Available online at http://ijim.srbiau.ac.ir/
Int. J. Industrial Mathematics (ISSN 2008-5621)
Vol. 10, No. 2, 2018 Article ID IJIM-00829, 9 pages
Research Article

Ranking Two-Stage Process Using a Common Set of Weights in DEA

S. Mamizadeh-Chatghayeh *†, A. A. Noura ‡

Received Date: 2016-02-16 Revised Date: 2016-12-02 Accepted Date: 2017-12-26

Abstract

Supply chain management is the combination of art and science that goes into improving the supply chain. In some cases of supply chain especially two-stage process, differing weights for the same factors, may not acceptable. The purpose of this paper is a performance evaluation of two-stage process using DEA and based on a CSW model and this method for ranking two-stage process and could be used to measure the efficiency of two-stage process.

Keywords : Two-stage process; Supply chain management; Data envelopment analysis; Common set of weights.

1 Introduction

IN today's competitive business environment, two-stage process for example supply chain, has been one of the core subjects in most industrial parts, since it has found to create value for each subsystem i.e., suppliers, manufacturers, distributions, retailers and customers. The supply chain process has gained a prodigious of attention from both managers and industries since the last decade. In fact, the market is growing hand over fist and value to the supply chain by enhancing efficiency and effectiveness of performance evaluation programs. Until now there are many researches that were professional and depth research on supply chain management, ([13], [7], [26], [25] and [10]). But there is still a lack of integration between the performance evaluation method and common set of weights (CSW) for subsystems.

Significant research has been done on a common set of weighted problem. Examples include the models of [20] and [21], that there are controlling factor weights in Data Envelopment Analysis (DEA) and alternate methods of treating factor weights in DEA. [24] presented a nonlinear discriminate analysis to provide the common set weights and the discriminated analysis of ratios for ranking units. [9] suggested a multiple objectives max-min model to determine a common set of weights. [6] presented minimizes a convex of these deviations measured in terms of a couple of distances in such family and improving the discriminating power of DEA. [11] proposed a DEA compromise programming model for comprehensive ranking. In addition, [12] proposed an allocation that is based on a common dual weights approach. Abbas Ali [18] applied common set of weights approach methodology in stochastic DEA. [8] proposed a common set of weights to

*Corresponding author. somayeh_mamizadeh@yahoo.com, Tel: +(98)9191142890
†Department of mathematics, Islamic Azad University, Central Tehran Branch, Tehran, Iran.
‡Faculty of matematics, Sistan and Baluchestan University, Zahedan, Iran.

create the best efficiency scores on the DEA frontier with common weight and S. [19] modify and improve the method introduced by [8].

The types of two stage DEA models for two-stage process as described by [14], [5], [22], [23], [3], [4], [5], [16], [17]. In some cases of two-stage process for example supply chain process, differing weights for the same factors of two-stage processes may not acceptable in the performance evaluation of two-stage processes, for instance, the general manager of a chain store or bank desires to measure the performance of all stores or bank branches using a common set of weights. On the other hand, modeling is an important tool for understanding and managing the two-stage process and improving the two-stage process performance. Therefore, the contribution of this research is that it provides a method for not only a common set of weights for all of the two-stage process s but also show common set input excess, intermediate products and output shortfalls all of the two-stage process s simultaneously. It is necessary to mention that one of the advantages of the proposed method it is a ranking of two-stage processes, and could be measuring the efficiency of twostage processes. The remainder structure of this paper is organized as follows: Section 2 our proposed approach is explained with the common set weight DEA models. Section 3 we apply the proposed approach to appraise the performance of 17 bank branches of China Construction Bank in Anhui province for twostage process.

2 Method

Throughout this paper, we assume to deal with **n** observed two-stage process. Figure (1) shows the structure of a supplier-manufacturer, that each manufacturer uses **m** inputs $(x_{ij}, i = 1, 2, ..., m)$ to produce **f** outputs $(z_{kj}, k = 1, 2, ..., f)$ and supplier uses **f** intermediate production to produce **s** outputs $(y_{rj}, r = 1, 2, ..., s)$.

