Performance Evaluation of Banking Organizations Using the New Proposed Integrated DEA-BSC Model

Kianoosh Kianfar[1*], Mahnaz Ahadzadeh Namin[2], Akbar Alam Tabriz[3], Esmaeil Najafi[4], Farhad Hosseinzadeh Lotfi[5]

[1]Department of Industrial Engineering, Science and Research branch, Islamic Azad University, Tehran, Iran
[2]Department of Mathematics, Shahr-e-Qods Branch, Islamic Azad University, Tehran, Iran
[3]Department of Management, Shahid Beheshti University, Tehran, Iran
[4]Department of Industrial Engineering, Science and Research branch, Islamic Azad University, Tehran, Iran
[5]Department of Mathematics, Science and Research branch, Islamic Azad University, Tehran, Iran
*Email of corresponding author: kianoush.kianfar@gmail.com
Received:January 25, 2017; Accepted:April 18, 2017

Abstract
Data envelopment analysis (DEA) is a nonparametric approach to estimate relative efficiency of Decision Making Units (DMUs). DEA is one of the best quantitative approaches and balanced scorecard (BSC) is one of the best qualitative methods to measure efficiency of an organization. Since simultaneous evaluation of network performance of the quad areas of BSC model is considered as a necessity and separate use of DEA and BSC is not effective and leads to miscalculation of performance, integrated DEA-BSC model is applied. Regarding to multi-objective nature of the proposed model, two techniques including goal programming and weighted average method are used to solve such problems. At the end of the study, based on data relating to indexes of quad areas of BSC model, the results of the mentioned methods are compared. Besides assessing validation of the proposed model, the overall efficiency and each of the different stages of BSC are obtained. So that, finding a model for decision making units in various stages of BSC is the innovation of this research study.

Keywords
Data Envelopment Analysis, Balanced Scorecard, Decision Making Units, Goal Programming, Weighting Objective Function, Multi Objective Programming

1. Introduction

Nowadays, performance assessment of industrial and economical units plays important role in achieving their managerial success and continuous progress. In recent years, a number of sophisticated systems have been proposed to measure performance. Some of important ones are balanced scorecard [1], criteria for measurement system design [2], performance measurement matrix [3] and computer aid manufacturing approaches [4]. Among these methods, BSC is one of the most famous, comprehensive and simple performance assessment frameworks in many industries that provide both aspects of financial and non-financial, long-term and short-term strategies as well as internal and external business measures. The main strength of BSC is processing of the cause and effect relations between strategies by four significant perspectives including financial, customer, internal process, learning and growth. Data envelopment analysis (DEA) is a nonparametric method used to analyze and evaluate the performance of Decision

Making Units (DMUs) which converts multiple inputs into multiple outputs and takes the qualitative and quantitative measures into account. The network DEA (NDEA) model was proposed by Lewis and Sexton [5] to overcome the weakness of the traditional DEA model. This model has a multi-stage structure which accounts for both divisional efficiencies and the overall efficiency in a unified framework. Also, it considers internal interaction within DMUs where the intermediate measures among the stages play crucial roles in evaluation of the efficiency. In recent years, the attentions of a large number of researchers have been drawn to efficiency assessment in multistage production processes, where each DMU transforms some external inputs to final outputs by the intermediate products. Details of some researches in this field can be found in Despotis and Koronakos [6], Carayannis et al. [7], Jarosz et al. [8], and Gang et al. [9].The first DEA model, CCR, was proposed by Charnes et al. [10] with assumption of constant-returns-to-scale. The evolutionary form of this model, named BCC [11], is proposed by extending to variable-returns-to-scales. Despite strong point and widespread application of BSC, several researches have criticized the limitation of BSC. They are: (1) several variables are involved in BSC model that causes complex optimization. (2) Common scale of measurement and benchmark for comparison of performance is not provided by BSC model. Therefore, the identification of proper goals for each of the performance indicators is difficult in practice. (3) BSC does not have a mathematical or quantitative model and objective weighting scheme for the performance measure. (4) BSC model is unable to determine the input and output variables. According to the above mentioned points, the integration of DEA with the BSC model can tackle the weakness of the BSC. Despite the popularity of the DEA and the BSC approaches, there have been very few researches about the integration of these two models for evaluation of performance. n DMUs is considered (j=1,…….,n) under assessment. Each DMU consumes m inputs (i=1,…,m) and produces s outputs (r=1,…,s), denoted by ($x_{ij}, x_{2j}, \ldots, x_{mj}$) and ($y_{1j}, y_{2j}, \ldots, y_{sj}$) respectively. The efficiency of DMU_k can be calculated by the CCR and BCC models as Equations (1) and (2):

$$Max \quad E_k = \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \text{(CCR)} \tag{1}$$
$$s.t. \quad \frac{\sum_{r=1}^{s} u_r}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \;, \quad j = 1,2,\ldots,n$$
$$u_r, v_i \geq \varepsilon \quad, r = 1,2,\ldots,s \;; \quad i = 1,2,\ldots,m$$
$$Max \quad E_k = \frac{\sum_{r=1}^{s} u_r y_{rk} - u_o}{\sum_{i=1}^{m} v_i x_{ik}} \text{(BCC)} \tag{2}$$
$$s.t. \quad \frac{\sum_{r=1}^{s} u_r y_{rj} - u_0}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \;, \quad j = 1,2,\ldots,n$$
$$u_r, v_i \geq \varepsilon \quad, r = 1,2,\ldots,s \;; \quad i = 1,2,\ldots,m$$

u_0 Unrestricted in sign

In Equations (1) and (2), E_k is the objective function which is maximized for every DMU_k individually; u_r and v_i are weights of the outputs and inputs respectively; X_{ik} and Y_{rk} are the *i-th* input and *r-th* output of DMU_k; and ε is a small positive value which indicates positive weights; u_0

is the intercept of the production function in the BCC model. Matin and Azizi [12] measured performance of production systems by a new unified generalized network DEA model when interrelationships between individual sub-processes are considered. General network DEA model is evaluated by some illustrative numerical examples. Chiang and Lin [13] developed a balance scorecards (BSC) and data envelope analysis (DEA) model for measuring management performance. Auto and commercial bank industries are selected as the targets for empirical investigation. Interrelationships among four perspectives of BSC were empirically valid. Kádárová et al [14] proposed an innovative integrated BSC – DEA model in order to obtain comprehensive performance and efficiency management system for industrial companies and their processes. The proposed integrated BSC-DEA model has both quantitative and qualitative approaches. In this study, the DEA-BSC model is used by applying goal programming solution method and weighting objective function method for evaluating efficiency of 21 branches of National Bank and finding relations between the four perspectives of BSC models.

