Performance monitoring and showing the weakness of periodic assessment of data envelopment analysis

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Abstract: For analysing the performance of a decision making unit (DMU) and acquiring correct information about the performance of DMUs during the evaluation, measuring relative efficiency, is not sufficient. Therefore, by taking advantages of complementary techniques relative efficiency of an entity, while each of the entities are being considered independently, should be measured and investigated in population. Here the shortfall of the efficiency evaluation in successive time periods have been investigated and for preserving mistakes for correct monitoring the organisation performance different techniques such as DEA, MPI and etc. have been simultaneously utilised.

Keywords: bank; efficiency; data envelopment analysis; DEA; Malmquist productivity index; MPI.

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1 Introduction

Controlling bank activities step by step, at each period in turn, and identifying and improving the direction according to the previous assembled strategy are one of the fundamental concerns of senior managers of organisations. The ability of competing with the rivals in these days is the flexibility in the trend procedure according to the created variations and the on time improving the shortfall. Evaluating the relative efficiency in the different time periods, merely, does not indicate the bank performance and will lead the decision maker (DM) to the ambiguous difficulties. Therefore, for controlling performance at various stages, population (technology) variations along as efficiency variations should be examined. In what follows this issue will be entirely discussed. The main focus of this paper is about the variations of the condition of the production technology and analysis of its alterations which give the organisation management valuable information about the trend procedure of the decision making units (DMUs).

For evaluating the relative efficiency of DMUs and identifying efficient production frontiers, DEA was initiated and developed by Charnes et al. (1978) and after that developed by Banker et al. (1984). As existed in literature efficiency evaluation gains important attention in application issues. Ray and Ray (2012) evaluated efficiency growth pattern for India's chemical industry while considering data envelopment analysis (DEA) and Malmquist productivity growth. Moreover, they investigated the progress or regress of units for better guiding the system. In their paper, Abid and Tadj (2012) found solutions for measure and improve the efficiency of DP-World ports by using DEA technique. As they noted one of the major advantages of using DEA technique is that it can calculate efficiency score while bundles of input-output data are considered.

In this paper, Zhu et al. (2012) based on DEA evaluated operation performance of domestic airlines from cost efficiency and service-effectiveness and cost-effectiveness. This method is a data-oriented methodology in which each DMU is an entity responsible for converting multiple inputs into multiple outputs. DEA, from among a set of observed units, is utilised to construct a frontier with the best practice group, and by comparing to this frontier it identifies the inefficient units. Technically efficient DMUs are those that operate best practice, whereas the degree of technical inefficiency of the rest is calculated according to the Euclidean distance of their input-output ratio from the frontier of production function. One of the advantages of utilising DEA is that it reveals the improvements possible for the inefficient units and also shows the magnitude of the inefficiencies. If different component have been considered with in DMU efficiency can be measured relative to these components. As an instance, Fare and Grosskopf (1996), look at a multistage process wherein intermediate products or outputs at one stage, can be both final products and inputs to later stages of production. The aim is to evaluated efficiency at each stage. Hence, it is possible to provide a better representation of the technology than a black box model in which just the initial input and final output are incorporated. Malmquist (1953), for use in consumption analysis, published a quantity index in which input distance functions are used to make comparison among two or more consumption bundles. Also, the reference set is considered as an indifference curve of one of the consumers. Later on basis of what Malmquist has proposed, Caves et al. (1982) in production analysis, introduced Malmquist productivity index (MPI). Nowadays applications, in the literature, which uses the MPI have become widespread and the measurement and analysis of productivity change has enjoyed a great deal of attention. New development about Malmquist index is made. As Afsharian et al. (2012) mentioned in their paper, Malmquist index, based on DEA models, is the prominent index for measuring the relative productivity change of decision-making units (DMUs) in multiple time periods. They introduced a new insight into the Malmquist index for measuring the productivity change of a master unit (master-DMU) that encompasses a set of units, its sub-DMUs, in multiple time periods. There exist variety of models which made modifications in Malmquist indexes to be used in banking systems such as Lin et al. (2009), Wang and Lin (2009) and Wu et al. (2009). Performance evaluation of a set of DMUs in successive time periods is very common for target setting, policy making and guiding the system in future. In this paper this issue discussed and mentioned that this type of evaluation may result in wrong assessment. Measuring efficiency of each cards of a balanced scored problem is of major importance to be informed about the condition of the entities. Thus, finding a method for separately assessing efficiency of cards with common data is important. In a paper, Vaez-Ghasemi et al. (2012) performed multi-component efficiency assessment in DEA technique for efficiency assessment of card performance in a balanced scored problem. In their paper, Rahnamay Roodposhti et al. (2010) used DEA technique for acquiring targets in balanced scorecard method. They used DEA which helped to identify the condition of being MPSS for all units in new period. In doing so DEA empowered the method to use proper pattern to estimate the volume of increase or decrease in each perspective. As mentioned earlier many paper deals with efficiency evaluation of DMUs not obtaining correct results would put the managers and the whole system into trouble. Also, for preserving mistakes for correct monitoring the organisation performance different techniques such as DEA, MPI, and etc., have been simultaneously utilised. According to what has been mentioned, considering to DEA technique, multi component efficiency evaluation have been performed and the efficiency scores of each component have been calculated also with the use of MPI productivity change of entities evaluated.

The paper unfolds as follows: in Section 2, some preliminaries will be briefly reviewed. In Section 3, main subject will be presented and the results are sufficiently discussed and Section 4 concludes the paper.

2 Preliminaries

As mentioned earlier, the aim of this paper is to show the shortfall of the efficiency evaluation in successive time periods. Moreover, for preserving these mistakes for correct monitoring the organisation performance, different techniques such as DEA, MPI multi-component efficiency assessment have been simultaneously utilised which can, to a major extent, overcomes this difficulty.

2.1 Data envelopment analysis

DEA was initiated and developed by Charnes et al. (1978) and after that developed by Banker et al. (1984). Considering DEA models, under different assumptions, relative efficiency of DMUs can be derived. As mentioned earlier, in DEA technique production frontier is constructed that with which those units performs efficiently can be identified. Moreover, according to these best practice units, targets for inefficient units can be recognised. These two achievements are of great importance in policy making and guiding a system that can be performed for multi-component DMUs. In such case, efficiency of each sub-process as well as the entire DMU can be derived.