2.1 Performance evaluation of two-stage process

Managing the performance of the two-stage process without subsystems is not an effective and it will not adequately alert the manager to a problem in business. An effective performance evaluation process enables two-stage process manager to evaluate and measure subsystems in the overall performance of the two-stage process. In the two-stage process for example supply chain; there are two key elements when we consider performance evaluation. First, represent the relative importance of supplier and second represent the relative importance of manufacturer to the overall performance of the two-stage process. Therefore, in this section we computed the overall efficiency of the two-stage process under a constant return to scale, [4]

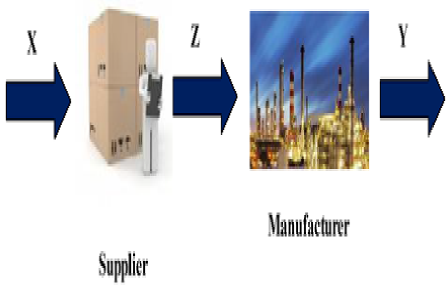

Figure 1: A two-stage.

$$Max \left(\alpha \frac{\sum_{k=1}^{f} w_k z_{ko}}{\sum_{i=1}^{m} v_i x_{io}} + \beta \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{k=1}^{f} w_k z_{ko}} \right)$$

$$s.t. \quad \frac{\sum_{k=1}^{f} w_k z_{kj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \forall j$$

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{k=1}^{f} w_k z_{kj}} \leq 1, \forall j \tag{2.1}$$

$$u_r \geq \epsilon, \ w_k \geq \epsilon, v_i \geq \epsilon, \quad \forall r, \forall k, \forall i. \tag{2.2}$$

A focus on objectives, α and β are supplier and manufacturer specific weights such that $\alpha + \beta = 1$. It is important to identify the contribution of supplier and manufacturer in objective of the model (2.1). Under each contribution of supplier and manufacturer, we have:

Contribution to the performance of supplier:

$\alpha = \frac{\sum_{i=1}^{m} v_i x_{io}}{\sum_{i=1}^{m} v_i x_{io} + \sum_{k=1}^{f} w_k z_{ko}}$

Contribution to the performance of manufacturer: $\beta = \frac{\sum_{k=1}^{f} w_k z_{ko}}{\sum_{i=1}^{m} v_i x_{io} + \sum_{k=1}^{f} w_k z_{ko}}$

Then the objective function of model (2.1) becomes:

$$
\begin{aligned}
& Max \left(\frac{\sum_{k=1}^{f} w_k z_{ko} + \sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io} + \sum_{k=1}^{f} w_k z_{ko}} \right) \\
& s.t. \quad \frac{\sum_{k=1}^{f} w_k z_{kj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \forall j \\
& \qquad \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{k=1}^{f} w_k z_{kj}} \leq 1, \forall j \\
& \qquad u_r \geq \epsilon, \; w_k \geq \epsilon, v_i \geq \epsilon, \quad \forall r, \forall k, \forall i. \qquad (2.3)
\end{aligned}
$$

Using the [2] transformation, we let $t = \frac{1}{\sum_{i=1}^{m} v_i x_{io} + \sum_{k=1}^{f} w_k z_{ko}}$ and set $\pi_i = t.v_i$, $\sigma_k = t.z_k$ and $\varphi_q = t.u_q$. Then it is formulated as follows:

$$
\begin{aligned}
\eta^* = Max \; & \sum_{k=1}^{f} \sigma_k z_{ko} + \sum_{r=1}^{s} \varphi_r y_{ro} \\
s.t. \; & \sum_{i=1}^{m} \pi_i x_{io} + \sum_{k=1}^{f} \sigma_k z_{ko} = 1 \\
& \sum_{k=1}^{f} \sigma_k z_{kj} - \sum_{i=1}^{m} \pi_i x_{ij} \leq 0, \forall j \\
& \sum_{r=1}^{s} \varphi_r y_{rj} - \sum_{i=1}^{m} \sigma_k z_{kj} \leq 0, \forall j \\
& \pi_i \geq 0, \; \sigma_k \geq 0, \varphi_r \geq 0, \quad \forall i, \forall k, \forall r. \qquad (2.4)
\end{aligned}
$$