2. General State of the Integrated DEA-BSC Model

Assume n units under assessment (DMU) are given; j = 1, ..., n . Each unit has a network in the form of Figure 1 which includes 4 stages. It is assumed that the input x_j entered to stage 1 and its output includes $z_j, \bar{z}_j, \hat{z}_j, \tilde{z}_j$ which are outputs from the system, output that plays role of input of stage 2, output that plays role of input of stage 3, and output that plays role of input of stage 4 respectively. Now consider stage 2. Assume that $\bar{x}_j$ is independent input of this stage and its outputs are T_j, $\overline{T}_j$, $\widehat{T}_j$ which are output from the subunit, output that plays role of input of stage 4, and output that plays role of input of stage 3. Furthermore, assume that $\tilde{x}_j$ is independent input of stage 3 andH_j , $\overline{H}_j$, $\widehat{H}_j$ are outputs from stage 3 which are output from the system, output that plays role of input of stage 2, and output that plays role of input of stage 4. Also, assume that, $\hat{x}_j$is independent input of stage 4 and y_j is output of this subunit.

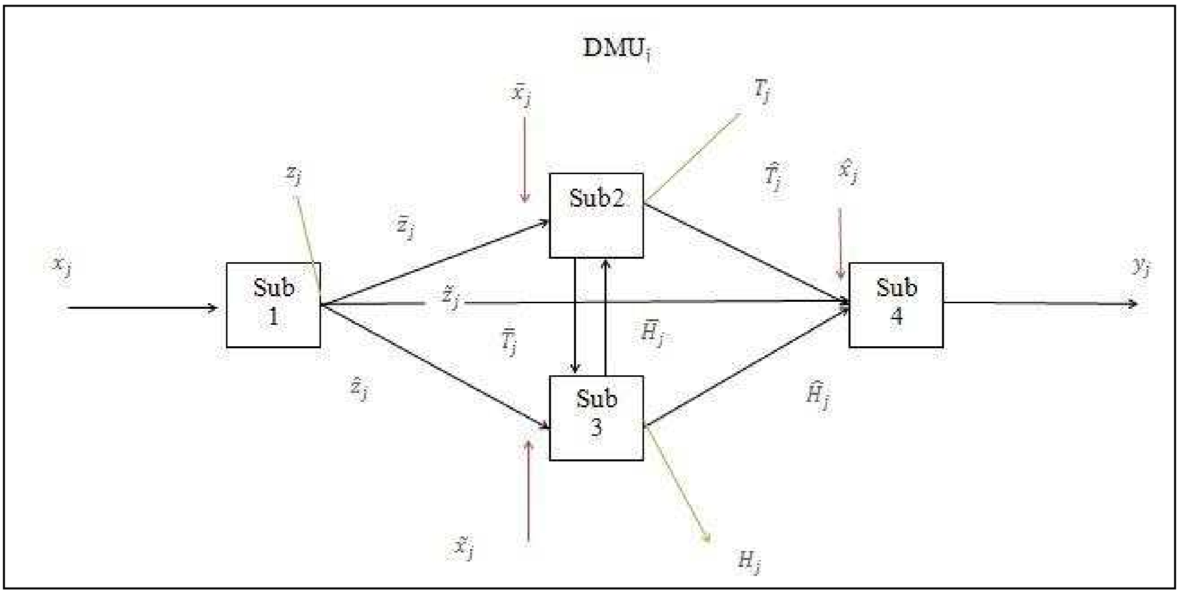

Figure1. General form of network BSC

Input of stage 1: $x_j = (x_{1j}, x_{2j}, \dots, x_{mj})$
Independent input of stage 2: $\bar{x}_j = (\bar{x}_{1j},\ \bar{x}_{2j}, \dots, \bar{x}_{\bar{m}j})$
Independent input of stage 3: $\tilde{x}_j = (\tilde{x}_{1j},\ \tilde{x}_{2j}, \dots, \tilde{x}_{\tilde{m}j})$
Independent input of stage 4: $\hat{x}_j = (\hat{x}_{1j},\ \hat{x}_{2j}, \dots, \hat{x}_{\hat{m}j})$
Output of stage 1: $z_j = (z_{1j}, z_{2j}, \dots, z_{pj})$
Output of stage 1that plays role of input of stage 2:$\bar{z}_j = (\bar{z}_{1j},\ \bar{z}_{2j}, \dots, \bar{z}_{\bar{p}j})$
Output of stage 1that plays role of input of stage 4: $\tilde{z}_j = (\tilde{z}_{1j},\ \tilde{z}_{2j}, \dots, \tilde{z}_{\tilde{p}j})$
Output of stage 1that plays role of input of stage 3: $\hat{z}_j = (\hat{z}_{1j},\ \hat{z}_{2j}, \dots, \tilde{z}_{\hat{p}j})$
Output of stage 2:$T_j = (t_{1j},\ t_{2j}, \dots, t_{qj})$
Output of stage 2that plays role of input of stage 3:$\bar{T}_j = (\bar{t}_{1j},\ \bar{t}_{2j}, \dots, \bar{t}_{\bar{q}j})$
Output of stage 1that plays role of input of stage 4: $\hat{T}_j = (\hat{t}_{1j},\ \hat{t}_{2j}, \dots, \hat{t}_{qj})$
$H_j = (h_{1j},\ h_{2j}, \dots, h_{sj})$**:** output of stage 3
Output of stage 3that plays role of input of stage 2: $\bar{H}_j = (\bar{h}_{1j},\ \bar{h}_{2j}, \dots, \bar{x}_{\bar{s}j})$
Output of stage 3that plays role of input of stage 4:$\hat{H}_j = (\hat{h}_{1j},\ \hat{h}_{2j}, \dots, \hat{h}_{\hat{s}j})$
Output of stage 4: $y_j = \left(y_{1j},\ , y_{2j}\ \dots, y_{rj}\right)$; j = 1, … , n

