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Measuring relative performance of banking industry using a DEA and TOPSIS

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One of the primary concerns in banking industry is to measure the relative importance of banking industry using popular multi criteria decision making (MCDM) techniques such as data envelopment analysis (DEA) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). In this paper, we use these two MCDM techniques to measure the relative efficiencies of 16 private and governmental banks in terms of electronic payment. There are three inputs with DEA methods including the number of issued cards, the number of ATM machines and the number of POSs and there are two outputs including the number of successful ATMs and the number of successful POSs transactions. The proposed study of this paper uses the necessary data of one of Iranian provinces and the results of the implementation of DEA and TOPSIS have indicated that 9 out of 16 banks were efficient. Our study also indicates that mean of relative efficiency for private banks was 82% while this number was 75% for governmental banks.

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1. Introduction

During the past few years, there have been tremendous efforts on using recent advances in technology to provide electronic services and helping people transfer funds electronically, which increases security and bring peace of mind among banks' customers. One of the primary concerns in banking industry is to measure the relative efficiency of banking industry in terms of e-business. This could be done through considering different criteria and measures them in terms of various perspectives using multi criteria decision making (MCDM) approaches such as data envelopment analysis (DEA) (Charnes et al., 1978, 1994; Andersen et al., 1993), analytical hierarchy process (AHP) (Saaty, 1992), Entropy and **T**echnique for **O**rder **P**reference by **S**imilarity to **I**deal **S**olution (TOPSIS).

Fallah et al. (2011) implemented DEA models for the estimating organizational inputs and outputs to enhance management and decision making processes. They performed an empirical DEA analysis on

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banking sector by considering several financial and non-financial inputs and outputs and measured the relative efficiencies of different branches of banks and analyzed them under various scenarios. Their results indicated that there were some non-financial items, which could significantly change the overall performance of a unit along with other financial items.

Avkiran (2010) performed an empirical investigation on the relationship between the supper-efficiency estimations and some major important financial ratios for selected Chinese banking sector. The method provided some opportunity to find the inefficient units where there was a low correlation between the supper-efficiency and good financial ratios. Staub et al. (2010) investigated various factors influencing the relative efficiency of Brazilian banks such as cost and technical efficiencies over the period 2000-2007. They reported that Brazilian banks relatively suffered from low levels of efficiency compared with European or North American banks. They also explained that state-owned banks were substantially more cost efficient than other foreign banks. However, they did not detect any evidence to claim that the differences in economic efficiency were due to any kind of activity and bank size.

Lin et al. (2009) used various DEA techniques for 117 branches of a certain bank in Taiwan and stated an overall technical efficiency of 54.8 percent among all banks. Yang et al. (2010) presented an integrated bank performance assessment and management planning using hybrid minimax reference point – DEA approach. Zaheri et al. (2012) studied customer loyalty and prioritizing based one private bank in Kurdistan province. They investigated customer loyalty by using Recency Frequency Monetary factor for prioritizing customer based on loyalty properties and TOPSIS.

In this paper, we present an empirical study to measure the relative efficiency of banking industry in terms of electronic payment using DEA and TOPSIS techniques. The organization of the paper first presents details of the propsoed method in section 2. The results are discussed in section 3 and concluding remarks are given in the last to summarize the contribution of the paper.

2. The proposed model

In this paper, we use two methods of DEA and TOPSIS for measuring the relative efficiencies of banks and we first introduce details of two techniques,

2.1. DEA method

Charnes, et al. (1978, 1994) are believed to be the first who introduced the idea of constant return to scale DEA (CCR) as a mathematical technique for measuring the relative efficiency of decision making units (DMU).

