Performance Assessment of a Technology Company Using Decision Making Approach

Nazli Goker
Research Assistant
Faculty of Engineering and Technology
Galatasaray University, Istanbul, Turkey
nagoker@gsu.edu.tr

Mehtap Dursun
Associate Professor
Faculty of Engineering and Technology
Galatasaray University, Istanbul, Turkey
mdursun@gsu.edu.tr

Abstract

Performance management aligns individual aims with organizational aims. It is to obtain better organizational outcomes managing and understanding performance within an agreed framework of planned objectives, standards and requirements. The main elements of performance management are agreement, measurement, feedback, positive reinforcement and dialogue. The data envelopment analysis (DEA) model, also named as the CCR model, proposed by Charnes et al. (1978), computes the relative efficiency of a decision-making unit (DMU) by maximizing the ratio of its total weighted outputs to its total weighted inputs subject to the condition that the output to input ratio of every DMU be less than or equal to unity. However, conventional DEA model assigns unrealistic weights to the inputs and outputs to produce high efficiency score for the evaluated DMU and therefore the number of efficient DMUs can be quite high. To overcome that issue, common-weight DEA-based models are proposed by the scholars. In this study, performance evaluation of a technology company that performs in the retail sector is conducted and the results are analyzed.

Keywords
Data envelopment analysis, decision making, performance management, retail sector

1. Introduction
Performance management is to achieve better organizational outcomes by understanding and managing performance within an agreed framework of planned objectives, standards and requirements. This process exists to establish a common understanding of what needs to be done for the management and development in the short and long terms.

The main elements of performance management are agreement, measurement, feedback, positive reinforcement and dialogue. Performance management focuses on planning and improving future performance rather than a retrospective performance assessment. It operates as a continuous and evolving process, in which performance improves over time; and provides the basis for regular and frequent dialogues between managers and individuals on performance and development needs. It mainly concerns individual performance but can also apply to teams.

In the literature, it is seen that many studies on performance evaluation have been carried out. In recent years, personnel evaluation (Parades et al. 2019; He 2019), project performance evaluation (Brelih et al. 2019; Chatterjee 2018), evaluation of logistics service providers (Zarbakhshnia et al. 2018; Narkhede et al. 2017) supplier performance evaluation (Prashanth et al. 2020; Dos Santos and Godoy 2019; Liu et al. 2019) are at the forefront. Data envelopment analysis (Sun et al. 2020; Zhou et al. 2019; Zhu et al. 2019) and decision-making models were frequently used in performance studies (Li et al. 2020; Wu et al. 2019; Yang et al. 2019).

In this study, performance assessment of a technology company that performs in the retail sector is conducted. 12 stores in the same region and category are selected, and data envelopment analysis (DEA), which solves the decision-making problems that require considering multiple inputs and outputs to evaluate the efficiency scores of decision-making units, is employed for the evaluation. To overcome the inadequacy of discriminating power of DEA, common weight DEA-based models taken from the literature are employed for obtaining full ranking of DMUs. For that reason, two common weight models addressed in Jahanshahloo et al. (2010) and a model proposed in Toloo (2012) are solved and the ranking results are compared.

The rest of the study is organized as follows. In Section 2, data envelopment analysis is briefly explained. The case study is illustrated in Section 3. Finally, conclusions are given in the last section.

2. Data Envelopment Analysis

The original DEA model, also named as the CCR model, proposed by Charnes et al. (1978), computes the relative efficiency of a DMU by maximizing the ratio of its total weighted outputs to its total weighted inputs subject to the condition that the output to input ratio of every DMU be less than or equal to unity. The conventional DEA model can be represented as follows:

$$max\ E_{j0} = \frac{\sum_{r=1}^{s} u_r y_{rj0}}{\sum_{i=1}^{m} v_i x_{ij0}}$$

subject to, (1)

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \quad \forall j,$$

$$u_r, v_i \geq \varepsilon, \quad \forall r, i$$

where E_{J0} is the efficiency score of the evaluated DMU, u_r is the weight assigned to output *r*, v_i is the weight assigned to input *i*, y_{rj} is the quantity of output *r* generated and x_{ij} is the amount of input *i* consumed by DMU *j*, respectively, and ε is a small positive scalar.

