Assessing the Competitive Ability of companies listed on the Tehran stock exchange based on Cross Efficiency Model and its Relationship with Cost of Equity

Avaliação da capacidade competitiva das empresas listadas na bolsa de valores de Teerã com base no modelo de eficiência cruzada e sua relação com o custo do patrimônio líquido

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ABSTRACT

This study aimed to evaluate the relationship between competitiveness score and cost of equity. To this end, efficiency scores of companies were measured based on competitiveness using a cross efficiency model in data envelopment analysis (DEA), and its relationship with the cost of equity was examined using a multivariate regression model for 19 pharmaceutical companies listed on the Tehran Stock Exchange during the years 2015 to 2019. The investigation of the subject was carried out in two stages. In the first stage, assessment of competitiveness and obtaining the competitiveness efficiency score of companies were addressed using the mathematical model presented in this study, which was a secondary goal in cross efficiency. Moreover, the cost of equity was calculated using the Gordon model. In the second stage, statistical techniques were exploited to evaluate the competitiveness efficiency score and the cost of equity. The results achieved from the research indicated that there is a significant positive correlation between the variables of companies' efficiency scores based on competitiveness and cost of equity. This means that cost of equity and dividends will also increase by increasing competitiveness, which causes an increase in the external financing of companies.

Keywords: assessment of competitiveness; cross-efficiency; Data Envelopment Analysis (DEA); cost of equity; pharmaceutical companies.

RESUMO

Este estudo teve como objetivo avaliar a relação entre o escore de competitividade e o custo de capital próprio. Para tanto, os escores de eficiência das empresas foram medidos com base na competitividade por meio de um modelo de eficiência cruzada em análise envoltória de dados (DEA), e sua relação com o custo do capital próprio foi examinada por meio de um modelo de regressão multivariada para 19 empresas farmacêuticas listadas na Bolsa de Valores de Teerã, no período entre os anos de 2015 a 2019. A investigação sobre o assunto foi realizada em duas etapas. Na primeira etapa, a avaliação da competitividade e a obtenção do escore de eficiência de competitividade das empresas foram abordadas por meio do modelo matemático apresentado neste estudo, o que era um objetivo secundário na eficiência cruzada. Além disso, o custo de capital próprio foi calculado usando o modelo de Gordon. Na segunda etapa, foram exploradas técnicas estatísticas para avaliar o escore de eficiência de competitividade e o custo de capital próprio. Os resultados obtidos na pesquisa indicaram que existe uma correlação positiva significativa entre as variáveis dos escores de eficiência das empresas com base na competitividade e no custo de capital próprio. Isso significa que o custo do capital próprio e dos dividendos também aumentará com o aumento da competitividade, o que acarreta um aumento no financiamento externo das empresas.

Palavras-chave: avaliação de competitividade; eficiência cruzada; Análise Envoltória de Dados (AED); custo de capital próprio; empresas farmacêuticas.

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1 INTRODUCTION

The cost of capital plays an essential role in financing decisions. In order to determine the financial resources, the management of the company must identify the expenses of financing and specify the factors affecting it. Capital cost is regarded as a measure of performance in the economic value added (EVA) model. The cost of capital has other applications and is employed as a criterion for the acceptance of new investment projects and discount rates to calculate market value added (MVA) (Gupta, 2016). Moreover, the cost of equity is one of the fundamental concepts in the field of finance literature, which has a major role in financing and investment decisions. In order to determine the appropriate financial resources, the management of the company must pay attention to the cost of equity. Since the cost of equity is based on the rate of return expected by investors and is linked to the amount of risk accepted by them and because the bulk of the non-operating expense imposed on the company is financing costs, the conversion of operating profit into a loss due to the continuous activities of the company results from the imposition of this type of costs (Verdi, 2006). The cost of equity primarily reflects the interests of the original owners in a business institution. The cost of equity is the return that the investor takes into account on his investment in the company and is largely exploited in the mere estimation of the investment risk and assessment of investment projects. Empirical research such as Sharma (2010) demonstrated that the competitiveness of the product market is among the critical factors affecting the stock returns.

In the opinion of Sarkar (2013), as the company's ability in the competitive market increases, then this will affect decisions regarding capital structure, including the cost of capital. Competitiveness is equivalent to the economic power of a unit against its competitors in a market where goods, services, skills, and ideas are easily offered across geographical boundaries. Barecly, Holderness and Sheelan (2006) introduced a framework consisting of three elements of competitive performance, competitive potential, and management processes called the performance process asset approach to assessing the competitiveness of an enterprise. However, some experts also consider competitiveness to depend on the competitiveness of the firm. This T approach is a resource-based or capability-based approach. They emphasized the role of internal factors of the organization on its competitiveness (Towit, & Mendelson, 2013). Porter (1990) on the other hand, considers the competitiveness of a firm to be more influenced by the firm's position in the market. This approach is also called the market-based approach. But Schumpeter (1950) and von Bern (1999) employed the discussions associated with knowledge for the assessment of competitiveness. This is also called the knowledge-based approach (McGuane, & Zhou, 2016).

