Shiraz Journal of System Management
Vol. 1, No. 3, (2013), 31-55

Profitability and Effectiveness by Means Two Stage DEA Model in Iranian Bank

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Abstract. The purpose of this paper is to provide a framework for evaluating the overall performance of bank branches in terms of profitability efficiency and effectiveness. Ioannis E.Tsolas (2010) introduced "Modeling Bank Branch Profitability and Effectiveness by Means DEA". But this study has several problems regarding modeling and the results it claims to be withstanding. In 2010 Kumer and Gulati introduced a model for performance evaluation. But this study also has a problem with regard to modeling. We can say that the model introduced in Tsolas, Kumer and Gulati‘s studies was already introduced by Ho and Zhu (2004) and Ho (2007). This paper tries to take a close look at these problems and offer a solution to modify it in a more practical model. First, we analyze the Ho and Zhu (2004) Ho (2007), Tsolas (2010), Kumer and Gulati‘s (2010) model and prove them to be incorrect. Then we apply a modified two stage model proposed by Chen, Liang and Zhu (2009) in bank branches in Iran. This study aggregates profitability efficiency and effectiveness into overall performance. In Ho and Zhu (2004) Ho (2007), Tsolas (2010), Kumer and Gulati‘s (2010) studies, they assume that profitability efficiency and effectiveness are independent, and with that assumption, they design a two stage DEA model. We show that this assumption is wrong, and we cannot design a two stage DEA model with this assumption. There are some relations between profitability efficiency and effectiveness which are very important. Without considering these relations we cannot obtain a superior insight about the overall performance. Finally, we show that the results of the modified model are proved to be more accurate than those of Tsolas, Kumer and Gulati‘s model. This study shows the importance of profitability efficiency and effectiveness in overall performance of bank branches in Iran.

Keywords: Banking; process efficiency; organizational effectiveness; data envelopment analysis (DEA); banks; banks performance.

Received: May (2013) ; Final Revision: July (2013)

1. Introduction

The banking sector is one of most important sectors in an economy, and the importance of adequately measuring the performance of banks has been recognized for a long time. Initially studies on bank performance analysis used different ratios, such as return on assets, return on investments, return on equity, equity to assets, internal growth of equity, etc. Though these ratios are still used in the financial industry, it has been recognized that these ratios can be called as partial productivity indicators, and holistic total factor productivity can be measured by considering various indicators simultaneously. Data envelopment analysis (DEA) can be considered as a tool for measuring total factor productivity.

DEA has received numerous applications for performance measurement in the last few decades, with several significant applications in the finance and banking sectors. When DEA is employed for measuring the performance of a set of banks, the most efficient of all the banks considered in the analysis is (are) used as benchmark(s). The performances of other banks are measured using an efficiency measure relative to the best performing ones.

Perhaps one of the earliest attempts to use DEA for banking was reported by Sherman and Gold (1985) in the context of evaluating branches of a bank. Since then, there are several studies on measuring the performance of banks or branches of banks using DEA. Examples of studies that studied efficiencies of bank branches include Golany and Storbeck (1999), Vassiloglou and Giokas (1990), Sherman and Ladino (1995), Zenios et al. (1999) and Kantor and Maital (1999). There are also studies that used DEA to compare performance among different banks in many countries of the world, including the USA, Spain, Europe, India, Turkey, Kuwait, Australia, Canada and Japan. Thanassoulis (1999) discusses some features of applications of DEA to banks, with illustrations of DEA applications for UK and Finland. Berger and Humphrey (1997) provide a recent review of studies of the efficiencies of various financial institutions including banks. A study of the literature points to the absence of studies that provide a comprehensive analysis of the performance of banks in the countries of the Middle East, with the exception of Kuwait.

A two stage model for performance evaluation was introduced for the first time by Ho and Zhu (2004) for Taiwan's commercial banks. They proposed a two stage structure for performance evaluation. They calculated efficiency of each stage using the classical BCC DEA model, and then they calculated performance evaluation by the product of efficiency score of stage 1 and stage 2. Then Ho (2007) used this model and the same method for performance evaluation. Finally Tsolas (2010) used the model of Ho and Zhu (2004) and Ho (2007) with the same method. He determined Profitability efficiency using the BCC model in the first stage, and by applying the BCC model, he determined the effectiveness in the second stage. Finally he determined the overall performance by the product of profitability efficiency and effectiveness.

