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Research Article

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Presentation of a Novel Integrated DEA-BSC Model with Network Structure in Multi Objective Programmig

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Abstract

Data envelopment analysis (DEA) is a nonparametric approach to estimate relative efficiency of Decision Making Units (DMUs). DEA and is one of the best quantitative approach and balanced scorecard (BSC) is one of the best qualitative method 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 is compared. Besides assessing validation of the proposed model, the overall efficiency and each of the different stages of BSC is 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

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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], 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 provides 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. In recent years, extensive application of DEA is observed in several contexts such as health care, education, manufacturing, retailing, banking, etc. In the conventional DEA model, two types of models namely 1) the aggregation and 2) separation approaches are applied to measure efficiencies. In the aggregation model, divisions are aggregated into a single company, the DMU is evaluated as a black box and the internal linking activities are neglected. Therefore, it is not possible to evaluate the performance of individual division. In the separation model, each division in a DMU is considered as a separate unit and the linking activities between divisions are completely ignored. Thus, efficiencies of the organization's linking processes via both mentioned methods cannot be evaluated [5]. The network DEA (NDEA) model was proposed by Lewis and Sexton [6] 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 attention 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 [7], Carayannis et al. [8], Jarosz et al. [9], and Gang et al. [10]. The first DEA model, CCR, was proposed by Charnes et al. [11] with assumption of constant-returns-to-scale. The evolutionary form of this model, named BCC [12], 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 aboved 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):

$$Max \quad E_k = \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \qquad \text{(CCR)} \qquad (1)$$

$$s.t. \quad \frac{\sum_{r=1}^{s} u_r}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \ , \quad j = 1,2,\ldots,n$$

$$u_r, v_i \geq \varepsilon \ \ , r = 1,2,\ldots,s \ ; \quad i = 1,2,\ldots,m$$

$$Max \quad E_k = \frac{\sum_{r=1}^{s} u_r y_{rk} - u_o}{\sum_{i=1}^{m} v_i x_{ik}} \qquad \text{(BCC)} \quad (2)$$

$$s.t. \quad \frac{\sum_{r=1}^{s} u_r y_{rj} - u_0}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \ , \quad j = 1,2,\ldots,n$$

$$u_r, v_i \geq \varepsilon \ \ , r = 1,2,\ldots,s \ ; \quad i = 1,2,\ldots,m$$

$$u_0 \ \text{Unrestricted in sign}$$

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 [13] 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 [14] 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 [15] 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. Al-Najjar and Kalaf [16] constructed a BSC model that was used to measure the Large Local Bank (LLB) performance using the concepts of Kaplan and Norton, and the data from the bank. The cause-effect relationships between the non-financial, and the financial dimensions of the BSC was achieved. Ehsanbakhsh and Izadikhah [17] applied BSC-DEA model to evaluate an organization's efficiency. DEA performs optimization analysis on each individual unit (DMUs) and generates relative efficiency value of each DMU.

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 model. The remainder of this paper is structured as follows: In section 2, general state of the integrated DEA-BSC model is discussed.

In section 3, our proposed integrated DEA-BSC model and a causal relation between four perspectives of BSC model are evaluated. In section 4, two methods including weighting objective function and goal programming method for solving the proposed model are discussed. Results of the integrated DEA-BSC model for the mentioned methods are given in section 5. The conclusion section is given at the end of the paper.

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 stage. 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 output 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.