In this study, the competitiveness assessment of pharmaceutical companies listed on the Tehran Stock Exchange will be discussed using mathematical models. With regard to the importance of equity costs for investors' decisions, after calculating the efficiency score of companies based on competitiveness using a cross-efficiency model, its relationship with the cost of equity will be paid.

2 THEMATIC LITERATURE RESEARCH

2.1 Competitive Ability

Based on the views of Hitt (1995), competitiveness is the amount of producing goods and services that can enter the international markets by a country while simultaneously increase the real income of its citizens and at least prevent to reduce it. Siggel & Cockburn (1995) consider competitive ability as a condition that enables a firm to offer their products with higher quality by employing superior methods and provide more profits for firms in competition with rivals (Siggel, 2000). Indeed, the competitiveness is efforts and activities of a firm for profitable sales of its products. In other words, if a firm could have a competitive ability, it should supply its products with lower prices and higher quality. In 1993, Siggel in an article addressed the theoretical study of international competitiveness and provided a framework to assess competitiveness and its constituent resources through economic and mathematical relations. In 1995, in collaboration with Cockburn, he presented two papers. They addressed different aspects of competitiveness in one of these articles. In another article, they provided indicators for competitive ability and thoroughly explained their resources. In 1997, they employed their method for assessing the competitiveness of industries in Mali against the industries in Ivory Coast, which is the main rival of Mali. In 1999, they employed the same approach in the form of a research project to study the competitiveness of industries in Uganda and Kenya to the country joining regional and international associations and calculated indicators of competitiveness for the industry of the two countries. In 2000, Siggel applied his method for India with a slight modification through which he evaluated the effect of economic policies of the country on the competitiveness of industries. Furthermore, researchers such as Gaspar & Massa (2006), Pepall, Richards and Norman (2008), Choua, Ng, Sibilkov, Qinghai et al. (2011), and Leventis and Weetman (2011) take into account one of three ratios: one minus the cost ratio of goods sold to sales, one minus the ratio of fixed assets to total assets, and the ratio of sales of each company to the total sales of the industry as indicators of competitiveness.

2.2 Cost of Equity

Cost of equity is the minimum rate of return required by investors in order to finance the company, which relies on the assumption that the company aims to maximize shareholder wealth. If a connection is established between the cost of equity and maximization of shareholder wealth, with the assumption of a fixed value of other variables, one can say that the cost of equity is the minimum rate of return that would maintain the value of companies (Munteanu, 2011). Each company has its own risk and return. Each group of investors (bondholders, common stock, and preferred stock) want to measure the rate of return that is commensurate with the risk. Estimating the cost of equity is among the major matters associated with investment decisions, which are used by firms and stakeholders to evaluate and assess investment opportunities, especially when the cost of equity represents the return rates expected by investors. In previous studies, many researchers employed the capital asset pricing model (CAPM) to calculate the cost of equity (Chen, 2013). The basis for the development of this model was named by Harry Markowitz (1959) and Tobin (1958). Then, Sharpe (1964), Lintner (1964), and Black (1972) were among the persons who have attempted to use the theory of Markowitz for the pricing mechanism of market securities effectively. This is a one-factor model, which was tested repeatedly and the latest amendments on this model were applied; however, the use of the CAPM model was not free of criticism in spite of the development and widespread (Chen, 2013). Fama & French (2013) found ambiguities and inaccuracies in assessing the cost of equity on the basis of the CAPM model. They indicated that these ambiguities are because of the difficulty in identifying the correct model, ambiguity caused by assessing the susceptibility of factors that cause their differentiation over time, as well as the evaluation of the risk premium. Fama & French model has more explanatory power. Later, Carhart in 1997 offered a four-factor model by adding a new variable to Fama & French three-factor model as a momentum, which had better performance relative to the Fama & French three-factor model. Eventually, with the development of their three-factor model to five-factor model, Fama & French attempted to increase the explanatory power of their model (Fama & French, 2013, Fama & French 2015).

2.3 Competitive Ability and Cost of Capital

Zhang (2005) studied the competitive behavior of companies and capital structure. They revealed that equity financing has a direct relationship with companies' competitiveness. They considered the issue due to shareholders' expectations and pressure on managers to achieve their expected profits, which is a stimulus to improve competition in the product market.

Aggarwal & Kyaw (2010), in examining the relationship between capital structure in multinational corporations, found that as the activity and competitiveness of companies abroad increase, they use less debt in the capital structure compared to companies operating in the country. Sharma (2010) studied the impact of product competition structure in the market with stock returns. The results of this study represented that firms in centralized industries earn lower returns. Meanwhile, companies with high substitution ability of goods earn higher returns compared to companies with less substitution ability. Jiang, Kim, Nofsinger & Zhu (2015), in a study, investigated the relationship between product market competition and investment in companies using a sample of Chinese manufacturing companies from 1999 to 2010. The achieved results indicate a positive relationship between competition and investment. Besides, it was found that high investment is under the influence of high competition. On the basis of the investigations conducted in this survey, the impact of market competitiveness on the cost of equity of pharmaceutical companies listed on the stock exchange in Iran is explored. In accordance with the definition of equity cost, i.e., the rate of return expected by investors, dividends among investors and consequently the cost of equity seem to be increased by increasing the efficiency of companies based on competitiveness.

