Evaluation of the efficiency of Restaurants using DEA Method (the case of Iran)

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Abstract: The purpose of this study is to evaluate the efficiency and ranking of 15 Restaurants in Iran, paying attention to efficiency improvement using a data envelopment analysis (DEA) model. The model considers three inputs (monthly working hours, branch area (square meters), and years of experience as manager) and two outputs (monthly number of customers who bought something from the branch, and monthly sales in USD). The results indicate that data envelopment analysis is a Useful tool to evaluate the efficiency of Restaurants. Moreover, the results show that Noor restaurant and Nemoone restaurant is the most efficient restaurants Compared to other restaurants. Restaurants or other service providers should find this alternative DEA model helpful and more flexible in re-examining their resource utilization and possibly reshuffling their resource pool.
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1. Background

The DEA Model measures the relative efficiency of public and nonprofit organizations having no market value. One of the main advantages in using the DEA Model is that it can measure the efficiency of a group without adopting predetermined fractional linear programming while evaluating the input and output factors. Many services such as banks, hotels, and food chains like Pizza Hut and McDonald's and retail stores like Wal-Mart are composed of multi-branch firms. Numerous papers have explored the efficiency and relative efficiency of branches. Typically, these papers used the data envelopment analysis (DEA) methodology, its variants, various ranking methods, regression analysis and other indicators. Past literature on DEA has shown that DEA has been widely applied in measuring efficiency particularly in external benchmarking issues. DEA has been utilized for selection of partners for benchmarking in telecommunications industry (Collier and Storbeck, 1993) and in travel management (Bell and Morey, 1995). Collier and Storbeck (1993) used standard DEA approach, which calculate "technical" efficiencies for determining benchmarking partners. Bell and Morey (1995) used DEA to identify appropriate benchmarking partners that use a different mix of resources that are more cost efficient compared to that used by the firm. Other areas on external benchmarking using DEA are the banking and finance industry (Barr and Seiford, 1994) and grocery industry (Athanassopoulos and Ballantine, 1995). Wang et al. (2005) use a fixed and unified production frontier (i.e. the same constraint set) to measure the interval efficiencies. Jahanshahloo et al. (2004) solve interval efficiencies by analysis of sensitivity and stability in DEA with interval data. Post and Spronk (1999) present a performance measurement technique that combines DEA and interactive multiple goal programming and call it "a decision support tool to select performance benchmarks that are both feasible and desirable." Donthu et al. (2004) while using DEA for benchmarking "marketing productivity" state, "We use DEA to identify benchmarks (role models) and set goals for improvement. These represent two very important steps of benchmarking." Soteriou and Stavrinides (1997) and Soteriou and Zenios (1999) have proposed DEA as a technique for benchmarking of "service delivery system characteristics of bank branches." Manandhar and Tang (2002) present a framework for simultaneous benchmarking of "performance of bank branches" using a modified DEA formulation DEA has been successfully used to provide bank branch benchmarks in line with three approaches (Paradi et al., 2004; Giokas, 2008): production, intermediation and profitability or profit.

The remainder of this paper is organized as follows: Section 2 presents the DEA Method. Section 3 presents a real-life case study of 15 restaurants that their efficiency is evaluated. Section 4 presents the Efficiency analysis. Section 5 gives a summary and suggestions.

2. Data envelopment analysis (DEA)

The methodology of data envelopment analysis, initially introduced by Charnes *et al*. (1978), is a mathematical programming technique used to evaluate the relative efficiency of homogeneous units. This efficiency evaluation derives from analysing empirical observations obtained from decision-making units (DMUs), a term coined by Charnes *et al*. (1978) to define productive units which are characterized by common multiple outputs and common designated inputs. DEA can be used to measure the efficiency of each similar firm or decision-making unit (DMU), and it is a powerful tool to determine whether DMUs perform efficiently or inefficiently on the efficiency performance (Zhang et al., 2006). The objective of the DEA exercise is to identify the DMUs that produce the greatest amount of outputs by consuming the least amount of inputs. A DMU is deemed to be efficient if the ratio of weighted sum of outputs to the weighted sum of inputs is the highest. Hence, the DEA program maximizes the ratio of weighted outputs to weighted inputs for the DMU under consideration subject to the condition that similar ratios for all DMUs be less than or equal to one.