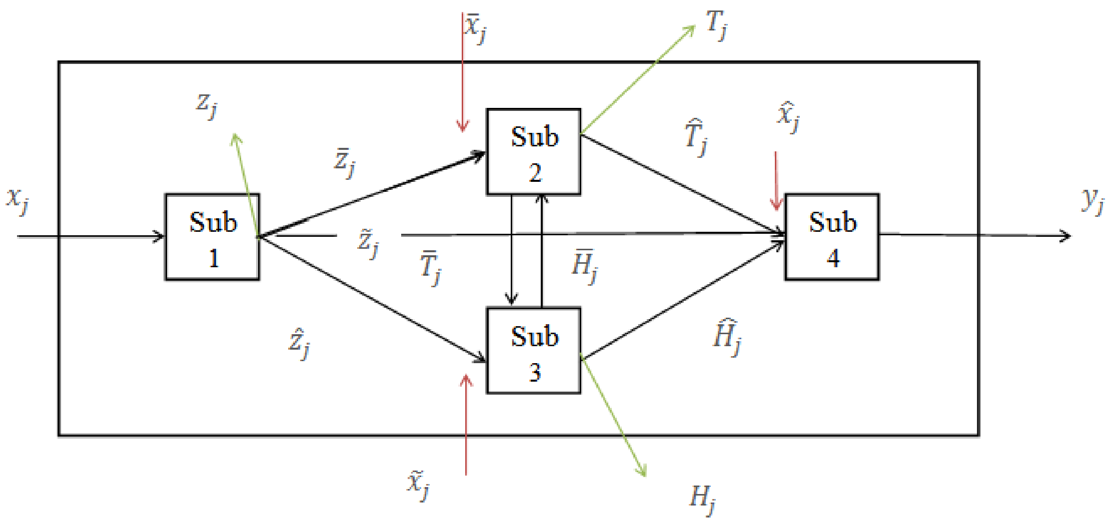

Figure 1. General form of network BSC

Assume that $\bar{x}_j$ is independent input of this stage and its outputs are T_j, $\bar{T}_j$, $\hat{T}_j$ 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 and H_j ,$\bar{H}_j$, $\hat{H}_j$ 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.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 ۴: $\hat{x}_j = (\hat{x}_{1j}, \hat{x}_{2j}, \dots, \hat{x}_{\hat{m}j})$

Output of stage 1: $z_j = (z_{1j}, z_{2j}, \dots, z_{pj})$

Output of stage 1 that playes role of input of stage 2 : $\bar{z}_j = (\bar{z}_{1j}, \bar{z}_{2j}, \dots, \bar{z}_{\bar{p}j})$

Output of stage 1 that playes role of input of stage ۴: $\tilde{z}_j = (\tilde{z}_{1j}, \tilde{z}_{2j}, \dots, \tilde{z}_{\tilde{p}j})$

Output of stage 1 that playes role of input of stage 3: $\hat{z}_j = (\hat{z}_{1j}, \hat{z}_{2j}, \dots, \tilde{z}_{\hat{p}j})$

Output of stage ۲ :$T_j = (t_{1j}, t_{2j}, \dots, t_{qj})$

Output of stage 2 that playes role of input of stage 3: $\bar{T}_j = (\bar{t}_{1j}, \bar{t}_{2j}, \dots, \bar{t}_{\bar{q}j})$

Output of stage 1 that playes 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 3 that playes role of input of stage 2: $\bar{H}_j = (\bar{h}_{1j}, \bar{h}_{2j}, \dots, \bar{x}_{\bar{s}j})$

Output of stage 3 that playes 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: $y_j = (y_{1j}, , y_{2j} \dots, y_{rj})$;

$j = 1, \dots, n$ 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:

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

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

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

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

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

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

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.

$$
\begin{aligned}
& max\ e_o^{(1)} \\
& max\ e_o^{(2)} \\
& max\ e_o^{(3)} \\
& max\ e_o^{(4)} \\
& \text{s.t.} \quad e_j^{(i)} \le 1 \ ; \ i=1,2,3,4 \ ; \ j=1,\dots,n
\end{aligned} \tag{8}
$$

Assume that all weights greater than or equal to zero

and; (9)

$$\text{s.t.} \quad e_j^{(i)} \le 1 \ ; \ i=1,2,3,4 \ ; \ j=1,\dots,n$$

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 : X_j Melli bank branches in west of Tehran and find relations between the four perspectives of the balanced scorecard (growth and learning, internal process, customer, financial). 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 is in the following terms:

