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# A DEA with Categorical DMUs Based Model in Profit Sharing

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**Abstract:** Companies around the world normally assign a portion of their benefits to their employees. This policy is used as an encouragement to increase the motivation of employees. If the profit sharing seems unfair, its expected results will be lost. In this paper, a model is developed to determine a desirable profit sharing policy which relates the profit sharing with the efficiency of organizational units. The proposed method is designed based on the data envelopment analysis. The proposed method is applied in a real application and its results are shown.

**Key words:** Profit sharing · Efficiency · Data envelopment analysis · Categorization

## INTRODUCTION

Many organizational experts believed that participation of employees in organization's financial consequences would influence performance of individual employee and respectively, organization's performance. German economist, Johann Heinrich von Thunen proposed theoretical arguments for profit sharing as early as 1850 [1]. In a simple word, profit sharing programs give employees a portion of company's earnings [2]. Most companies which operate profit sharing scheme have one or more of the following objectives:

- To encourage employees to identify themselves more closely with the company by developing a common concern for its progress;
- To stimulate a greater interest among employees in the affairs of the company as a whole;
- To encourage better cooperation between management and employees;
- To recognize that employees of the company have a moral right to share in the profits they have helped to produce;
- To demonstrate in practical terms the goodwill of the company toward its employees;
- To reward success in businesses where profitability is cyclical [3].

Florkowski [4], Jones and Pliskin [5], Wadhwani and Wall [6], Shepard [7], Coyle Shapiro *et al*. [8] and Mangan and St-Onge [9] are some who examined the impacts of profit sharing. However, Hellriegel and Slocum [2] expressed that according to Hewitt Associate, more than one-third of the companies that use profit sharing do not track the results of such programs, while 28 percent indicate that profit sharing plans do not meet the objectives. One of the main affecting criteria on the success of profit sharing is its plan. Profit sharing plans differ in the proportion of profits shared with employees and in the distribution and form of payment [9]. There must be a clear measure that determines the basis for profit sharing.

The main purpose of this paper is to design a scheme for profit sharing in a chain store holding from Iran. This holding consists of 51 different stores across the country. Until now, the base for profit sharing was based on individual stores' profit. Indeed, every store participates in profit based on its profit proportion regard to holding's total profit. This method causes some problems in holding. Some stores work on difficult conditions while others have the advantages of location. Also the resources of stores are different. So, holding's managers seek an efficient way to correct their profit sharing pattern. This paper proposes an approach to determine a good policy toward profit sharing. First, a

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DEA model with categorical DMUs is used to determine the efficiency of different stores. In second stage, the profit sharing policy is determined based on obtained efficiency scores. This approach solves the problem of decision making based on one criterion, ignoring any attention to resources.

The rest of the paper is organized as follows. A brief overview of DEA model is presented in section 2. Section 3 describes the problem under consideration and considered variables for evaluation of DMUs. The profit sharing policy based on efficiency is explained in section 4. Section 5 illustrates the results of the approach and section 6 consists of conclusions and clue for future researches.

**Data Envelopment Analysis:** Data envelopment analysis is a nonparametric method to evaluate the relative efficiency of a group of homogenous units. Charnes, Cooper and Rhodes [10] firstly originated the data envelopment analysis in 1978 and presented the basic CCR model. Seiford [11] and Emrouznejad *et al*. [12] Surveys illustrated that thousands of projects and studies are done based on different DEA models in previous three decades after its emersion. The DEA model is used to evaluate the relative efficiency of a group of *n* congruent units (DMUs) which used *m* inputs to produce *s* outputs. A comprehensive review on the exploitation of basic CCR model and its economic concepts and its relation to production possibility set (PPS) presented by Cooper *et al*. [13]. The basic multiplier form of CCR model can be illustrated as follows:

$$Max\lozenge u^t y_0 \Big| v^t x_0 \copyright 1, u^t y_j \ \lceil v^t x_j \ \} \ 0, u^t, v^t \ \mu \ 0, \lesssim \tag{1}$$

where, there are $n$ DMUs under evaluation, $j = I,...n$. Every DMU used $m$-dimensional input vector $x_j = |x_{lj},...,x_{mj}|$ to produce an $s$-dimensional output vector $y_j = |y_{lj},...,y_{sj}$. The m-dimensional vector $u^t = [u_l,...,u_m]$ is the weight of input variables and the $s$-dimensional vector $v^t = [v_l,..., v_s]$ is the weight of output variables that applied to determine the relative efficiency of under evaluation's unit. DEA model is run for each DMU and determined the optimal values of $u_t$ and $v^t$ to measure the relative efficiency of units. There are many extensions that proposed to this initial model with different assumption.

