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EFFICIENCY MEASUREMENT OF REAL ESTATE INVESTMENT TRUSTS TRADED IN BIST WITH DATA ENVELOPMENT ANALYSIS AND MALMQUIST TOTAL FACTOR PRODUCTIVITY INDEX

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ABSTRACT

Purpose- The aim of the study is to measure the efficiency of real estate investment trusts traded on BIST with data envelopment analysis and the Malmquist total factor productivity index. Efficiency and productivity were measured using the Malmquist total productivity analysis and the Data Envelopment Analysis approach, both of whose application fields have grown recently.

Methodology- The Malmquist total factor productivity index is used to analyze changes in total factor productivity of 20 real estate investment trusts operating in 2019–2020–2021, as well as the reasons for these changes, on the axis of variables such as current ratio, leverage ratio, long-term debt-to-asset ratio, short-term debt-to-asset ratio, equity-to-asset ratio, return on assets, net profit margin, and gross profit margin.

Findings- The results of the analysis show that 8 companies that are relatively efficient according to their CCR technical efficiency values have been identified; these are ALGYO, AVGYO, HLGYO, MRGYO, MSGYO, PAGYO, RYGYO, and SNGYO. It has been observed that these companies have been effective in an output-oriented way over the past three years.

Conclusion- The firms that are below the efficiency limit need to take a few things into account, according to the results. They need to alter a few input variables to reach a higher level of efficiency. It is anticipated that all these findings will support the decision-making of the companies and the investors who are considering investing in these companies.

Keywords: Real estate investment trusts**,** data envelopment analysis, Malmquist total factor productivity index, efficiency measurement.
JEL Codes: C67, L25, G29.

1. INTRODUCTION

Companies that need to compare their own circumstances to those of their competitors and investors who plan to participate in these businesses should take several aspects into account in today's continuously evolving and competitive world. There is a need for approaches that can develop a simultaneous decision-making mechanism by combining all these aspects into a single model in order for them to be employed in a decision-making process in a healthy manner. Decision makers find Data Envelopment Analysis to be a very helpful tool in all these decision-making situations. Data Envelope Analysis, according to the study, concurrently establishes the relative differences under the efficiency criterion and presents them to the decision-maker in the choice of the most suitable unit that can vary from one another under common conditions.

Data envelope analysis, on the other hand, is a static analysis because it performs a cross-sectional analysis on the decision unit data over a specific period. A decision unit whose effectiveness has been determined by Data Envelopment Analysis may lose its effectiveness and its ability to be a reference when examined in later periods. However, in the process of evaluating the activities, it is very important to reveal how the activity has developed over time. For this reason, the "Malmquist Total Factor Productivity Index," which includes the time dimension, has been developed. With the use of the Total Factor Efficiency Index, this missing aspect of Data Envelopment Analysis is eliminated, and it turns into a much more beneficial tool in the decision-making process (Dinçer, 2008).

Efficiency measures how well predefined plans and programs for production factors and/or an enterprise's production are carried out. In other words, it demonstrates efficacy by highlighting how closely the actual performance matches the previously projected and planned performance. When the literature is evaluated, it becomes clear that a performance that is regarded as effective requires an efficiency ratio of 1. In this context, a ratio greater than 1 is read as an efficiency level above the norm, and a ratio less than 1 is interpreted as an activity that is not proceeding as intended (Savaş, 2009).

Efficiency measures enable businesses to identify their location. When assessing their performance in this regard, organizations commonly employ efficiency analysis. Because efficiency assessments allow companies to assess where they stand in the economies they operate in and provide guidance on how to get the greatest results from the resources they already have at their disposal (Yolalan, 1993). Businesses should decide in advance which inputs and outputs will be most effective in achieving the objective. Businesses can then compare their efficiency levels by exposing how close they are to the degree of effectiveness needed to be effective in their production (Özgür and Eleren, 2006). In other words, through efficiency measurements, organizations may determine whether the production process is operating properly.

The Malmquist total productivity analysis and Data Envelopment Analysis (DEA) methods, which have recently become popular in measuring efficiency and productivity, were applied in this work. The Malmquist total factor productivity index is used to analyze changes in total factor productivity of 20 real estate investment trusts (REITs) operating in 2019-2020-2021, as well as the reasons for these changes, on the axis of variables such as current ratio, leverage ratio, long-term debt-to-asset ratio, short-term debt-to-asset ratio, equity-to-asset ratio, return on assets, net profit margin, and gross profit margin.

2. LITERATURE REVIEW

Although there is much research in the literature that uses the DEA approach to estimate enterprise efficiency, the number of studies that use the Malmquist Productivity Index to quantify efficiency is still far fewer. The fact that there isn't much research on real estate investment trusts, the topic of this study, and the use of these analysis tools show the study's importance and contribution to the literature.

By Kaya and Coşkun (2016), the 2009–2013 data of 17 companies trading in the BIST Food, Beverage, and Tobacco sector were examined using the output-oriented CCR DEA approach. KRVTS and KNFRT firms were found to be productive during the analysis period based on the study's empirical analysis.

Data from 22 firms in the textile, apparel, and leather sectors, whose stocks are traded on the BIST, were evaluated by DEA and ordinal logistic regression methods based on eight chosen variables in the study by Abacıoğlu and Ünal (2017). The study covered the years 2013-2016 and the companies were from the woven, clothing and leather sectors. According to empirical data, businesses are divided into four classes based on their efficiency scores. However, it was discovered that seven out of the eight variables utilized in the DEA application had a statistically significant impact on the enterprises' productivity. On the other hand, Çelik and Ayan (2017) used the input-oriented CCR DEA approach to evaluate the 2010–2014 period data of businesses operating in the BIST manufacturing sub-sectors. The manufacturing industry sector was found to have efficiency average values of 90% for 2010, 91% for 2011, 91% for 2012, 92% for 2013, and 94% for 2014. However, the manufacturing sector did not attain average efficiency values of 100% for any of the five sub-sectors in the study.

In their study, Özcan and Anıl (2017) used both the DEA and the Malmquist total factor productivity index, which is based on the DEA, to examine the productivity of 13 iron and steel companies that are among the largest 500 enterprises in Turkey for the years 2013, 2014, and 2015. The analysis led to its acquisition using the DEA approach, in which a single company demonstrated efficient work over the course of three years. Eleven companies improved, as assessed by the Malmquist total factor productivity index data. According to Münyas (2018), the DEA approach was used to examine the data for 27 REITs throughout the period of 2011–2017, whose stocks are traded on the BIST. Five input variables and three output variables were employed in the study's DEA analysis. The effectiveness of 13 REITs in 2011, 13 REITs in 2012, 12 REITs in 2013, 10 REITs in 2014, 17 REITs in 2015, 16 REITs in 2016, and 11 REITs in 2017 has been evaluated through empirical investigation.