Let DMU_o denotes a unit from among n units whose relative efficiency is being assessed. Also, define $x_o \in Rm_+$ and $y_o \in Rs_+$, respectively, as inputs and outputs of DMU_o. The most routine way to characterise production technology is production possibility set (PPS) T, which is defined with a set of semi-positive (x, y) as follows:

$$T = \left\{ (x, y) \middle| x \geq \sum_{j=1}^{n} \lambda_j x_j, \quad y \leq \sum_{j=1}^{n} \lambda_j y_j, \quad \sum_{j=1}^{n} \lambda_j = 1 \ \lambda_j \geq 0, \quad j = 1, \ldots, n \right\}$$

The variable returns to scale form of the enveloping problem, which was first introduced by Banker et al. (1982), is as follows:

$$
\begin{aligned}
\min \quad & \theta \\
s.t. \quad & \sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{io}, \quad i = 1, \ldots, m, \\
& \sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{ro}, \quad r = 1, \ldots, s, \\
& \sum_{j=1}^{n} \lambda_j = 1, \\
& \lambda_j \ge 0, \qquad j = 1, \ldots, n.
\end{aligned} \tag{1}
$$

This model is designated as BBC model in which the variable returns to scale technology has been considered. This model is widely used for relative efficiency evaluation. For CCR model, it is just needed to eliminate the convex constraint from the constraints of the model (Charnes et al., 1978).

2.2 Malmquist productivity index

MPI used in order to measure the productivity changes over time. As mentioned earlier *DEA* models are linear programming (*LP*) models that derive the frontier production function of the *DMU* included in the sample. While working with 'best practice frontier' is constructed. The inclusion of aspect of the production process that constitutes the best practice frontier can obviously change over time has gained a major significance. An efficiency measure for one year relative to the prior year, while allowing the best frontier to shift can be calculated by the Malmquist *DEA* approach. Between these time points, time t and $t + 1$, the frontier function has shifted from frontier t to frontier $t + 1$. technical efficiency change (EC) and technological change (TE) is the decomposition of MPI relative to the frontier. Therefore, Malmquist growth is the product of technical efficiency change and technological change. Considering efficiency changes of each entity and technology changes simultaneously, MPI can be defined. DEA is used in this paper to compute the distance functions of MPI. Consider DMU_l with the input-output data which are discussed in previous section. Also, consider the PPS T_c as:

$$T = \left\{ (x, y) \middle| \, x \ge \sum_{j=1}^{n} \lambda_j x_j, \quad y \le \sum_{j=1}^{n} \lambda_j y_j, \quad \lambda_j \ge 0, \quad j = 1, \ldots, n \right\}$$

As discussed earlier MPI can be calculated via several functions, such as distance function:

$$D\left(X_l, Y_l\right) = \inf \left\{ \theta : \left(\theta X_l, Y_l\right) \in T \right\}$$

By solving linear programming problems the resultant distance function can be computed. Now, consider an input-oriented *CCR* model as follows:

$$
\begin{aligned}
& D^f\left(x_l^k, y_l^k\right) = \min \quad \theta \\
& s.t. \qquad \sum_{j=1}^{n} \lambda_j x_{ij}^f \leq \theta x_{il}^k, \quad i = 1, \ldots, m, \\
& \qquad\qquad \sum_{j=1}^{n} \lambda_j y_{rj}^f \geq y_{rl}^k, \quad r = 1, \ldots, s, \\
& \qquad\qquad \lambda_j \geq 0, \qquad j = 1, \ldots, n.
\end{aligned} \tag{2}
$$

where l is the under assessment unit and each of k and f vary between time t and $t + 1$. As an instance for assessing DMU_l consider $k = t$ and $f = t + 1$, $D^{t+1}(x_l^t, y_l^t)$, this means that technology is considered in time $t + 1$ and DMU_l is considered in time t. Considering this notification, four *LP* problems can be defined.

Regarding this issue the MPI have been introduced as follows by Caves et al. (1982), in which the results obtained from the mentioned models are being used.

$$
M\left(x_l^{t+1}, y_l^{t+1}, x_l^t, y_l^t\right) = \left(\frac{D^t\left(x_l^{t+1}, y_l^{t+1}\right) D^{t+1}\left(x_l^{t+1}, y_l^{t+1}\right)}{D^t\left(x_l^t, y_l^t\right) D^{t+1}\left(x_l^t, y_l^t\right)} \right)^{\frac{1}{2}} \tag{3}
$$

It needs to be mentioned that x_l^t and y_l^t are the input and output vectors for unit l, used in period t, l and t varies between t and $t + 1$. Also, x_l^{t+1} and y_l^{t+1} are the input and output vectors for unit l, used in period $t + 1$. This index measures the productivity of unit l at the production (x_l^{t+l}, y_l^{t+l}) relative to (x_l^t, y_l^t). The above equation can be further decomposed into two components one for measuring the change in technical efficiency and the other for measuring the technical change which means the technology frontier shift between the two time periods, t and $t + 1$:

$$
M\left(x_l^{t+1}, y_l^{t+1}, x_l^t, y_l^t\right) = \frac{D^{t+1}\left(x_l^{t+1}, y_l^{t+1}\right)}{D^t\left(x_l^t, y_l^t\right)} \left[\frac{D^t\left(x_l^{t+1}, y_l^{t+1}\right) D^t\left(x_l^t, y_l^t\right)}{D^{t+1}\left(x_l^{t+1}, y_l^{t+1}\right) D^{t+1}\left(x_l^t, y_l^t\right)} \right]^{\frac{1}{2}} \tag{4}
$$

The efficiency change share in the above-mentioned equation is equal to the ratio of the Farrell technical efficiency measure at time $t + 1$, which is divided by the Farrell technical efficiency measure at time t. The technical change part is captured by the geometric average of the two ratios reflecting the shifts in the frontier at time t, and $t + 1$. The interpretation of this equation is that $M(x_l^{t+1}, y_l^{t+1}, x_l^t, y_l^t) > 1$ indicates an improvement in total productivity, $M(x_l^{t+1}, y_l^{t+1}, x_l^t, y_l^t) < 1$ indicates a decline, and $M(x_l^{t+1}, y_l^{t+1}, x_l^t, y_l^t) = 1$ shows an unchanged productivity growth (Caves et al., 1982).

Note that this issue can be performed for deriving MPI for each stage of a multi-component DMUs. Thus, by identifying the progress and regress in each sub-process as well as the entire unit, policy making and guiding the system will be more accurate.

2.2.1 Component efficiency

In many paradigms and applications, it is possible that a DMU has a sub-processes with in. Conventional DEA models, consideres each DMU without pays attention to the subprocceses may exist with in the DMU, and measure corresponding relative efficieny. This would not give accurate information about the existing sub-processes for the managers. Thus, for further analysed the system and having information in order to guide the system it seems necessary to evaluate the sub-processes.