There are some situations under which managers of organizations do not have total control. For instance, in evaluating the performance of a branch store of a supermarket, it is necessary to consider the sales environment of the store, including whether it has severe competition, is in a normal business situation, or in a relatively advantageous one. If the efficiency of the above supermarkets is evaluated as scratch players, the evaluation would be unfair to the stores in the highly competitive situation and would be too indulgent to the stores in the advantageous one. A hierarchical category is suitable for handling such situations. As for the supermarket example, stores can be classified in different group based on their competition status. So, for instance, if stores are classified in 3 categories, that category 1 faces with severe competition and category 3 being in mild status, then stores in category 1 are evaluated only within the category while stores in category 2 are evaluated with reference to categories 1 and 2 and stores in category 2 are evaluated with reference to all stores. This scheme is called "hierarchical category" [13].

**Problem Definition:** FITC is one the leading textile companies in Iran that delivers a different set of textile products and has a set of 41 stores across the country. More than 500 employees and a cash flow of 1 billion dollar make FITC a large company in its field. In recent years, managers of FITC decided to follow a profit sharing scenario for their stores and they seek a good pattern for profit sharing and determination of stores share in company's profit. A committee is formed consist of FITC's planning manager, financial manager and quality manager to solve this problem. Also, an academic advisor is joined to the team. After revision of different potential methods, the team considers this fact that several factors must be taken into account for this purpose. Therefore, data envelopment analysis is suggested by academic advisor. However, the different competition environment of stores across the country must be taken into account during the formulation process.

**Determination of Inputs and Outputs:** The first step in accomplishing every DEA study is to determine the set of input and output variables. In this course, the team members examine historical performance assessment procedure of ECSG and review some similar researches that apply DEA in chain stores. So, they identify the following variables:

- Inputs: (I1) Number of employee and (I2) annual budget;
- Outputs: Sale value (O1) and (O2) Properties cycle ratio.

Table 1: Stores' inputs and outputs data

| Category | Store | I1 | I2(×1000) | O1(×1000) | O2 | Score |
|---|---|---|---|---|---|---|
| A | 1 | 5 | 103,917,988 | 27,037,170 | 2.89 | 100.00% |
| | 2 | 3 | 29,438,498 | 1,961,759 | 4.40 | 100.00% |
| | 3 | 5 | 72,563,090 | 8,780,964 | 2.46 | 57.47% |
| | 4 | 2 | 345,845,115 | 24,901,084 | 2.68 | 100.00% |
| | 5 | 4 | 89,130,027 | 9,257,032 | 1.91 | 51.80% |
| | 6 | 3 | 70,901,014 | 5,784.687 | 1.40 | 31.36% |
| | 7 | 3 | 65,734,112 | 8,516,388 | 2.27 | 71.76% |
| | 8 | 5 | 132,809,012 | 11,798,785 | 3.54 | 57.64% |
| | 9 | 4 | 91,437,600 | 8,020,337 | 3.24 | 61.92% |
| | 10 | 4 | 410,893,247 | 32,418,175 | 1.00 | 87.34% |
| | 11 | 4 | 27,165,798 | 3,824,777 | 1.97 | 84.15% |
| | 12 | 3 | 47,520,734 | 7,035,636 | 2.80 | 83.74% |
| | 13 | 5 | 119,741,262 | 12,584,231 | 4.75 | 72.33% |
| | 14 | 2 | 75,526,119 | 9,761,130 | 3.02 | 100.00% |
| B | 15 | 3 | 35,121,963 | 20,479,758 | 4.14 | 100.00% |
| | 16 | 5 | 420,963,075 | 18,181,377 | 4.09 | 33.47% |
| | 17 | 5 | 109,723,011 | 18,061,618 | 2.65 | 40.57% |
| | 18 | 4 | 54,090,674 | 4,352,871 | 3.37 | 57.62% |
| | 19 | 5 | 120,212,679 | 10,033,253 | 3.89 | 39.51% |
| | 20 | 3 | 114,203,745 | 21,380,184 | 2.34 | 68.25% |
| | 21 | 5 | 203,891,594 | 22,399,664 | 1.68 | 42.23% |
| | 22 | 4 | 435,678,212 | 30,548,310 | 3.29 | 61.95% |
| | 23 | 4 | 51,834,907 | 6,709,689 | 3.03 | 52.60% |
| | 24 | 3 | 200,987,650 | 11,408,660 | 4.03 | 54.98% |
| | 25 | 4 | 311,569,434 | 26,178,805 | 3.42 | 55.14% |
| | 26 | 3 | 103,920,739 | 17,937,049 | 1.31 | 58.59% |
| | 27 | 5 | 21,980,518 | 13,963,911 | 2.73 | 100.00% |
| | 28 | 4 | 403,313,967 | 31,025,394 | 3.08 | 63.41% |
| | 29 | 3 | 13,525,792 | 1,714,823 | 3.00 | 100.00% |
| C | 30 | 3 | 490,246,934 | 52,619,908 | 3.55 | 77.97% |
| | 31 | 4 | 335,784,524 | 30,050,262 | 2.83 | 41.67% |
| | 32 | 4 | 247,913,580 | 18,616,663 | 4.55 | 38.82% |
| | 33 | 5 | 311,583,853 | 27,789,054 | 4.15 | 31.90% |
| | 34 | 4 | 315,764,395 | 29,219,854 | 3.35 | 40.77% |
| | 35 | 3 | 28,113,812 | 30,065,370 | 5.06 | 100.00% |
| | 36 | 5 | 25,992,263 | 2,225,776 | 5.08 | 92.58% |
| | 37 | 3 | 393,927,264 | 35,980,847 | 3.03 | 60.56% |
| | 38 | 4 | 407,953,011 | 44,369,907 | 3.75 | 60.43% |
| | 39 | 3 | 31,217,124 | 2,812,079 | 2.98 | 58.89% |
| | 40 | 4 | 79,919,111 | 9,995,711 | 4.46 | 66.11% |
| | 41 | 2 | 498,103,864 | 58,830,737 | 2.86 | 100.00% |