Note that in some BSC networks, some relations between the stages may not be available. In this section it is assumed that all relations are established between the subunit. Efficiency of each subunit is as follows:

$$e_j^{(1)} = \frac{\sum_{i=1}^{p} w_i z_{ij} + \sum_{i=1}^{\bar{p}} \bar{w}_i \bar{z}_{ij} + \sum_{i=1}^{\hat{p}} \hat{w}_i \hat{z}_{ij} + \sum_{i=1}^{\tilde{p}} \tilde{w}_i \tilde{z}_{ij}}{\sum_{i=1}^{m} v_i x_{ij}} = \frac{e_j^{(1)y}}{e_j^{(1)x}} \tag{3}$$

$$e_j^{(2)} = \frac{\sum_{i=1}^{q} \mu_i t_{ij} + \sum_{i=1}^{\bar{q}} \bar{\mu}_i \bar{t}_{ij} + \sum_{i=1}^{\hat{q}} \hat{\mu}_i \hat{t}_{ij}}{\sum_{i=1}^{\bar{m}} \bar{v}_i \bar{x}_{ij} + \sum_{i=1}^{\bar{p}} \bar{w}_i \bar{z}_{ij} + \sum_{i=1}^{\bar{s}} \bar{\alpha}_i \bar{h}_{ij}} = \frac{e_j^{(2)y}}{e_j^{(2)x}} \tag{4}$$

$$e_j^{(3)} = \frac{\sum_{i=1}^{s} \alpha_i h_{ij} + \sum_{i=1}^{\bar{s}} \bar{\alpha}_i \bar{h}_{ij} + \sum_{i=1}^{\hat{s}} \hat{\alpha}_i \hat{h}_{ij}}{\sum_{i=1}^{\tilde{m}} \tilde{v}_i \tilde{x}_{ij} + \sum_{i=1}^{\hat{m}} \hat{w}_i \hat{z}_{ij} + \sum_{i=1}^{\bar{q}} \bar{\mu}_i \bar{t}_{ij}} = \frac{e_j^{(3)y}}{e_j^{(3)x}} \tag{5}$$

$$e_j^{(4)} = \frac{\sum_{i=1}^{r} u_i y_{ij}}{\sum_{i=1}^{\hat{m}} \hat{v}_i \hat{x}_{ij} + \sum_{i=1}^{\tilde{m}} \tilde{w}_i \tilde{z}_{ij} + \sum_{i=1}^{\hat{s}} \hat{\alpha}_i \hat{h}_{ij} + \sum_{i=1}^{\hat{q}} \hat{\mu}_i \hat{t}_{ij}} = \frac{e_j^{(4)y}}{e_j^{(4)x}} \tag{6}$$

Also, efficiency of DMU_j can be calculated from the following equation.

$$\mathrm{e_j} = \frac{\sum_{i=1}^{p} w_i z_{ij} + \sum_{i=1}^{q} \mu_i t_{ij} + \sum_{i=1}^{s} \alpha_i h_{ij} + \sum_{i=1}^{s} u_i y_{ij}}{\sum_{i=1}^{m} v_i x_{ij} + \sum_{i=1}^{\bar{m}} \bar{v}_i \bar{x}_{ij} + \sum_{i=1}^{\tilde{m}} \tilde{v}_i \tilde{x}_{ij} + \sum_{i=1}^{\hat{m}} \hat{v}_i \hat{x}_{ij}} = \frac{e_j^y}{e_j^x} \tag{7}$$

To calculate the overall efficiency of DMUj, all inputs entered into –ith unit and all outputs coming out of –jth have been taken into account and internal relations between stages are not considered. The following models can be used to calculate the efficiency of the DMU. Model (8) is a 4-objective model which is expressed as follows.

$$max\ e_o^{(1)} \qquad (8)$$
$$max\ e_o^{(2)}$$
$$max\ e_o^{(3)}$$
$$max\ e_o^{(4)}$$
s.t.$e_j^{(i)} \leq 1$;i=1,2,3,4 ; j=1,…, n

Assume that all weights greater than or equal to zero and;

$$\text{Max } e_o^{(i)} \qquad (9)$$
s.t.$e_j^{(i)} \leq 1$; i=1, 2, 3, 4 ; j=1, …, n

3. The New Proposed Integrated DEA-BSC Model

In the present study an integrative BSC-DEA approach has been used. goal programming and weighting objective function methods are applied in order to evaluate relative efficiency of decision making units which includes 21 Melli bank branches in west of Tehran and find relations between the four perspectives of the balanced scorecard. The Balanced Scorecard (BSC) is used as a tool for design of performance assessment indexes and DEA is used as a tool for evaluation of efficiency. Relations between 4 perspectives are in the following terms:

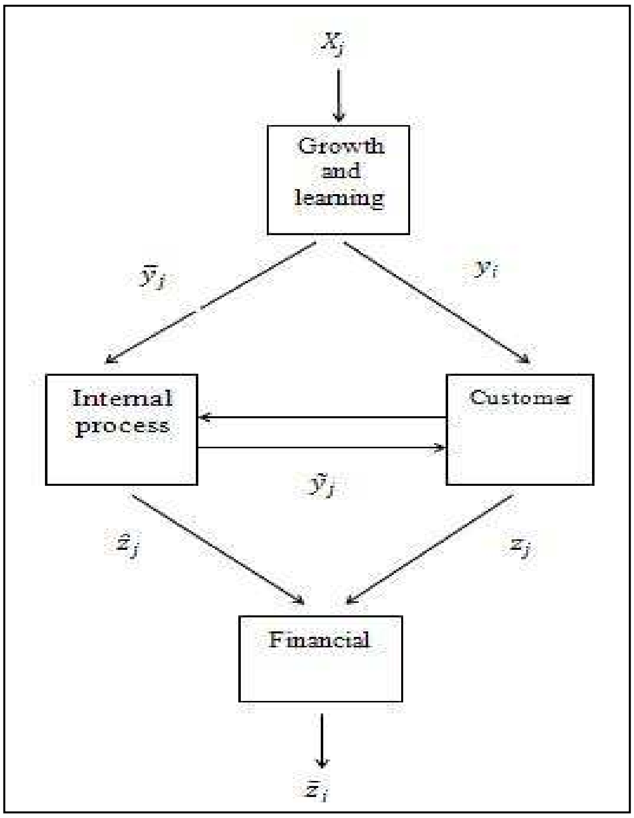

Figure2. Relations between 4 perspectives of BSC model

$$X_j = (x_{1j}, x_{2j}, \ldots, x_{mj}) Y_j = (y_{1j}, y_{2j}, \ldots, y_{sj}) \bar{y}_j = (\bar{y}_{1j}, \bar{y}_{2j}, \ldots, \bar{y}_{\bar{s}j}) \qquad (10)$$
$$\hat{y}_j = (\bar{y}_{1j}, \bar{y}_{2j}, \ldots, \bar{y}_{\hat{s}j}) \tilde{y}_j = (\tilde{y}_{1j}, \tilde{y}_{2j}, \ldots, \tilde{y}_{\tilde{s}j}) Z_j = (z_{1j}, z_{2j}, \ldots, z_{kj})$$