Every decision-making unit (DMU) is measured relative to all other DMUs. A composite unit (hypothetical best practice unit) is composed of a subset of efficient DMUs. The efficient DMUs define a production frontier that envelops the observed data of inefficient DMU's. The DMU being measured will be judged inefficient if the hypothetical composite unit requires fewer inputs to obtain the same output. A unit will be judged efficient if it requires the same amount of inputs to produce an output as the composite unit. Distance from the frontier determines how inefficient an individual DMU is. Inefficient DMUs can become efficient by increasing outputs or decreasing inputs in a fashion that causes them to resemble their efficient reference set. Golany and Roll (1989) generalize the main process of employing DEA to assess the performance of a group of organizations including decision-making unit decisions; input and output selection; data collection; assessment model choice; model administration; assumptions and the explanation of outcome. Oral and Yolalan (1990) proposed the reference aggregate of the inefficiency unit and the relative dual weight of the reference aggregate, which is helpful in identifying the local leader and analyzing local economies of scale.

The relative efficiency of the multiple input and multiple output in DMU is typically defined as an engineering like ratio(weighted sum of the DMU 's outputs divided by weighted sum of the DMU ' s input),i.e. for the generic *j*th DMU:

$$E_j = \frac{\text{weighted sum of outputs}}{\text{weighted sum of inputs}}$$

DEA model computes weights that give the highest possible relative efficiency score to a DMU while keeping the efficiency scores of all DMUs less than or equal to 1 under the same set of weights. The fractional form of a DEA mathematical programming model is given as follows:

$$Maximize\ \ Z = \frac{\sum_{r=1}^{t} U_r Y_{rj0}}{\sum_{r=1}^{m} V_r X_{ij0}}$$

Subject to:

$$\frac{\sum_{r=1}^{t} U_r Y_{rj}}{\sum_{r=1}^{m} V_r X_{ij}} \leq 1 \quad j = 1, 2, \ldots., n \quad i = 1, \ldots., m \quad U_r, V_i \geq 0 \qquad (1)$$

Where U_r, the weight for output r; v_i, the weight for input *i*; y_{rj}, the amount of output r of DMU $_j$; *xij*, the amount of input *i* of DMU*j*; *t*, the number of outputs; *m*, the number of inputs; *n*, the number of DMUs. The objective function of equation (1) seeks to maximize the efficiency score of a DMU$_{j0}$ by choosing a set of weights for all inputs and outputs. The first constraint set of equation (1) ensures that, under the set of chosen weights, the efficiency scores of all DMUs are not more than 1. The second and third constraint sets of equation (1) ensure that no weights are set to 0 in order to consider all inputs and outputs in the model. A DMU$_{j0}$ is considered efficient if the objective function of the associated (equation (1)) results in efficiency score of 1, otherwise it is considered inefficient. By moving the denominator in the first constraint set in equation (1) to the right-hand side and setting the denominator in the objective function to 1, (equation (1)) can be converted into a LP problem as follows:

$$Maximize\ \ Z = \sum_{r=1}^{t} U_r Y_{rjo}$$

Subject to:

$$\sum_{i=1}^{m} V_i X_{ij0} = 1$$

$$\sum_{r=1}^{t} U_r Y_{rj} - \sum_{i=1}^{m} V_i X_{ij} \leq 0 \qquad j = 1, \ldots., n$$

$$r = 1, \ldots., t \quad i = 1, \ldots., m \quad U_r, V_i \geq 0 \qquad (2)$$

U_r: the weight given to output *r*.
V_i: the weight given to input *i*.
Y_{rj}: the amount of output *r* (r = 1,…,t) from DMU "*j*"
Y_{rj0}: the amount of output *r* (r = 1,…,t) from DMU "*j0*"

X_{ij}: the amount of input i (i = 1,…, m) from DMU"j".
X_{ij0}: the amount of input i (i = 1,…, m) from DMU"$j0$".
n: the number of DMU.
t: the number of outputs.
m: the number of inputs.

