = \frac{bank\ demand\ deposit + cash\ accounts}{Current\ liabilities} \tag{6}$$

According to financial standard, ILO, the average and normal amount of this ratio for industry is one. While this ratio is being obtained more than one the company can compete with other challenger companies. Under such circumstances, the company can sell its own securities and collect debtors' account and it will be able to pay current debts without selling assets.

3.1.2 Capital Structure

In capital structure, some ratios are used to show how much creditors achieve their demands in that unit, whenever the operations of the unit make loss. The capital of bank is a support that allows the bank to pay off debit and keen on its operations in spite of internal difficulties or economic complexities.

There are some ratios to assess capital structure.

For example:

$$Debt\ Ratio = \frac{total\ liabilities}{total\ assets} \tag{7}$$

$$\text{Ownership Ratio} = \frac{\text{Stockholders' Equity}}{\text{Total Assets}} \tag{8}$$

$$\text{Assets quality} = \frac{\text{Incoming Assets}}{\text{Total Assets}} \tag{9}$$

This ratio shows that how much bank assets have been used in production affairs by its management. Although for supporting bank operation the bank tools are essential, it doesn't make income directly.

Incoming assets consists of demands of central bank – bank and credit institute – credit loans and demands of government, private sector – papers participations and similar – investments and participations.

$$\frac{\text{deferred accounts} + \text{Past maturity}}{\text{Total loans}} \quad (10) \qquad \frac{\text{cost of accounts}}{\text{Total loans}} \quad (11)$$

Bank receives deposit and makes loans. Further, the bank operations face the danger that some borrowers are not interested or capable to pay off loan.

Every kind of shortcoming in paying off the loan decreases the bank value. If a bank becomes able to pay off its debits, it should compensate the reduction from the profits of paid loans and this matter decreases bank profitability.

3.1.3 Profitability

The great income and profitability of a bank show its capability for supporting present and future operations. Generally, income and profitability determine the capacity in attracting capital by making suitable foundation in investing for developing and paying enough profit to stockholders.

The most common ratios for evaluating profitability are assets efficiency and capital efficiency.

$$\text{Assets Output} = \frac{\text{Profit before tax deficit}}{\text{total assets}} \quad (12)$$

This ratio relates operation profit to total resources that are under control of bank management. This ratio is the best proportion for management evaluation.

In order that this ratio becomes more vivid two conditions should necessarily be satisfied. First, its better that inflation effects affect fixed assets and amortization. Second, incoming assets can be used the average item in late months instead of closed year. This standard ratio explains that the least of this ratio should be 1%.

$$\text{Capital Output} = \frac{\text{Profit before tax deficit}}{\text{shareholders' Equity}} \quad (13)$$

This ratio evaluates stockholders' capital efficiency. Bank who have high level ratio, when they access borrowing fund with lower rate, can cause high efficiency for shareholders' salary especially.

Standard ratio explains that at least of this ratio should be 15%.

$$\text{Profit Margin} = \frac{\text{received profit - paid profit}}{\text{average of total assets}} \quad (14)$$

This ratio of main income of bank means that it signifies the income of operative difference to the total assets. Net profits margin is good.

$$\text{Net of balance of profit} = \frac{\text{received profit}}{\text{loans}} - \frac{\text{paid profit}}{\text{deposits}} \tag{15}$$

Here, we should minus the legal reserve lacking profitability from deposits. Something which can be useful in this ratio it provides the effects of profitability sources of the bank and consequently, vulnerability of bank earnings.

$$\text{Operational Margin} = \frac{\text{Operative profit}}{\text{Total assets}} \tag{16}$$

Operative profit makes by misusing operative income and operative expense. This ratio is a good criterion for relative efficiency evaluation of the bank in compared with some organizations in market.

$$\frac{\text{Operative expenses}}{\text{Operative income}} \tag{17}$$

This ratio indicates how much operative impure income of the bank spends on operative expenses. Operative expense includes of paid profit, the prize of money loaned without interest, paid wage and ….

Operative impure income causes by collecting the paid profit of Islamic contracts loans, loan profit and granted credit, legal deposit and other received profits. It's a function of various factors including the amount of bank deposits, cooperation in profitable plans, deals and Islamic agreements. As this index is less, the bank situation is more desirable in profitability and performance.