These models have a major problem in applying the DEA model for performance evaluation in two stage structure. The aim of this paper is to identify these problems and then propos a modified model for these situations. Since Tsolas (2010) study is based on Ho and Zhu (2004) and Ho (2007) we'll introduce this study in next section, and then propos a modified model. This modified model is applied in real case situations and is compared with the models under study. Final section is conclusion.

2. Background

Data Envelopment Analysis (DEA)

The concept of efficiency is derived from physical and engineering science and indicates the relationship between inputs and outputs. Charnes et al. (1978) introduced the ratio definition of efficiency, also known as the CCR ratio definition, which generalizes the single-output to single-input ratio definition used in classical science to multiple outputs and inputs without requiring pre-assigned weights. The main strength of DEA model as it is applied in this study lies in its ability to combine multiple inputs and outputs into a single summary measure to select the most efficient unit.

Since being proposed by CharnEs et al. (1978) and Banker et al. (1984), the DEA models have been widely applied in evaluating the efficiencies of manufacturing and service industries. A recent research by Mostafa (2007) employed DEA to evaluate the relative efficiency of the top 100 Arab banks. However, the DEA models are rarely used in portfolio management.

CCR and BCC Models

Let $Xij, i = 1...m$ and $Yrj, r = 1...s$, be the ith input and rth output, respectively, of the jth DMU, $j = 1...n$. The DEA model for measuring the relative efficiency of DMUk under an assumption of constant returns to scale is the CCR model (Charnes et al. 1978):

$$\max = \sum_{r=i}^{k} u_r y_j o$$

$s.t$

$$\sum_{i=1}^{m} v_j x_{ijo} = 1 \qquad i = 1, 2, 3, ..., m$$

$$\sum_{r=i}^{k} u_r y_{rj} - \sum_{i=r}^{m} v_i x_{ij} \leqslant 0 \qquad j = 1, 2, ..., jo, ..., n$$

$$u_r \geqslant 0 \qquad v_i \geqslant c$$

Given a set of n decision making units (DMUs), i.e. bank branches, j = 1, . . . , n, utilizingquantities of inputs X [(m to produce quantities of outputs Y [(k, we can denote xij and yrj the amount of the ith input and rth output respectively used by the jth DMU. The following BCC input oriented value-based model (Banker, 1984) can be used to assess efficiencies.

$$\max h = \sum_{r=i}^{k} u_r y_j o + w$$

$s.t$

$$\sum_{i=1}^{m} v_j x_{ijo} = 1 \qquad i = 1, 2, 3, ..., m$$

$$\sum_{r=i}^{k} u_r y_{rj} - \sum_{i=r}^{m} v_i x_{ij} + w \leqslant 0 \qquad j = 1, 2, ..., jo, ..., n$$

$$u_r \geqslant 0 \qquad v_i \geqslant c$$

Efficiency, Effectiveness and Performance Evaluation

Druker (1977) distinguished efficiency and effectiveness. He defined efficiency as "doing things right" and effectiveness as "doing the right things". In this terminology, efficiency is defined as the ability of an organization to attain the outputs with the minimum level of inputs, and effectiveness is defined as the ability of an organization to reach its goals and objectives. So we can say that efficiency and effectiveness are two components of overall performance. Ho and Zhu (2004) introduced overall performance as a product of efficiency and effectiveness. He defined Return on assets (ROA) as performance (Ho and Zhu, 2004), and obtained performance from the product of Profit margin ratio as effectiveness and Total assets turnover ratio as efficiency. Ho and Zho (2004) introduced a model with two stages to obtain overall performance. Other researchers have combined this model with the DEA model such as Tsolas (2010), Kumar and Gulati (2010) Keh et al.(2006), and Garcia-Sanchez (2007). In these studies researchers designed a model with two stages, one stage from efficiency and another from effectiveness. Efficiency and effectiveness score were then obtained with a DEA model separately. Finally, they determined the overall performance by product the efficiency and effectiveness score.