$\hat{Z}_j = \left(\hat{z}_{1j}, \hat{z}_{2j}, \dots, \hat{z}_{\hat{k}j}\right)\bar{Z}_j = \left(\bar{z}_{1j}, \bar{z}_{2j}, \dots, \bar{z}_{\bar{k}j}\right)$

$$e_j^{(1)} = \frac{\sum_{r=1}^{s} u_r y_{rj} + \sum_{r=1}^{\bar{s}} \bar{u}_r \bar{y}_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} = \frac{\bar{e}_j^{(1)}}{\tilde{e}_j^{(1)}} \tag{11}$$

$$e_j^{(2)} = \frac{\sum_{r=1}^{\hat{s}} \hat{u}_r \hat{y}_{rj} + \sum_{k=1}^{K} w_k z_{kj}}{\sum_{r=1}^{s} u_r y_{rj} + \sum_{r=1}^{\tilde{s}} \tilde{u}_r \tilde{y}_{rj}} = \frac{\bar{e}_j^{(2)}}{\tilde{e}_j^{(2)}}$$

$$e_j^{(3)} = \frac{\sum_{k=1}^{K} \widehat{w}_k \hat{z}_{kj} + \sum_{r=1}^{\tilde{s}} \tilde{u}_r \tilde{y}_{rj}}{\sum_{r=1}^{\hat{s}} \hat{u}_r \hat{y}_{rj} + \sum_{r=1}^{\bar{s}} \bar{u}_r \bar{y}_{rj}} = \frac{\bar{e}_j^{(3)}}{\tilde{e}_j^{(3)}}$$

$$e_j^{(4)} = \frac{\sum_{k=1}^{\bar{K}} \overline{w}_k \bar{z}_{kj}}{\sum_{k=1}^{K} \widehat{w}_k \hat{z}_{kj} + \sum_{k=1}^{K} w_k z_{kj}} = \frac{\bar{e}_j^{(4)}}{\tilde{e}_j^{(4)}}$$

The following model is used to calculate the efficiency of the DMU_o.

$$Max\ e_o^{(1)} Max\ e_o^{(2)} Max\ e_o^{(3)} Max\ e_o^{(4)} \tag{12}$$

$$s.t.\ \ e_j^{(h)} \le 1 \quad , \quad j = 1, \dots, n \quad h = 1, \dots, 4$$

Table1. Data related to indexes of BSC in bank

DMU			DMU_1	DMU_2	DMU_3	DMU_4	DMU_5	DMU_6	DMU_7	DMU_8
growth and learning aspect		Motivational costs%	12	18.2	13	16.3	17.8	14.4	12.6	15.7
		Increasing expertise of employees %	10.5	12.1	10.8	11.8	11	10.7	12.2	12
		Employee Satisfaction%	60	73	64.5	63.2	68	77.4	69	64.4
Growth and learning to Internal process		Improvement of computer software %	3	3.2	4.6	4.8	5.2	3.9	6.8	6.2
		involvement of the bank's development programs%	50	52	61	55	62	66	59	70
Growth and learning to customer		Training hours related to CRM	72	97	88	84	79	101	90	73
		encourage price of customers to invest (millions)	80	98	92	117	85	99	105	111
Internal process aspect	Internal process to customer	Increasing speed of service%	80	83.4	90.4	92	94.5	88.2	91.1	82.4
		banking services%	45	47	63.3	55	60.1	66.5	48.2	54.2
	Internal process to Financial	Improvement of operational processes%	4	7.6	7	4.5	6.3	4.2	7.2	5.1
		Reducing internal costs%	5	6.2	7.5	9.3	9.1	8.6	6.4	5.6
Customer aspect	Customer to Financial	The number of implemented ideas from customer	3	5	9	4	4	7	5	3
		Customer satisfaction%	45	47.2	53.4	56.7	49	51.1	46.8	49.2
		customer acquisition rate%	17	19.3	25.6	22.4	17.7	26.1	20.5	18.4
Financial aspects		profit margin%	3.5	5.3	3.9	6	4.8	6.5	4.4	5.7
		Returns to Investment%	2	5.3	7.5	2.9	4	6.6	6.1	3.8

DMU_9	21.5	11.9	75.5	6	46	112	87	87	58	5.5	8.8	8	54.3	27.6	5.2	5.7
DMU_{10}	13.2	10.6	66	6.5	45	85	102	89.9	45.7	7.8	8.2	6	52	25.2	6.1	4.5
DMU_{11}	19.8	10.8	62	4.1	66	84	98	96.7	69.5	6	6	4	56.6	23	3.7	7.1
DMU_{12}	15.3	12.2	78	7	58	109	89	93	64	4.6	7.9	6	51.3	19.4	5.8	6.2
DMU_{13}	18.5	11	71.3	6.9	53	114	117	96.2	58.4	5.9	5.5	7	49.2	22.4	6.2	5.1
DMU_{14}	21	11	79.1	5.3	69	76	90	81	55.7	6.1	9	7	47.5	24.5	5.5	5.5
DMU_{15}	19.1	10.9	65.6	5.9	48	94	104	84.1	47	5	6.1	3	45.6	20.7	5	4.8
DMU_{16}	15	11	72.8	5.5	49	99	95	82.6	67.1	4.1	9.4	10	53.5	23.5	4.8	7.4
DMU_{17}	16.6	12.5	64	5.9	67	116	84	90	59.5	7.4	8.1	8	47.2	26.2	5.6	5.6
DMU_{18}	20	11.7	62	4.3	47	81	81	86.9	65.3	7	7.3	5	54.2	21.9	6.6	4.1
DMU_{19}	14	12	74.5	4.4	63	93	117	91.5	49	4.4	7.6	5	52.9	22.7	4.5	3.9
DMU_{20}	22	12.3	80	4.8	46	119	120	95	70	8	10	10	57	28	7	8
DMU_{21}	15.1	11.6	77	3.7	68	102	118	94	56	6.9	9.5	9	48	17.2	4.6	7.3