Consider the CRS fractional model which is used for introduced relative efficiency evaluation, and has been introduced by Charnes et al. (1978) as follows:

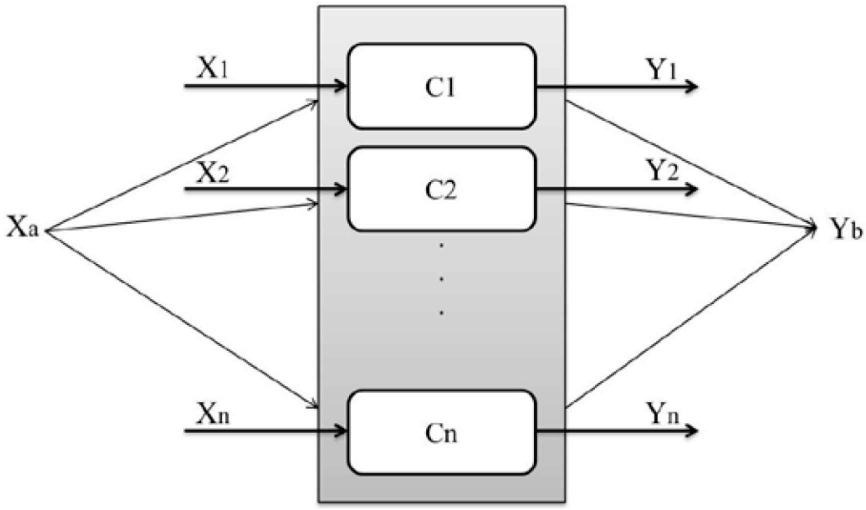
$$\begin{aligned} \max \quad & \frac{U^t Y_k}{V^t X_k} \\ s.t. \quad & \frac{U^t Y_j}{V^t X_j}, \qquad j = 1, \ldots, n, \\ & U \geq 0 \quad V \geq 0 \end{aligned} \tag{5}$$

In which input vector X_k is used to produce output vector Y_k for each DMU_k (DMU under evaluation) $k \in \{1,\ldots,n\}$, vector X_j is used to produce output vector Y_j for each DMU_j $j = 1,\ldots,n$ (see Figure 1). The structure in (5) pays no attention for the performance of subunits that may exist within the DMU. As in real word many units which consist of different sub-processes within itself. Considering this issue, assume that one desires to measure the overall efficiency of each *DMU* and moreover efficiency of each subunits. Thus, it is needed to provide a performance measurement tool with component-based information as part of the aggregate efficiency score, while the components of a *DMU* is being emphasised. Now, let $Y_1^k, Y_2^k, \ldots, Y_n^k$ be the set of each component transactions of DMU_k in which

$$Y_i^k = \left(Y_{k1}^i, Y_{k2}^i, \ldots, Y_{kJ_i}^i\right), \quad i = 1, \ldots, b.$$

Moreover, let $X_1^k, X_2^k, \ldots, X_n^k$ be $I_1, I_2, \ldots, I_b$-dimensional vectors of dedicated inputs to each components and X_k^a be a I_a-dimensional vector of shared inputs. All components are involved in producing the J_a-dimensional vector of output Y_k^a. Some portion α_i of the shared input X_k^a 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^a. It should be noted that $\alpha_i \geq 0$, $\beta_i \geq 0$ and $\sum_{i=1}^{b} \alpha_i, \sum_{i=1}^{b} \beta_i = 1$.

Figure 1 A DMU with *n* components



In this model α_i and β_i are decision variables which must be determined. Each elements of these decisions variables shows the portion of inputs and outputs for the DMU under assessment. Thus, considering what Jahanshahloo et al. (2004) has been provided a measure of aggregate performance e_k^a has been represented as the following in which the operation * for two vectors like $K \in R^n$ and $L \in R^n$ is defined as $(k_1L_1,\ldots,K_nL_n) \in R^n$.

$$e_k^a = \frac{U^{1t}Y_k^1 + \ldots + U^{bt}Y_k^b + U^{S_1t} * \beta_1 Y_k^a + \ldots + U^{S_bt} * \beta_b Y_k^a}{V^{1t}X_k^1 + \ldots + V^{bt}X_k^b + V^{S_1t} * \alpha_1 X_k^a + \ldots + V^{S_bt} * \alpha_b X_k^a}$$

such that $\sum_{i=1}^{b} \alpha_i = 1, \sum_{i=1}^{b} \beta_i = 1.$ In this representation, the vectors U and V would be determined in a *DEA* manner as discussed below in the following multiplier model. These variables are input and output weights, respectively. Now, while e_k^a is being considered, performance measures for each components of DMU_k can be represented from the following expression.

$$e_k^i = \frac{U^{it}Y_k^i + U^{S_it} * \beta_i Y_k^a}{V^{it}X_k^i + V^{S_it} * \alpha_i X_k^a}, \quad i = 1,\ldots,b.$$

Moreover, Jahanshahloo et al. (2004) have been proven that the aggregate performance measure e_k^a is a convex combination of e_k^is (Charnes et al., 1978). For efficiency evaluation of multi component DMUs, the following LP model has been presented by Jahanshahloo et al. (2004):

$$
\begin{aligned}
\max \quad & \sum_{i=1}^{b} U^{it} Y_k^i + \sum_{i=1}^{b} \bar{U}^{s_i t} Y_k^a \\
s.t. \quad & \sum_{i=1}^{b} V^{it} X_k^i + \sum_{i=1}^{b} \bar{V}^{s_i t} X_k^a = 1 \\
& \sum_{i=1}^{b} U^{it} Y_j^i + \sum_{i=1}^{b} \bar{U}^{s_i t} Y_j^a - \sum_{i=1}^{b} V^{it} X_j^i + \sum_{i=1}^{b} \bar{V}^{s_i t} X_j^a \le 1, \quad j = 1, \ldots, n, \\
& U^{it} Y_j^i + \bar{U}^{s_i t} Y_j^c - \bar{V}^{it} X_j^i - \bar{V}^{s_i t} X_j^c \le 0, \quad i = 1, \ldots, b, \quad j = 1, \ldots, n, \\
& U^i \ge \varepsilon \quad V^i \ge \varepsilon, \quad i = 1, \ldots, b, \\
& U^{s_i} \ge \beta_i \varepsilon \quad V^{s_i} \ge \alpha_i \varepsilon, \quad i = 1, \ldots, b, \\
& \sum\nolimits_{i=1}^{b} \alpha_i = 1, \\
& \sum\nolimits_{i=1}^{b} \beta_i = 1, \\
& \alpha_i \ge 0, \quad \beta_i \ge 0, \quad i = 1, \ldots, b.
\end{aligned}
\tag{6}
$$

where ε is a non-Archimedean constant, U and V are output and input weights for those data that are not shares and $\bar{U}$ and $\bar{V}$ are output and input weights for shared data after variable transformation to reach the linear model. And α and β indicate the portion of shared inputs and outputs.

