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Investigating the Effect of Price Adjustment in the Efficiency of Industrial Units using Data Envelopment Analysis Method

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Abstract: In the present research a method has been proposed to adjust price of products regarding the concept of efficiency in data envelopment analysis. For this, fifteen different types of tiles from different tiling factories have been considered as decision making units. Further, BCC input oriented model has been used to calculate efficiency of units in which the price of each product has been considered as the input and four indices of water absorption, bending strength, abrasion resistance and breaking strength have been considered as the output of data envelopment analysis model. The obtained results indicate that some countries after price adjustment have faced reduction in efficiency which this is due to change in quality of products. Yet, in some others, the price adjustment has not led to reduction in efficiency of product. These results assist the purchasers to select the most suitable company to purchase their product in case of price adjustment.

Key words: Data envelopment analysis, efficiency, price adjustment, performance assessment, purchase

INTRODUCTION

Setting the price is a very controversial and complex issue in industrial marketing. If a company and the managers seek to get successful in their market they should have a deep understanding of nature of competitor's activity and their competitive strategy. The problems that are facing the companies include the development of the organization, creation of a new product, prediction of markets, development of lasting relationships with customers, cost control, quality, etc. and the manager is required having a strategic outlook and applicable program. Price is the benefit paid by the consumer to have the benefits of having or using the product (Ghahramanzadeh *et al*., 2015). The process of setting the price to sale and purchase orders either manually or automatically is called pricing. Providing better products than other competitors and using proper steps in selecting the strategy to achieve the optimum position against competitors are considered as the most important principles to achieve profitability in the business model. Thus, a firm should be able to price its products in a way to gain the earnings commensurate with the value provided to the customer and thus maintain its position towards customers, complementary products, competitors and potential new entrants. Pricing is the most important component of the business model and decisions on it put a great impact on the profitability of the firm. Pricing refers to an activity which should be repeated, found as a constant process (Bastani and Damircheli, 2016). This continuity derives from the environmental changes and instability of conditions at market which raise the price adjustment. It is argued that pricing has turned to a creative practice in mathematics and behavioral economics and the companies should focus on their earnings (Molaei *et al*., 2012). Planning for setting price has turned to one of the issues which has been less likely taken into account in industrial marketing. Traditionally, before any attention to pricing, emphasis has been on product development, advertising strategy and distribution channel, resulted in setting price regardless of cost factors which affect the final decisions. Development and creation of a price planning requires for a company to have specified achievable and executive goals and/or a proper performance method and/or an operating strategy and ultimately the monitoring and control methods on process of production of products. programs is coordinated with other activities involved in determining the market price which includes an analysis of market opportunities, research and selection of the final market, marketing and organizing strategy design. Yet, design of a program to set price is not always simple (Khani and Farahani, 2008). With regard to significance of price in efficiency of product, it requires measuring effect of this key parameter on other parameters related to the

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product. In the meantime, numerous studies on measurement of efficiency of product have been conducted. The research by Gonzalez *et al.* (2013) has been mentioned as the most important research. In this research and the same research, an attempt has been made to include the input indices with the initial cases and parts to produce products and to include the output indices with price and quality of product. Yet, price as a key factor puts a special effect on other parameters of product. Thus, efficiency of end product is highly dependent on the performance of the product (Gonzalez *et al.*, 2013). Thus, the ultimae aim of this research is to measure the efficiency of product based on price adjustment. in this research, effect of price adjustment on quality of end product is examined. As a result, it can measure, examine and analyze efficiency of product based on different prices of that product for this, data envelopment analysis will be used. data envelopment analysis refers to one of the most common methods to measure efficiency of decision making units. In this technique, after selecting type of envelopment analysis method, the input and output values are determined (Dehghan and Bastani, 2017). Then efficiency of decision making unit is specified by solving the mathematical model of the selected method. Thus, in this research, effect of price adjustment and off-sale on increase of efficiency at industrial units has been examined using data envelopment analysis. Further, to display the applicability of this issue, the proposed method in this research will be implemented in the tile industry. Many researchers have conducted research on price and pricing and reached to major conclusions such as development of suitable pricing program, creative pricing strategy, acquisition of maximum earnings and so forth; the present research by considering the results above seek to the results for price adjustment and increase of efficiency (Bastani *et al.*, 2013).