The above constraints restrict the efficiencies of all of the DMUs ($j = 1, . . ., N$) to have an upper bound of 1. The variables U_r (r = 1,…, n) and V_i (i = 1, . . ., m) are the weights to be derived for the corresponding output and input factors while maximizing the efficiency of the *kth* DMU. That is, DEA allows that individual DMUs may have their own preference structures and value systems, and thus, can determine their own weights.

3. The case study

Restaurants are characterized as a day-to-day high-risk business (Muller, 1999). Demand is highly randomized, and the arrival of customers is highly unpredictable. Moreover, other external factors have to be taken into account, such as seasonal fluctuations. The data set of our case study includes 15 restaurants in Iran. Iran has thousands of fast-food businesses and sales points selling hamburgers, pizzas, falafel, kebab, etc.

In order to demonstrate the applicability of the proposed method, we performed a case study involving 15 restaurants belonging to one of Iran's cities. The outputs, the inputs for our restaurant case study include the following:

(1) Inputs:
V1- monthly working hours.
V2-branch area (square meters).
V3-years of experience as manager.

(2) Outputs:
U1-monthly number of customers who bought something from the branch.
U2-monthly sales in USD.

An important issue in employing DEA is the appropriate selection of inputs and outputs. In this case study, the inputs and outputs were chosen by consulting experts. Table 1 includes the data (three inputs and two outputs) for 15 restaurants in Iran. For the data given in Table 1, we set bounds for various weights according to the DEA method. Then we ran the A&P super-efficiency model that ranks all the branches from 1 (the most efficient branch) to 15 (the most inefficient one).

Table 1. Inputs and outputs for 15 restaurants

		Inputs			Outputs	
Branch	**DMU**	**V_1**	**V_2**	**V_3**	**U_1**	**U_2**
Tajmahal	1	900	60	2	3600	4100
Noor	2	800	130	5	7600	7450
Eghbali	3	1200	90	8	5400	6250
Yas	4	1050	35	6	3855	4220
Nemoone	5	950	55	4	8560	8500
Khatam	6	750	40	1	4000	4000
Bahar	7	1100	70	6	3500	3950
Tiktak	8	950	25	8	2400	2800
Good boy	9	825	30	1	1855	2450
Khansalar	10	925	35	3	2650	2700
Deshlame	11	1075	38	5	2750	2900
Ponak	12	950	40	1	1500	2100
Ghasr	13	1300	100	9	4700	4900
Ghods	14	850	110	10	5200	5150
Baghgherdoo	15	1000	170	2	2600	2830

For example linear programming form for DMU 10 as follows:

Max z = 2650u1+2700u2

Subject to
925v1+35v2+5v3=1
3600u1+4100u2-900v1-60v2-2v3≤ 0
7600u1+7450u2-800v1-130v2-5v3≤ 0
5400u1+6250u2-1200v1-90v2-8v3≤ 0
3855u1+4220u2-1050v1-35v2-6v3≤ 0
8560u1+8500u2-950v1-55v2-4v3≤ 0
4000u1+4550u2-750v1-40v2-1v3≤ 0
3500u1+3950u2-1100v1-70v2-6v3≤ 0
2400u1+2800u2-950v1-25v2-8v3≤ 0
1855u1+2450u2-825v1-30v2-1v3≤ 0
2650u1+2700u2-925v1-35v2-5v3≤ 0
2750u1+2900u2-1075v1-38v2-5v3≤ 0
1500u1+2100u2-950v1-40v2-1v3≤ 0
4700u1+4900u2-1300v1-100v2-9v3≤ 0
5200u1+5150u2-850v1-110v2-10v3≤ 0
2600u1+2830u2-1000v1-170v2-2v3≤ 0