3 Monitoring and efficiency measurement

For competing in the economy which is based upon the business and keeping the quality of the services in long-terms at a high level, a bank should give services with low expenses. Moreover, it should be able to sufficiently invest in the number of stage, equipment and machinery. This is due to spend a specific amount of the acquired revenue for protecting services. The main role of a bank is receiving funds, mainly via deposit and stocks, investing them in finances with high productivity which will result in revenue outcome from the difference to the profit. Moreover, banks in accordance with the received earning will present financial services which yields in the commission revenue. For achieving this goal the bank should invest resources and some of the resulted gross profit for employing stocks and supported facilities. This condition requires the suitable management which guarantee the optimality of the allocated funds. Managers of a bank, in a competitive business, face a set of compensating factors and their decisions can have a remarkable effect on characteristics and performance of their banks. Previously, for the performance assessment away from the strategies and anticipated policies, relative efficiency measured via the simple operations such as transaction of individuals or the financial operations such as deposit to the loans or return of assets. In recent methods, efficiency evaluation from the aspect of time, partial management of stage activities and optimality of work process or the utilised systems will be evaluated. Now, the utilised resources and quality of products, as long as profitability are considered linked and joint. Since the major goal of the examination and relative efficiency evaluation of the bank operations in a competitive environment is not just ranking them due to their efficiency scores, but also is gaining the insight with regard of nature of operation for finding the management criterion for improving performance. In the current research for the under evaluation banks, those challenges which are significant for the senior managers are defined and all the banks are to improve their performance in these challenges and moreover their performance are monthly evaluated via DEA and specifically with BCC model. According to authors opinion 17 challenges have been recognised for the under evaluation banks in which five of them are of fundamental importance since the banks have weaknesses in them. Therefore, here, the authors consider these five challenges for analysis and our aim is to guide and set target for banks to improve their weaknesses in these challenges. These challenges are:

1 challenge of profitability
2 challenge of promotion and preservation of competition
3 challenge of necessity of finding resources at the lowest price (cost structure of resources)
4 challenge of deducing delayed items
5 challenge of optimal consumption management.

On the other hand it should be noted that for each of these challenges specific inputs and outputs are allocated. For each of them in the confronted periods, a short-term goal has been defined and their relative performance measured and again, according to the obtained results at each period, the improving direction will be corrected. Each of these challenges are considered as a component in the multi component model for which the input-output data are as follows. These inputs and outputs have been considered on basis of bank researches and are gathered in Table 1.

Table 1 Component indexes

K1	Joint income	K10	Saving account
K2	Wage	K11	Short term investment
K3	Payable premium for resource absorption	K12	Long term investment
K4	Surplus expenses of resources and consumption	K13	Residue claims of facilities
K5	Employment and official expenses	K14	Residue claims of commitment
K6	Four non-governmental savings	K15	Residue of the issued guaranty
K7	Other resources	K16	Residue of the opened documental credit
K8	Governmental current account	K17	Facilities
K9	Private current account	K18	Resources

As it can be seen in Figure 2 some of the inputs are consumed in common among the challenges but in evaluation each of the challenges are considered independently. Actually, as it was propound in this way an entire control of these inputs and its allocation to challenges are under the control of manager. Manages have an all-around independence in consuming these resources for gaining better productivity in order to acquire an improved efficiency score in each of these challenges. It should be noted that the ability of managers meanwhile, for allocating resources to challenges are one of the fundamental duties for them. The periods of evaluation for these branches are 18 monthly periods and in this way performance of one and half a year of bank branches are monthly monitoring. For each of them during the evaluation period average of efficiency has been calculated and as an instance one of the challenges for the superior branches are gathered in Table 2. The efficiency corresponds to each challenges in 18 periods of evaluation and the obtained average are gathered in Table 2.

Figure 2 A DMU with five components

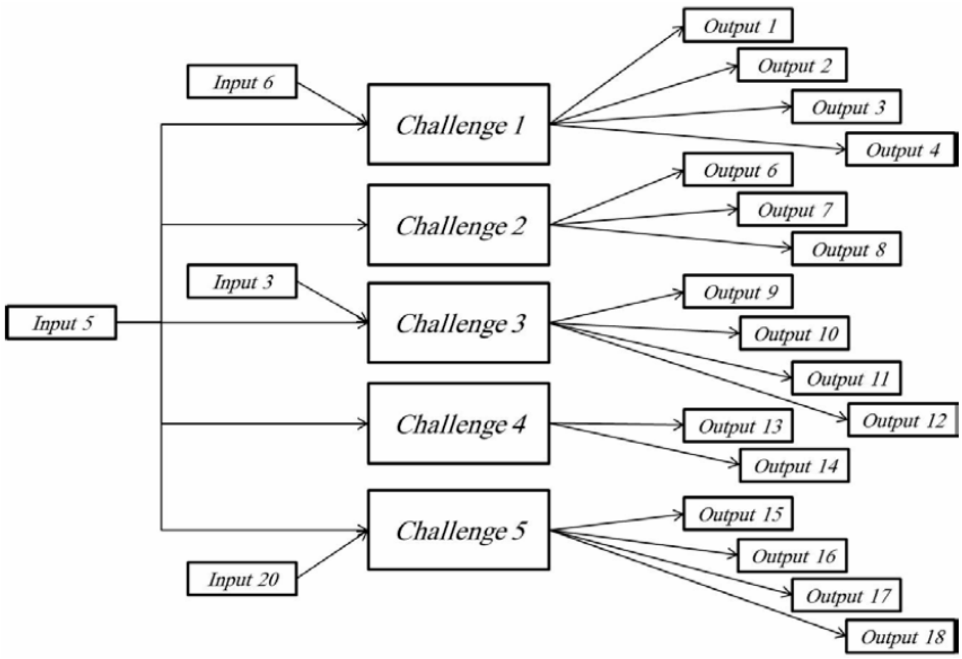


Table 2 Component efficiency scores

Rank	*Code*	*Efficiencies of branches in five challenges*					
		C.E.1	*C.E.2*	*C.E.3*	*C.E.4*	*C.E.5*	*Average*
1	63065	0.772	0.467	0.415	0.823	0.407	0.577
2	67579	0.311	0.861	0.933	0.591	0.150	0.569
3	65441	0.684	0.545	0.383	0.649	0.473	0.547
4	91736	0.627	0.293	0.574	0.253	0.875	0.525
5	63404	0.654	0.110	0.423	0.186	0.889	0.452
6	63529	0.443	0.261	0.543	0.049	0.908	0.441
7	62026	0.539	0.342	0.520	0.208	0.496	0.421
8	55558	0.403	0.221	0.415	0.690	0.356	0.417
9	63560	0.658	0.097	0.214	0.193	0.914	0.415
10	43414	0.351	0.117	0.775	0.500	0.173	0.383
11	62356	0.559	0.061	0.314	0.272	0.697	0.381
12	67603	0.480	0.138	0.484	0.237	0.535	0.375
13	67736	0.350	0.087	0.179	0.268	0.984	0.374