Formulation (1) has nonlinear and nonconvex properties; however, it can be transformed into a linear programming model via a transformation. The linear programming model for calculating the relative efficiency of a DMU is given in the following set of equations.

$$E_{j0} = \sum_{r=1}^{s} u_r y_{rj0}$$

subject to, (2)

$$\sum_{i=1}^{m} v_i x_{ij0} = 1,$$

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geq 0,$$

$$u_r, v_i \geq \varepsilon, \quad \forall r, i$$

Traditional DEA – CCR Model has many positive properties in terms of efficiency measurement, however, it also has some limitations. One of the shortcomings of conventional DEA model is that it assigns unrealistic weights to the inputs and outputs to produce high efficiency score for the evaluated DMU and therefore the number of efficient

DMUs can be quite high. Throughout the literature, many new DEA-based models have been proposed in order to overcome these disadvantages. In this study, common weight DEA-based models addressed in Jahanshahloo et al. (2010) and Toloo (2012) are utilized to provide efficiency analysis in retail sector.

Jahanshahloo et al. (2010) proposed two mathematical programming models. First formulation aimed to minimize the sum of deviations from efficiency and obtain the common set of weights. Second formulation defined a special DMU and compares all the other DMUs with it and ranked them. First formulation is as follows:

$$\Delta^* = \sum_{j=1}^{n} \Delta_j$$

subject to (3)

$$\sum_{r=1}^{s} u_r \bar{y}_r - \sum_{i=1}^{m} v_i \bar{x}_i = 0, \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + \Delta_j = 0, \forall j, \Delta_j \geq 0, \forall j, u_r \geq \varepsilon > 0, \forall r, v_i \geq \varepsilon > 0, \forall i,$$

where Δ_j is the deviation from efficiency, $\bar{x}_i = \{x_{ij} | j = 1, \ldots, n\}$, i=1,2,…,m and $\bar{y}_r = \{y_{rj} | j = 1, \ldots, n\}$, r=1,2,…,s. Second, Jahanshahloo et al. (2010) developed the following formulation that provides comparison of the DMUs with respect to a special unit.

$$\Delta^* = \sum_{j=1}^{n} \Delta_j$$

subject to (4)

$$\sum_{r=1}^{s} y_{rj} u_r - \sum_{i=1}^{m} x_{ij} v_i + \Delta_j = 0, \forall j, \sum_{r=1}^{s} y_{rl} u_r - \sum_{i=1}^{m} x_{il} v_i = 0, \sum_{r=1}^{s} u_r + \sum_{i=1}^{m} v_i = 1, u_r \geq \varepsilon > 0, \forall r, v_i \geq \varepsilon > 0, \forall i,$$

$$\Delta_j \geq 0, \forall j,$$

where DMU$_l$=(X_l, Y_l) denotes the special DMU. The second model enables to compare the DMUs with respect to a special unit with the requirement of defining the special DMU.

Toloo (2012) extended a linear programming model and obtained the single best efficient DMU by providing the following mixed integer linear programming model for cases with multiple inputs and outputs.

$$z^* = d_{max}$$

subject to (5)

$$d_{max} - d_j \geq 0, \forall j, \sum_{i=1}^{m} v_i x_{ij} \leq 1\ \forall j, \sum_{r=1}^{n} u_r y_{rj} - u_0 - \sum_{i=1}^{m} v_i x_{ij} + d_j = 0\ \forall j, \sum_{j=1}^{n} \theta_j = n - 1 d_j \leq M\theta_j\ \forall j, \theta_j \leq N d_j\ \forall j, d_j \geq 0\ \forall j, \theta_j \in \{0,1\}\ \forall j, v_i, u_r \geq \varepsilon^*\ \forall i, r,$$

where $\varepsilon^* = \frac{1}{\{\sum_{j=1}^{m} x_{ij}, \forall j\}}$, M and N are large numbers, d_{max} is the maximum deviation from efficiency, and u_o is a free variable. The model guarantees to identify the single efficient DMU by solving one mixed integer linear programming model. However, the author guarantees to identify the single best efficient DMU by adding constraints that restrict to obtain more than one efficient DMU. In addition, introducing the binary variable θ_j, and the penalty values M and N are required to solve the model.

3. Case Study

In this work, performance assessment of a technology company that performs in the retail sector is provided. 12 different stores in the same region and category are selected as DMUs to apply DEA approach. Employee numbers, sales amounts, customer evaluation scores, turnovers, working hours and similar data are collected and the performance of stores are evaluated employing the models given in Section 2.

The input and output data are given in Table 1. Employee number, area of the store, and total premium are the inputs, whereas NPS, conversion rate, and total turnover are regarded as outputs. The results of the DEA methodologies are provided in Tables 2-5.