3.2 A causal relation between four perspectives of BSC model

According to researches of Kaplan and Norton [15] there is a causal relation between BSC's four perspectives. Based on previous research, it seems that the relations between the four areas BSC are considered remarkable. A well-organized BSC should describe strategy via the objectives and the criteria selected. These criteria must be joined to each other in the cause and effect chain between the areas of financial and non-financial performance as well as internal relations between non-financial perspectives. Non-financial criteria are classified into three perspectives: learning and growth, internal processes and customer.

3.2.1 The Effect of Growth and Learning on Internal Process

To have a strong internal process, growth and learning aspect must be strengthened. Growth and learning are generally focused on human resource (knowledge and skills), systems and methods and information sources and technologies. Improving internal processes requires dynamic mechanisms of growth. It is natural that efficient human resources, systems and powerful methods can cause powerful and flexible internal process. Professional training given to the human resources of bank gives them ability that can use updated software. Use of instructions and a new way can accelerate workflows and lending to people is done properly.

3.2.2 The Effect of Growth and Learning on Customer

Training and increasing skill of relationship with customer will have an important role in customer satisfaction and this was one of the rights and expectations of customer. The customer needs to access more information through new tools and methods which bank uses them to inform and raise the awareness of customer knowledge and banks can introduce these tools and approaches to customer. In other words, training programs named bank promotional products make knowledge and the expectations of customers of the bank reasonable. Employees equipped with more knowledge and skills (training in the effectiveness of sales, customer service, profitable products and local knowledge banks, etc.) are better able to assess the needs of our customers deliver higher quality services. Because of improvement of interaction with customer, that number of people introduced by older customer will be higher and cross-sell will be more successful (effect of growth and learning on internal process). As a result, greater customer satisfaction and more new customers (due to the suggestions and more quality interactions with customers) will be achieved.

3.2.3 The Effect of Internal Process on Financial Issue

There are direct impact and positive on the financial aspects (cost reduction) in important internal processes. Contrary to the widespread assumption in previous studies related to BSC that claim that internal process affects only the customer perspective, in fact, this effect is strongest relationship between BSC perspectives. Good performance of internal processes in cases such as reducing cycle time processes, increasing the number of services, working capital, property, absorbing investment and customer participation have direct influence on the area of financing and the profitability of banks. The effectiveness of investment in Research & Development (R&D) as another key indicator of internal processes on the area of financing is well-known. Furthermore, more introduced people and increase of cross-selling as another indexes of internal processes increase non-interest income. On the other side, modification of processes over set can make this important. For example, modification of processes related to lending can maximize the repayment of bank loans. Any improvement or development of internal processes, its impact and feedback can be seen in the area of financing. In other words, in this model, internal processes play enabling role and the financing area plays role of one of the main results (key performance indicators). i.e., the bank's internal processes should present indexes of financing area such as deposit growth, profitability, recording facilities granted to deposits, return on capital, working capital, asset growth rate and so on.

3.2.4 The Effect of Customer on Financial Issue

Customer satisfaction, which requires services with high quality and speed, development of current and future services and appropriate treatment has direct impact on the attraction amount of customer investment and bank working capital and improve financial indexes of bank. In other words, the financial impact on customers means more willing of customer to deposit and as a result, increase of income. In accordance with the assumptions used in previous studies, the customer area has a tremendous impact on financing the area. Two aspects of customer usually are measured: customer satisfaction (by receivable accounts) and customer retention (by market share). The negative sign for standardized coefficients related to receivable accounts is consistent with existing theory [16]. A positive sign for the standard coefficients relating to market share shows that organizations that are able to retain customers and secure a large share of the market tend to improve other organizations with lower rates of customer retention and market share in terms of financial area. Another interpretation that can explain such a causal relationship is that retaining customers provides the basis for growth in deposit and loan balance.

3.2.5 The Effect of Internal Process on Customer

Internal processes such as the receipt and payment processes, facilities, foreign exchange services, providing bank guarantees, transactions, all of them are designed to meet the needs of customers. For example, customers request to go to bank afternoon to do their work so that the presence of emergency bank is essential or customers need to increase the number of ATM machines or the customer wants to buy through menopause device. The good performance of internal processes including higher quality of introduced people and cross-selling offers leads to more satisfaction of customer and more maintenance of customer. All things considered by customer are realized through the bank's internal processes. If internal processes operate well, it can provide higher satisfaction and loyalty of customer. What is more important for the customer is that bank processes can present customer services desirably in minimum time and with proper treatment of owners and executors of processes.

3.2.6 The Impact of Customer on Internal Processes

Customer knowledge management is discussed here. Unit named CRM has this assignment. We are looking for customer wishes for changing internal processes. In the financial area, the aim is profitability which can occur in two forms: (1) Reduce costs (2) An increase in revenue. The customer use of bank's internal processes is somewhat indicative of performance of the mentioned process. Customer can be effective via surveys or suggestions and criticisms mechanisms in the development of internal processes. If customers can be divided into two general categories: actual customers and corporate customers, demands of each bank processes are different. Of course, corporate customers have more expectations from bank processes mainly in the areas of production, trade and services which are concerned. Of course, the participation of each category of customers will help to improve processes.