**Categorization of Stores:** As noted earlier, different stores of FITC work in different environment. The management of company classified its stores into 3 distinct categories based on population density in each stores area and the average income of the stores customers. Category A (12 Stores) includes stores in area with high average income. Stores in category B (15 Stores) lie in area with an average income, while category C (14 Stores) stores compete on areas which their customers average income are very low. Table 1 shows the information about inputs and outputs of different stores.

The DEA with hierarchical categorization is done as follows: first, the stores in category C are analyzed. Then, categories C and B stores' are aggregated and analyzed which determined the efficiency of stores in category B. finally, category A stores' efficiencies are determined by simultaneously considering all three categories A, B and C. these efficiencies are evaluated and shown in the last column of Table 2 under the title of "score".

**Profit Sharing Policy:** In this section a solution is developed to determine the profit share of a set of units

Table 2: Stores' profit share

| Category | Store | $x_{iC}$ | Category | Store | $x_{iB}$ |
|---|---|---|---|---|---|
| C | 1 | 181321.7 | B | 15 | 181321.7 |
| | 2 | 181321.7 | | 16 | 60688.37 |
| | 3 | 104205.6 | | 17 | 73562.21 |
| | 4 | 181321.7 | | 18 | 104477.6 |
| | 5 | 93924.64 | | 19 | 71640.2 |
| | 6 | 56862.48 | | 20 | 123752.1 |
| | 7 | 130116.4 | | 21 | 76572.15 |
| | 8 | 104513.8 | | 22 | 112328.8 |
| | 9 | 112274.4 | | 23 | 95375.21 |
| | 10 | 158366.4 | | 24 | 99690.67 |
| | 11 | 152582.2 | | 25 | 99980.78 |
| | 12 | 151838.8 | | 26 | 106236.4 |
| | 13 | 131150 | | 27 | 181321.7 |
| | 14 | 181321.7 | | 28 | 114976.1 |
| | | | | 29 | 181321.7 |
| A | 30 | 141376.5 | | | |
| | 31 | 75556.75 | | | |
| | 32 | 70389.08 | | | |
| | 33 | 57841.62 | | | |
| | 34 | 73924.85 | | | |
| | 35 | 181321.7 | | | |
| | 36 | 167867.6 | | | |
| | 37 | 109808.4 | | | |
| | 38 | 109572.7 | | | |
| | 39 | 106780.3 | | | |
| | 40 | 119871.8 | | | |
| | 41 | 181321.7 | | | |

based on their efficiency. Suppose that there are a set of $n$ DMUs, where are categorized in $k$ groups, where the number of DMUs in $j^{th}$ group is $k_j$. The profit value that is assigned to share is $P$.