Using the Malmquist-TFP index approach based on the DEA output-oriented CCR model, Gelmez et al. (2018) studied the changes in the productivity of the businesses operating in the textile sector and the sources of the change. Each enterprise's total factor productivity for the years 2014-2016 was assessed separately in the study, and the causes of change based on time periods were attempted to be identified. Following the analysis, it was discovered that the companies' Total Factor Productivity had decreased. The evaluation of the results led to the conclusion that, despite the positive situation in the technical efficiency of the companies, the decrease in the total factor productivity could not be prevented. The decrease in the TFPs of the companies was attributed to their inability to implement the technological changes on time.

Data from 2005 to 2019 were analyzed using the DEA approach by Şahin and Özdemir (2020) to assess the efficiency levels of 23 banks. Interest income and non-interest income are preferred as the study's output variables; the number of branches, number of employees, interest expenses, and non-interest expenses are used as input factors. According to the empirical investigation, Citibank had the highest efficiency value. Additionally, studies have shown that foreign banks perform better than domestic banks. The objective of the study conducted by Kıllı and Uludağ (2020) was to assess the cost performance of 19 companies in the woven, clothing and leather industries whose stocks are traded on the BIST. According to the study, five companies operated on the fixed scale and nine under the variable scale as of 2017. Five companies operated under the fixed scale in 2018 whereas ten businesses operated under the variable scale. On the other hand, it has been established that 7 companies are effective for 2019 under the fixed scale and 10 companies are effective under the variable scale. Furthermore, it was discovered that 25 other companies had cited BLCYT.

3.DATA ENVELOPMENT ANALYSIS (DEA)

The Data Envelopment Analysis method is a "parameterless" efficiency measurement that was first developed by Charnes, Cooper, and Rhodes (1978) to measure the "relative" efficiency of similar economic decision units in terms of the goods or services they produce (Yolalan, 1993). The method is used to compare the success of production processes with multiple inputs and multiple outputs, where classical regression analysis cannot be applied directly (Baysal et al., 2004).

The foundations of the DEA method were put forward by Farrell in 1957. Later, the current DEA method was developed by Charnes, Cooper and Rhodes (1978) to measure the relative efficiency of decision-making units (DMUs) with multiple inputs and multiple outputs. The DEA method is a linear programming-based efficiency measurement method that aims to measure the relative effectiveness of DMUs with similar structures. Formally, the basis of the Data Envelopment Analysis consists of boundary approaches rather than measures of central tendency. When compared to other analysis methods, DEA is a successful measure for determining effectiveness. For example, if a person wants to express efficiency, or more generally, show that a decision unit is more efficient than other decision units, he or she can easily do so with the DEA method without the rational expectations of various linear and non-linear regression models. (Cook and Zhu, 2005).

The DEA method does not have to assume a specific method for the production- and cost-bound approach. It provides production and cost boundary measurement with the convex boundary method by using the observed input and output data. The linear programming model is generally used for the estimation of the boundary approach. Linear programming is an analytical method developed long before Data Envelopment Analysis to assist decision-making units. The general purpose of the linear programming model is to select decision-making units that aim to achieve maximum profit or minimum loss. DEA uses linear programming as a tool for efficiency measurement. The DEA technique ranks decision-making units based on their efficiency ratings. First place goes to the decision-making unit with the highest efficiency score, and last place goes to the decision-making unit with the lowest efficiency score. The effective decision-making units, however, are given the value "1.000," and it is not possible to rank the effective decision-making units within one another. Inefficient decision-making groups are ranked among themselves (Thanassoulis, 2001). Although Farrell used more than one input and one output in the DEA method, the linear equation system he established for the measurement of efficiency formed the basis for the calculation of efficiency for multiple outputs (Farrell, 1957). Based on Farrell's work in 1957, Charnes, Cooper, and Rhodes (1978) proposed a non-parametric model based on linear programming, known as the CCR model. Later, in 1984, Banker, Charnes and Cooper developed the BCC model, which is another basic model of DEA (Banker et al., 1984).

The industries where data envelopment analysis can be performed are the production, service, and financial sectors. Contrary to conventional analysis techniques, it is possible to measure a company's efficiency by combining various variables. DEA is widely used to assess the productivity level of many profit-oriented organizations after initially measuring the comparative efficiency of non-profit public institutions (Gülcü et al., 2004).

In studies using the DEA method in the literature, it is seen that different scientists consider one of two constraints when determining the number of decision-making units. In this study, the number of decision-making units was determined by considering the second constraint.

1. Constraint: When the number of inputs is m and the number of outputs is n, the number of decision-making units must be at least “$m + n + 1$” (Babacan et al., 2009).

   Number of decision-making units $\geq\ m + n + 1$

2. Constraint: If the number of inputs is m and the number of outputs is n, at least (m+n)*2 decision making units are needed (Eleren and Özgür, 2006).

Number of decision-making units = $(m + n) * 2$

The most important advantage of DEA over parametric methods is that it can measure efficiency in studies where multiple input and output variables are used without the need to predict the existence of a predetermined analytical production function, as in parametric methods. However, the input and output variables are also independent of the units. This allows for the simultaneous testing of multiple dimensions of companies or decision-making units (Karsak and İşcan, 2000). Another important advantage of the DEA method is that there is no need for an analytical production function to be determined before the analysis in cases where the multi-criteria decision-making process needs to be run. However, input and output variables and units of measurement are independent of each other. With this feature, DEA provides the opportunity to measure different dimensions of companies in the same process. (Karsak and İşcan, 2000).

3.1. Data Envelopment Analysis Models

Different models are applied in DEA. These models can be broadly classified into two groups. One is based on constant returns to scale and is called CCR (Charnes-Cooper-Rhodes), while the other is based on variable returns to scale and is called BCC (Banker-Charnes-Cooper). Additionally, it can be noted that the studies also use additional models. The model to be utilized is determined by the scope of the research and the assumptions to be made.

3.1.1. Charnes-Cooper-Rhodes (CRR) Model

The input-oriented CCR model is a model that aims to reduce the level of inputs to meet the current output level (Kıran, 2008). In this model, which is made by weighting the input variables, it is determined how much reduction in the input values should be made without changing the output values in order for the inactive DMUs to be effective. The input-oriented CCR model developed by Charnes, Cooper, and Rhodes (1978) maximizes the ratio of weighted output to weighted input to determine the efficiency value of each decision unit.