2.2 Common set of weights

In the DEA methodology, are run separately for each decision making units to calculate the maximum relative efficiency. Its efficiency is defined as a ratio of weighted sum of outputs to a weighted sum of inputs. The common weights DEA introduced by [20] is an approach for identifying best unique weights in which all decision making units (DMUs) in the presence of multiple inputs and outputs. Therefore, we have:

$$
\begin{aligned}
& Max \left\{ \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}, j = 1, ..., n \right\} \\
& s.t. \quad \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \forall j \\
& \qquad u_r \geq \epsilon, v_i \geq \epsilon, \quad \forall r, \forall i. \qquad (2.5)
\end{aligned}
$$

But since MOFP programming cannot handle fraction, we need to transform the formulation, [18]:

$$
Max \left\{ \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij}, j = 1, ..., n \right\}
$$

A common set of weights to create the best performance evaluation scores of the group of two-stage processes. Therefore, the following Multi Objective Fractional Programming (MOFP) can be used to maximize the performance evaluation of all two-stage process s in the model (2.3). Then, we have:

$$
\begin{aligned}
& Max \left\{ \frac{\sum_{k=1}^{f} w_k z_{k1} + \sum_{r=1}^{s} u_r y_{r1}}{\sum_{i=1}^{m} v_i x_{i1} + \sum_{k=1}^{f} w_k z_{k1}}, \frac{\sum_{k=1}^{f} w_k z_{k2} + \sum_{r=1}^{s} u_r y_{r2}}{\sum_{i=1}^{m} v_i x_{i2} + \sum_{k=1}^{f} w_k z_{k2}}, ..., \frac{\sum_{k=1}^{f} w_k z_{kj} + \sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij} + \sum_{k=1}^{f} w_k z_{kj}} \right\} \\
& s.t. \quad \frac{\sum_{k=1}^{f} w_k z_{kj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \forall j \\
& \qquad \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{k=1}^{f} w_k z_{kj}} \leq 1, \forall j \\
& \qquad u_r \geq \epsilon, \; w_k \geq \epsilon, v_i \geq \epsilon, \quad \forall r, \forall k, \forall i. \qquad (2.6)
\end{aligned}
$$

Table 1: Data of 17 bank branches.

NO.	Bank Branch	FA (10^8)	EM (10^3)	EX (10^8)	CR (10^8)	IL (10^8)	LO (10^8)	PR (10^8)
SC1	Hefei	1.0168	1.221	1.2215	166.9755	8.3098	122.1954	3.7569
SC2	Bengbu	0.5915	0.611	0.4758	50.1164	1.7634	19.4829	0.6600
SC3	Huainan	0.7237	0.645	0.6061	48.2831	3.4098	34.4120	0.7713
SC4	Huaibei	0.5150	0.486	0.3763	35.0704	2.3480	15.2804	0.3203
SC5	Maanshan	0.4775	0.526	0.3848	49.9174	5.4613	34.9897	0.8430
SC6	Tongling	0.6125	0.407	0.3407	23.1052	1.2413	32.5778	0.4616
SC7	Wuhu	0.7911	0.708	0.4407	39.4590	1.1485	30.2331	0.6732
SC8	Anqing	1.2363	0.713	0.5547	37.4954	4.0825	20.6013	0.4864
SC9	Huangshan	0.4460	0.443	0.3419	20.9846	0.6897	8.6332	0.1288
SC10	Fuyang	1.2481	0.638	0.4574	45.0508	1.7237	9.2354	0.3019
SC11	Suzhou	0.7050	0.575	0.4036	38.1625	2.2492	12.0171	0.3138
SC12	Chuzhou	0.6446	0.432	0.4012	30.1676	2.3354	13.8130	0.3772
SC13	Luan	0.7239	0.510	0.3709	26.5391	1.3416	5.0961	0.1453
SC14	Xuancheng	0.5538	0.442	0.3555	22.2093	0.9886	13.6085	0.3614
SC15	Chizhou	0.3363	0.322	0.2334	16.1235	0.4889	5.9803	0.0928
SC16	Chaohu	0.6678	0.423	0.3471	22.1848	1.1767	9.2348	0.2002
SC17	Bozhou	0.3418	0.256	0.1594	13.4364	0.4064	2.5326	0.0057