During the late 1980s and particularly in the 1990s, the DEA method has been used extensively to evaluate banking institutions. In their review, Berger and Humphrey (1997) count 130 studies on the efficiency of the banking industry in 21 countries; 116 of them were published between 1992 and 1997. Miller and Noulas (1996) examined the efficiency of large US banks. They found an overall technical efficiency of around 97 percent. However, the majority of banks were found to be too large and experiencing decreasing returns to scale. A second-stage regression analysis showed that pure technical efficiency is positively related to bank size and bank profitability. Bhattacharya et al. (1997) used a two-stage DEA approach to examine the impact of liberalization on the efficiency of the Indian banking industry. In the first stage a technical efficiency score was calculated, whereas in the second stage a stochastic frontier analysis was used to attribute variation in efficiency scores to three sources: temporal, ownership and noise component.

Alirezaee et al. (1998) utilized data from 1,282 bank branches in Canada to conduct numerical experiments relating to DEA results to sample size. They found that the average branch efficiency score varied inversely with the number of branches in the sample and directly with the total number of inputs and outputs. They also cautioned that using relatively small sample sizes in a model with as few as three inputs and three outputs could lead to a substantial upward bias in efficiency scores.

Krishnasamy (2003) used both DEA and Malmquist total factor productivity index (MPI) to evaluate bank efficiency and productivity changes in Malaysia over the period 2000-2001. The results from the analysis indicated that total MPI increased in all the bans studied. The growth of productivity in these banks was attributed to technological change rather than technical efficiency change.

Wu et al. (2006) integrated DEA and neural networks (NNs) to examine the relative branch efficiency of a large Canadian bank. Findings suggest that the predicted efficiency using the DEA-NN model has good correlation with that calculated by DEA, which indicates that the predicted efficiency using the DEA-NN approach is a god proxy to classical DEA approach.

From this brief review we find that although numerous studies have attempted to assess banks efficiency in the West and other parts of the world. There are numerous studies on Bank efficiency evaluation with the DEA model such as Aly et al. (1990), Elysasiani and Mehdian (1990), Yue (1992), Grabowski et al. (1994), Fukuyama (1993, 1995), Berg et al.(1993), Avkiran (1999), Cook and Hababou (2001), Vivas et al. (2002), Luo (2003), Drake and Hall (2003), Kao and Liu (2004), Oliveira and Tabak (2005), Kirkwood and Nahm (2006), Havrylchyk (2006), Drake et al. (2006), Hahn (2007) and Sharkas et al. (2008) Sherman and Gold (1985), Tulkens (1993), Drake and Howcroft (1994), Haag and Jaska (1995), Sherman and Ladino (1995), Athanassopoulos

(1998), Berger et al. (1997), Lovell and Pastor (1997), Camanho and Dyson (1999, 2005), Zenios et al. (1999), Schaffnit et al. (1997), Golany and Storbeck (1999), Avkiran (1999), Kantor and Maital (1999), Soteriou et al. (1999), Cook et al. (2000), Cook and Hababou (2001), Dekker and Post (2001), Hartman et al. (2001), Bala and Cook (2003), Portela et al. (2003, 2004), Paradi and Schaffnit (2004) and Portela and Thanassoulis (2005, 2007).

Several researchers have worked on profitability efficiency such as Athanassopoulos (1997), Oral et al. (1992), Oral and Yolalan (1990), Soteriou and Zenios (1999), and Manandhar and Tang (2002). Profitability efficiency evaluates the ability of branches to minimize inputs for the level of outputs generated. Profitability efficiency is obtained from the ratio of the weighted sum of revenue to the weighted sum of expenses (Giokas, 2008).

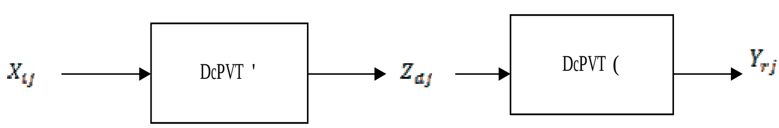
In recent years, few studies have been completed which explicitly recognize the efficiency and effectiveness as two mutually exclusive components of the overall performance of an organization. For example, Schinnar et al. (1990), karlaftis (2004), Ho and Zhu (2004, 2007), Mouzas (2006), Keh et al. (2006), Garcia-Sanchez (2007), Yu and Lin (2007),Rho and An (2007), and Kao and Hwang (2008).