Suppose that n DMUs are considered in a DEA model, and there are m inputs and s outputs for each of these DMUs. In this case, the fractional CCR model for the input will be as follows: where the i-th input amount of the j-th DMU is $X_{ij} \geq 0$ and the r-th output amount produced by the j-th DMU is $Y_{rj} \geq 0$ (Cooper et al., 2004).

$$Max\frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{i0}}\ ,\ Max\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 0 \qquad j = 0,1, \dots, n \qquad u_r, v_i \geq 0 \tag{1}$$

$Max =$ Maximal,

u_r= weight given to the r-th output of the k-th DMU,

v_i= weight given to the r-th input of the k-th DMU

y_{rj}= r-th output of the j-th DMU

x_{ij}= j i-th input of the j-th DMU

The number of models to be created in DEA is as large as the number of DMUs to be analyzed. For example, if the number of DMUs to be analyzed is n, then the number of models to be created will be n. In order to calculate the efficiency of DMUs, these n models must be analyzed separately. The linear programming (primal) model of the fractional model above is formed as follows (Cooper et al., 2004):

$$Maxz = \sum_{r=1}^{s} \mu_r\, y_{ro}, \quad \sum_{r=1}^{s} \mu_r\, y_{rj} - \sum_{r=1}^{s} v_i\, x_{ij} \leq 0\ \ ,\ \ \sum_{r=1}^{s} v_i\, x_{i0} = 0\ ,\ \ \mu_r, v_i \geq 0 \tag{2}$$

This model, like all linear programming models, also has dual. The dual of the above model is as follows:

$$Min\theta, \qquad \sum_{j=1}^{n} x_{ij}\, \lambda_j \leq \theta x_{i0}\ , \qquad \sum_{j=1}^{n} y_{rj}\, \lambda_j \geq y_{r0}\ , \qquad \lambda_j \geq 0 \tag{3}$$

$$i = 1, \dots, m\,; r = 1, \dots, s\,;\ \ j = 1, \dots, n$$

The relative efficiency of any DMU means that the objective function in the primal model is equal to 1. For any DMU to be effective in the dual model,

$$\theta = 1, \qquad s_i^- = 0, \qquad s_i^+ = 0$$

conditions must be met together.

In order to convert inequalities in linear programming models into equality, s_i^- denotes slack variables related to overused inputs, and s_r^+ denotes slack variables related to underproduced outputs (Erpolat, 2011).

Output Oriented CCR Model:

This is a model that aims to maximize outputs so that no more than the current inputs are needed (Kıran, 2008). The difference between the output-oriented CCR model and the input-oriented CCR model is that the result of a weighted input and weighted output ratio is minimized. (Erpolat, 2011:77).

The fractional CCR model for the output consists as follows (Cooper et al., 2004):

$$Min\frac{\sum_{i=1}^{m} v_i x_{i0}}{\sum_{i=1}^{m} u_r y_{ro}} \geq 1, \qquad \frac{\sum_{i=1}^{m} v_i X_{ij}}{\sum_{i=1}^{m} u_r Y_{rj}} \geq 1, \quad u_r \geq 0, \quad v_i \geq 0,$$

$$r = 1, \dots, s,\ i = 1, \dots, m,\ j = 1, \dots, n, \quad Min\!: Minimal \tag{4}$$

The expression of the output-oriented primal CCR model as a linear programming model is as follows:

$$\sum_{i=1}^{m} v_i x_{i0}, \quad \sum_{i=1}^{m} v_i X_{ij} - \sum_{i=1}^{m} \mu_r Y_{rj} \geq 0,\ \sum_{i=1}^{s} \mu_r Y_{r0} = 1,\ u_r \geq 0, \quad v_i \geq 0, \quad \mu_r \geq 0 \tag{5}$$

The dual model of the CCR model for the primal output above consists as follows:

$$Max \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+, \qquad \sum_{j=1}^{n} x_{ij}\, \lambda_j + s_i^- = x_{i0}, \qquad \sum_{j=1}^{n} y_{rj}\, \lambda_j + s_r^+ = \phi y_{i0},\ \ \lambda_j \geq 0,\ \phi > 0, \quad r = 1, \dots, s,\ i = 1, \dots, m,\ j = 1, \dots, n \tag{6}$$

3.1.2. Banker-Charnes-Cooper (BCC) Model

The BCC Model is interpreted in two different ways, just like the CCR Model, for input and output. The input-oriented BCC model aims for the maximum movement along the frontier line along with the proportional decrease of the inputs, while the output-oriented BCC model aims for the maximum movement along the frontier line with the proportional increase of the outputs.

The following constraint, known as the convexity constraint, is added to the dual of the CCR models, allowing the efficiency limit to demonstrate the variable returns to scale property. This is the only difference between the CCR and BCC models. (Ramathan, 2003; Cooper, Seiford and Tone, 2000; Cooper, et al., 2004).

$$\sum_{j=1}^{n} \lambda_{jk} = 1 \tag{7}$$

With this constraint, it is also possible to determine the return types of DMUs according to scale. If the sum of the λ_{js} calculated for the DMU is more than 1, the DMU is operating with decreasing returns to scale, if it is less than 1, it is operating with increasing returns, and if it is 1, it is operating with constant returns (Erpolat, 2011).

Input-Oriented BCC Model:

Under the premise of variable returns to scale, this model is the one that determines how much the input variables should be reduced in order to achieve this output level in the most effective way, without affecting the outputs (Erpolat, 2011).

Fractional, primal linear programming and dual linear programming formulations of the input-oriented BCC model are as follows (Cooper et al., 2000):

Fractional model,

$$Max \frac{uy_0 - u_0}{vx_0} \ , \quad Max \frac{uy_j - u_0}{vx_j} \leq 1, \quad (j = 1,..,n), \ v \geq 0, \ u \geq 0, \ u_0: unrestricted \tag{8}$$

Primal linear programming model:

$$Min \ \theta_b, \ \ \theta_b X_0 - X\lambda \geq 0, \ \ Y\lambda \geq y_0 \ , \ \ e\lambda = 1, \ \ \lambda \geq 0 \tag{9}$$

Dual model:

$$Max \ z = uy_0 - u_0, \quad vx_0 = 1, -vX + uY - u_0 e \leq 0, \quad v,u \geq 0, \ u_0: unrestricted \tag{10}$$

Efficiency solutions in this model are carried out in two steps, like those in the CCR model. The first step is to minimize θ_B and to maximize input surpluses and output deficits. For any DMU to be effective in the model, the objective function must be equal to 1 (Cooper et al. 2000).

Output-Oriented BCC Model:

It is a model that determines how much the outputs should be increased in order to reach the maximum output level that can be obtained from these inputs without making any reductions in the inputs of the variables. (Erpolat, 2011).

Fractional, primal linear programming and dual linear programming formulations of this model are as follows (Cooper et al., 2000).