It is an easy task to show that DMU works whenever a production function is available. However, in different cases obtaining an analytical form for this function is not practical. Therefore, we form a set of production feasibility, which includes some principles such as fixed-scale efficiency, convexity and feasibility as follows,

$$T_C = \left\{ (X,Y) \middle| X \geq \sum_{j=1}^{n} \lambda_j X_j, Y \leq \sum_{j=1}^{n} \lambda_j Y_j, \lambda_j \geq 0, j = 1, \cdots n \right\}, \tag{1}$$

where X and Y are input and output vectors, respectively. The CCR production feasibility set border defines the relative efficiency in which any off-border DMU is considered as inefficient point. The CCR model is determined in two forms of either input or output oriented.

The input CCR aims to decrease the maximum input level with a ratio of θ so that, at least, the same output is produced, i.e.:

$$\min \quad \theta$$

subject to

$$\begin{aligned} &\theta X_p - \sum_{j=1}^{n} \lambda_j X_{ij} \geq 0, \\ &\sum_{j=1}^{n} \lambda_j Y_{rj} \geq Y_{rp}, \\ &\lambda_j \geq 0, \qquad j = 1, \cdots, n. \end{aligned} \tag{2}$$

Model (2) is called DEA form of input CCR where θ is the relative efficiency of the DMU and we can verify that the optimal value of θ, θ^*, is a number between zero and one. In the case of the output oriented DEA technique, the primary aim is to maximize the output level, φ, by implementing the same amount of input as follows,

$$\begin{aligned} &\min \quad \varphi \\ &\text{subject to} \\ &\sum_{j=1}^{n} \lambda_j X_{ij} \leq X_{ip}, \sum_{j=1}^{n} \lambda_j Y_j \geq \varphi Y_{ip}, \qquad \lambda_j \geq 0, \qquad j = 1, \cdots, n. \end{aligned} \tag{3}$$

2.2. TOPSIS technique

Let x_{ij} be the inputs for matrix of priorities where we have $i = 1, \cdots, m$ alternatives and $j = 1, \cdots, n$ criteria. TOPSIS maintains six steps as follows,

Step 1. Form normalized decision matrix

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij}^2}} \tag{1}$$

Step 2. Form the weight normalized matrix

$$v_{ij} = w_i r_{ij}, i = 1, \cdots, m \quad j = 1, \cdots, n \tag{2}$$

Step 3. Calculate the positive and negative ideal solutions

$$\begin{aligned} A^+ &= \left\{ v_1^+, \cdots, v_n^+ \right\}, \text{ where } v_j^+ = \left\{ \max(v_{ij}) \text{ if } j \in J; \min(v_{ij}) \text{ if } j \in J' \right\} \\ A^- &= \left\{ v_1^-, \cdots, v_n^- \right\}, \text{ where } v_j^* = \left\{ \min(v_{ij}) \text{ if } j \in J; \max(v_{ij}) \text{ if } j \in J' \right\} \end{aligned} \tag{3}$$

Step 4. Evaluate seperation (positive and negative) measures for each alternative

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_j^+ - v_{ij})^2}, S_i^- = \sqrt{\sum_{j=1}^{n} (v_j^- - v_{ij})^2}, i = 1, \cdots, m \tag{4}$$

Step 5. Measure the relative closness to the ideal solution

$$C_i^+ = \frac{S_i^-}{S_i^- + S_i^+}, 0 < C_i^+ < 1, i = 1, \cdots, m \tag{5}$$

3. The results

The proposed study of this paper considers three inputs and two outputs for the implementation of DEA technique and Table 1 demonstrates the input/output data as well as the results of the implementation of DEA method.