3. Two Stage DEA Model

Tsolas proposed that overall performance encompasses two performance dimensions. These dimensions are profitability efficiency and effectiveness. He said that overall performance is profitability efficiency times effectiveness (the same method of Tsolas, 2010, Kumar and Gulati, 2010, Ho and Zhu 2004, 2007). He applied two BCC-DEA models to evaluate profitability efficiency (stage1) and effectiveness (stagr2). In stage 1 (profitability efficiency) personal expenses rental expenses, other operating expenses and depreciation are inputs and origination income, outcome of a predetermined function mapping loans selling branch performance, commissions and other non-interest income are outputs. In stage 2 (effectiveness) origination income, outcome of a predetermined function mapping loans selling branch performance, commissions and

BTab^]P[Tg_T]bTb CT]cP[Tg_T]bTb AcWTa ^_TaPcX]V Tg_T]bTb 6T_aTRXPcX^]	DcPVT' → Ba^UXcPQX[Xch 7UUXRXT]Rh 455#673 ?^ST[L'M!	AaXVX]PcX^] X]R^\T AdcR^\T ^U P _aTSTcTa\X]TS Ud]RcX^] \P__X]V [^P]b bT[[X]V QaP]RW _TaU^a\P]RT 5^\ \XbbX^]b AcWTa]^]#X]cTaTbc X]R^\T	DcPVT(→ 7UUTRcXeT]Tbb 455#673 ?^ST[L(M!	@Tc X]R^\T

BWhbXRP[5P_XcP[>^P]PQ[T 8d]Sb >PQ^da	DcPVT' → 7UUXRXT]Rh 55C#673 ?^ST[L'M!	3SeP]RTb ;]eTbc\T]cb	DcPVT(→ 7UUTRcXeT]Tbb 55C#673 ?^ST[L(M!	@Tc#X]cTaTbc X]R^\T


X_{ij}
DcPVT '
Z_{dj}
DcPVT (
Y_{rj}

In stage $1X_{ij} \quad i = 1, 2, ..., m$ is input vector and $Z_{dj} \quad d = 1, 2, ..., d$ is output vector. Z_{dj} is input vector in stage 2 and $Y_{rj} \quad r = 1, 2, , s$ is output vector in stage 2. Suppose that p is under evaluation unit. For stage 1, we design BCC-DEA model to evaluate profitability efficiency. So we have:

$$\min \theta$$

$$s.t \begin{cases} \sum_{j=1}^{n} \lambda_j X_j = \theta X_p - s_{1i}^{-} \\ \sum_{j=1}^{n} \lambda_j Z_j - Z_p + s_{1d}^{+} \\ \qquad \sum_{j=1}^{n} \lambda = 1 \\ s_1^{-} \geqslant 0 \quad s_1^{+} \geqslant 0 \quad \lambda_j \geqslant 0 \end{cases} \tag{2}$$

Then we design BBC-DEA model in stage 2 to evaluate effectiveness. So we have:

$$\min \acute{\theta}$$

$$s.t \begin{cases} \sum_{j=1}^{n} \lambda_j X_j = \acute{\theta} Z_p - s_{1d}^{-} \\ \sum_{j=1}^{n} \lambda_j Y_j Y_p + s_{2r}^{+} \\ \qquad \sum_{j=1}^{n} \quad \lambda = 1 \\ s_2^{-} \geqslant 0 \quad s_2^{+} \geqslant 0 \quad \lambda_j \geqslant 0 \end{cases} \tag{3}$$

The overall performance is obtained from the product of θ and $\acute{\theta}$.

$$Overallperfomance = \theta \times \acute{\theta}$$

Let's assume that the under evaluation unit in stage1, profitability efficiency, is P. So, is the input and is the output vector. The projection of under evaluation unit that was obtained from the optimum solution of model (2) is:

$$(X_p \quad Z_p) \xrightarrow{optimumsolution} (\theta^* X_p - s_{1i}^{-*} \quad Z_p + s_{id}^{+*})$$