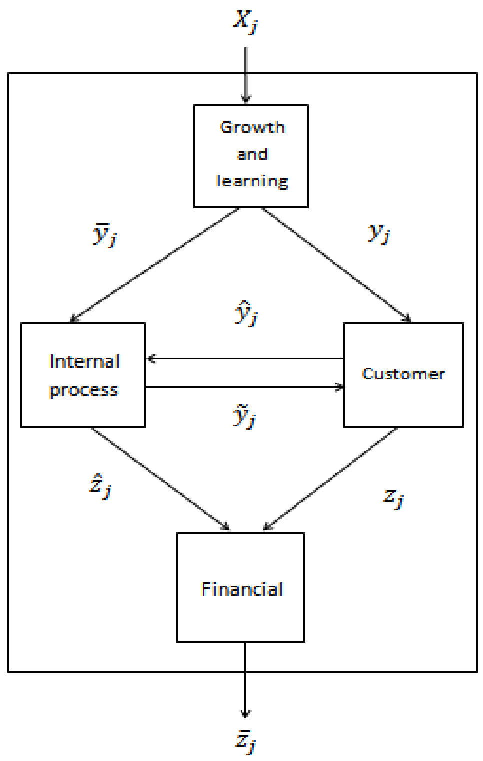

Figure 2. Relations between 4 perspectives of BSC model

$$
\begin{aligned}
X_j &= (x_{1j}, x_{2j}, \dots, x_{mj}) \\
Y_j &= (y_{1j}, y_{2j}, \dots, y_{sj}) \\
\bar{y}_j &= (\bar{y}_{1j}, \bar{y}_{2j}, \dots, \bar{y}_{\bar{s}j}) \\
\hat{y}_j &= (\bar{y}_{1j}, \bar{y}_{2j}, \dots, \bar{y}_{\hat{s}j}) \\
\tilde{y}_j &= (\tilde{y}_{1j}, \tilde{y}_{2j}, \dots, \tilde{y}_{\tilde{s}j}) \\
Z_j &= (z_{1j}, z_{2j}, \dots, z_{kj}) \\
\hat{Z}_j &= (\hat{z}_{1j}, \hat{z}_{2j}, \dots, \hat{z}_{\hat{k}j}) \\
\bar{Z}_j &= (\bar{z}_{1j}, \bar{z}_{2j}, \dots, \bar{z}_{\bar{k}j})
\end{aligned} \tag{10}
$$

$$
\begin{aligned}
e_j^{(1)} &= \frac{\sum_{r=1}^{s} u_r y_{rj} + \sum_{r=1}^{\bar{s}} \bar{u}_r \bar{y}_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} = \frac{\bar{e}_j^{(1)}}{\tilde{e}_j^{(1)}} \\
e_j^{(2)} &= \frac{\sum_{r=1}^{\hat{s}} \hat{u}_r \hat{y}_{rj} + \sum_{k=1}^{K} w_k z_{kj}}{\sum_{r=1}^{s} u_r y_{rj} + \sum_{r=1}^{\tilde{s}} \tilde{u}_r \tilde{y}_{rj}} = \frac{\bar{e}_j^{(2)}}{\tilde{e}_j^{(2)}} \\
e_j^{(3)} &= \frac{\sum_{k=1}^{K} \widehat{w}_k \hat{z}_{kj} + \sum_{r=1}^{\tilde{s}} \tilde{u}_r \tilde{y}_{rj}}{\sum_{r=1}^{\hat{s}} \hat{u}_r \hat{y}_{rj} + \sum_{r=1}^{\bar{s}} \bar{u}_r \bar{y}_{rj}} = \frac{\bar{e}_j^{(3)}}{\tilde{e}_j^{(3)}}
\end{aligned} \tag{11}
$$

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

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

$$\begin{aligned} & Max\ e_o^{(1)} \\ & Max\ e_o^{(2)} \\ & Max\ e_o^{(3)} \\ & Max\ e_o^{(4)} \\ & s.t.\ \ e_j^{(h)} \le 1 \quad , \quad j = 1, \dots, n \quad h = 1, \dots, 4 \end{aligned} \tag{12}$$

Table 1- Data related to indexes of BSC in bank

DMU	growth and learning aspect			Growth and learning to Internal process		Growth and learning to customer	
	Motivational costs%	Increasingexpertise of employees %	Employee Satisfaction %	Improvement of computer software %	involvement of the bank's development programs%	Training hours related to CRM	encourage price of customers to invest (millions)
DMU_1	12	10.5	60	3	50	72	80
DMU_2	18.2	12.1	73	3.2	52	97	98
DMU_3	13	10.8	64.5	4.6	61	88	92
DMU_4	16.3	11.8	63.2	4.8	55	84	117
DMU_5	17.8	11	68	5.2	62	79	85
DMU_6	14.4	10.7	77.4	3.9	66	101	99
DMU_7	12.6	12.2	69	6.8	59	90	105
DMU_8	15.7	12	64.4	6.2	70	73	111
DMU_9	21.5	11.9	75.5	6	46	112	87
DMU_{10}	13.2	10.6	66	6.5	45	85	102
DMU_{11}	19.8	10.8	62	4.1	66	84	98
DMU_{12}	15.3	12.2	78	7	58	109	89
DMU_{13}	18.5	11	71.3	6.9	53	114	117
DMU_{14}	21	11	79.1	5.3	69	76	90
DMU_{15}	19.1	10.9	65.6	5.9	48	94	104
DMU_{16}	15	11	72.8	5.5	49	99	95
DMU_{17}	16.6	12.5	64	5.9	67	116	84
DMU_{18}	20	11.7	62	4.3	47	81	81
DMU_{19}	14	12	74.5	4.4	63	93	117
DMU_{20}	22	12.3	80	4.8	46	119	120
DMU_{21}	15.1	11.6	77	3.7	68	102	118