Fractional model:

$$Min \frac{ux_0 - v_0}{vy_0}, \quad Max \frac{ux_j - u_0}{vy_j} \geq 1, \quad (j = 1,..,n), \ v \geq 0, \ u \geq 0, \ v_0: unrestricted \tag{11}$$

Primal model:

$$Max\eta_B, \quad X\lambda \leq x_0, \ \eta_B y_0 - Y\lambda \leq 0, \quad e\lambda = 1, \ \lambda > 0 \tag{12}$$

Dual model.

$$Min \ z = vx_0 - u_0, \ \ u_y = 1, \ \ uX - uY - v_0 e \geq 0, \ \ v,u \geq 0, \ \ v_0: unrestricted \tag{13}$$

If the BCC and CCR values are both 1, the DMUs are fully active. In this case, DMUs have an optimal scale size. That is, they operate at an optimal scale. If the CCR value is 1 and the BCC value is less than 1, the DMU is total effective according to the scale size, but the technique is not efficient. (Kutlar and Babacan, 2008).

3.2. Malmquist Total Factor Productivity Index

DEA's structure is static, and it only uses data from decision units for the designated time period to do cross-sectional analysis. An effective decision unit determined through DEA analysis may lose its effectiveness in the future and cease to be a reference unit. The Malmquist Total Factor Efficiency Index was created in order to study how efficiency changes over time. The first advantage of the Malmquist index over the Tornqvist and Fisher Ideal Indices is that it does not calculate total factor productivity by making the same assumptions as the Tornqvist Index and Fisher Ideal Index do, namely, cost reduction or revenue maximization. Second, there is no requirement to set a price, unlike these two indices. since it's not always possible to receive accurate price information. Finally, it allows calculation using panel data. Despite the benefits described, the Malmquist TFP index has the drawback of not being stochastic, which prevents statistical inferences (Kılıçkaplan et al., 2004).

The Malmquist total factor productivity index is a method that measures the change in total factor productivity of two observations as the ratio of the distances to a common technology. The "distance function" is used for this measurement. This index, developed by Caves et al. (1982), was named Malmquist because the idea of establishing an index with the help of distance functions was first introduced by Sten Malmquist (Malmquist, 1953). With the distance function, it is used when there are inputs and outputs, and when there are targets, such as cost minimization or profit maximization.

According to the output, the distance function is defined as:

$$d(x,y) \;=\; min\,\{\delta\colon (y/\,\delta) \;\in\; S\}$$

and the values that the distance function d(x, y) will take are,

- If the vector y is on the boundary of S (production frontier) =1
- If vector y describes a technically inefficient point in S >1
- If vector y describes an impossible point other than S <1.

The Malmquist Total Factor Productivity Index of Change is derived using the formula

$$m(Y_s, X_s, Y_t, X_t) = \sqrt{\frac{d^s(Y_t,X_t)}{d^s(Y_s,X_s)} \times \frac{d^t(Y_t,X_t)}{d^t(Y_s,X_s)}} \tag{14}$$

on the "distance function" axis based on the output between the s period used as the basis and the following t period. In this notation, $d^s(Y_t, X_t)$ represents the distance of the observation of period t from the technology of period $s(t = s + 1)$. Here, the value of the function $m(Y_s, X_s, Y_t, X_t)$) greater than 1 indicates that there is an increase in total factor productivity from the s period to the t period, and if it is less than 1, when the same periods are taken into account, there is a decrease in the total factor productivity (Cingi and Tarım, 2000).

3. DATA AND METHODOLOGY

Efficiency and productivity were analyzed in the study using the Data Envelopment Analysis method and the Malmquist total productivity analysis, whose application area has grown recently. On the axis of variables such as current ratio, leverage ratio, long-term debt-to-asset ratio, short-term debt-to-asset ratio, equity-to-asset ratio, return on assets, net profit margin, and gross profit margin, the Malmquist total factor productivity index is used to analyze changes in total factor productivity of 20 real estate investment trusts (REITs) operating in 2019-2020-2021, as well as the reasons for these changes. Total factor productivity changes and their causes were examined using the Malmquist total productivity index. Determinative outcomes have been attained in the development of the sector's future strategies by computing the "technological change, technical efficiency, and scale efficiency change values" required for the creation of the index, determining whether the companies operate at a scale suitable to them, the direction of the change in the amount of output produced with the same input, and managerial activities. In the analysis, the efficiency values and productivity of 20 companies in the years 2019-2020-2021 were measured with the Win4DEAP2-Window for Deap package program. Firms with a value of 1 are considered efficient firms, and firms with a value below 1 are considered inefficient firms. In the Data Envelopment analysis, the selection of 'orientation', 'enveloping surface' and 'model' was decided by using the following steps.:

Orientation; 'DEA Output Oriented Approach',

- Returns to Scale; 'CCR Variable Model',
- Returns to Scale; 'BCC Variable Model',
- Calculate; 'DEA multi-stage'.

3.1. Purpose of the Study and Data

The purpose of the study is to assess the effectiveness of the companies included in its scope, as well as the financial ratios and their corresponding weights in assessing effectiveness. For this aim, the end-of-period financial statements of the 38 companies participating in the BIST Real Estate Investment Trust index for the years 2019-2020-2021 were used to create 8 different financial ratios for each year. The Data Envelopment analysis excluded a total of 18 companies, including 12 companies with negative values and 6 companies with non-continuous data. The financial statements of the companies were obtained by using the Public Disclosure Platform (KAP-Kamuyu Aydınlatma Platformu) website (www.kap.org.tr). In order to measure the efficiency of the companies, the data obtained from the 3-year balance sheet and income statements for the period 2019-2020-2021 was used. The list of companies included in the study is given in Table 1.

Table 1: Companies Included in the Study

No	Code	Company Title
1	AKMGYO	AKMERKEZ GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
2	ALGYO	ALARKO GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
3	AGYO	ATAKULE GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
4	AVGYO	AVRASYA GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
5	DZGYO	DENİZ GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
6	EKGYO	EMLAK KONUT GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
7	HLGYO	HALK GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
8	ISGYO	İŞ GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
9	KGYO	KORAY GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
10	KRGYO	KÖRFEZ GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
11	MRGYO	MARTI GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
12	MSGYO	MİSTRAL GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
13	OZKGYO	ÖZAK GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
14	PAGYO	PANORA GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
15	RYGYO	REYSAŞ GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
16	SRVGYO	SERVET GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
17	SNGYO	SİNPAŞ GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
18	TRGYO	TORUNLAR GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
19	VKGYO	VAKIF GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.
20	YGGYO	YENİ GİMAT GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.

Studies in the literature were reviewed to identify the input and output variables used in the study. The input and output variables are listed in Table 2.