Data envelopment analysis: Measurement of efficiency due to its significance in evaluation of performance of a company or organization has been taken into consideration by researchers. There have been many objections to the parametric method so in 1957, Farrell presented non-parametric methods in which Farrell has measured efficiency for a manufacturing unit using a method such as measurement of efficiency in engineering issues. The case considered by Farrell to measure efficiency included an input and an output (Goharshenasan *et al.*, 2016). Charnes *et al.* (1978) developed Farrell's view and presented a model to measure efficiency with several inputs and several outputs. this model was called with data envelopment analysis (Horta *et al.*, 2013). Data envelopment analysis refers to a technique to calcualte relative efficiency of a series of decision making units which are made using mathematical programming. The term "relative" is used for the reason that efficiency is the result from comparison of units with each other. When we say that an efficient decision-making unit the unit works well and uses resources well. When we say a decision making unit is efficient, it means that it works out proper and uses resources properly. Using data envelopment analysis, a border or pattern (a comparison base) of decision making units with the best performance is made and then efficiency of the considered units to that border is measured. Data envelopment analysis examines performance of n units by making and solving n models. In this method a virtual unit with highest efficiency is made and the ineffiicent units are measured with it (Karray, 2015). Since, in this research, input-orineted BCC Model presented by Banker *et al.* (1984) is used this model has been introduced in following. Assume there are "n" decision making units which j th unit consumes m inputs ($x_j = (x_{1j}, x_{2j}, \ldots, x_{mj})$) to produce s outputs ($y_j = (y_{1j}, y_{2j}, \ldots, y_{mj})$). In this state, input-oriented BCC Model to evaluate DMU_O is as follow:

$$\text{Max } \theta = \sum_{i=1}^{m} v_i x_{io} + \varepsilon$$

s.t:

$$\sum_{i=1}^{m} v_i x_{io} + \varepsilon = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + \varepsilon \le 0, \ j = 1, 2, \ldots, n \qquad (1)$$

$$u_r \ge 0, \ r = 1, 2, \ldots, s$$

$$v_i \ge 0, \ r = 1, 2, \ldots, m$$

If optimal value of objective function in Model 1 equals to 1, DMU_O is efficient, otherwise, it is inefficient.

MATERIALS AND METHODS

In this study, the main method on price adjustment is introduced using data envelopment analysis. For this, after determining decision making units the inputs and outputs the efficiency of DMUs before and after price adjustment is calculated. As explained in next sections, the price will be considered as the only input. Thus, by comparing the main price of product, discounted price and the proposed price from DEA Model before and after discount, four price indices are obtained for each unit which one of those four price prices can be selected as the most suitable price for the unit under evaluation by considering the change or lack of change in efficiency of each DMU, so that, price of each unit has to have the highest proportionality with its efficiency. In addition, with regard to optimal responses and optimal values from solving Model 1, it can define indices of improvement in competition, distributor's commercial efforts and commercial efforts by competition intensifier in a relative way and use them in analysis of results for price adjustment. In next sections, the method presented in this section is explained for price adjustment in a practical example in detail.

Selection of data and variables for performance evaluation: To evaluate and measure efficiency of units under study regarding model of data envelopment analysis, it requires selecting the suitable standards to put them as inputs and outputs in the model so as to make a precise measurement of the performance of factories. For this, numerous studies have been conducted and ultimately five criteria have been selected for measurement regarding related works and theses as well as previous research and field studies and polling experts at this industry. One case has been considered as input and four cases have been considered as output and these criteria are as follows:

Input variable; price: Since, price is considered as a negative criterion in evaluation and increase of price by fixed input and output results in decrease of efficiency, the factor of price was considered as input.

Output variables: Water absorption, bending strength, abrasion resistance and breaking strength. It should take this point into consideration that four above criteria are recognized as the positive indices for a type of tile, thus increase in each of them by fixed inputs and outputs causes increase in efficiency thus these criteria are considered as output: water absorption, bending strength, abrasion resistance and breaking strength. In following, these indices are explained.

Water absorption: This is displayed with letter 'E' which meant percent of absorbed water to the initial mass based on standard 3994 Islamic Republic of Iran. The lesser this index, the quality of product will be higher. The variable "water absorption" is displayed with y_1. Water absorption indicates the amount of porosity in a tile which the more porosity, the strength of tile will increase. The higher baking temperature and the higher press pressure, the porosity will decrease. The water absorption of kitchen wall tiles, floor tile, Porcelain tile, granite tiles is about 17-21%, 5-7%, under 0.5% and under 0.1%, respectively.