Table 2: Efficiency scores and ranks.

Table Data	Bank Branch	ℓ^*	Rank	η^*	Rank
SC1	Hefei	0.7651	1	1.0000	1
SC2	Bengbu	0.5547	6	0.6899	4
SC3	Huainan	0.5595	5	0.6429	6
SC4	Huaibei	0.5343	7	0.5811	7
SC5	Maanshan	0.7385	2	0.8671	2
SC6	Tongling	0.6626	3	0.6648	5
SC7	Wuhu	0.6078	4	0.7082	3
SC8	Anqing	0.4694	11	0.5362	12
SC9	Huangshan	0.3971	16	0.4041	17
SC10	Fuyang	0.4760	10	0.5435	11
SC11	Suzhou	0.5020	8	0.5627	8
SC12	Chuzhou	0.4762	9	0.5595	9
SC13	Luan	0.3900	17	0.4281	16
SC14	Xuancheng	0.4503	12	0.5444	10
SC15	Chizhou	0.4200	14	0.4307	15
SC16	Chaohu	0.4130	15	0.4528	13
SC17	Bozhou	0.4259	13	0.4324	14

We call the model (2.6) the common set of weights of the performance evaluation model. It maximizes the joint efficiency of the supplier and manufacturer and two subsystems to agree on a common set of weights on the intermediate production. To solve the above MOFP, i. e.:

$$Max \left\{ \frac{\sum_{k=1}^{f} w_k z_{kj} + \sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij} + \sum_{k=1}^{f} w_k z_{kj}}, j = 1, ..., n \right\}$$

We need to transform the formulation:

$$Max \left\{ (\sum_{k=1}^{f} w_k z_{kj} + \sum_{r=1}^{s} u_r y_{rj}) - (\sum_{i=1}^{m} v_i x_{ij} + \sum_{k=1}^{f} w_k z_{kj}), j = 1, ..., n \right\}$$

And then we obtain:

$$Max \sum_{r=1}^{s} u_r \sum_{j=1}^{n} y_{rj} - \sum_{i=1}^{m} v_i \sum_{j=1}^{n} x_{ij}$$

To address this method, we introduce $\hat{x}_i = \sum x_{ij}$ and $\hat{y}_r = \sum y_{rj}$, [18]. We now propose the model:

$$\begin{aligned}
\gamma^* = Max\ & \sum_{r=1}^{s} u_r \hat{y}_r - \sum_{i=1}^{m} v_r \hat{x}_i \\
s.t.\ & \sum_{k=1}^{f} w_k z_{kj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \forall j \\
& \sum_{r=1}^{s} u_r y_{rj} - \sum_{k=1}^{f} w_k z_{kj} \le 0, \forall j \\
& u_r \ge \epsilon,\ w_k \ge \epsilon, v_i \ge \epsilon, \quad \forall r, \forall k, \forall i.
\end{aligned} \tag{2.7}$$

Using (V^*, W^*, U^*) optimal common set of weights from (2.7), the common set of weights performance evaluation of two-stage process s is defined as follows:

$$\ell^* = \frac{\sum_{k=1}^{f} w_k^* z_{kj} + \sum_{r=1}^{s} u_r^* y_{rj}}{\sum_{i=1}^{m} v_i^* x_{ij} + \sum_{k=1}^{f} w_k^* z_{kj}}, j = 1, ..., n \tag{2.8}$$

Definition in this relation (2.8), the p^{th} two-stage process (X_p, Z_p, Y_p) is CSW efficiency if and only if $\ell_p^* = 1$.