Table 1. Input and Output Data

Stores	**Inputs**			**Outputs**		
	Employee number	**Area of the store (m^2)**	**Total premium**	**NPS**	**Conversion rate**	**Total turnover**
1	60	3542	₺100697.33	52.13	0.12	₺1317523.58
2	32	1866	₺66934.26	51.38	0.06	₺9028861.46
3	41	3114	₺95236.95	51.01	0.07	₺10847285.92
4	43	2824	₺63058.25	51.92	0.15	₺12010550.56
5	29	2121	₺38450.87	49.27	0.10	₺7027468.57
6	27	2415	₺29992.94	58.26	0.09	₺5421230.97
7	34	2613	₺88856.25	60.52	0.14	₺7104473.45
8	31	2010	₺78222.24	49.60	0.24	₺7945112.71
9	31	2364	₺70617.73	60.08	0.13	₺7773632.54
10	18	1253	₺7618.37	48.14	0.10	₺4058008.19
11	37	3783	₺19876.83	51.63	0.16	₺7306513.52
12	24	2762	₺33944.39	50.49	0.10	₺5366156.74

Table 2. Results of CCR model

Stores	**CCR**	**CCR - Rank**
1	0.857420	10
2	1	1
3	0.937679	6
4	1	1
5	0.925862	7
6	0.858249	9
7	0.838657	12
8	1	1
9	0.975688	5
10	1	1
11	0.853643	11
12	0.915772	8

Table 3. Ranking results of Model (3) addressed in Jahanshahloo et al. (2010)

Stores	Jahanshahloo et al. (2010) Model(3)
1	10
2	2
3	6
4	4
5	7
6	9
7	12
8	3
9	5
10	1
11	11
12	8

Table 4. Ranking results of Model (4) addressed in Jahanshahloo et al. (2010)

Stores	Jahanshahloo et al. (2010) Model(4)
1	10
2	3
3	6
4	4
5	7
6	9
7	12
8	2
9	5
10	1
11	11
12	8

Table 5. Ranking results of Model (5) addressed in Toloo (2012)

Stores	Toloo (2012) Model(5)
1	12
2	6
3	4
4	1
5	9
6	5
7	3
8	8
9	2
10	11
11	7

12	10

According to the results of CCR model, stores 2, 4, 8, and 10 are efficient. Model (3) addressed in Jahanshahloo et al. (2010) ranks the DMUs that are efficient with regard to the CCR results, in other words, it ranks the units that CCR model does not able to discriminate. In addition, Model (4) addressed in Jahanshahloo et al. (2010) ranks the DMUs according to a special unit, which is selected as DMU_{10} in this study since that DMU is the best performing unit with regard the Model (3). On the other hand, DMU_4 is determined as the most efficient DMU according to the model proposed by Toloo (2012), followed by DMU_9 and DMU_7.

4. Conclusion

Customer needs vary daily in a globalizing environment because of the competition and rapid change. Companies' ability to survive in this complicated structure is dependent on their grasp of environmental changes and their ability to adjust to them. Employees' levels of knowledge and abilities, on the other hand, are rising, and they are expected to do more than just their duties; they are also expected to think and make decisions. The performance management system is regarded as one of the most significant management systems for achieving a company's objectives.

In this work, performance assessment of a technology company that performs in the retail sector is conducted. First classical CCR method is employed to determine the efficient stores. Employee number, area of the store and total premium are considered as inputs whereas NPS, conversion rate and total turnover are supposed as outputs of the model. CCR model dichotomized stores as efficient and inefficient but it did not provide full ranking of the stores. Common-weight DEA-based model introduced by Jahanshahloo et al. (2010) and Toloo (2012) are utilized for ranking the stores. Future research will focus on including qualitative data into the decision framework.

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Biography

Nazli Goker is a research assistant of Industrial Engineering at Galatasaray University, Turkey. She holds BS, MS, and PhD degrees in Industrial Engineering from Galatasaray University. Her areas of interest include DEA-based models and multi-criteria decision making with special focus on performance management. She has co-authored article that appeared in Applied Soft Computing, Soft Computing, Socio Economic Planning Sciences, Kybernetes, Technologic and Economic Development of Economy, and Social Indicators Research.

Mehtap Dursun is an associate professor of Industrial Engineering at Galatasaray University, Turkey. She holds BS, MS, and PhD degrees in Industrial Engineering from Galatasaray University. Her areas of interest include quality function deployment, fuzzy optimization, and multi-criteria decision making with special focus on waste management, personnel selection, and supplier selection. She has coauthored articles that appeared in Expert Systems with Applications, Resources Conservation and Recycling, International Journal of Production Research, Applied Mathematical Modelling, Computers & Industrial Engineering, Soft Computing, Socio Economic Planning Sciences, Kybernetes, and Social Indicators Research.

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