Standard ratio explains that at most 50 percent of operative income should be spent on operative expenses.

Nowadays, wages have become an increasing source of income for banks. Because legal or competitive pressure is on instructions rate loans, banks must reduce rate and observe rules of competence capital so these limitations affect instruction rate loans and banks are forced to provide service for going wage.

$$\text{Loans to deposit ratio} = \frac{\text{Total loans}}{\text{deposits}} \tag{18}$$

This ratio is one of the main ratios that is examined by most of the bank analysts and measured all deposits that bank management has assigned for loans.

Generally, ratio 70 to 80 percent is known as a reasonable balance between liquidity and incomes.

$$\text{Ratio of personal cost to gross bank} = \frac{\text{personnel casts}}{\text{profit before tax deficit}} \tag{19}$$

Because personnel costs show main part of non-profitable cost of bank, comparing personnel cost with impure income of bank can be useful criterion for specifying the production of bank staff.

If saving is done on cast of current bank through making extra limitation on personnel income, it can reduce quality and staff motivation, so it causes to reduce bank efficiency in long term. The standard ratio of this is at most 30 percent in practical banks.

3.1.4. Efficiency

For calculating bank growth, we use components depicted below:

- growth rate of profit before tax
- growth rate of efficient deposits
- growth rate of granted loans
- contribution of efficient deposited
- income growth rate

3.2 Required components for calculating performance evaluation of banks

In this section, we will show the effective indicators on performance of banks in different parts such as capital structure, profitability and growth.

All bank information is from 2000 to 2005.

Selected indicators are as follow:

Table 1 Input and Output indices for all components

Components	*Input*	*Output*
Capital Structure		
	debt ratio	operation
	equity total asset	asset quality
	personnel's costs to total incomes	deferred accounts and
	fixed asset to total asset	Past maturity to total loan
		cost of accounts to loan
Profitability		
	operational costs to total income	asset output
	equity to total asset	capital output
	personnel cost to total income	profit margin
	fixed asset to total asset	net of balance of profit
		loan to deposit
		operational income
		received commission
Growth		
	equity to total asset	rate of profit growth
	personnel costs to total income	rate of loan growth
	fixed asset to total asset	rate of deposit growth
		deposit share
		loan share
		rate of income growth

Resources and components in this project are as follow:

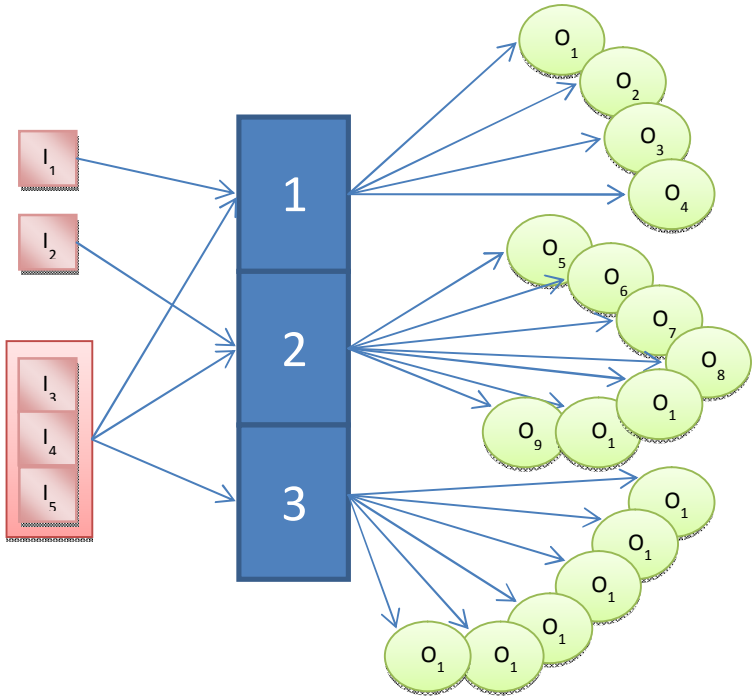

Fig. 2 Components and Shared Resources

5 Analysis of result in commercial bank

In this part, we discuss the relative efficiency in Iranian commercial banks from 2000 to 2005. For each bank we calculate the multi component efficiency in each component such as capital structure, profitability and growth, and finally we calculate aggregate financial efficiency. The results of these calculations are presented in the following table.