Table 2: Input and Output Variables

Input/Output	Ratios	Definitions
Input	Current rate	Current Assets / Current Liability
	Leverage Ratio	(Short Term Liabilities + Long Term Liabilities) / Total Resource
	Long Term Debt-Asset Ratio	Long Term Load. / Total Assets
	Short Term Debt-Asset Ratio	Short Term Load. / Total Assets
	Equity-Asset Ratio	Total Equity / Total Assets
Output	Assets Profitability Ratio	Net Profit (Loss) for the Period / Total Assets
	Net Profit Margin	Net Profit / Net Sales
	Gross Margin	(Sales - Cost of Sales) / Sales Revenues

The data obtained by examining the balance sheets and income statements of 20 companies within the scope of the analysis for the years 2019–2020–2021 were included in the analysis. In DEA, the number of decision units should be one more than the sum of the number of inputs and the number of outputs, and twice the sum of the number of inputs and outputs (Boussofiane, Dyson, and Thanassoulis, 1991: 1–15, as cited in Kayalıdere and Kargın 2004: 205). These two constraints are provided for the reliability of DEA.

4. APPLICATION

Table 3 lists the financial ratios that were determined through calculations based on the years using the input and output variables.

Table 3: Financial Ratios of Companies by Years

Order	Code	Output Variables									Input Variables														
		Return on Assets			Net Profit Margin			Gross Profit Margin			Current Ratio			Leverage Ratio			Long-Term Debt-Asset Ratio			Short-Term Debt-Asset Ratio			Equity-Asset Ratio		
		2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
1	AKMGYO	0.32	0.21	0.36	0.69	0.65	0.79	0.69	0.64	0.72	9.09	3.62	18.58	0.04	0.10	0.03	0.01	0.01	0.01	0.03	0.09	0.02	0.96	0.90	0.97
2	ALGYO	0.25	0.18	0.41	10.76	12.31	10.34	0.95	0.93	0.99	58.21	59.72	22.21	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.99	0.99	0.99
3	AGYO	0.06	0.00	0.13	1.00	0.05	2.32	0.42	0.44	0.51	0.89	0.31	5.81	0.07	0.07	0.01	0.04	0.01	0.01	0.02	0.06	0.01	0.93	0.93	0.99
4	AVGYO	0.16	0.20	0.08	3.42	5.11	3.07	0.94	0.96	0.97	36.42	39.60	2.70	0.01	0.00	0.04	0.00	0.00	0.00	0.01	0.00	0.04	0.99	1.00	0.96
5	DZGYO	0.02	0.01	0.10	0.88	0.02	0.21	0.71	0.19	0.28	0.18	1.08	2.18	0.69	0.65	0.28	0.30	0.09	0.00	0.38	0.55	0.28	0.31	0.35	0.72
6	EKGYO	0.03	0.03	0.04	0.14	0.18	0.20	0.27	0.24	0.33	2.34	2.17	2.03	0.43	0.49	0.49	0.07	0.11	0.07	0.36	0.39	0.42	0.57	0.51	0.51
7	HLGYO	0.11	0.10	0.08	2.47	2.32	3.62	0.68	0.57	0.68	0.43	0.21	0.26	0.15	0.17	0.28	0.00	0.02	0.04	0.15	0.14	0.24	0.85	0.83	0.72
8	ISGYO	0.05	0.05	0.20	0.25	0.48	2.72	0.21	0.36	0.59	1.01	0.48	0.49	0.32	0.21	0.18	0.11	0.03	0.03	0.22	0.18	0.15	0.68	0.79	0.82
9	KGYO	0.05	0.02	0.20	0.09	0.04	0.41	0.22	0.21	0.21	4.59	4.61	4.33	0.16	0.14	0.12	0.07	0.06	0.05	0.08	0.08	0.08	0.84	0.86	0.88
10	KRGYO	0.11	0.04	0.13	1.16	0.29	0.87	0.83	0.58	0.68	14.14	5.20	4.75	0.08	0.28	0.22	0.02	0.16	0.10	0.06	0.11	0.12	0.92	0.72	0.78
11	MRGYO	0.03	0.01	0.11	0.79	0.34	16.20	0.92	0.91	0.79	0.34	1.28	1.63	0.52	0.51	0.24	0.00	0.38	0.19	0.52	0.12	0.05	0.48	0.49	0.76
12	MSGYO	0.14	0.05	0.44	2.44	1.06	5.39	0.76	0.85	0.83	7.95	9.32	4.84	0.03	0.03	0.05	0.00	0.00	0.00	0.03	0.03	0.04	0.97	0.97	0.95
13	OZKGYO	0.07	0.11	0.28	0.59	0.52	1.71	0.43	0.33	0.47	1.80	3.28	2.30	0.49	0.41	0.26	0.26	0.29	0.12	0.22	0.12	0.14	0.51	0.59	0.74
14	PAGYO	0.06	0.03	0.21	0.71	0.56	3.32	0.74	0.65	0.69	5.70	1.23	5.07	0.01	0.03	0.01	0.00	0.00	0.00	0.01	0.02	0.01	0.99	0.97	0.99
15	RYGYO	0.20	0.12	0.27	2.55	1.55	4.76	0.87	0.87	0.84	0.15	0.42	0.66	0.39	0.40	0.30	0.23	0.22	0.15	0.17	0.18	0.15	0.61	0.60	0.70
16	SRVGYO	0.05	0.37	0.13	0.55	0.74	1.66	0.63	0.85	0.44	0.57	3.10	0.62	0.50	0.36	0.43	0.36	0.18	0.21	0.15	0.18	0.22	0.50	0.64	0.57
17	SNGYO	0.04	0.03	0.28	0.13	0.08	1.49	0.32	0.39	0.48	1.43	1.10	3.25	0.89	0.88	0.57	0.53	0.48	0.47	0.36	0.40	0.10	0.11	0.12	0.43
18	TRGYO	0.06	0.02	0.27	0.87	0.26	3.58	0.69	0.61	0.79	0.90	0.49	0.48	0.38	0.36	0.27	0.22	0.18	0.13	0.16	0.18	0.14	0.62	0.64	0.73
19	VKGYO	0.05	0.04	0.10	4.38	1.53	1.91	0.34	0.31	0.76	0.37	1.17	1.22	0.40	0.51	0.47	0.26	0.16	0.11	0.14	0.35	0.36	0.60	0.49	0.53
20	YGGYO	0.15	0.05	0.25	1.47	0.66	2.52	0.78	0.71	0.75	13.22	15.02	9.55	0.01	0.01	0.02	0.00	0.00	0.00	0.01	0.01	0.02	0.99	0.99	0.98

In the analysis, the input- and output-oriented CCR and BCC models of DEA are used to maximize the outputs. Table 4 provides descriptive statistics for the three-year financial ratios of the companies included in the analysis for the years 2019–2020–2021.