Abrasion resistance: Abrasion of a solid surface has caused by contact with another surface. This process occurs as the result of mechanical contact of two surfaces with each other. Abrasion resistance is made via EN154 test method, based on ISO10545-7 standard. Destruction of tile from the floor surface is examined based on the factors such as light, temperature and pressure. The more value of this index, the higher quality displays higher quality of product. The variable abrasion resistance is displayed with y3. This variable is used to specify the resistance of unglazed tiles. This quantity is usually expressed with cubic millimeter (mm^3) that represented "volume" isolated from pieces "under normal conditions". It can determine abrasion resistance of glazed tiles by rotating the "abrasive load" on the tile surface and view the abrasion raised on it as compared abraded and non-abraded samples. After abrasion on the glaze surface by device the glaze surface has been examined and no particular problem had been raised for it.

Bending resistance: Bending resistance is measured via devices for the bending strength. This index indicates the ability of tile to tile against lateral forces to the surface of tile in such a way that the forces try to change the appearance of tile. The variable of bending resistance is displayed with y2. To calculate this index, unit is used. To determine bending strength and failure of the tiles, device for the bending strength meter is used in this state, after measuring the parameters of dimensions and thickness of tile, the tile is put into the device and the tile is placed under compressive force and broken in a specified force by moving the actuator where by the required force will be specified for failure of tile as well as bending strength.

Failure force: This equals to minimum force which collapse of the molecular structure of the tile. This index is made at respective laboratory using the destructive tests on various tile samples. The variable of failure force is displayed with y4. The test method is in this way that the sample tiles are put into an autoclave at pressure 500 kPa and temperature of 159°C and put 2 h at this pressure and then the temperature is diminished and examined after cooling tiles. Using methylene blue and under 300 LX light, surface of samples is examined in terms of hairline cracks. Finally the surface of tile has been tested with methylene blue and no particular problem should be created in the glazed surface.

Table 1: The information on output of factories

Name of factory (tile) (%)	Output of water absorption	Output of bending strength	Output of abrasion resistance	Output of breaking strength
Mahceram	0.5	45	205	2500
Marjan	2.0	29	205	2000
Nain	0.5	38	180	1700
Firouzeh	3.0	26	190	1800
Hafez	0.5	39	175	1650
Saadi	3.0	40	170	1600
Nilu	3.0	27	165	1550
Nafis	3.0	40	115	1300
Esfehan	3.0	22	120	1350
Aras	4.0	30	110	1200
Pasargad	5.0	22	105	1000
Everst	3.0	22	110	1000
Khatereh	6.0	25	90	950
Noavaran	10.0	25	80	750
Eram	10.0	32	75	700

Table 2: The information on inputs of factories

DMU tile manufacturer	Base price P_o	Adjusted price p_d
Mahceram	28000	26350
Marjan	22000	20350
Nain	20000	18350
Firouzeh	20000	18350
Hafez	19000	17000
Saadi	17500	15850
Nilu	16500	14900
Nafis	14500	12850
Esfehan	14500	12900
Aras	14000	12300
Pasargad	12000	10200
Everst	11500	9800
Khatereh	11000	9300
Noavaran	9500	7600
Eram	9000	7000

Data collection for the criteria: To collect data on the considered criteria the annual reports and documents of factories were used. The data on output of decision making units have been represented in Table 1. It should take this point into consideration that that name of factory has been used instead of name of the tile produced in those factors in Table 1. For instance, the name "Mahceram" 50×50 cm tiles has been mentioned instead of Mahceram.

Further, the input variable which is price and divided into two parts of base and adjusted price has been represented in Table 2.

Calculate efficiency of DMUs using DEA: At this stage a variety of tiles using DEA are evaluated. As explained, price (P_j) has been considered as input and water absorption, bending strength, abrasion resistance and breaking strength have been considered as outputs. Thus, Model 1 is written as follow to evaluate DMU_o:

$$\text{Max } \theta = \sum_{r=1}^{s} u_r y_{ro} + \varepsilon$$

s.t.:

$$v_o P_o = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - v_o P_j + \varepsilon \leq 0, \; j = 1, \ldots, n \quad (2)$$

$$u_r \geq 0, \; r = 1, 2, \ldots, s$$

$$v_o \geq 0$$

If the efficiency size from Model 2 are displayed with symbols θ_o and θ_d, provided that base price and adjusted price are considered as inputs. Improvement of competition is obtained from θ_d/θ_o. In addition, optimal Price (P_o^F) from Model 2 is calculated as: $p_o \times \theta_o$ where p_o and θ_o represent initial price and efficiency level based on base price. Further, p_d^F is called the adjusted optimal price from Model 2 and obtained from $p_d \times \theta_d$ where p_d and θ_d represent adjusted price and efficiency level based on adjusted price. Further, the distributor's business efforts are obtained from p_o/p_d and commercial efforts by competition intensifier is obtained from p_o^F/p_d^F regarding the definitions above. With regard to the results for each of factors introduced before, it can evaluate the discount given to each type of tile.