Table 2 Component efficiency scores (continued)

Rank	*Code*	*Efficiencies of branches in five challenges*					
		C.E.1	*C.E.2*	*C.E.3*	*C.E.4*	*C.E.5*	*Average*
14	63255	0.272	0.192	0.762	0.390	0.238	0.371
15	70003	0.570	0.254	0.313	0.328	0.388	0.371
16	30874	0.544	0.090	0.334	0.323	0.561	0.371
17	67397	0.277	0.275	0.303	0.367	0.619	0.368
18	62018	0.334	0.111	0.590	0.184	0.573	0.358
19	92106	0.281	0.106	0.652	0.565	0.180	0.357
20	67033	0.318	0.242	0.418	0.753	0.054	0.357
21	65078	0.381	0.504	0.355	0.262	0.221	0.345
22	65128	0.660	0.038	0.200	0.210	0.562	0.334
23	63214	0.490	0.108	0.239	0.018	0.796	0.330
24	65607	0.293	0.282	0.373	0.536	0.106	0.318
25	66225	0.444	0.090	0.204	0.392	0.459	0.318
26	37309	0.282	0.080	0.508	0.339	0.352	0.312
27	47241	0.340	0.177	0.379	0.545	0.111	0.310
28	30908	0.341	0.089	0.375	0.521	0.205	0.306
29	65318	0.343	0.105	0.150	0.615	0.315	0.305
30	66548	0.427	0.084	0.272	0.245	0.496	0.305
31	58735	0.361	0.107	0.299	0.406	0.329	0.300
32	63073	0.286	0.196	0.315	0.577	0.125	0.300
33	62117	0.377	0.117	0.334	0.407	0.213	0.290
34	67025	0.255	0.118	0.502	0.403	0.164	0.288
35	63594	0.318	0.131	0.389	0.206	0.367	0.282
36	65169	0.295	0.201	0.293	0.454	0.157	0.280
37	96776	0.323	0.189	0.213	0.339	0.321	0.277
38	65359	0.189	0.107	0.615	0.339	0.121	0.274
39	65201	0.290	0.178	0.282	0.238	0.379	0.273
40	55459	0.328	0.064	0.203	0.478	0.246	0.264
41	65086	0.366	0.203	0.204	0.295	0.240	0.262
42	63032	0.257	0.130	0.270	0.447	0.199	0.260
43	65144	0.278	0.157	0.355	0.266	0.222	0.256
44	88468	0.268	0.071	0.294	0.350	0.251	0.247
45	65573	0.305	0.048	0.163	0.370	0.345	0.246
46	62067	0.397	0.038	0.101	0.298	0.387	0.244
47	88054	0.336	0.054	0.229	0.299	0.300	0.244
48	30965	0.273	0.199	0.242	0.389	0.110	0.242
49	62463	0.291	0.052	0.137	0.295	0.433	0.242

Table 2 Component efficiency scores (continued)

Rank	*Code*	*Efficiencies of branches in five challenges*					
		C.E.1	*C.E.2*	*C.E.3*	*C.E.4*	*C.E.5*	*Average*
50	62182	0.286	0.163	0.194	0.272	0.273	0.238
51	62059	0.235	0.177	0.200	0.556	0.015	0.237
52	61259	0.292	0.077	0.199	0.241	0.366	0.235
53	38901	0.270	0.097	0.259	0.333	0.197	0.231
54	65052	0.166	0.077	0.496	0.368	0.047	0.231
55	49221	0.183	0.123	0.359	0.264	0.142	0.214
56	13425	0.232	0.086	0.232	0.218	0.275	0.209
57	62216	0.320	0.034	0.129	0.433	0.127	0.209
58	63420	0.245	0.102	0.188	0.256	0.208	0.200
59	44172	0.354	0.165	0.197	0.233	0.050	0.200
60	49411	0.234	0.070	0.163	0.320	0.186	0.195
61	65177	0.267	0.089	0.197	0.242	0.117	0.183
62	67355	0.169	0.069	0.214	0.357	0.068	0.175
63	64188	0.174	0.059	0.162	0.244	0.230	0.174

By paying attention to the acquired efficiency for each of the bank branches in this project, all of the bank branches have an improving performance. This point can be seen in average of challenges obtained via all of the branches as shown in Table 3. In Table 3, the average of challenges are listed.

Table 3 Average efficiency of each challenge

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Challenge 1	0.228	0.369	0.423	0.574	0.503	0.451	0.588	0.499	0.505
Challenge 2	0.05	0.13	0.12	0.1	0.1	0.13	0.15	0.12	0.13
Challenge 3	0.14	0.21	0.21	0.29	0.36	0.36	0.3	0.12	0.28
Challenge 4	0.03	0.34	0.33	0.37	0.4	0.44	0.43	0.44	0.44
Challenge 5	0.33	0.37	0.39	0.37	0.37	0.37	0.37	0.33	0.31
Average	0.154	0.284	0.296	0.338	0.347	0.349	0.369	0.303	0.332
	10	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*
Challenge 1	0.456	0.323	0.409	0.117	0.197	0.201	0.159	0.209	0.260
Challenge 2	0.18	0.19	0.21	0.18	0.11	0.28	0.28	0.24	0.21
Challenge 3	0.36	0.31	0.42	0.44	0.4	0.39	0.47	0.51	0.54
Challenge 4	0.44	0.44	0.43	0.09	0.05	0.47	0.38	0.45	0.5
Challenge 5	0.29	0.36	0.35	0.35	0.35	0.39	0.24	0.28	0.29
Average	0.345	0.324	0.362	0.234	0.222	0.345	0.306	0.338	0.360