Table 4: Descriptive Statistics

N=20	Year	Mean	Median	Stand. D.	Min	Max
Asset Profitability	2019	0.10	0.06	0.08	0.02	0.32
	2020	0.08	0.05	0.09	0.00	0.37
	2021	0.20	0.20	0.11	0.04	0.44
	Total	0.13	0.10	0.11	0.00	0.44
Net Profit Margin	2019	1.77	0.88	2.42	0.09	10.76
	2020	1.44	0.54	2.81	0.02	12.31
	2021	3.35	2.42	3.80	0.20	16.20
	Total	2.19	0.94	3.13	0.02	16.20
Gross Margin	2019	0.62	0.69	0.25	0.21	0.95
	2020	0.58	0.60	0.26	0.19	0.96
	2021	0.64	0.69	0.22	0.21	0.99
	Total	0.61	0.68	0.24	0.19	0.99
Current Ratio	2019	7.99	1.62	14.56	0.15	58.21
	2020	7.67	1.73	15.16	0.21	59.72
	2021	4.65	2.50	5.89	0.26	22.21
	Total	6.77	2.18	12.48	0.15	59.72
Leverage Ratio	2019	0.28	0.24	0.26	0.01	0.89
	2020	0.28	0.25	0.25	0.00	0.88
	2021	0.21	0.23	0.18	0.01	0.57
	Total	0.26	0.23	0.23	0.00	0.89
Long-Term Liabilities/Assets Ratio	2019	0.12	0.06	0.15	0.00	0.53
	2020	0.12	0.08	0.14	0.00	0.48
	2021	0.08	0.05	0.11	0.00	0.47
	Total	0.11	0.06	0.14	0.00	0.53
Short Term Liabilities/Assets Ratio	2019	0.15	0.15	0.15	0.01	0.52
	2020	0.16	0.12	0.15	0.00	0.55
	2021	0.13	0.11	0.12	0.01	0.42
	Total	0.15	0.12	0.14	0.00	0.55
Equity/Asset Ratio	2019	0.72	0.76	0.26	0.11	0.99
	2020	0.72	0.76	0.25	0.12	1.00
	2021	0.79	0.77	0.18	0.43	0.99
	Total	0.74	0.77	0.23	0.11	1.00

According to the 3-year data of real estate investment trusts, it has been determined that the return on assets is 13%, the net profit margin is 219%, and the gross profit margin is 61%. Additionally, it has been determined that the average leverage ratio for real estate investment trusts is 0.26, the average long-term debt-to-asset ratio is 0.11, and the average short-term debt-to-asset ratio is 0.15, all of which are above the optimal value (current ratio > 1) of 1 and equity financing accounts for 74% of its average assets.

Table 5 contains the coefficients of the findings of the Pearson correlation analysis between the input and output variables used for the DEA study.

Table 5: Correlation Analysis Between Variables

	Year	Asset Profitability	Net Profit Margin	Gross Margin
Current Ratio	2019	0.58**	0.81**	0.50*
	2020	0.37	0.93**	0.51*
	2021	0.59**	0.17	0.33
Leverage Ratio	2019	-0.74**	-0.47*	-0.42
	2020	-0.36	-0.46*	-0.51*
	2021	-0.33	-0.31	-0.34
Long-Term Liabilities/Assets Ratio	2019	-0.51*	-0.42	-0.56**
	2020	-0.21	-0.36	-0.27
	2021	-0.05	-0.10	-0.21
Short Term Liabilities/Assets Ratio	2019	-0.70**	-0.47*	-0.38
	2020	-0.26	-0.40	-0.58**
	2021	-0.51*	-0.35	-0.40
Equity/Asset Ratio	2019	0.74**	0.47*	0.42
	2020	0.36	0.45*	0.51*
	2021	0.33	0.31	0.34

Indicates significance at the *5% level, ** at the 1% level.

According to the correlation values of 2019; It was observed that there is a positive and significant relationship between current ratio and return on assets ($r=0.58$, $p<0.01$), net profit margin ($r=0.81$, $p<0.01$) and gross profit margin ($r=0.50$, $p<0.05$). It was observed that there was no significant relationship between leverage ratio and gross profit margin ($r=-0.42$, $p>0.05$) and there is a significant negative correlation between return on assets ($r=-0.74$, $p<0.01$) and net profit margin ($r=-0.47$, $p<0.05$). There is no significant relationship between long-term debt-to-asset ratio and net profit margin ($r = -0.42$, $p > 0.05$). In addition, it was observed that there is a negative significant relationship between return on assets (r = -0.51, p 0.05) and gross profit margin (r = -0.56, p 0.01). There is no significant relationship between short-term debt-to-asset ratio and gross profit margin ($r = -0.38$, $p > 0.05$). In addition, it was observed that there was a significant negative correlation between return on assets (r = -0.70, p 0.01) and net profit margin (r = -0.47, p 0.05). There is no significant relationship between equity-asset ratio and gross profit margin ($r = 0.42$, $p > 0.05$). In addition, it was observed that there was a significant positive correlation between return on assets (r = 0.74, p 0.01) and net profit margin (r = 0.47, p 0.05).

According to the correlation values of 2020; There is no significant relationship between current ratio and return on assets ($r=0.37$, $p>0.05$). In addition, it was observed that there was a significant positive correlation between net profit margin ($r=0.93$, $p<0.01$) and gross profit margin ($r=0.51$, $p<0.05$). There is no significant relationship between leverage ratio and return on assets ($r=-0.36$, $p>0.05$). However, it was observed that there was a significant negative correlation between net profit margin ($r=-0.46$, $p<0.05$) and gross profit margin ($r=-0.51$, $p<0.05$). There is a significant difference between the long-term debt-to-asset ratio and return on assets ($r = -0.21$, $p > 0.05$), the net profit margin ($r = -0.36$, $p > 0.05$), and the gross profit margin ($r = -0.27$, $p > 0.05$). No relationship was observed. There is no significant relationship between short-term debt-to-asset ratio and return on assets ($r = -0.26$, $p > 0.05$) or net profit margin ($r = -0.40$, $p > 0.05$). On the other hand, it was observed that there was a significant negative correlation between short-term debt-asset ratio and gross profit margin (r = -0.58, p 0.01). There is no significant relationship between the equity-asset ratio and return on assets ($r = 0.36$, $p > 0.05$). It was observed that there is a significant positive correlation between net profit margin (r = 0.45, p 0.05) and gross profit margin (r = 0.51, p 0.05).

According to the correlation values of 2021; There is no significant relationship between current ratio and net profit margin (r=0.17, p>0.05) and gross profit margin (r=0.33, p>0.05). It was observed that there is a significant positive correlation between return on assets (r=0.59, p<0.01). It was observed that there was no significant relationship between leverage ratio and return on assets (r=-0.33, p>0.05), net profit margin (r=-0.31, p>0.05), gross profit margin (r=-0.34, p>0.05). There is no significant relationship between long-term debt-to-asset ratio and return on assets (r=-0.05, p>0.05), net profit margin (r=-0.10, p>0.05), gross profit margin (r=-0.21, p>0.05). There is no significant relationship between short-term debt-asset ratio and net profit margin (r=-0.35, p>0.05) and gross profit margin (r=-0.40, p>0.05). It was observed that there is a negative significant relationship between short-term debt-asset ratio and return on assets (r=-0.51, p<0.05). It was observed that there was no significant relationship between equity-asset ratio and return on assets (r=0.33, p>0.05), net profit margin (r=0.31, p>0.05), gross profit margin (r=0.34, p>0.05).