It means that, if the DMU is inefficient then it will become efficient by changing inputs and outputs to

$$\theta^* X_p - S_1^* \ and \ Z_p + S_1^{+^*}.$$

$$if \ \theta^* X_p - S_1^{-^*} = \hat{X} \ and \ Z_P + S^{+^*} = \hat{Z}, \ wehave:$$

$$(X_p \quad Z_p) \xrightarrow{optimumsolution} (\hat{X} \quad \hat{Z})$$

In stage 2, Z_p effectiveness, is the input and Y_p is the output vector. The projection of under evaluation unit which was obtained from the optimum solution of the model (3) is:

$$(Z_p \quad Y_p) \xrightarrow{optimumsolution} (\acute{\theta}^* Z_p - S_2^{-^*} d \quad Y_p + S_2^{+^*} r)$$

$$if \ \acute{\theta}^* Z_p S_2^{-^*} = \hat{Z} \ and \ Y_P + S_2^{+^*} = \hat{Y}, \ wehave:$$

$$(Z_p \quad Y_p) \xrightarrow{optimumsolution} (\hat{Z} \quad \hat{Y})$$

The optimum solution of model (2) shows that for it to be efficient, the output in stage 1 must be , and the optimum solution of model (3) shows that for it to be efficient, the input in stage 2 (output in stage 1) must be . Since the output in stage 1 is the same as input in stage 2 we must obtain . But in the model proposed by Ho and Zhu (2004) Ho (2007), Tsolas (2010), Kumer and Gulati‘s (2010), we find that . Where we know that the relationship between and in Tsolas model and other is always:

$$\hat{Z} \geqslant Z_p \ and \ \tilde{Z} \leqslant Z_P$$

So we conclude that this method is incorrect.

[redacted]

DMUs	Profitability Efficiency				Effectiveness			
	Input (1)	input (2)	output (1)	output (2)	Input (1)	input (2)	output (1)	output (2)
DMU (1)	2	1	1.5	2.5	1.5	2.5	1.5	2
DMU (2)	4	2.6	4	4.3	4	4.3	5	2.5
DMU (3)	3.5	3	4	1.6	4	1.6	6	4
DMU (4)	6	9	2	4.7	2	4.7	4	1
DMU (5)	2.5	5	3	6.4	3	6.4	3	5
DMU (6)	7	8	4	7	4	7	4	7
DMU (7)	3	5	5	7	5	7	5.8	6.5
DMU (8)	4	9	8	9	8	9	6	7
DMU (9)	6.5	9	12	10	12	10	3	12
[redacted]								6

[redacted]

DMUs	Profitability Efficiency	s_{11}^{-}	s_{12}^{-}	s_{11}^{+}	s_{12}^{+}
DMU (1)	1.0000	0.0000	0.0000	0.0000	0.0000
DMU (2)	1.0000	0.0000	0.0000	0.0000	0.0000
DMU (3)	0.9227	0.0000	1.9048	0.0000	5.0667
DMU (4)	0.3596	0.0000	3.7600	0.8200	0.0000
DMU (5)	1.0000	0.0000	0.0000	0.0000	0.0000
DMU (6)	0.5414	0.0000	3.600	0.2000	0.0000
DMU (7)	1.0000	0.0000	7.7778	0.0000	1.3333
DMU (8)	1.0000	0.0000	0.0000	0.0000	0.0000
DMU (9)	1.0000	0.0000	0.0000	0.0000	0.0000
DMU (10)	0.4455	0.0000	0.0000	1.9636	0.0000

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DMUs	Profitability Efficiency	s^{-}_{11}	s^{-}_{12}	s^{+}_{11}	s^{+}_{12}
DMU (1)	1.0000	0.0000	0.0000	0.0000	0.0000
DMU (2)	1.0000	0.0000	0.0000	0.0000	0.0000
DMU (3)	0.9227	0.0000	1.9048	0.0000	5.0667
DMU (4)	0.3596	0.0000	3.7600	0.8200	0.0000
DMU (5)	1.0000	0.0000	0.0000	0.0000	0.0000
DMU (6)	0.5414	0.0000	3.600	0.2000	0.0000
DMU (7)	1.0000	0.0000	7.7778	0.0000	1.3333
DMU (8)	1.0000	0.0000	0.0000	0.0000	0.0000
DMU (9)	1.0000	0.0000	0.0000	0.0000	0.0000
DMU (10)	0.4455	0.0000	0.0000	1.9636	0.0000