Table 4 Efficiency scores in first period

Num.	*Code*	*Efficiency of the first component in different months*																		
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*Average*
40	63065	0.904	0.863	0.515	0.758	0.651	1.000	0.777	0.706	0.562	0.451	0.250	0.464	1.000	1.000	1.000	1.000	1.000	1.000	*0.772*
14	65441	0.716	1.000	1.000	0.958	1.000	0.913	1.000	0.854	0.937	0.943	0.466	0.683	0.099	0.166	0.327	0.350	0.456	0.440	*0.684*
46	65128	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.333	0.323	0.340	0.150	0.159	0.174	0.168	0.236	*0.660*
8	63560	0.230	1.000	0.941	1.000	0.731	0.900	0.832	0.704	1.000	1.000	0.544	0.645	0.270	0.322	0.400	0.364	0.495	0.458	*0.658*
6	63404	0.021	0.141	1.000	1.000	1.000	0.969	1.000	1.000	1.000	1.000	1.000	1.000	0.031	0.070	0.330	0.314	0.363	0.537	*0.654*
17	91736	0.676	0.396	0.701	1.000	1.000	1.000	0.812	0.383	0.751	0.791	0.199	0.633	0.139	1.000	0.450	0.278	0.527	0.546	*0.627*
60	70003	1.000	0.622	1.000	1.000	0.645	0.676	0.735	0.713	0.688	0.694	0.887	0.601	0.216	0.297	0.118	0.089	0.103	0.172	*0.570*
38	62356	0.248	0.369	0.401	0.828	0.526	0.563	0.688	1.000	0.573	0.568	0.967	1.000	0.246	0.314	0.325	0.375	0.637	0.441	*0.559*
1	30874	0.467	0.458	1.000	1.000	0.757	0.667	0.812	0.794	0.884	0.651	1.000	0.535	0.142	0.133	0.130	0.084	0.130	0.156	*0.544*
3	62026	0.175	0.617	0.878	1.000	0.806	0.709	0.800	0.469	0.540	0.610	0.266	0.513	0.043	0.255	0.619	0.354	0.534	0.512	*0.539*
5	63214	0.075	0.116	0.333	0.818	0.627	0.495	0.557	0.477	1.000	1.000	1.000	1.000	0.044	0.156	0.298	0.127	0.199	0.502	*0.490*
58	67603	0.177	0.223	0.502	0.621	0.644	0.728	0.744	0.543	0.723	0.730	0.432	0.967	0.132	0.191	0.322	0.354	0.287	0.326	*0.480*
53	66225	0.160	0.365	0.685	0.720	0.662	0.638	0.815	0.730	0.554	0.562	0.397	0.604	0.118	0.175	0.187	0.138	0.226	0.260	*0.444*
7	63529	0.098	0.260	0.337	0.768	0.770	0.803	0.803	0.677	0.461	0.506	0.388	0.605	0.058	0.134	0.338	0.327	0.270	0.367	*0.443*
54	66548	0.406	0.184	0.559	0.836	0.682	0.434	0.738	0.484	0.860	0.647	0.243	0.604	0.057	0.085	0.214	0.161	0.251	0.250	*0.427*
30	55558	1.000	0.519	0.389	0.550	0.406	0.296	0.475	0.405	0.369	0.340	0.224	0.318	0.391	0.937	0.129	0.168	0.156	0.190	*0.403*
34	62067	0.412	0.355	0.813	1.000	0.700	0.719	0.518	0.330	0.417	0.403	0.159	0.456	0.079	0.161	0.159	0.114	0.149	0.196	*0.397*
10	65078	0.022	0.526	0.483	0.976	0.790	0.528	0.703	0.673	0.487	0.409	0.267	0.366	0.015	0.066	0.115	0.081	0.131	0.224	*0.381*
35	62117	0.191	0.392	0.390	0.564	0.497	0.461	0.665	0.471	0.449	0.412	0.215	0.475	0.085	0.273	0.389	0.247	0.319	0.295	*0.377*
11	65086	0.040	0.596	0.790	0.848	0.598	0.318	0.609	0.515	0.496	0.490	0.266	0.321	0.091	0.085	0.131	0.109	0.132	0.154	*0.366*
31	58735	1.000	0.280	0.425	0.571	0.431	0.378	0.572	0.478	0.386	0.385	0.305	0.392	0.110	0.159	0.159	0.114	0.168	0.193	*0.361*

Table 4 Efficiency scores in first period (continued)

Num.	*Code*	*Efficiency of the first component in different months*																	
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*Average*
25	44172	0.022	0.341	0.446	0.508	0.445	0.298	0.489	0.591	0.358	0.337	0.301	0.347	0.016	0.101	0.524	0.222	0.487	0.543	*0.354*
24	43414	0.193	0.338	0.345	0.480	0.503	0.410	0.642	0.683	0.411	0.437	0.320	0.592	0.263	0.116	0.136	0.123	0.126	0.194	*0.351*
59	67736	0.100	0.164	0.264	0.378	0.679	0.390	0.636	0.620	0.522	0.536	0.521	0.460	0.054	0.085	0.192	0.225	0.199	0.269	*0.350*
49	65318	0.090	0.428	0.365	0.617	0.569	0.344	0.659	0.517	0.489	0.435	0.251	0.312	0.106	0.147	0.265	0.143	0.196	0.233	*0.343*
20	30908	0.306	0.569	0.424	0.446	0.454	0.399	0.605	0.569	0.675	0.377	0.281	0.275	0.107	0.117	0.119	0.119	0.121	0.168	*0.341*
26	47241	0.149	0.420	0.231	0.451	0.335	0.302	0.509	0.466	0.516	0.334	0.239	0.341	0.231	0.889	0.185	0.109	0.129	0.278	*0.340*
61	88054	0.165	0.294	0.427	0.605	0.450	0.536	0.536	0.440	0.585	0.610	0.236	0.346	0.091	0.162	0.128	0.090	0.157	0.188	*0.336*
2	62018	0.083	0.246	0.415	0.482	0.544	0.526	0.597	0.463	0.558	0.514	0.381	0.401	0.083	0.082	0.138	0.129	0.165	0.204	*0.334*
29	55459	0.279	0.487	0.354	0.479	0.382	0.325	0.512	0.408	0.418	0.348	0.217	0.418	0.128	0.519	0.133	0.122	0.138	0.228	*0.328*
18	96776	0.075	0.302	0.381	0.495	0.479	0.444	0.559	0.357	0.546	0.528	0.233	0.357	0.080	0.123	0.234	0.141	0.227	0.261	*0.323*
37	62216	0.228	0.286	0.323	0.439	0.326	0.379	0.521	0.448	0.567	0.360	0.233	0.424	0.178	0.244	0.182	0.134	0.169	0.315	*0.320*
9	63594	0.166	0.287	0.431	0.662	0.455	0.338	0.552	0.547	0.473	0.627	0.276	0.290	0.078	0.093	0.097	0.100	0.119	0.135	*0.318*
56	67033	0.106	0.477	0.321	0.556	0.516	0.336	0.684	0.586	0.493	0.409	0.284	0.276	0.070	0.092	0.098	0.068	0.150	0.197	*0.318*
57	67579	0.013	0.529	0.415	0.462	0.460	0.318	0.536	0.480	0.552	0.452	0.300	0.323	0.007	0.060	0.118	0.090	0.194	0.288	*0.311*
51	65573	0.104	0.229	0.302	0.459	0.729	0.533	0.537	0.422	0.466	0.352	0.175	0.446	0.076	0.116	0.126	0.105	0.141	0.180	*0.305*
47	65169	0.231	0.525	0.436	0.658	0.469	0.352	0.631	0.368	0.457	0.276	0.129	0.241	0.123	0.060	0.065	0.068	0.102	0.122	*0.295*
52	65607	0.071	0.332	0.276	0.458	0.558	0.317	0.628	0.465	0.453	0.410	0.245	0.281	0.025	0.083	0.130	0.105	0.186	0.261	*0.293*
32	61259	0.116	0.166	0.225	0.324	0.286	0.301	0.498	0.449	0.485	0.459	0.505	0.463	0.152	0.188	0.165	0.093	0.144	0.230	*0.292*
4	62463	0.216	0.213	0.354	0.435	0.361	0.437	0.554	0.476	0.557	0.355	0.228	0.358	0.055	0.116	0.129	0.100	0.133	0.166	*0.291*
13	65201	0.068	0.249	0.262	0.495	0.426	0.792	0.438	0.321	0.296	0.280	0.163	0.272	0.038	0.080	0.176	0.175	0.339	0.348	*0.290*
36	62182	0.139	0.177	0.205	0.341	0.265	0.384	0.483	0.480	0.606	0.382	0.472	0.444	0.087	0.129	0.125	0.106	0.106	0.214	*0.286*