4.1. Data Envelopment Analysis Efficiency Results

The CCR model output-oriented scale efficiency results of 20 companies in the real estate investment partnership index are given in Table 6.

Tablo 6: CCR Technical Efficiency Changes

Company	**CCR Technical Efficiency**		
	2019	**2020**	**2021**
AKMGYO	1.000	1.000	0.863
ALGYO	1.000	1.000	1.000
AGYO	1.000	1.000	0.726
AVGYO	1.000	1.000	1.000
DZGYO	1.000	0.427	0.569
EKGYO	0.303	0.389	0.502
HLGYO	1.000	1.000	1.000
ISGYO	0.308	0.625	1.000
KGYO	0.290	0.265	0.488
KRGYO	1.000	0.670	0.772
MRGYO	1.000	1.000	1.000
MSGYO	1.000	1.000	1.000
OZKGYO	0.539	0.503	0.874
PAGYO	1.000	1.000	1.000
RYGYO	1.000	1.000	1.000
SRVGYO	0.872	1.000	0.630
SNGYO	1.000	1.000	1.000
TRGYO	0.807	0.753	1.000
VKGYO	1.000	0.995	1.000
YGGYO	1.000	1.000	0.897
Mean	0.856	0.831	0.866
Number of Effective Decision Units	14	12	11
Efficiency Percentage	70%	60%	55%

Eight companies that were relatively active in2019,2020, and 2021 were identified using the CCR technical efficiency values. It has been observed that these companies ALGYO, AVGYO, HLGYO, MRGYO, MSGYO, PAGYO, RYGYO, SNGYO have become output-oriented in 3 years. According to the output-oriented CCR technical efficiency values, 55% of the 20 companies in 2021, 60% of the 20 companies in 2020, and 70% of the 20 companies in 2019 are all operating in a reasonably efficient way.

Real estate investment trusts performed better in 2021 than they did in 2019 and 2020, according to average efficiency values.

Figure 1: Output Oriented CCR Technical Efficiency Changes by Years

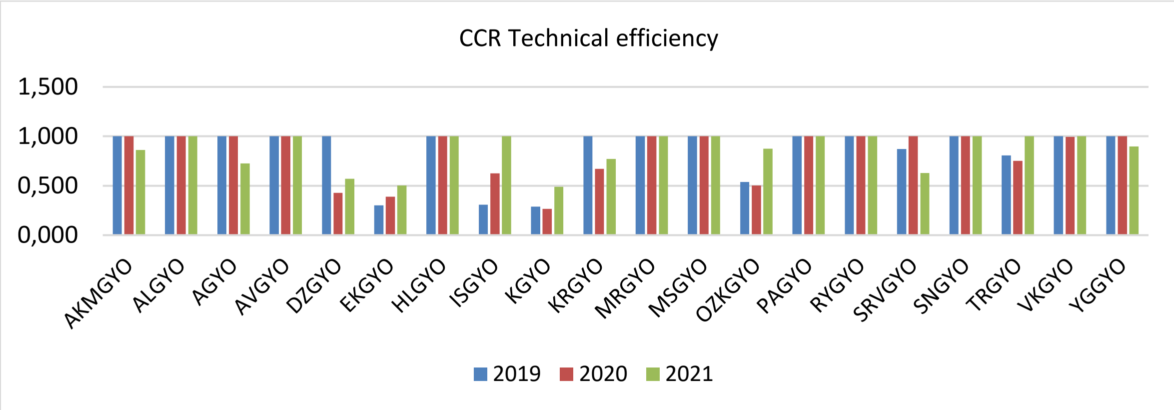


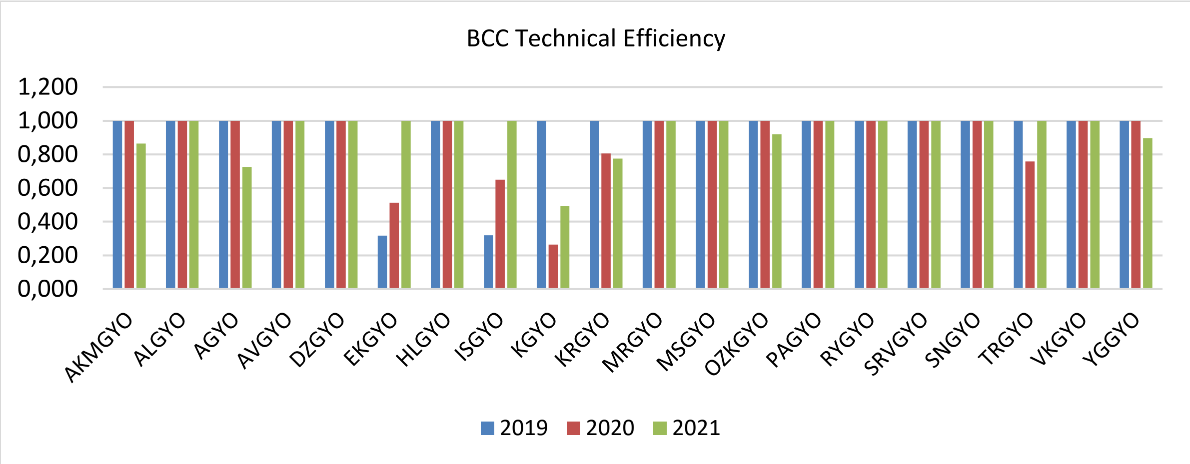
Table 7 displays the output-oriented scale efficiency statistics for 20 enterprises that are members of the real estate investment partnership index.