2.4 Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) is a nonparametric method to evaluate relative efficiency for a number of decision-making units (DMUs). The method does not need to estimate the production function for measuring the efficiency (Liu, Lin, & Shu, 2017). Charnes, Cooper & Rhodes proposed this method for the first time in 1978. Before that, Farrell in 1957 initially raised estimation of efficiency with non-parametric methods. A sample considered by Farrell to evaluate the efficiency contained an input of an output. After that, in 1978, Charnes, Cooper & Rhodes developed Farrell perspective and offered a fractional and nonlinear programming model. This model has the ability to measure the efficiency with multiple inputs and outputs. This model was named DEA or CCR model (Charnes et al., 1978). By changing the model, in 1984, Banker, Charnes & Cooper proposed a new model that became known as BCC, which was capable of measuring the efficiency in the mode of varying return to scale. However, the nature of self-evaluation in the DEA (evaluation at best) is criticized a lot. That's why cross efficiency evaluation method was introduced in DEA. In this method, we calculate the efficiency of other units using the weights obtained from the evaluation of DMU_j (j=1,…,n), and form a matrix known as the cross efficiency matrix. Ultimately, we will pay the rating of DMUs by obtaining the cross-efficiency index from this matrix (Sexton, Silkman, Hogan, 1986).Because the basic DEA models have multiple optimal solutions, the cross-efficiency matrix gained from it varies concerning the type of software exploited. This lack of uniqueness of the cross-efficiency matrix was the first problem with the cross-efficiency method. In order to overcome the problem, models with secondary goals were presented. For example, Duel and Green (1994) for the first time presented optimistic and pessimistic secondary models with respect to the maximization and minimization of the efficiency of other DMUs, respectively. Moreover, Liang, Wu, Cook and Zhu (2008) presented other models for secondary goals by the concepts of deviation from efficiency. Moeini, Karimi and Khorram (2015) suggested a multi-objective model for secondary goals and turned it into a linear programming model using multi-objective methods. In addition to the above-listed approaches, other models have been proposed for secondary goals in cross-efficiency (Moeini et al., 2015, Davtalab Olyaie, 2019).

3 METHODOLOGY

This is a descriptive survey study with a practical nature and is cross-sectional research in terms of time. In this study, a survey method will be exploited to collect data. Hence, it can be placed in the group of field research. The statistical population of this research included pharmaceutical companies listed on the Tehran Stock Exchange. The data associated with active pharmaceutical companies were collected from sites related to the Tehran Stock Exchange. Indicators of efficiency evaluation and dividend were proposed by studying and searching in the valid books and papers, and some of them were considered by academic experts and the Tehran Stock Exchange, and the rest of the indicators were eliminated. After data collection, the data analysis was performed. Library studies and internet searches and articles and books were exploited to collect preliminary data. We gathered information to answer the research questions in a field method. Data collection tools were documents and statistical data in the yearbook of the Tehran Stock Exchange. Data associated with research variables were collected during the five years of 2015 and 2019. Eventually, the competitiveness assessment of pharmaceutical companies listed on the Tehran Stock Exchange was studied using the cross-efficiency method in data envelopment analysis (DEA) and the relationship between this efficiency score and cost of equity was examined.

3.1 How to Calculate Variables

In this section, research variables will be introduced and how their operational calculation will be expressed. These variables are as follows:

- Competitive Ability

Competitive ability is the company's share of industry sales. That is, this ratio is as follows (Leventis & Weetman, 2011).

$$\text{Competitive ability} = \frac{\text{Company sales per year}}{\text{The sum of the industry sales in which the company is located}}$$

- Calculating the Efficiency of Competitive Ability:

With regard to the concept of efficiency, which evaluates the comparison of the obtained outputs with the consumed inputs, the competitive ability can be used as an output factor, and some variables related to competitive ability can be employed as input factors to calculate the competitiveness efficiency of companies. Indeed, competitiveness was regarded as output, and the following variables were considered as inputs of the cross-efficiency model in data envelopment analysis (DEA) to calculate the efficiency competitive ability.

1. Number of employees
2. Company size (total assets)
3. The cost price of the goods sold
4. Sales and administrative costs.

However, the cross-efficiency method in data envelopment analysis exploited in this study is as follows.

- **Cross Efficiency**

One of the ranking methods of efficient units is to use the "cross-efficiency" model, which has high power in distinguishing efficient units (Bazrkar & Iranzadeh, 2017). As previously mentioned, efficiency in data envelopment analysis (DEA) is calculated by the ratio of "weighted sum of outputs" to "weighted sum of inputs". The choice of weights in the DEA linear programming model is such that it allows the unit under study to maximize its efficiency size compared to other units. Evaluating the efficiency of each unit with the best set of weights calculated by the model is called "simple efficiency".