Table 4 Efficiency scores in first period (continued)

Num.	*Code*	*Efficiency of the first component in different months*																	
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*Average*
41	63073	0.093	0.360	0.285	0.659	0.516	0.287	0.560	0.410	0.428	0.352	0.215	0.280	0.121	0.107	0.104	0.066	0.124	0.181	*0.286*
22	37309	0.068	0.167	0.223	0.366	0.312	0.337	0.535	0.456	0.412	0.368	0.353	0.435	0.141	0.219	0.181	0.126	0.142	0.236	*0.282*
63	92106	0.134	0.311	0.213	0.489	0.458	0.286	0.592	0.428	0.419	0.358	0.213	0.267	0.089	0.224	0.132	0.076	0.158	0.214	*0.281*
12	65144	0.088	0.349	0.363	0.450	0.517	0.335	0.548	0.396	0.400	0.382	0.233	0.310	0.025	0.075	0.113	0.084	0.153	0.185	*0.278*
16	67397	0.010	0.139	0.154	0.182	0.181	0.328	0.624	0.618	0.490	0.463	0.414	0.395	0.081	0.033	0.168	0.164	0.133	0.401	*0.277*
21	30965	0.176	0.560	0.392	0.401	0.381	0.299	0.514	0.483	0.313	0.271	0.192	0.183	0.094	0.125	0.136	0.115	0.112	0.167	*0.273*
42	63255	0.475	0.360	0.333	0.441	0.359	0.453	0.575	0.352	0.317	0.272	0.198	0.201	0.030	0.078	0.119	0.059	0.116	0.154	*0.272*
23	38901	0.202	0.197	0.372	0.513	0.403	0.276	0.472	0.395	0.345	0.355	0.253	0.325	0.077	0.110	0.190	0.080	0.126	0.162	*0.270*
62	88468	0.086	0.235	0.241	0.399	0.432	0.293	0.428	0.391	0.362	0.351	0.422	0.388	0.115	0.155	0.137	0.119	0.111	0.161	*0.268*
48	65177	0.112	0.250	0.455	0.516	0.395	0.310	0.463	0.422	0.410	0.311	0.254	0.316	0.090	0.096	0.102	0.072	0.102	0.130	*0.267*
39	63032	0.077	0.330	0.287	0.478	0.424	0.273	0.534	0.405	0.396	0.345	0.159	0.239	0.083	0.106	0.108	0.080	0.128	0.175	*0.257*
55	67025	0.229	0.321	0.275	0.379	0.318	0.227	0.462	0.430	0.373	0.266	0.157	0.313	0.127	0.159	0.163	0.111	0.127	0.156	*0.255*
43	63420	0.140	0.166	0.133	0.230	0.196	0.238	0.292	0.236	0.242	0.175	0.110	0.141	0.044	0.501	0.553	0.276	0.384	0.353	*0.245*
33	62059	0.154	0.326	0.226	0.435	0.346	0.326	0.468	0.391	0.340	0.306	0.224	0.207	0.032	0.064	0.081	0.052	0.100	0.157	*0.235*
28	49411	0.067	0.376	0.214	0.348	0.305	0.285	0.423	0.386	0.286	0.281	0.171	0.278	0.087	0.118	0.131	0.144	0.140	0.179	*0.234*
19	13425	0.097	0.160	0.203	0.309	0.289	0.278	0.395	0.349	0.392	0.339	0.285	0.357	0.098	0.116	0.085	0.131	0.121	0.175	*0.232*
50	65359	0.019	0.231	0.218	0.311	0.286	0.256	0.383	0.303	0.295	0.260	0.170	0.192	0.034	0.064	0.074	0.055	0.103	0.142	*0.189*
27	49221	0.028	0.342	0.174	0.292	0.253	0.166	0.319	0.255	0.248	0.251	0.143	0.188	0.049	0.086	0.108	0.124	0.117	0.141	*0.183*
44	64188	0.073	0.192	0.160	0.260	0.232	0.221	0.303	0.241	0.247	0.201	0.107	0.225	0.076	0.116	0.114	0.101	0.106	0.159	*0.174*
15	67355	0.080	0.265	0.193	0.350	0.221	0.136	0.331	0.283	0.256	0.187	0.130	0.169	0.052	0.078	0.064	0.042	0.079	0.119	*0.169*
45	65052	0.040	0.240	0.179	0.289	0.263	0.165	0.348	0.263	0.255	0.206	0.125	0.182	0.055	0.060	0.057	0.047	0.075	0.132	*0.166*

As one can see, average of these challenges from 15%, at the beginning of the period, has reached 36%, at the end of the period. These results indicate the bad efficiency of branches but it should be noted that this procedure made the average twice as much. The essential problem became apparent after obtaining the results. This problem is that the efficiency scores cannot reveal the actual performance of branches. Some of the branches have remarkable improving performance in some months and these variations do not have any influence on efficiency scores. Actually the entire under evaluation population (technology) have being improved and this has caused these variations to leave no effect on relative efficiency. The reason is that relative efficiency does not mind the technology of the previous and following periods and just in accordance with the current time, have investigated the efficiency. Therefore, when the entire population have made progress or regress, efficiency scores identified without considering their improvement to that of previous periods and just by considering the current technology. This is the main subject of this paper and the aim to make this condition clear in order to have an thorough insight about the efficiency evaluation. As an instance, if an entity in the three periods have the efficiency score of 0.7, from the first judgment, it does not have a special performance or particular variations. But from the management point of view this branch has made a remarkable progress and could produce more outputs to those of previous ones. This occasion can be perceived according to MPI and efficiency scores in each periods. As shown in Figure 3, the efficiency scores of an specific branch, which is named as A, at the time t and $t + 1$ with the efficiency scores of 0.7 in different technologies. This difficulty has occurred in under consideration data and the average efficiency in the mentioned challenges gathered in Table 1 are listed in Table 4. Moreover, efficiency variations of challenges are also depicted in a diagram in Figure 4.