Theorem 2.1 *The CSW efficiency of the p^{th} two-stage process (X_p, Z_p, Y_p) is better than of the q^{th} two-stage process (X_q, Z_q, Y_q) if only if $\ell_q^* < \ell_p^*$.*

Proof. Based on the (X_p, Z_p, Y_p) and (X_q, Z_q, Y_q) for p^{th} and q^{th} two-stage process, respectively, we suppose (V^*, W^*, U^*) is the optimal common set of weights. Then we have for input of both of supplier and manufacturer:

$$\begin{cases} X_p > X_q \longrightarrow V^* X_p > V^* X_q, (V^* > 0) \\ Z_p > Z_q \longrightarrow W^* Z_p > W^* Z_q, (W^* > 0) \end{cases} \tag{2.9}$$

$$\Longrightarrow V^* X_p + W^* Z_p > V^* X_q + W^* Z_q$$

$$\Longrightarrow \frac{1}{V^* X_q + W^* Z_q} > \frac{1}{V^* X_p + W^* Z_p}$$

And for output of both of two stages:

$$\begin{cases} Y_q > Y_p \longrightarrow U^* Y_q > U^* X_q, (U^* > 0) \\ Z_q > Z_p \longrightarrow W^* Z_q > W^* Z_p, (W^* > 0) \end{cases} \tag{2.10}$$

$$\Longrightarrow U^* Y_q + W^* Z_q > U^* Y_p + W^* Z_p$$

Therefore (2.9) and (2.10):

$$\Longrightarrow \frac{U^* Y_q + W^* Z_q}{V^* X_q + W^* Z_q} > \frac{U^* Y_p + W^* Z_p}{V^* X_p + W^* Z_p} \tag{2.11}$$

Then, $\ell_q^* > \ell_p^*$. That is contradiction.

The dual form of (2.7) is (2.9):

$$\begin{aligned}
\delta^* = Max\ \epsilon & \left(\sum_{i=1}^{m} s_i + \sum_{k=1}^{f} s_k + \sum_{r=1}^{s} s_r \right) \\
s.t. & \sum_{j=1}^{n} \lambda_j x_{ij} + s_i = \hat{x}_i,\ i = 1, ..., m \\
& \sum_{j=1}^{n} \mu_j y_{rj} - s_r = \hat{y}_r,\ r = 1, ..., s \\
& \sum_{j=1}^{n} (\lambda_j - \mu_j) z_{kj} - s_k = 0,\ k = 1, ..., f \\
& \lambda_j \ge 0, \mu_j \ge 0 \quad \forall j \\
& s_i \ge 0, s_k \ge 0, s_r \ge 0 \quad \forall i, \forall k, \forall r.
\end{aligned} \tag{2.12}$$

Model (2.12) defines the total shortfalls and excess of all two-stage process s corresponding to the inputs, intermediate products and outputs by s_i , s_k and s_r.