4. Solving Method of the Proposed Model and Drawing Related Flow Chart

4.1 Weighting Objective Function Method

One of the solving methods of multi-objective problem (MODM) is use of weighted average method or weighting objective function method. By using the Shannon entropy method, weights for each goal are determined. For this purpose, at first, a weight for each of our objectives is identified by DM.

$$\sum_{i=1}^{n} w_i = 1 \tag{13}$$

Then a linear combination of the purposes is written

$$\left.\begin{array}{l} \sum_{i=1}^{n} w_i f_i(x) \\ {}^{max}/_{min}\, f_i(x) \\ {}^{max}/_{min}\, f_n(x) \\ s.t.\ y_i(x) \geq 0 \\ \qquad y_i(x) \leq 0 \end{array}\right\} \quad \begin{array}{l} {}^{max}/_{min}\, f_i(x) \\ {}^{max}/_{min} \sum_{i=1}^{n} w_i f_i(x) \\ s.t.\ y_i(x) \geq 0 \\ \qquad y_i(x) \leq 0 \end{array} \tag{14}$$

The above MOLP model can be turned to NLP single objective model by weighting objective function method.

$$Max\ w_1\, e_o^{(1)} + w_2\, e_o^{(2)} + w_3\, e_o^{(3)} + w_4\, e_o^{(4)} \tag{15}$$

$$s.t.\ \ e_j^{(h)} \leq 1 \quad , \quad j = 1, \dots, n \quad h = 1, \dots, 4$$

Where

$$\sum_{i=1}^{4} w_i = 1$$

$$\sum_{r=1}^{s} u_r + \sum_{r=1}^{\bar{s}} \bar{u}_r + \sum_{r=1}^{\hat{s}} \hat{u}_r + \sum_{i=1}^{m} v_i + \sum_{r=1}^{\tilde{s}} \tilde{u}_r + \sum_{k=1}^{\hat{K}} \widehat{w}_k + \sum_{k=1}^{K} w_k + \sum_{k=1}^{\bar{K}} \overline{w}_k = 1$$

Gams software is not able to solve the above NLP.

To calculate weight through Shannon entropy method, a questionnaire in strategic areas for the four perspectives of the balanced scorecard is given to experts and the result of the experts' opinions in form of paired comparison matrix are given in Table 2.

Entropy method: Computation of w_1, w_2, w_3, w_4

Table2. Paired comparison matrix based on strategic areas

Strategic areas	growth and learning	Internal process	Customer	Financial
growth and learning= w_1	1	7	5	6
Internal process= w_2	0.142	1	8	8
Customer= w_3	0.2	0.125	1	9
Financial= w_4	0.166	0.125	0.111	1
Total amounts	1.508	8.25	14.111	24

Step 1: Computation of p_{ij}

$$p_{ij} = \frac{a_{ij}}{\sum_{i=1}^{\mu} a_{ij}} \quad , \quad \forall j \tag{16}$$

A result of step 1 is given in Table 3.

Table3. Results of step 1

Strategic areas	Growth and learning	Internal process	Customer	Financial
growth and learning= w_1	0.663	0.848	0.354	0.25
Internal process= w_2	0.094	0.121	0.566	0.333
Customer= w_3	0.132	0.015	0.070	0.375
Financial= w_4	0.110	0.015	0.007	0.041

Step 2: Computation of entropy value E_j(confidence value)

$$E_j = -k \sum_{i=1}^{\mu} \left[p_{ij} ln p_{ij}\right] \quad ; \quad \forall j \tag{17}$$

$$k = \frac{1}{\ln(\mu)} = \frac{1}{\ln 4} = 0{,}721$$

Table4. Results of step 2

$\mathbf{E_1}$	$\mathbf{E_2}$	$\mathbf{E_3}$	$\mathbf{E_4}$
0,723	0,375	0,651	**0,873**

Step 3: Computation of uncertainty value d_j

$$d_j = 1 - E_j \quad ; \quad \forall j \tag{18}$$

Table5. Results of step 3

$\mathbf{d_j}$	$\mathbf{d_1}$	$\mathbf{d_2}$	$\mathbf{d_3}$	$\mathbf{d_4}$	$\sum_{j=1}^{4} \mathbf{d_j}$
$\mathbf{1 - E_j}$	0,277	0,625	0,344	0,127	1.373

Step 4: Computation of weights w_j

$$w_j = \frac{d_j}{\sum_{j=1}^{\mu} d_j} \quad ; \quad \forall j \tag{19}$$

Table6. Results of step 4

growth and learning $=w_1$	Internal process $= w_2$	Customer $= w_3$	Financial $= w_4$	$\sum_{i=1}^{4} w_i$
0.21	0.45	0.25	0.09	1

4.2 Goal Programming Method

One of the solving method of multi-objective problem is goal programming (Table 7). For each target, a goal is defined and goal is expectations that we want to achieve in problem.

Table7. goal programming

goal	Deviation from goal
$\boldsymbol{b_1}$	$d_1{}^+, d_1{}^-$
$\boldsymbol{b_2}$	$d_2{}^+, d_2{}^-$
$\boldsymbol{b_3}$	$d_3{}^+, d_3{}^-$
$\boldsymbol{b_p}$	$d_p{}^+, d_p{}^-$
$\boldsymbol{b_n}$	$d_n{}^+, d_n{}^-$

Writing ideal form of a target (objective function):

Three states can happen.

$z_p(x_j)$is a target.

1) $z_p(x_j) \geq b_p \rightarrow z_p(x_j) = b_p + d^+ - d^- \quad \Rightarrow \quad z_p(x_j) - d^+ + d^- = b_p$

2) $z_p(x_j) \leq b_p \rightarrow z_p(x_j) = b_p + d^+ - d^- \quad \Rightarrow \quad z_p(x_j) - d^+ + d^- = b_p$

3) $z_p(x_j) = b_p \rightarrow z_p(x_j) = b_p + d^+ - d^- \quad \Rightarrow \quad z_p(x_j) - d^+ + d^- = b_p$

$b_p$is generally, the objective function of a problem

$$\min \sum_{i=1}^{n} \left(d_i{}^+ + d_i{}^-\right) \tag{20}$$

$p_k$is prioritization of goals because goals are not equally important

$$\min \sum_{k=1}^{q} \sum_{i=1}^{m} p_k \left(d_i{}^+ + d_i{}^-\right) \tag{21}$$

Modeling algorithm of b_p (6 steps):

1- Objectives functions (MODM) are identified.

2-Goal values of the objective function are defined.

3-Deviation from the goals are identified deviation should not happen.

4- The objective function of p is identified.

5-Normal limits of problem are written.