Let $e_{ij}$, $i = 1,2,...,k$; $j = 1,2,...,k$ be the efficiency score of $i^{th}$ unit in category $j$. Also, $x_{ij}$, $i = 1,2,...k_i$; $j = 1,2,...,k$ is defined as the share of $i^{th}$ DMU in category $j$.

The profit sharing model's objective function is defined as follows:

$$Max \sum_{j=1}^{k}\sum_{i=1}^{k_j} e_{ij}x_{ij} \quad (2)$$

The model constraints are constructed as follows. First, the sum of all shared values must be smaller than $P$. In fact:

$$\sum_{j=1}^{k}\sum_{i=1}^{k_j} x_{ij} \leq P \quad (3)$$

Since the share of each DMU must be proportional to its efficiency, the following constraint is constructed for each DMU. It is required that each DMU at least has a share larger than its part in total efficiency, i.e.:

$$x_{ij} \geq \frac{e_{ij}}{\sum_{j=1}^{k}\sum_{i=1}^{k_j} e_{ij}} \sum_{j=1}^{k}\sum_{i=1}^{k_j} x_{ij} \quad (4)$$

On the other hand, the share of each DMU must not exceed from its part in total efficiency of its category, i.e.

$$x_{ij} \leq \frac{e_{ij}}{\sum_{i=1}^{k_j} e_{ij}} \sum_{j=1}^{k}\sum_{i=1}^{k_j} x_{ij} \quad (5)$$

Finally, the profit sharing model based on efficiency (PSM-E) is constructed as follows:

$$\begin{aligned} & Maximize \sum_{j=1}^{k}\sum_{i=1}^{k_j} e_{ij}x_{ij} \\ & S.T. \quad \sum_{j=1}^{k}\sum_{i=1}^{k_j} x_{ij} \leq P \\ & x_{ij} \geq \frac{e_{ij}}{\sum_{j=1}^{k}\sum_{i=1}^{k_j} e_{ij}} \sum_{j=1}^{k}\sum_{i=1}^{k_j} x_{ij}, \forall i,j \\ & x_{ij} \leq \frac{e_{ij}}{\sum_{i=1}^{k_j} e_{ij}} \sum_{j=1}^{k}\sum_{i=1}^{k_j} x_{ij}, \forall i,j \\ & x_{ij} \geq 0, i = 1,2,\dots,k_j; j = 1,2,\dots,k \end{aligned} \quad (6)$$

The model (6) has a unique optimal solution as follows:

$$x_{ij}^{*} = \frac{e_{ij}}{\sum_{i=1}^{k_j} e_{ij}} P, i = 1,2,\dots,k_j; j = 1,2,\dots,k \quad (7)$$

In fact, the most fair profit sharing pattern is to determine the share of each unit according to its share in total efficieny.

**Applying PSM-E in FITC Company:** In this section, the PSM-E model is applied for FITC. By designing and solving the model (5), the values of profit share for each store in each category is determined. These results are shown in Table 2. Here, there are 3 categories $j = A,B,C$ and for each category, the sum of its DMUs efficiency is as follows:

The company determined a profit of P = 5,000,000 to share between stores. Based on efficiency scores of stores in Table 1, the model (5) is designed and solved. Table 2 shows the result of PSM-E in FITC Company.

## CONCLUSION

Profit sharing is one the motivational policies that companies have used to encourage their employees to participate actively in company's tasks and to create an ownership feel which help in alignment of employees and organization's objectives. However, if employees feel that the profit sharing is not done fairly; its consequences might be destructive. To avoid such situation, it is better that the profit sharing be proportional to employees effort and their achievements. In this paper, a formal procedure is developed for profit sharing. To proportionate profit sharing with efforts and achievements, the proposed scheme is designed based on the DEA efficiency scores of a set of units. Then it is shown that the most satisfaction can be obtained by assigning profit shares based on efficiency of units. The proposed method is applied in a textile production and distribution company. The proposed model's results determine the profit share of each unit. This method can remove the limitations of current methods and frameworks in profit sharing and strength its positive results based on a logical and clear algorithm.

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