Table 1- Data related to indexes of BSC in bank

DMU	Internal process aspect				Customer aspect			Financial aspects	
	Internal process to customer		Internal process to Financial		Customer to Financial				
	Increasing speed of service %	banking services %	Improvement of operational processes%	Reducing internal costs%	The number of implemented ideas from customer	Customer satisfaction %	customer acquisition rate%	profit marigin %	Returns to Investment %
DMU_1	80	45	4	5	3	45	17	3.5	2
DMU_2	83.4	47	7.6	6.2	5	47.2	19.3	5.3	5.3
DMU_3	90.4	63.3	7	7.5	9	53.4	25.6	3.9	7.5
DMU_4	92	55	4.5	9.3	4	56.7	22.4	6	2.9
DMU_5	94.5	60.1	6.3	9.1	4	49	17.7	4.8	4
DMU_6	88.2	66.5	4.2	8.6	7	51.1	26.1	6.5	6.6
DMU_7	91.1	48.2	7.2	6.4	5	46.8	20.5	4.4	6.1
DMU_8	82.4	54.2	5.1	5.6	3	49.2	18.4	5.7	3.8
DMU_9	87	58	5.5	8.8	8	54.3	27.6	5.2	5.7
DMU_{10}	89.9	45.7	7.8	8.2	6	52	25.2	6.1	4.5
DMU_{11}	96.7	69.5	6	6	4	56.6	23	3.7	7.1
DMU_{12}	93	64	4.6	7.9	6	51.3	19.4	5.8	6.2
DMU_{13}	96.2	58.4	5.9	5.5	7	49.2	22.4	6.2	5.1
DMU_{14}	81	55.7	6.1	9	7	47.5	24.5	5.5	5.5
DMU_{15}	84.1	47	5	6.1	3	45.6	20.7	5	4.8
DMU_{16}	82.6	67.1	4.1	9.4	10	53.5	23.5	4.8	7.4
DMU_{17}	90	59.5	7.4	8.1	8	47.2	26.2	5.6	5.6
DMU_{18}	86.9	65.3	7	7.3	5	54.2	21.9	6.6	4.1
DMU_{19}	91.5	49	4.4	7.6	5	52.9	22.7	4.5	3.9
DMU_{20}	95	70	8	10	10	57	28	7	8
DMU_{21}	94	56	6.9	9.5	9	48	17.2	4.6	7.3

3-2 Causal Relation between Four Perspectives of BSC Model

According to researchs of Kaplan and Norton [18] there is a causal relation between BSC's four perspectives. Based on previous research, it seems that the relations between the four areas BSC is considered remarkable. A well-organized BSC should describe strategy via the objectives and the criteria selected.These criteria must 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 is 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 give them ability who can use updated software. Use of instructions and a new way can accelerate workflows and lending to people is done properly.

Increasing knowledge and skills of human resources:

- Reducing the error percentage
- Reducing process cycle time
- More efficiency of processes
- Job rotation and employees training

Using the mechanisms and new technologies leads to:

- Alternative methods and existing technologies
- Activity and compete on global banks level with their work optimum
- Reducing the process time
- Designing and creating new processes in accordance with the advancement of technology
- The competitiveness of processes

3-2-2The 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 makes 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, so 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 happen.

3-2-3 The Effect of Internal Process on Financial

There is a direct impact, positive and important internal processes on the financial aspects (cost reduction). 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 that 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 indicators of internal processes on the 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

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 [17]. 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 need to 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 is 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 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 is 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 Flowchart

4-1 Weighting Objective Function Method

One of the solving method 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 goals are determined. For this purpose, at first, a weight for each of our objectives is identified by DM.

$$\sum_{i=1}^{n} w_i = 1 \qquad (13)$$

Then a linear combination of the purposes is written

$$\sum_{i=1}^{n} w_i f_i(x) \qquad (14)$$

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

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

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

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

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

Step 1: Computation of p_{ij}

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

Results of step 1 is given in table 3.

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

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

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

Step 3: Computation of uncertainty value d_j

$$d_j = 1 - E_j \quad ; \quad \forall j \qquad (18)$$

Step 4: Computation of weights w_j

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

Table 2- 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

Table 3- 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	0.222
Customer= w_3	0.132	0.015	0.070	0.375
Financial= w_4	0.110	0.015	0.007	0.041

Table 4- Results of step 2

E_1	E_2	E_3	E_4
0,723	0,375	0,651	**0,873**

Table 5- Results of step 3

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

Table 6-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	0.2	0.09	1

4-2 Goal Programming Method

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

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 a target (objective function):

Three states can happen.