2.3 Ranking

We could introduce to the common set of weights by taking the slack variable, [8], [9]. The Common set of weights model is formulated as:

$$\begin{aligned}
Min\ & \sum_{j=1}^{n} \left(2\Psi_j + \Phi_j + \Gamma_j \right) \\
s.t.\ & \frac{\sum_{k=1}^{f} w_k z_{kj} + \Psi_j}{\sum_{i=1}^{m} v_i x_{ij} - \Phi_j} = 1, \forall j \\
& \frac{\sum_{r=1}^{s} u_r y_{rj} + \Gamma_j}{\sum_{k=1}^{f} w_k z_{kj} - \Psi_j} = 1, \forall j \\
& \Psi_j \ge 0, \Phi_j \ge 0, \Gamma_j \ge 0,\ j = 1, ..., n \\
& u_r \ge \epsilon,\ w_k \ge \epsilon, v_i \ge \epsilon, \quad \forall r, \forall k, \forall i.
\end{aligned} \tag{2.13}$$

The ratio form of constraints in the model (2.13) can be translated into linear form:

$$\begin{aligned}
Min\ & \sum_{j=1}^{n}\Big(2\Psi_j+\Phi_j+\Gamma_j\Big)\\
s.t.\ & \sum_{k=1}^{f} w_k z_{kj}-\sum_{i=1}^{m} v_i x_{ij}+\Psi_j+\Phi_j=0, \forall j\\
& \sum_{r=1}^{s} u_r y_{rj}-\sum_{k=1}^{f} w_k z_{kj}+\Gamma_j+\Psi_j=0, \forall j\\
& \Psi_j\ge 0, \Phi_j\ge 0, \Gamma_j\ge 0, \forall j
\end{aligned} \tag{2.14}$$

$$u_r\ge\epsilon,\ w_k\ge\epsilon, v_i\ge\epsilon,\quad \forall r,\forall k,\forall i. \tag{2.15}$$

Following the transformation of the model (2.14), we let $\Psi_j+\Phi_j=\Delta_j$ and $\Psi_j+\Gamma_j=\Omega_j$ and then we have:

$$\begin{aligned}
Min\ & \sum_{j=1}^{n}\Big(\Delta_j+\Omega_j\Big)\\
s.t.\ & \sum_{k=1}^{f} w_k z_{kj}-\sum_{i=1}^{m} v_i x_{ij}+\Delta_j=0, \forall j\\
& \sum_{r=1}^{s} u_r y_{rj}-\sum_{k=1}^{f} w_k z_{kj}+\Omega_j=0, \forall j\\
& \Delta_j\ge 0, \Omega_j\ge 0, \forall j
\end{aligned} \tag{2.16}$$

$$u_r\ge\epsilon,\ w_k\ge\epsilon, v_i\ge\epsilon,\quad \forall r,\forall k,\forall i. \tag{2.17}$$

By removing the slack variable Δ_j, Ω_j and setting $\hat{x}_i=\sum x_{ij}$ and $\hat{y}_r=\sum y_{rj}$. We can obtain the model (2.7). In other words, the model (2.7) and (2.16) is equivalent.

Definition 2.1 *The p^{th} two-stage process is efficient if and only if $\Delta_p^*+\Omega_p^*=0$.*

Definition 2.2 *Suppose $\ell_q^*=\ell^{*"}{}_p<1$, then the efficiency of p^{th} two-stage process is better than the CSW efficiency of q^{th} two-stage process if $(\Delta_p^*+\Omega_p^*)<(\Delta_q^*+\Omega_q^*)$.*

Theorem 2.2 *If $\sum_{i=1}^{m} v_i^* x_{ip} = \sum_{r=1}^{s} u_r^* y_{rp}$, $p\epsilon\{1,...,n\}$ or $\Delta_p^*+\Omega_p^*=0$ then the performance of p^{th} two-stage process is CSW efficiency, i.e., $\ell_p^*=1$.*

Proof. See definition (2.1) and according to the model (2.8) we will $\ell_p^*=1$.

In our model will address three important issues:

(1) Two-stage process management obtains the preferable ranking with determining the common weights.

(2) One of the popular methods for evaluating and ranking DMUs is the common set of weights (CSW) method. Another advantage is that common set of weights does not require different weights for two-stage processes.

(3) This method is applied in order to obtain a ranking by modifying the model (2.4).