The cross-efficiency of data envelopment analysis (DEA) was first proposed by Sexton et al. (1986) and further developed by Doyle and Green (1994). The basic idea of cross-efficiency is to use DEA as a reference evaluation for the mere evaluation model (self-evaluation). The two main advantages of cross-efficiency evaluation are as follows:

Cross-efficiency provides an efficiency ranking among all decision-making units (DMUs) to distinguish between best and worst performance.

The cross-efficiency can eliminate the need for weight constraints for a variety of applications and thus violate the DEA unrealistic weighting method (Anderson et al., 2002; Liang et al., 2008).

In DEA, we have the following classic symbols: Suppose there is a set of DMUs. Each DMUj has m distinct input x_ij (i=1,.., m) and s distinct output y_rj (r=1,…,s).

Cross-efficiency of DEA is a traditional extension in a two-step process. More specifically, in step 1, the self-evaluation efficiencies of each DMU will be calculated based on the DEA model of constant returns to scale (CRS) developed by Charans, Cooper, & Rhodes (1978) (hereinafter CCR). In Step 2, the weights obtained from Step 1 will be employed for each DMU in order to obtain a score, hereinafter referred to as the cross-efficiency evaluation score. Then, a mathematical model for the two-step process described above will be provided.

Step 1: Self-evaluation efficiency from DMU_d using the CCR model in DEA will be displayed as follows:

$$\max E_{dd} = \sum_{r=1}^{s} u_{rd} y_{rd} \qquad (1)$$

$$\text{S.t}$$
$$\sum_{i=1}^{m} v_{id}x_{ij} - \sum_{r=1}^{s} u_{rd}y_{rj} \geq 0 \quad j = 1, \dots, n$$
$$\sum_{i=1}^{m} v_{id}x_{id} = 1$$
$$v_{id} \geq 0 \qquad i = 1, \dots, m$$
$$u_{rd} \geq 0 \qquad r = 1, \dots s$$

Where u_{rd} and v_{id} are the representations of the weights of r-th output and i-th input from DMU_d, respectively. For each DMU_d, we obtain a set of optimal weights v_{1d}^* ، v_{2d}^* ، ....، v_{md}^* ، u_{1d}^* ، u_{2d}^* ، ....، u_{sd}^* by solving the model in step 1.

Step 2: The cross-efficiency of each $\mathrm{DMU_j}$ using the optimal weights $\mathrm{DMU_d}$ i.e., $\mathrm{E_{dj}}$ can be calculated as follows:

$$\frac{\sum_{r=1}^{s} u^*_{rd} y_{rj}}{\sum_{i=1}^{m} v^*_{id} x_{ij}} \qquad \mathbf{d}, \mathbf{j} = \mathbf{1}, \dots, \mathbf{n} \qquad (2)$$

Therefore, we form a cross-efficiency matrix (CEM) using the above equation.

For each DMU_j $(\mathrm{j} = 1, \dots, \mathrm{n})$, the average of all $\mathrm{E_{dj}}$ (d=1,…,*n*)

$$\overline{\mathrm{E}}_{\mathrm{j}} = \frac{1}{n} \sum_{d=1}^{n} \mathrm{E_{dj}} \qquad (3)$$

is expressed as the cross-efficiency score for DMU_j. Cross-efficiency can also be referred to as the cumulative score with the same weight 1⁄n. The existence of multiple optimal solutions in the model (1) causes the lack of uniqueness of the cross-efficiency matrix (CEM) and cross-efficiency score. To fix this problem in data envelopment analysis (DEA), the secondary goal method was introduced (Liang et al., 2008; Roeder and Rutcher, 2011, 2012; Moeini et al., 2015, Davtalab Olyaie, 2019). In the continuation of this subsection, we will present a linear programming model for secondary goals in data envelopment analysis.

- A Linear Model for the Secondary Goal

In this subsection, a secondary model for cross efficiency will be provided. The purpose of the secondary model is to obtain the most appropriate weight among the optimal weights in order to have the best efficiency index. Initially, the CCR model of DMU_d is implemented, and it is assumed that E_dd^* is the amount of efficiency obtained for DMU_d. Now, we will have the following linear programming model:

$$\max \sum_{r=1}^{s} u_{rd}y_{rd} - E_{dd}^* \sum_{i=1}^{m} v_{id}x_{id} \qquad (4)$$
$$s.t.$$
$$\sum_{r=1}^{s} u_{rd}y_{rj} - E_{jj}^* \sum_{i=1}^{m} v_{id}x_{ij} \leq 0 \quad : \quad j = 1, \dots, n$$
$$\sum_{r=1}^{s} u_{rd} + \sum_{i=1}^{m} v_{id} = 1$$
$$u_{rd} \geq o \quad : \quad r = 1, \dots, s$$
$$v_{id} \geq o \quad : \quad i = 1, \dots, m$$

Where $\mathrm{E_{jj}^*}$ is the value of the efficiency obtained for DMU_j $(\mathrm{j} = 1, \dots, \mathrm{n})$ and the constraint $\sum_{r=1}^{s} u_{rd} + \sum_{i=1}^{m} v_{id} = 1$ is the normalizing constraint, which is used to prevent the optimal zero solution. Suppose that (v_d^*, u_d^*) is the optimal weight vector for model (4). In this case, the following theorem states that the optimal solution of the model (4) is zero.