RESULTS AND DISCUSSION

Results from performing the model: After determining input and output and the used model we take step to calculate efficiency of a variety of tiles produced by various companies as decision making units for base and adjusted price. These results together with Competitiveness Improvement (CI) have been displayed in Table 3.

Since, there is an input-oriented model for efficiency evaluation, efficiency of all decision making units has to be under or equal to 1 and any unit with efficiency (1) is recognized as efficient tile and any unit with efficiency under 1 is recognized as inefficient decision making unit. Competitiveness Improvement (CI) has been represented in Table 1 which equals to 1 in 10 cases, under 1 in 4 cases and more then 1 in 1 case. Indeed as explained, if the seller's discounts move the model towards the boundary of the best purchase, Competitiveness Improvement (CI) will be more then 1 indicating competitiveness improvement in the efficiency of product at distribution stage. On the other hand, if Competitiveness Improvement (CI) be under 1, then the seller's discounts will not be sufficient to maintain the model's competitive demand at market, caused emergence of competitive collapse. Firouz tile has Competitiveness Improvement (CI) under 1, thus, it has not competitive improvement. This factory should change the adjusted price p_d to p_d^F so as to have the efficiency (θ_d) equal to 1, thus, competitive improvement equaled to 1, thereby Esfahan aras and

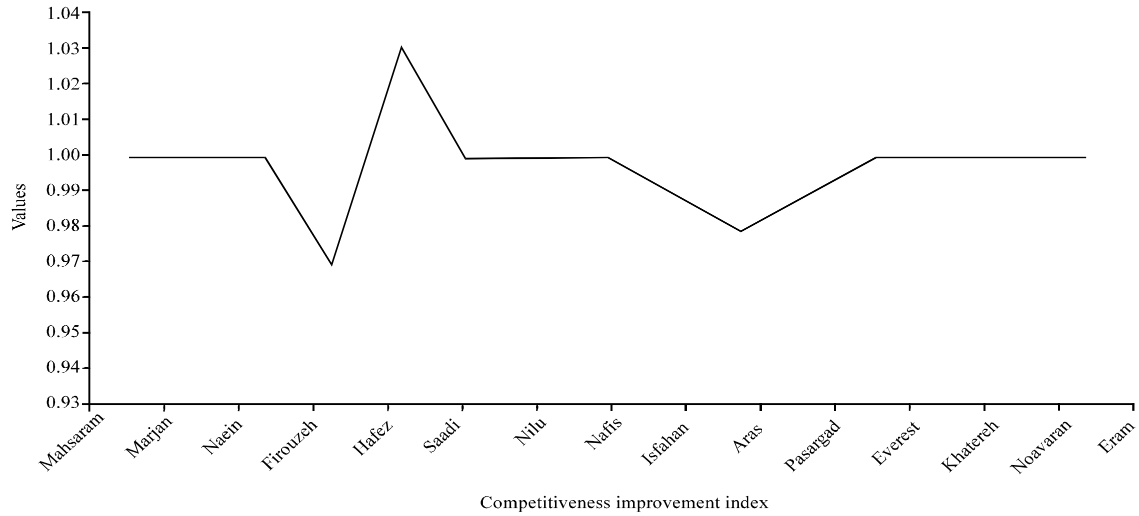

Fig. 1: Competitiveness improvement for 15 factors

Table 3: Base efficiency, adjusted efficiency and competitiveness improvement

Rows	Name of factory (tile)	Base efficiency (θ_o)	Adjusted efficiency (θ_o)	CI = θ_d/θ_o
1	Mahceram	1.00	1.00	1.000
2	Marjan	1.00	1.00	1.000
3	Nain	0.96	0.96	1.000
4	Firouzeh	1.00	0.97	0.970
5	Hafez	0.96	0.99	1.0313
6	Saadi	1.00	1.00	1.000
7	Nilu	1.00	1.00	1.000
8	Nafis	1.00	1.00	1.000
9	Esfehan	1.00	0.99	0.990
10	Aras	0.95	0.93	0.9789
11	Pasargad	0.96	0.95	0.9896
12	Everst	1.00	1.00	1.000
13	Khatereh	1.00	1.00	1.000
14	Noavaran	1.00	1.00	1.000
15	Eram	1.00	1.00	1.000