(4) Model (2.4) is to evaluate each two-stage process optimistically. But the common set of weights model proposed in this paper can be formulated to obtain performance evaluation and ranking all of the two-stage processes especially supply chain.

(5) This method reduces computation and high accuracy.

(6) This CSW is important when the number of two-stage process s regarding the number of inputs, intermediate products and outputs are small.

(7) CSW to create the best efficiency score of one group composed of efficient two-stage process s. Then, we use this common set of weights to evaluate the absolute efficiency of each efficient DMUs in order to rank them.

2.4 An application to bank branches

In this section we apply the proposed approach to appraise the performance of 17 bank branches of China Construction Bank in Anhui province, P.R. China. China Construction Bank (CCB) is one of the largest commercial banks of China. The banking process is a typical two-stage process. In the two stages DEA model, each of the DMU inputs Fixed Assets (FA), Employee (EM), and Expenditure (EX) are consumed to generate outputs are used to generate two outputs

Loan (LO) and Profit (PR). Credit (CR) and Interbank Loan (IL) are intermediate products, Table 1, (The data are taken from Annual Report (2004) of China Construction Bank in Anhui Province). In this application, the performance evaluation of each bank is shown in Table 2. The 3^{th} and 5^{th} column of Table 2 report the [4] efficiency and CSW efficiency score obtained from models (2.4) and (2.8), respectively. The model (2.8) shows that manager chooses the most favorable weights for the group that compromise all banks under the CSW. As listed in Table 2, performance evaluation of Hefi branch is better than all of another branch. The 4th and 6th column of Table 2 show the results of the ranking calculated from the model (2.4) and model (2.8). Hefi, Huaibei, Maanshan, Suzhou, Chuzhou branches is the same ranking in both the model (2.4 and (2.8). Our method reduces computation and high accuracy.

3 Conclusions

Performance improvement and the role of performance evaluation is an increasingly supply chain topic. Business pressures are now required to become even more effective and efficient, execute better on twostage process management on supply chain to remain competitive. In some cases of two-stage process s differing weights for the same factors of two-stage processes may not acceptable in the performance evaluation of two-stage processes. In this paper, we proposed a method for obtaining common set weights in a DEA two-stage process problem. The method proposed can obtain measure efficiency and ranking all of the two-stage processes.

The presented model has important applications in areas such as supply chain and small and medium enterprise (SME). This approach applied to serial process applies as well to more sub members of two-stage process structures under dynamic situation and cost, revenue and profit efficiencies in two-stage process. This method reduces computation and high accuracy.

Acknowledgments

The authors would like to thank institute for Trade Studies & Research (ITSR) for their constructive comments and suggestions which helped prove the paper.

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Somayeh Mamizadeh-Chatghayeh is an Iranian business executive. She is the current chair, president and Chief executive officer (CEO) of SDO and BSDO, and the first woman to head the company. She has got Ph.D and B.SC and M.SC degrees in Applied Mathematics, Operation Research field from Islamic Azad University, Central Branch, Tehran, Iran. Her research focuses on supply chain management, reverse logistic, Data Envelopment Analysis, Value Chain and Advance Analysis of Small to medium-sized manufacturing enterprises (SME). She is member of United Nations Industrial Development Organization, Asia Business Clusters Networks Development Foundation Cooperation.

In memory of Abbas Ali Noura is an associate professor in Applied Mathematics at Faculty of Mathematics, Sistan and Baluchestan University, Zahedan, Iran and Islamic Azad University, North Tehran Branch and also Head of Sistan and Baluchestan Elite Table. Main research interest includes Operation research, Data envelopment analysis, Fuzzy DEA Models and supply chain. He has supervised M.Sc and Ph.D students in these areas, and has published papers in international journals. He is Chairman of Representatives Headquarters of University President in the Provinces Islamic Azad University (IAU) and member of Iran's parliament.