Theorem 1: The value of the optimal objective function of model (4) is zero.

Conclusion: According to the above theorem, one can conclude that the efficiency index obtained for the CCR multiplicative model is equal to the efficiency index obtained by the model (4).

In order to select a weight from the optimal weights, the following multi-objective model as a secondary goal is presented.

$$\begin{aligned}
&\max_{\substack{1\le j\le n \\ j\neq o}} \left(\sum_{r=1}^{s} u_{rd}y_{rj} - E_{jj}^{*}\sum_{i=1}^{m} v_{id}x_{ij}\right) \\
&s.t. \\
&\sum_{r=1}^{s} u_{rd}y_{rj} - E_{jj}^{*}\sum_{i=1}^{m} v_{id}x_{ij} \le 0 \quad : \quad j = 1,..,n \qquad (5)\\
&\sum_{r=1}^{s} u_{rd}y_{rd} - E_{dd}^{*}\sum_{i=1}^{m} v_{id}x_{id} = 0 \\
&\sum_{r=1}^{s} u_{rd} + \sum_{i=1}^{m} v_{id} = 1 \\
&u_{rd} \ge o \quad : \quad r = 1,\dots,s \\
&v_{id} \ge o \quad : \quad i = 1,\dots,m .
\end{aligned}$$

In which E_{dd}^{*} is the value of the efficiency index achieved using the CCR model in DMU_d. The purpose of the above model is to obtain the optimal weight among the optimal weights in DMU_d so that the efficiency of this unit remains constant and the efficiency of other decision-making units is maximized. This multi-objective model can be solved using a variety of methods in the multi-objective domain (For example, Ehrgott, 2005, Karimi & Karimi, 2017). One of the methods exploited in this paper is the max-min method, which is in the following form:

$$\begin{aligned}
&\max \varphi \\
&s.t. \\
&\left(\sum_{r=1}^{s} u_{rd}y_{rj} - E_{jj}^{*}\sum_{i=1}^{m} v_{id}x_{ij}\right) \ge \varphi \quad : \quad j = 1,..,n,\ j \neq d \qquad (6)\\
&\sum_{r=1}^{s} u_{rd}y_{rj} - E_{jj}^{*}\sum_{i=1}^{m} v_{id}x_{ij} \le 0 \quad : \quad j = 1,..,n \\
&\sum_{r=1}^{s} u_{rd}y_{rd} - E_{dd}^{*}\sum_{i=1}^{m} v_{id}x_{id} = 0 \\
&\sum_{r=1}^{s} u_{rd} + \sum_{i=1}^{m} v_{id} = 1 \\
&u_{rd} \ge o \quad : \quad r = 1,\dots,s \\
&v_{id} \ge o \quad : \quad i = 1,\dots,m .
\end{aligned}$$

Actually, model (6) maximizes the minimum of the goals and thus a single-objective linear programming model is achieved and it can be easily solved. After solving this model, assume that v_{1d}^{*} ، v_{2d}^{*} ، ، ....v_{md}^{*} ، u_{1d}^{*} ، u_{2d}^{*} ، .... ، u_{sd}^{*} is the optimal solution of the model. In this case, the cross-efficiency score of each company can be calculated using equations (2) and (3).

- Cost of Equity

On the other hand, we intend to examine the relationship between cross-efficiency and cost of equity. How to calculate the cost of equity through Gordon Growth Model (GGM) (Davtalab Olyaie, 2019) is as follows:

In this model, the cost of equity can be achieved from the following equation:

In the above model:

$$\text{Cost of equity} = \frac{D_1}{P_0} + g \qquad (7)$$

D1: Dividend paid at the end of the first year,

P0: Price per share at the beginning of the year
g: The dividend growth rate obtained from the following equation.

$$g = \left[\frac{EPS_t}{EPS_0} \right]^{\left(\frac{1}{t}\right)} - 1 \qquad (8)$$

3.2 Statistical Model of the Research

In order to test the research hypothesis, the following regression model is exploited.

$$y_t = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \alpha_4 x_4 + \alpha_5 x_5 + \varepsilon_t \qquad (9)$$

In which
Y: Cost of equity
x_1: Competitiveness efficiency score of each company in each year
x_2: The company size, which is equal to the natural logarithm of the total assets of the company.
x_3: The ratio of debt to total assets
x_4: The ratio of profits to total assets
: Sales growthx_5
In fact, in this model, the variable of equity cost is the dependent variable, the competitive ability efficiency score variable is the independent variable, and the variables of company size, the ratio of debt to total assets, the ratio of profit to total assets, and sales growth are considered as control variables.