Table 2 Multi component measurement

	Capital Structure	Profitability	Growth	Financial
2000				
DMU 1	1.00	1.00	1.00	1.00
DMU 2	1.00	1.00	1.00	1.00
DMU 3	1.00	1.00	1.00	1.00
DMU 4	1.00	0.90	0.73	0.88
DMU 5	1.00	0.76	1.00	0.92
DMU 6	1.00	1.00	0.85	0.95
2001				
DMU 1	1.00	1.00	1.00	1.00
DMU 2	0.68	1.00	0.93	0.87
DMU 3	0.97	1.00	0.84	0.94
DMU 4	1.00	1.00	0.92	0.98
DMU 5	1.00	1.00	1.00	1.00
DMU 6	1.00	1.00	1.00	1.00
2002				
DMU 1	0.85	1.00	0.96	0.94
DMU 2	1.00	1.00	1.00	1.00
DMU 3	1.00	1.00	0.95	0.98

	Capital Structure	Profitability	Growth	Financial
DMU 4	1.00	1.00	0.76	0.92
DMU 5	1.00	1.00	1.00	1.00
DMU 6	0.70	1.00	0.72	0.81
2003				
DMU 1	0.91	1.00	1.00	0.97
DMU 2	1.00	1.00	1.00	1.00
DMU 3	1.00	1.00	0.61	0.87
DMU 4	1.00	1.00	0.83	0.94
DMU 5	1.00	1.00	0.86	0.95
DMU 6	0.83	0.52	0.70	0.68
2004				
DMU 1	1.00	1.00	1.00	1.00
DMU 2	1.00	0.87	1.00	0.96
DMU 3	0.74	0.93	0.73	0.80
DMU 4	0.93	0.79	0.71	0.81
DMU 5	0.81	0.95	0.69	0.82
DMU 6	1.00	0.76	1.00	0.92
2005				
DMU 1	1.00	1.00	0.47	0.82
DMU 2	0.67	0.98	1.00	0.89
DMU 3	0.66	1.00	0.51	0.72
DMU 4	0.65	1.00	0.87	0.84
DMU 5	0.78	1.00	0.66	0.81
DMU 6	0.54	0.60	1.00	0.71

Table 2 shows relative efficiency of commercial banks in 2000 to 2005. The relative efficiency calculated in three components as capital structure, profitability and growth and finally aggregate efficiency in financial. According to this table at 2000, DMU1, DMU2 and DMU3 were efficient DMU in all component and others were efficient in some of them. After 2000 we see an unstable situation in financial efficiency that decrease 2001 to 2005. We can see that an awful event is profitability in 2004 in all commercial banks. In capital structure and growth we can see a descend rate in all of them.

6 Conclusions

In this article, multi component efficiency and financial efficiency of Iranian banks have been calculated and examined by data envelopment analysis technique. In this kind of performance evaluation, the acquired information is so effective in assigning organization strategy and making decision based on previous performance and aiming at future trend of the organization.

One of the important issues for evaluation of a bank is utilization of financial resources which shows financial efficiency. Profitability elements, financial and growth can affect on liquidity resource management. Evaluation of risk in banks activity is included credit risk, liquidity risk and interest rate. Performance evaluation with multi component efficiency with capital structure, profitability and growth component that affect the liquidity and bank liquidity management is available.

The result of this study shows that the provided sample can be used for organization which have been examining like the sample. The most important factor in this kind of performance evaluation is the efficiency of organization with inputs and outputs that can have sensitivity analysis in the method of evaluating organization.

Iran banks including commercial and private in this kind of look have shown unstable situation in the studied years and clearly, making decision has been changed according to the effects of annual condition. All evaluated banks in developing component haven't shown correct and purposeful trend and according to other component efficiency and finally financial efficiency, the performance of banks regarding to pre-planned aims, hasn't experienced a growing act.

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