u1≥ 0 u2≥ 0 v1≥ 0 v2≥ 0 v3≥ 0

4. Efficiency analysis

In evaluating restaurant efficiency, we calculated the efficiency scores for all 15 restaurants using DEA model. In this paper for calculate the efficiency scores used LINDO software. The scores of all the branches were computed. The results are presented in Table 2. According to the results, DEA model indicate that almost one- Seventh of the restaurants (2 of 15) were efficient, having an efficiency score one. In this case study, it was found that only Noor restaurant and Nemoone restaurant are efficient. All the other DMUs are inefficient. Inefficient restaurants are: Tajmahal (0.5289), Eghbali (0.5812), Yas (0.7807), Khatam (0.7189), Bahar

(0.3989), Tiktak (0.7252), Good boy (0.3528), Khansalar (0.4995), Deshlame (0.4930), Ponak (0.2646), Ghasr (0.4165), Ghods (0.6592), and Baghgherdoo (0.3311). These DMUs should improve their efficiency by increasing the values of their outputs given the existing levels of the inputs. Those with an efficiency score of one do not need to make such changes (Noor and Nemoone).

This section highlights the managerial implications which can be inferred from the solutions obtained from the DEA model. Noor restaurant and Nemoone restaurant is the most efficient restaurant, with efficiency score of one. Ponak restaurant is the most inefficient restaurant, with an efficiency score only 0.2646 (from Table 2). It is also the last ranked observation (ranking 15 from Table 2). Next, managers need to identify the sources of inefficiencies for ponak restaurant and all the other DMUs that are inefficient.

Table2: The scores and the ranking of the branches

Branch	DMU	Score	Rank
Tajmahal	1	0.5289	8
Noor	2	1	1
Eghbali	3	0.5812	7
Yas	4	0.7807	3
Nemoone	5	1	1
Khatam	6	0.7189	5
Bahar	7	0.3989	12
Tiktak	8	0.7252	4
Good boy	9	0.3528	13
Khansalar	10	0.4995	9
Deshlame	11	0.4930	10
Ponak	12	0.2646	15
Ghasr	13	0.4165	11
Ghods	14	0.6592	6
Baghgherdoo	15	0.3311	14

5. Summary

This study is initiated by the authors because there is a lack of tools to measure restaurant efficiency. DEA has been proven to be a reliable, flexible and efficient tool in measuring restaurant performance. In summary, this paper presents a standard methodology for assessment and ranking of restaurants efficiency. The results indicate that data envelopment analysis is a Useful tool to evaluate the efficiency of Restaurants. Moreover, the results show that Noor, Nemoone and Yas are respectively the best restaurants Compared to other restaurants. All the other DMUs are inefficient. The structure and approach of this paper could be applied for other sectors in particular and other countries in general. The results of such studies would help policy makers and top managers to have better understanding of their sectors. The framework presented in this paper may be used by top managers to compare the performance of various units within an organization. The contribution of this study provides useful insights into the use of DEA as a modeling tool to aid managerial decision making in measuring restaurant efficiency. Reynolds and Thompson (2007) made a multiunit restaurant productivity assessment using three-phase DEA. Hadad et al. (2007) used DEA and some ranking methods to measure efficiency of restaurants and to rank them. Barros and Alves (2004) estimated total productivity changes and decomposed them into technically efficient changes and technological changes for a Portuguese retail store chain by implementing the efficient frontier approach and using the Malmquist productivity index (Caves et al., 1982). Their aim was to discover what practices best lead to improved performance throughout the whole chain. They ranked the stores according to their total productivity changes for the period 1999-2000. There are other multiple attribute decision-making methods such as ELECTRE, TOPSIS and VIKOUR, which could be applied for ranking the assessment and ranking of restaurants efficiency. Further research may be the application of these methods to the ranking of restaurants efficiency and the comparison of the results.

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