4 RESULTS

4.1 Research Data

The statistical population of this research consisted of pharmaceutical companies listed on the Tehran Stock Exchange. These companies must have the following characteristics in the five-year period 2013 and 2017:

1- Their fiscal year leads to the end of the fiscal year
2- During the period in question, their shares have been actively traded on the stock exchange.
3- To be among the profitable companies
4- To be among the companies that have distributed their profits

In fact, 19 companies apply in this situation. Moreover, because we have 5 financial years for study, the data of this research include 95 years of the company.

4.2 Calculation of Cross- Efficiency and Evaluation of Competitiveness Efficiency of Companies in the Statistical Sample

In this subsection, the calculation of the competitive ability efficiency score using the cross-efficiency model presented in this paper is addressed. In fact, the following procedure is carried out to evaluate the efficiency score of companies' competitiveness. Initially, evaluating the efficiency of companies using model (1) provided in the previous section is dealt with. The executive results of the model are given in Table (1) below.

Company	Efficiency value E_{dd}^{*} for 2015	Efficiency value E_{dd}^{*} for 2016	Efficiency value E_{dd}^{*} for 2017	Efficiency value E_{dd}^{*} for 2018	Efficiency value E_{dd}^{*} for 2019
1	1	1	1	1	1
2	0.70	0.83	0.68	0.82	0.75
3	0.78	0.82	0.81	0.89	0.73
4	0.73	0.73	0.72	0.69	0.78
5	0.77	0.84	0.79	0.74	0.72

6	0.92	1	0.98	0.89	0.82
7	1	0.97	0.88	0.87	1
8	0.75	0.78	0.75	0.78	0.75
9	0.86	1	0.76	1	1
10	1	1	1	1	1
11	1	0.78	1	0.71	1
12	0.73	0.76	0.78	0.66	0.75
13	0.58	0.79	0.48	0.72	0.51
14	0.59	0.90	0.89	0.76	0.65
15	1	1	1	1	1
16	1	1	1	1	1
17	0.69	0.74	0.79	0.78	0.72
18	0.86	0.90	0.86	0.82	0.83
19	1	1	1	1	1

Table 1. Efficiency of pharmaceutical companies listed on the stock exchange using model (1)
Source: Research Results (2021).

Note that the amount of efficiency $\boldsymbol{E^*_{dd}}$ can be the basis for ranking the competitiveness of companies. However, many companies have an efficiency score of 1 per year, which means that these companies are efficient. Concerning this model, they do not have a priority relative to each other and a unique ranking of companies for each year cannot be provided. This is because cross efficiency model is employed.

Subsequently, the presented secondary goal model (6) is exploited, and the efficiency of each $\boldsymbol{DMU_j}$ using the optimal weights $\boldsymbol{DMU_d}$, i.e., $\boldsymbol{E_{dj}}$ is calculated and cross efficiency matrix is formed from Equation (2). This continues for each year until five cross-efficiency matrices are achieved. Ultimately, using the average column, i.e. equation (3), the cross-efficiency score is calculated. The results are provided in the following Table (2).

Company	**Cross efficiency score in 2015**	**Cross efficiency score in 2016**	**Cross efficiency score in 2017**	**Cross efficiency score in 2018**	**Cross efficiency score in 2019**
1	0.97	0.88	0.60	0.57	0.52
2	0.56	0.64	0.93	0.72	0.66
3	0.68	0.68	0.85	0.71	0.61
4	0.69	0.65	0.79	0.61	0.57
5	0.72	0.76	0.76	0.61	0.56
6	0.80	0.86	0.87	0.70	0.60
7	0.86	0.73	0.25	0.34	0.30
8	0.64	0.66	0.86	0.71	0.61
9	0.80	0.95	0.62	0.58	0.53
10	0.91	0.96	0.59	0.57	0.52
11	0.85	0.70	0.59	0.57	0.52
12	0.53	0.59	0.55	0.88	0.78
13	0.49	0.57	0.52	0.89	0.79
14	0.51	0.64	0.52	0.90	0.78
15	0.67	0.70	1	0.62	0.56
16	0.74	0.84	0.38	0.44	0.40
17	0.62	0.62	0.96	0.69	0.64
18	0.82	0.63	0.95	0.51	0.48
19	0.94	0.89	0.80	0.63	0.58

Table 2. Cross efficiency score of pharmaceutical companies listed on the stock exchange
Source: Research Results (2021).

The cross-efficiency score for pharmaceutical companies is represented in Table (2). With respect to this obtained cross-efficiency score, the ranking of companies can be considered. Here, any company that has a higher cross-efficiency score has a better ranking in terms of competitiveness (competitive ability) than other companies. Besides, companies with lower cross-efficiency scores have worse ranking in terms of competitiveness compared to other companies.