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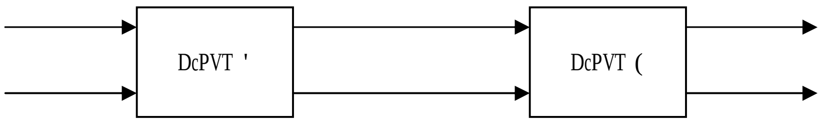

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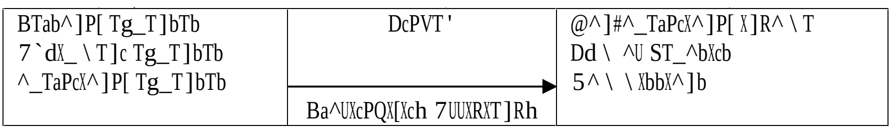
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7`dX_\T]c Tg_T]bTb
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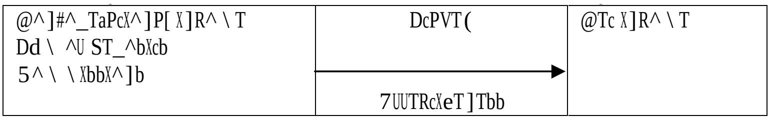

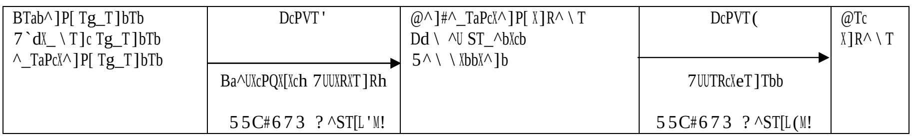

DMUs	Profitability Efficiency	Effectiveness	Overall performance	DMUs	Profitability Efficiency	Effectiveness	Overall performance
DMU (1)	0.5805	1	0.5805	DMU (20)	0.6296	0.7624	0.4800
DMU (2)	0.5278	1	0.5278	DMU(21)	1	0.6628	0.6628
DMU (3)	0.7119	1	0.7119	DMU(22)	1	1	1
DMU (4)	0.3772	0.7190	0.2712	DMU(23)	1	1	1
DMU (5)	0.5669	0.5526	0.3133	DMU(24)	0.3126	1	0.3126
DMU (6)	1	1	1	DMU(25)	0.5506	0.8078	0.4448
DMU (7)	0.8012	0.7422	0.5947	DMU(26)	0.3401	1	0.3401
DMU (8)	0.8808	1	0.8808	DMU(27)	0.4473	1	0.4473
DMU (9)	0.3040	0.8452	0.2569	DMU(28)	1	0.6619	0.6619
DMU (10)	0.5531	0.6505	0.3598	DMU(29)	0.5113	0.5298	0.2709
DMU(11)	0.3292	0.6682	0.2200	DMU(30)	0.3684	1	0.3684
DMU(12)	0.4242	0.6743	0.2860				
DMU(13)	1	0.5601	0.5601				
DMU(14)	0.6784	0.7801	0.5292				
DMU(15)	0.537	1	0.537				
DMU(16)	1	1	1				
DMU(17)	0.4628	0.6166	0.2854				
DMU(18)	0.9041	1	0.9041				
DMU(19)	1	0.1742	0.1742				

DMUs	Overall Performance	DMUs	Overall Performance
DMU (1)	0.7951	DMU (20)	0.6347
DMU (2)	0.5805	DMU(21)	0.8497
DMU (3)	0.7149	DMU(22)	0.9119
DMU (4)	0.4285	DMU(23)	1
DMU (5)	0.523	DMU(24)	0.4004
DMU (6)	0.7431	DMU(25)	0.6164
DMU (7)	0.6361	DMU(26)	0.496
DMU (8)	0.7525	DMU(27)	0.6896
DMU (9)	0.3882	DMU(28)	0.615
DMU (10)	0.5798	DMU(29)	0.4564
DMU(11)	0.3619	DMU(30)	0.437
DMU(12)	0.4508		
DMU(13)	0.7801		
DMU(14)	0.6544		
DMU(15)	0.6373		
DMU(16)	0.7845		
DMU(17)	0.4042		
DMU(18)	0.6841		
DMU(19)	0.5185		

(2010) and using mathematical and practical examples. We proved their impracticality. Furthermore a modified model was proposed to obtain correct and enhanced results meant by the model, which proved to be accurate when applied in real case situations.

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