6- Goal limits of the problem are written

$$Min\left(1 - e_o^{(1)}\right) + \left(1 - e_o^{(2)}\right) + \left(1 - e_o^{(3)}\right) + \left(1 - e_o^{(4)}\right) \tag{22}$$

$$s.t.\ \ e_j^{(h)} \le 1 \quad , \quad j = 1, \dots, n \quad h = 1, \dots, 4$$

Where

$$\sum_{r=1}^{s} u_r + \sum_{r=1}^{\bar{s}} \bar{u}_r + \sum_{r=1}^{\hat{s}} \hat{u}_r + \sum_{i=1}^{m} v_i + \sum_{r=1}^{\tilde{s}} \tilde{u}_r + \sum_{k=1}^{\hat{K}} \widehat{w}_k + \sum_{k=1}^{K} w_k + \sum_{k=1}^{\bar{K}} \overline{w}_k = 1$$

Since the above model is a fraction model, but Gams software simply can be applied to solve non-linear problem (NLP).

5. Results of the Integrated DEA-BSC Model

5.1 Weighting Objective Function Method

Efficiency of the integrated DEA-BSC model related to 21 DMUs using weighting objective function method with consideration of different weight are given in Table 8.

Table8. Efficiency of the integrated DEA-BSC model related to 21 DMUs using weighting objective function method with consideration of different weights (w_1= 0.21 , w_2=0.45 , w_3=0.25 , w_4=0.09)

No.	E_{Overal}	E_1,w_1=0.21	E_2,w_2=0.45	E_3,w_3=0.25	E_4,w_4=0.09
1	0.90191	0.8477	0.93089	0.99986	0.61145
2	0.87699	0.62936	0.92395	0.99999	0.87826
3	0.94494	0.98011	1	0.79857	0.99418
4	0.94069	0.81792	1	0.99999	0.76588
5	0.88737	0.73516	0.92105	0.99998	0.76134
6	0.92665	1	0.93486	0.82457	0.99805
7	0.87134	1	0.84254	0.81205	0.87978
8	0.88514	1	0.96852	0.62933	0.91079
9	0.92034	0.77652	1	0.95265	0.76792
10	0.95899	0.95565	0.94968	0.99954	0.90064
11	0.94333	0.8054	1	0.99979	0.82497
12	0.8712	0.96349	0.88204	0.76041	0.9094
13	0.87602	1	0.81645	0.83447	1
14	0.91444	1	1	0.73726	0.77916
15	0.86382	0.8953	0.7946	0.95532	0.88237
16	0.94313	0.90734	1	0.87804	0.92307
17	0.88986	0.98498	0.95454	0.74823	0.73791
18	0.96315	0.82456	1	0.99999	1
19	0.88385	0.90824	0.95085	0.81546	0.68192
20	0.9323	0.77921	0.95258	1	1
21	0.92162	0.91598	1	0.82387	0.81437

It is noteworthy that w_1, w_2, w_3 and w_4 mentioned in the above tables are weights related to growth and learning, customer, internal process and financial perspectives.

5.2 Goal Programming Method

Efficiency of the integrated DEA-BSC model related to 21 DMUs using Goal programming method is given in Table 9.

Table9. Efficiency of the integrated DEA-BSC model related to 21 DMUs using Goal programming method

No.	E_{Overal}	E_1	E_2	E_3	E_4
1	0.58699	0.85326	0.90966	0.99974	0.65035
2	0.4761	0.83968	0.72911	0.9998	0.95531
3	0.22374	0.98021	1	0.79605	1
4	0.27929	1	0.84896	0.99999	0.87176
5	0.53456	0.75188	0.85298	0.99996	0.86061
6	0.15343	1	0.8489	0.99998	0.99769
7	0.45162	1	0.81167	0.81022	0.9265
8	0.46326	1	0.95061	0.62653	0.9596
9	0.50291	0.77652	1	0.95265	0.76792
10	0.1939	0.95613	0.94935	0.99952	0.90111
11	0.29223	0.83232	0.93075	0.99999	0.94471
12	0.43571	0.9742	0.79732	0.79277	1
13	0.3091	1	0.76863	0.92228	1
14	0.43657	1	1	0.65878	0.90465
15	0.42084	0.93404	0.75288	0.99999	0.89224
16	0.27902	0.92538	1	0.8485	0.9471
17	0.47765	1	0.88705	0.7312	0.9041
18	0.17545	0.82456	1	0.99999	1
19	0.6255	0.92205	0.90149	0.86253	0.68843
20	0.23965	0.87314	0.88722	0.99999	1
21	0.34508	0.94838	0.84827	0.85827	1

Supplementary steps of algorithm of proposed model with integrated DEA-BSC approach areshown in Figure 3