4.3 The Relationship between Cross-Efficiency with Cost of Equity

In order to examine the relationship between the competitiveness efficiency of pharmaceutical companies listed on the stock exchange and the cost of equity, the multivariate regression method is exploited. The regression model used in this study was presented as Equation (9) in the previous section. Table (3) contains descriptive statistics of research variables.

		Range	Minimum	Maximum	Mean	Standard Deviation
X_1	Competitive ability efficiency score	0.75	0.25	1	0.677	0.160
X_2	Company size	0.81	5.95	6.76	6.29	0.255
X_3	Debt to asset ratio	0.64	0	0.64	0.355	0.162
X_4	Profit to asset ratio	0.34	0.02	0.37	0.185	0.099
X_5	Sales growth	0.96	-0.23	0.3	0.141	0.167

Table 3. Descriptive statistics
Source: Research Results (2021).

4.3.1 Pre-tests

-Test for Normality

Before checking the research hypotheses, the normality of the research variables should be initially examined by one-sample Kolmogorov-Smirnov test. The hypotheses of this test are as follows.

H_0: The variable under study has a normal distribution.

H_1: The variable under study has no a normal distribution.

		Kolmogorov-Smirnov statistic	Significance	Status
X_1	Competitive ability efficiency score	0.105	0.20	Normal
X_2	Company size	0.103	0.21	Normal
X_3	Debt to asset ratio	0.108	0.2	Normal
X_4	Profit to asset ratio	0.1	0.2	Normal
X_5	Sales growth	0.107	0.051	Normal
Y	Cost of equity	0.121	0.173	Normal

Table 4. One-sample Kolmogorov-Smirnov test for the research variables
Source: Research Results (2021).

On the basis of the results in Table (4), all variables are normal. Thus, parametric tests such as regression can be exploited.

- Unit Root Test (Augmented Dickey Fuller (ADF))

The augmented Dickey-Fuller test was used to test the stationary of the variables.

		Augmented Dickey-Fuller statistic	Significance	Status
X_1	Competitive ability efficiency score	-4.81	0.000	stationary
X_2	Company size	-5.754	0.000	stationary
X_3	Debt to asset ratio	-10.395	0.000	stationary
X_4	Profit to asset ratio	-5.346	0.000	stationary
X_5	Sales growth	-6.115	0.000	stationary
Y	Cost of equity	-5.853	0.000	stationary

Table 5. The augmented Dickey-Fuller test
Source: Research Results (2021).

In accordance with the results of Table (5), all research variables are at the stationary level and there is no need to differentiate from the variables, so we will not face the spurious regression and the estimation results will be reliable.

- **Estimation of the Research Model**

To estimate the model, the multivariate regression method was used. The results are provided in Table (6).

	Variables	Coefficients	Standard Deviation	t statistic	Probability
C	Fixed coefficient	-0.896	0.738	-1.214	0.233
X_1	Competitive ability efficiency score	-0.589	0.174	3.369	0.002
X_2	Company size	0.180	0.113	1.581	0.123
X_3	Debt to asset ratio	0.263	0.123	2.139	0.04
X_4	Profit to asset ratio	-0.978	0.273	-3.575	0.001
X_5	Sales growth	-0.092	0.114	-0.807	0.425
Mean of the dependent variable		0.569	Coefficient of determination		0.757
Standard deviation of the dependent variable		0.213	Adjusted coefficient of determination		0.719
Akaike Information Criterion (AIC)		-1.381	Standard deviation of regression		0.112
Schwartz criterion		-1.123	Residual sum of squares (RSS)		0.407
Hannan-Quinn criterion (HQ)		-1.289	Log likelihood		32.255
Durbin-Watson statistic		2.06	F statistic		20
			Probability (F statistic)		0.000

Table 6. Model coefficients
Source: Research Results (2021).

With regard to the estimation results in Table (6), the influence of the competitive ability efficiency score variable on the cost of equity is 0.589, which is statistically significant at the 95% confidence level ($p < 0.05$). Thus, the cost of equity will increase at a rate of 0.589 by one unit increase in the competitiveness efficiency score. Besides, the effect of control variables on the debt-to-assets ratio was significant to the amount of 0.263. Moreover, the effect of the profit-to-assets ratio on the dependent variable, i.e., cost of equity was significant at a rate of -0.978.

The impact of company size and sales growth on the cost of equity in the period under study was not significant ($p > 0.05$). The coefficient of determination, adjusted coefficient of determination, the standard deviation of regression, residual sum of squares, Akaike's information criterion, Hannan Quinn criterion, and Schwartz criterion represent good fit so that as the coefficient of determination and the adjusted coefficient of determination are higher and the other criteria introduced are lower, the model will have a better fit.

4.3.3 Diagnostic Tests for Validity of the Model

- **Autocorrelation Test**

To investigate the absence of autocorrelation for the disturbing elements of the first hypothesis regression, Glejser test was exploited. The null hypothesis of this test is the absence of autocorrelation in the disturbing elements.

Coefficient of determination	F statistic	F Probability (5.32)
8.16	0.107	0.989

Table 7. Breusch–Godfrey test of the first hypothesis
Source: Research Results (2021).