Table 1
Details of input/output data

Bank	Inputs			Outputs			
	# of issued cards	# of ATMs	# of POSs	Successful ATMs	Successful POSs	φ	$1/\varphi$
Eghtesad Novin	20382	2	124	5898	2921	2.7909	0.2938
Parsian	122422	2	3988	4373	344846	1	1
Pasargad	35246	3	1093	20253	66084	1.3383	0.7229
Tejarat	163521	52	1769	235377	83546	1.0636	0.6220
Refah	57183	12	244	41274	5064	1.4385	0.6952
Saman	734	2	170	5075	5548	1	1
Sina	14557	4	9	22256	506	1	1
Saderat	307033	41	3807	557067	113080	1	1
Mellat	337035	59	3556	369913	303595	1	1
Tose-Taavon	6075	2	266	2286	2483	6.3397	0.1076
Maskan	130466	19	509	116843	7659	1	1
Keshavarzi	304248	42	3436	377912	82503	1.3263	0.7343
Sanaat&Maadan	2200	2	88	7775	7762	1	1
Melli	233959	81	7881	930684	433394	1	1
Post bank	6973	7	116	7726	4931	1	1
Sepah	181102	40	565	115274	21415	1	1

As we can observe from the results of Table 1, there are 9 efficient units and 7 inefficient units, where it is possible to increase their efficiencies by increasing their outputs simply by multiplying φ to the outputs of these banks. Table 2 demonstrates the results of desirable outputs for inefficient units to become efficient.

Table 2
Desirable outputs for inefficient banks

Bank	Eghtesad-Novin	Pasardgad	Tejarat	Refah	Tose-Taavon	Keshavarzi	Post bank
Increase ATMs	10563	6852	14970	18099	12207	123313	7096
Increase POSs	5231	22356	5314	2221	13258	26921	4529

Another observation is that there is more than one efficient unit in our survey and we could use Anderson and Peterson (1993) method to provide ranking among efficient units. Table 3 shows details of our ranking based on their DEA technique.

Table 3
The results of Anderson and Peterson technique on nine efficient units

Bank	Sina	Melli	Saman	Sanaat & Madan	Mellat	Saderat	Maskan	Sepah	Parsian
θ	0.0928	0.3916	0.6582	0.6933	0.7710	0.8253	0.8348	0.9689	0
$1/\theta$	10.775	2.553	1.519	1.442	1.297	1.212	1.198	1.032	0
Rank	1	2	3	4	5	6	7	8	9

As we have explained earlier, we need to use a method to find the relative weights of five criteria used in DEA implementation so that we could implement TOPSIS technique. The implementation of our study uses Entropy technique to rank all 16 banks. The results of the implementation of Entropy technique yields 0.1352, 0.1679, 0.2101, 0.2463 and 0.2405 for the number of issued cards, the

number of ATM machines, the number of POSs, the number of successful ATMs and the number of successful POSs transactions, respectively. According the results of the implementation of TOPSIS based on five mentioned criteria for nine efficient banks, Bank Melli is the most efficient one with 0.9944, followed by Bank Mellat with relative rank of 0.5942, Bank Saderat with relative rank of 0.4918, Bank Parsian with relative rank of 0.2809. In addition, the relative ranking measure produced by TOPSIS technique for five other banks, Sepah, Maskan, Sina, Saman and Sanaat & Madan are 0.0647, 0.0243, 0.0004 and 0.0001, respectively.

In summary, we see that governmental banks seem to perform less efficiently compared with private banks. Note that most of these banks initially started their business as private organization and it seems that from the day first, they started with better management, which could lead them to have better systems.

4. Conclusion

In this paper, we have presented an empirical investigation to measure the relative efficiencies of some private and governmental banks. The proposed study of this paper has implemented DEA and TOPSIS methods for the purpose of this study. There were three inputs with DEA methods including the number of issued cards, the number of ATM machines and the number of POSs and there were two outputs including the number of successful ATMs and the number of successful POSs transactions. The proposed study of this paper has used the information of 16 different banks from private and governmental sectors to perform the study. The results of the implementation of DEA have indicated that 9 out of 16 banks were efficient. Therefore, we have decided to use supper efficiency technique to rank efficient units. We have also used TOPSIS technique to rank 9 efficient units by implementing Entropy method to find the relative weights of five criteria. These criteria include the number of issued cards, the number of ATM machines, the number of POSs, the number of successful ATMs and the number of successful POSs transactions, which are used as input criteria for the implementation of TOPSIS.

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