Pasargad should apply the same changes. On the other hand, however, Hafez factory has the value under 1 in two states θ_o and θ_d, it is inefficient but competitive improvement equals to 1.03 and above 1, indicated proper price adjustment. However, if this factory uses the price adjustment (p_d^F) instead of p_d, there will be θ_o with increase in competitive improvement. The competitiveness improvement has been drawn for 15 factors in Fig. 1.

In addition, base and adjusted prices as well as the optimal base and adjusted prices regarding the model have been introduced in Table 4.

Where p_o and p_d represent base and adjusted prices. It should take this point into account that p_o^F differs from p_o in 4 cases. Further p_d^F is less than p_d price in 6 cases. Ultimately, two indices of Commercial Efforts of distributor (CE) and commercial efforts by Competition Intensifier (IC) for these tile factories have been displayed in Table 5.

Table 4: Optimal base and adjusted prices

Factories	p_o	p_o^F	p_d	p^F_d
Mahceram	28000	28000	26350	26350
Marjan	22000	22000	20350	20350
Nain	20000	19200	18350	17616
Firouzeh	20000	20000	18350	5/17799
Hafez	19000	18240	17000	16830
Saadi	17500	17500	15850	15850
Nilu	16500	16500	14900	14900
Nafis	14500	14500	12850	12850
Esfehan	14500	14500	12900	12771
Aras	14000	13300	12300	11439
Pasargad	12000	11520	10200	9690
Everst	11500	11500	9800	9800
Khatereh	11000	11000	9300	9300
Noavaran	9500	9500	7600	7600
Eram	9000	9000	7000	7000

Table 5: Two indices of Commercial Efforts of distributor (CE) and commercial efforts by Competition Intensifier (IC)

Factories	CE = p_o/p_d	IC = p_o^F/p_d^F
Mahceram	1/062619	1/062619
Marjan	1/081081	1/081081
Nain	089918/1	089918/1
Firouzeh	1/089918	1/123627
Hafez	1176447/1	083778/1
Saadi	1/104101	1/104101
Nilu	1/107383	1/107383
Nafis	1/128405	1/128405
Esfehan	1/124031	1/135385
Aras	138211/1	162689/1
Pasargad	1764705/1	188854/1
Everst	1/173469	1/173469
Khatereh	1/182796	1/182796
Noavaran	1/25	1/25
Eram	1/285714	1/285714

As explained, CE index compares the official price with discounted price of tile. The larger discount compared to official price, CE index will be larger. It should take this point into consideration that Eram tile has the highest CE and Nain tile has the least CE. IC index compares the discounted objective price with official objective price which the larger IC will be more desirable.

CONCLUSION

Pricing decisions on industrial products are the main element at any commercial program with a direct influence on marketing strategy of the company. Simply, pricing means to determine the price for service or good; pricing refers to an activity which should keep repeating, considered as a constant process. This continuity is due to the environmental changes and instability at conditions undergoing market which raise the necessity for price adjustment. Pricing is made aiming at maximizing earnings, increasing market share, quality management, continuity of life and/or increase of market price. Managers are required considering the pricing as a strategic stage rather than an instant decision. Lack of a suitable pricing strategy can lead to fewer sales, loss of customer, less market share and earnings reduction. To have a suitable strategy and to access greater earnings, the cultural change within organization is required. Now a days, the necessity to set a suitable price has been recognized as a strategic program for the managers.

SUGGESTIONS

To evaluate the research model, the definite process was used in data envelopment analysis. In future researches, it can develop the model space and use at fuzzy environments. For instance, other methods such as fuzzy data envelopment analysis method can be used in analysis of the same models.

This method can be used in another statistical population such as refineries, various bank branches and so on which can be examined as the subject of another research.

The studies entitled "study on the relationship between price adjustment and other variables such as customer satisfaction, profitability, creativity, innovation and so on" should be conducted.

It is suggested to represent a mathematical model to examine efficiency of products based on price adjustment in a research and introduce this model as the specific model on efficiency analysis.

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