$z_p(x_j)$ is a target.

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

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

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

b_p is generally, the objective function of a problem

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

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

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

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 and determined what 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

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

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

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 appplied 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 7.

5-2- Goal Programming Method

Efficiency of the integrated DEA-BSC model related to 21 DMUs using Goal programming method is given in table 8.

Table 7- 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.

Table 8- 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

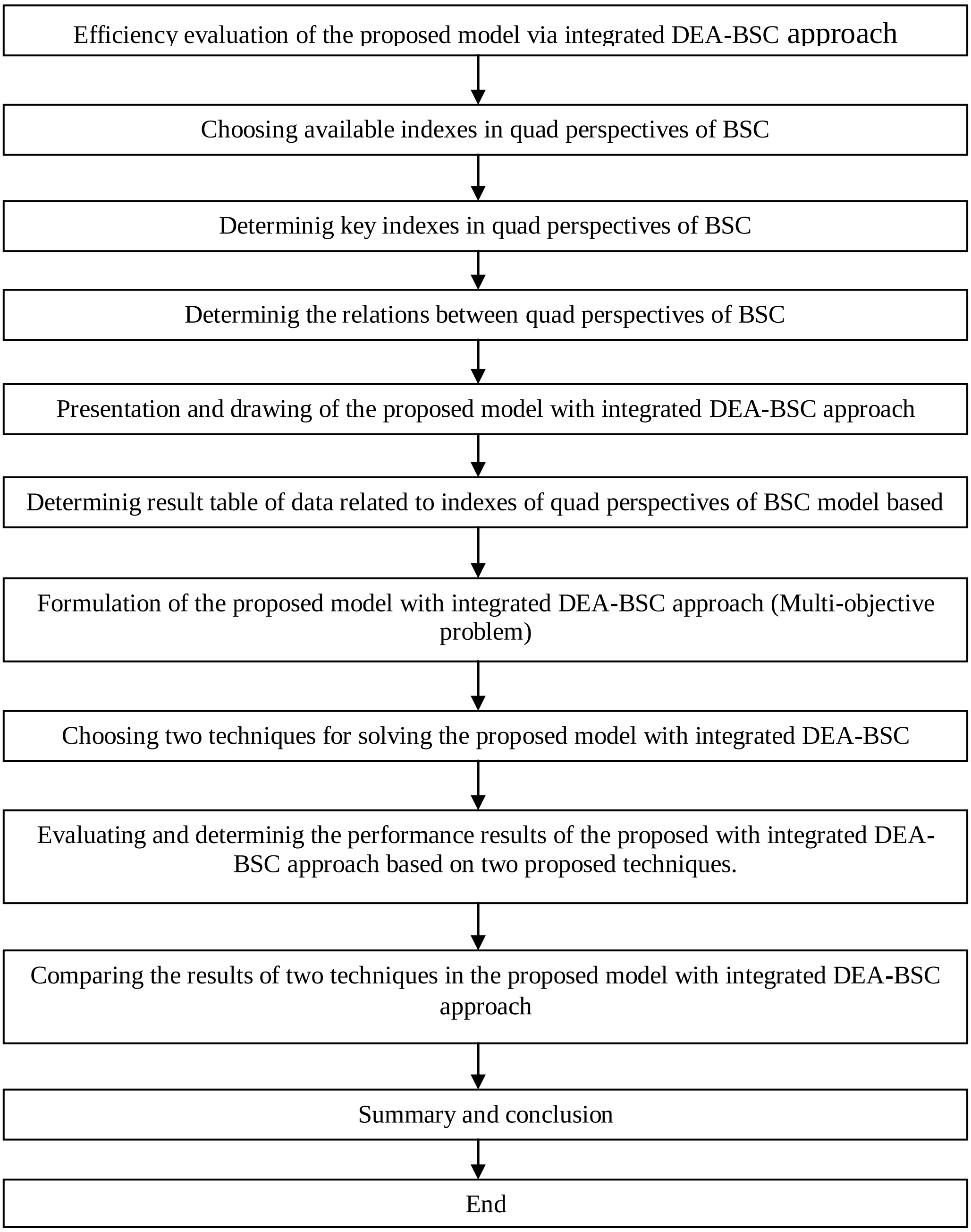

Figure 3. Flowchart of the proposed model with integrated DEA-BSC approach

6. Conclusion

In this paper the integrated DEA-BSC model is presented for measurement of efficiency of various banking units. This proposed integrated model applided in solving multi-objective problems remove 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 was 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 shows 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.

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