According to the results of Table (7), the F-statistical probability is obtained to be 0.989, which is more than 0.05. Thus, the null hypothesis, indicating the absence of autocorrelation in the disturbing elements of research regression is accepted and the existence of autocorrelation is rejected. Therefore, the regression results are reliable.

- Collinearity Test

In this section, the VIF test is exploited for the co-linearity test in the model.

	Central VIF
Fixed coefficient	-
Competitive ability efficiency score	1.594
Company size	2.464
Debt to asset ratio	1.163
Profit to asset ratio	2.138
Sales growth	1.061

Table 8. Co-linearity test
Source: Research Results (2021).

On the basis of the results of Table (8), the VIF statistic for all research variables is less than 10. Hence, one can conclude that the fitted model has no co-linearity and the results of estimating the coefficients are reliable.

5 CONCLUSIONS & SUGGESTIONS

Overall, this article aimed to evaluate companies based on competitive ability using cross-efficiency in data envelopment analysis (DEA) and its relationship with the cost of equity. In this survey, the information of pharmaceutical companies listed on the stock exchange was exploited. In accordance with Table (2), the cross-efficiency score for pharmaceutical companies was provided. With regard to these cross-efficiency scores obtained, the ranking of companies was performed. Here, any company with a higher cross-efficiency score has more competitive ability compared to other companies with a lower cross-efficiency score.

Generally, there is a significant relationship between the competitiveness efficiency score obtained using the cross-efficiency model and the cost of equity in pharmaceutical companies listed on the Tehran Stock Exchange. Taking into account the research results, there is a positive relationship between the level of efficiency of the company in competitiveness and the cost of equity. In other words, the higher the level of competitiveness of the company, the more the cost of equity will increase. This means that companies that have higher efficiency in the competitive ability can share greater profits, therefore increasing the cost of capital. On the basis of the findings of Linter (1956), Rozeff (1992), Beiner (2001), the factors affecting dividend policy can be generally divided into four groups:

1) Legal factors 2) Contractual factors 3) Internal factors of the company 4) Macroeconomic and market factors. Accordingly, competitiveness as one of the market factors also affects dividend policy.

This finding of the current study theoretically matches the existing theories about dividend (hunting theory). Based on the hunting theory, corporate governance mechanisms encourage managers of companies that are more vulnerable to being hunted to pay fewer dividends, so that the manager's performance is consistent with the interests of the company and shareholders.

Eventually, the relationship between the efficiency score of companies' competitive ability and cost of equity was specified. Based on the results of model estimation using the multivariate regression method, it was found that the influence of the competitive ability efficiency score variable on the cost of equity is 0.589, which is statistically significant at the 95% confidence level ($p < 0.05$). Thus, the cost of equity will increase at a rate of 0.589 by one unit increase in the competitiveness efficiency score.

The result obtained in terms of the significance of the relationship between competitiveness efficiency score and equity cost is consistent with the results obtained in the research of Jiang et al. (2015). The results of the present study and previous research indicate that the higher the efficiency score of competitive power; the cost of equity also increases.

Besides, the effect of control variables on the debt-to-assets ratio was significant to the amount of 0.263. Moreover, the effect of the profit-to-assets ratio on the dependent variable, i.e., cost of equity was significant at a rate of -0.978. The impact of company size and sales growth on the cost of equity in the period under study was not significant (p> 0.05). In other words, this study demonstrated that increasing the efficiency score of competitive ability will increase the cost of equity (increase the ratio of dividends to the price per share). Hence, a question raised in this study was answered. The results obtained in relation to the relationship between debt to asset ratio, profit to asset ratio with variable equity cost with the results obtained in the research of Smith, Chen and Anderson (2008), Kohansal, Dadrasmoghaddam, Karmozdi, & Mohseni (2013), Chaharmahali, Zahedi and Mohammadi (2019) has it. Based on the results, the role of both ratios on the variable cost of equity can be evaluated; however, the effect of earnings-to-assets ratio on equity is more significant.

The results obtained in relation to the relationship between firm size and equity were consistent with the results obtained in the study of Zhou, Keng, Faff & Zhu (2016). This indicates that in many studies, the relationship between firm size and cost of equity is typically a negative or inverse relationship, meaning that larger firms have lower equity costs.

The obtained results can be considered by the supervisory boards on the performance of managers, including the general meetings of shareholders and major shareholders, and the board of directors of listed companies. On the one hand, the dividend is a factor affecting the investments made by companies. The more profits are distributed, the less company's internal resources for investment projects, and the company will require greater financing outside the company. This factor affects the stock price in the future and increases the cost of equity. On the other hand, many shareholders of the company want to increase dividends. Thus, managers must always establish a balance between the different interests of shareholders in the distribution of dividends, while increasing the competitive ability of the company. Furthermore, it is recommended that investors who want more dividends choose companies that have a higher cross-efficiency score in competitive ability that, of course, have a higher financial risk as well.

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