Figure 3 Frontiers at time (t) and ($t + 1$) (see online version for colours)

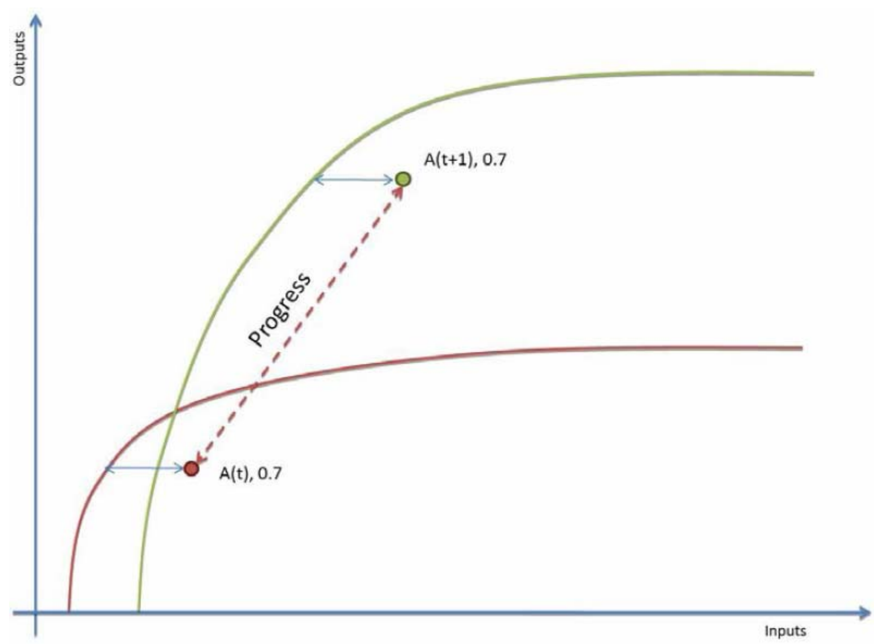
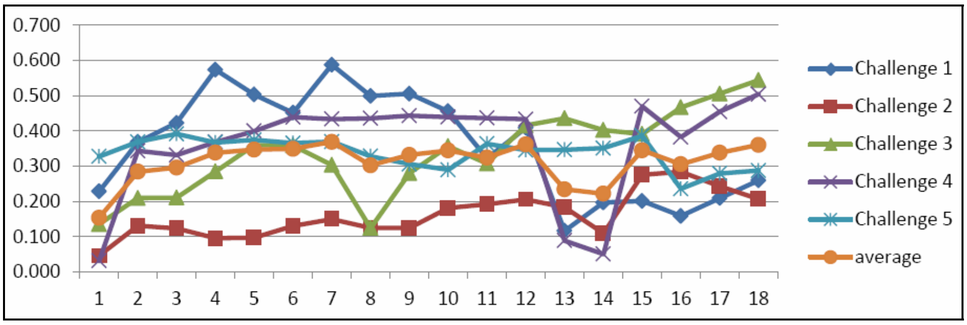
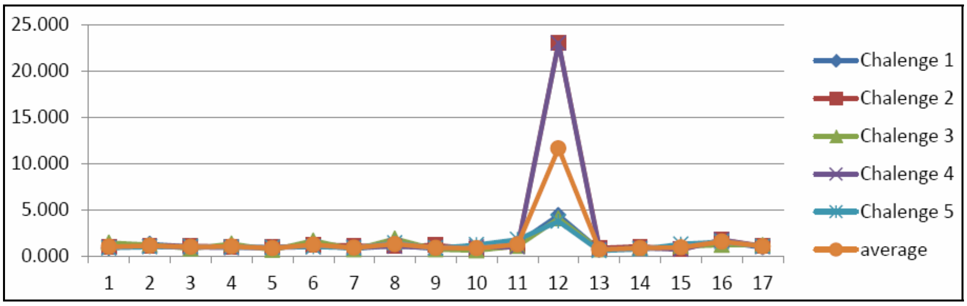


Figure 4 The efficiency trend of each challenge (see online version for colours)



The important issue is the reduction of average efficiency in considered periods which have happened in the 13th and 14th periods. In Figure 5, the corresponding diagram of MPI, in these periods, is shown.

Figure 5 A MPI of challenges (see online version for colours)



In the above diagram, as can be seen, in contrast to that of previous one there exists a remarkable increase in the 12th period for the entire population and this means that in performance evaluation in different periods, solely considering efficiency score is a serious mistake. As regards of what has been discussed above considering efficiency scores, merely, cannot show the reality of what has happened in population because in this case periodic performance assessment has not given the valuable and useful information for managers if performance improvement has been taken place in the entire population. Thus, it may results in making wrong decisions. Thus it is proposed that while a population is being assessed during different periods, it is needed to utilise another complementary method which compares the frontiers of each two successive periods. This issue has an important effect in real world application. Since in those applications the aim is to suggest a guideline and a direction path for policy making and decision making and target setting on basis of wrong results and incorrect analysis will result in failure. Lack of having a method or models which can consider both variations of each unit individually and population as a whole, to incorporate the environmental effect, can be seen in this application. What has been discussed through this paper has suggested a method for over-coming this short-coming.

4 Conclusions

The important issue discussed in this paper is that relative performance evaluation of the DMU, in different periods, is not a satisfactory scale for recognition of banking population performance. That means, if performance improvement has been taken place in the entire population, periodic performance assessment has not given the valuable and useful information for managers. Thus, it is proposed that while a population is being assessed during different periods, it is needed to utilise another complementary method which compares the frontiers of each two successive periods such as MPI. It should be noted that this index only shows progress or regress of units not their efficiencies. This method has been sufficiently discussed in an application in Iranian banks. Therefore, for further investigations relevant to DEA, it is proposed to formulate a model which evaluates efficiency of units both in the current period and also in comparison to other periods. As indicated in application this paper deals with target setting, persisting and monitoring it until achieving the desired results. As discussed this method overcomes the mentioned shortcoming which may be occurred during the periods of evaluation with DEA. In order to demonstrate the provided issue, in an application performance of a bank in 18 periods has been investigated in this manner. In ding so, at first these challenges, which each branch are facing, have been recognised and then for each of which short-term target has been defined and after that their performances have been specified monthly.

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