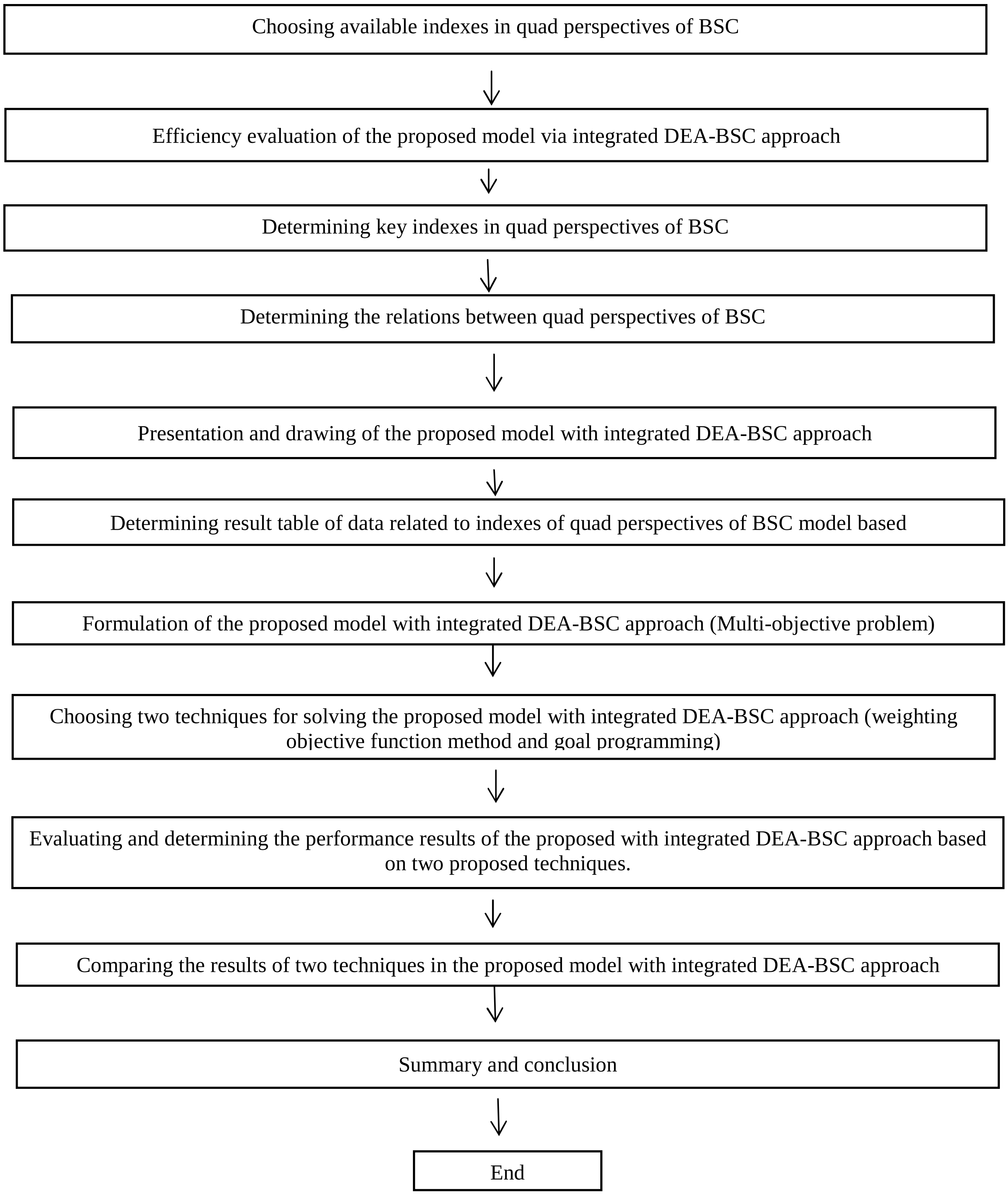

Figure3. Flowchart of the proposed model with integrated DEA-BSC approach

6. Conclusion

In this paper, the integrated DEA-BSC model is presented for measurement of efficiency of various banking units. This proposed integrated model applied in solving multi-objective problems removes drawbacks of DEA model in determination of input and output indexes and also, disability of BSC model in computation of numerical values. This model, in addition to presentation of financial and other indexes, provides good and acceptable results in decision-making to managers and experts in the evaluation area. So that with consideration of DEA and BSC models simultaneously weak points of each method were overcome.

The proposed model is a powerful technique in the strategic planning of organizations in implementation and codification stage. This approach is applied in 21 Melli bank branches in west of Tehran. Results and comparing both proposed method show that different units have various efficiencies in four perspectives of BSC model that some of these units are efficient in both mentioned methods in two perspectives of quad areas of BSC model. Furthermore, some of them are efficient in one perspective of this model. And some units have not reached the efficient level. Finally, the proposed integrated approach can be prioritized in bank projects as a new innovative method used in future research and it is considered as one of the innovations of the research work.

7. Reference

[1] Varmazyar, M., Dehghanbaghi, M. and Afkhami, M. 2016. A Novel Hybrid MCDM Model for Performance Evaluation of Research and Technology Organizations based on BSC Approach. Evaluation and Program Planning. 58: 125–140.

[2] Wang, J., Liu, S-Y. and Zhang, J. 2005. An Extension of TOPSIS for Fuzzy MCDM Based on Vague Set Theory. Journal of Systems Science and Systems Engineering. 14(1): 73–84.

[3] Yin, Y., Qin, S. and Holland R. 2011. Development of a Design Performance Measurement Matrix for Improving Collaborative Design During a Design Process. International Journal of Productivity and Performance Management. 60(2): 152–184.

[4] Tansel, Y. 2012. An Experimental Design Approach Using TOPSIS Method for the Selection of Computer-Integrated Manufacturing Technologies. Robotics and Computer-Integrated Manufacturing. 28(2): 245-256.

[5] Sexton, T.R. and Lewis, H.F. 2003. Two-stage DEA: An Application to Major League Baseball. Journal of Productivity Analysis. 19(2): 227-249.

[6] Despotis, D.K. and Koronakos, G. 2014. Efficiency Assessment in Two-stage Processes: A Novel Network DEA Approach. Pro. Computer Science. 31: 299-307.

[7] Carayannis, E.G., Goletsis Y. and Grigoroudis, E. 2015. Multi-level Multi-Stage Efficiency Measurement: The Case of Innovation Systems. Operations Research. 15(2): 253–274.

[8] Jarosz, P., Kusiak, J., MaBecki, S.B., Oprocha, P., Sztangret, A. and Wilkus, M. A. 2015. Methodology for Optimization in Multistage Industrial Processes: A Pilot Study. Mathematical Problems in Engineering. 1-10.

[9] Gang, D., Li, C., Yin-Zhen, L., Jie-Yan, S. and Tanweer, A. 2012. Optimization on Production-Inventory Problem with Multistage and Varying Demand.Journal of Applied Mathematics. 1-17.

[10] Charnes, A., Cooper, W.W. and Rhodes, E. 1978. Measuring the Efficiency of Decision Making Units. European Journal of Operational Research. 2(6): 429-444.

[11] Banke, R., Charnes, A. and Cooper, W.W. 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis.Management Science. 30 (9): 1078-1092.

[12] KazemiMatin, R. and Azizi R. 2015. A Unified Network-DEA Model for Performance Measurement of Production Systems. Measurement. 60: 186–193.

[13] Chiang, C.Y. and Lin, B. 2009. An Integration of Balanced Scorecards and Data Envelopment Analysis for Firm's Benchmarking Management. Journal of Total Quality Management & Business Excellence. 20(11): 1153-1172.

[14] Kádárová, J., Durkáčová, M., Teplická, K. and Kádár, G. 2015. The Proposal of an Innovative Integrated BSC – DEA Model. Procedia Economics and Finance. 23: 1503 – 1508.

[15] Kaplan, R.S. and Norton D.P. 1996. The Balanced Scorecard: Translating Strategy into Action. Boston: Harvard Business School Press.

[16] Ehsanbakhsh, H. and Izadikhah, M. 2015. Applying BSC-DEA Model to Performance Evaluation of Industrial Cooperatives: An Appliction of Fuzzy Inference System. Applied Research Journal. 1(1): 9-26.