Table 7: BCC Technical Efficiency Changes

Company	BCC Technical Efficiency		
	2019	2020	2021
AKMGYO	1.000	1.000	0.864
ALGYO	1.000	1.000	1.000
AGYO	1.000	1.000	0.726
AVGYO	1.000	1.000	1.000
DZGYO	1.000	1.000	1.000
EKGYO	0.318	0.513	1.000
HLGYO	1.000	1.000	1.000
ISGYO	0.320	0.650	1.000
KGYO	1.000	0.265	0.494
KRGYO	1.000	0.805	0.775
MRGYO	1.000	1.000	1.000
MSGYO	1.000	1.000	1.000
OZKGYO	1.000	1.000	0.919
PAGYO	1.000	1.000	1.000
RYGYO	1.000	1.000	1.000
SRVGYO	1.000	1.000	1.000
SNGYO	1.000	1.000	1.000
TRGYO	1.000	0.758	1.000
VKGYO	1.000	1.000	1.000
YGGYO	1.000	1.000	0.897
Mean	0.932	0.900	0.934
Number of Effective Decision Units	18	15	14
Efficiency Percentage	90%	75%	70%

According to BCC technical efficiency values, relatively active 11 companies have been identified in 2019, 2020 and 2021. It has been observed that these companies ALGYO, AVGYO, DZGYO, HLGYO, MRGYO, MSGYO, PAGYO, RYGYO, SRVGYO, SNGYO, VKGYO have been effective in 3 years with a focus on output. Looking at the output-oriented BCC technical efficiency values, 90% of 20 companies in 2019, 75% in 2020, and 70% in 2021 are operating relatively effective. Looking at the average efficiency values, it can be said that real estate investment trusts operated more effectively in 2021 compared to 2019 and 2020.

Figure 2: Output Oriented BCC Technical Efficiency Changes by Years



The CCR/BCC model output-oriented scale efficiency results of 20 companies included in the real estate investment partnership index are given in Table 8.

Table 8: CCR/BCC Scale Activity Changes

Company	CCR/BCC Scale Efficiency		
	2019	2020	2021
AKMGYO	1.000	1.000	0.998
ALGYO	1.000	1.000	1.000
AGYO	1.000	1.000	1.000
AVGYO	1.000	1.000	1.000
DZGYO	1.000	0.427	0.569
EKGYO	0.953	0.758	0.502
HLGYO	1.000	1.000	1.000
ISGYO	0.963	0.962	1.000
KGYO	0.290	1.000	0.989
KRGYO	1.000	0.832	0.996
MRGYO	1.000	1.000	1.000
MSGYO	1.000	1.000	1.000
OZKGYO	0.539	0.503	0.951
PAGYO	1.000	1.000	1.000
RYGYO	1.000	1.000	1.000
SRVGYO	0.872	1.000	0.630
SNGYO	1.000	1.000	1.000
TRGYO	0.807	0.993	1.000

VKGYO	1.000	0.995	1.000
YGGYO	1.000	1.000	1.000
Mean	0.921	0.923	0.932
Number of Effective Decision Units	14	13	13
Activity Percentage	70%	65%	65%

Ten businesses that were relatively active in 2019, 2020, and 2021 were identified using the CCR/BCC scale efficiency ratings. With an emphasis on output, it has been noted that the following companies—ALGYO, AGYO, AVGYO, HLGYO, MRGYO, MSGYO, PAGYO, RYGYO, SNGYO, and YGGYO—have been successful in the past three years.

Figure 3: Output Oriented CCR/BCC Scale Efficiency Changes by Years

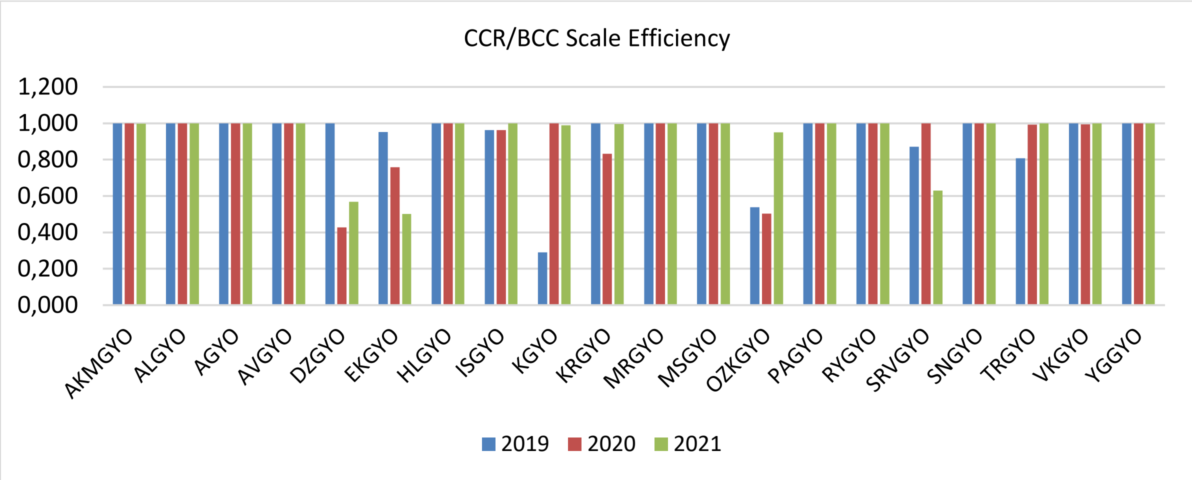
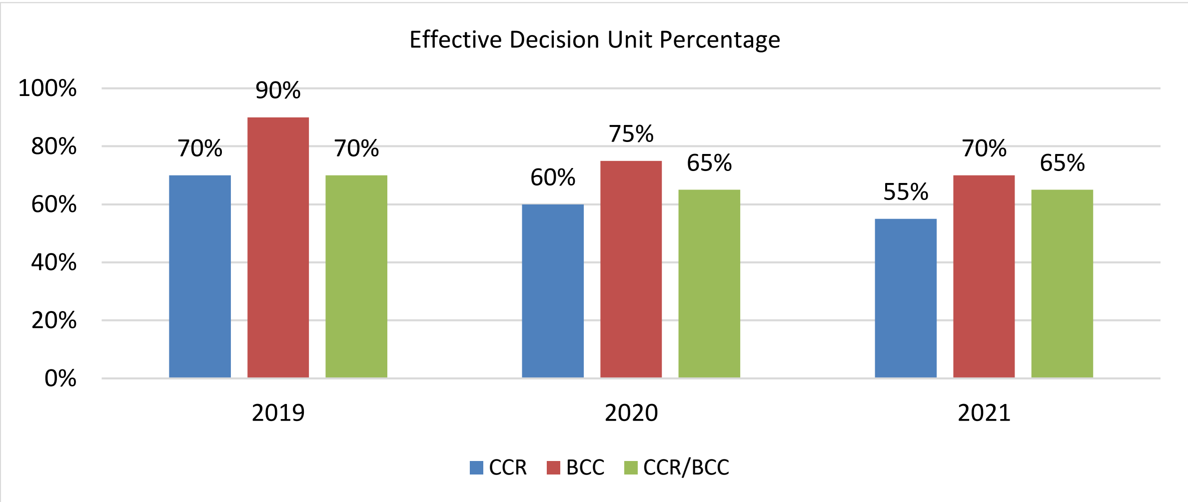


Figure 4: Effective Decision Unit Percentage



4.2. Malmquist Productivity Analysis Results

For the 20 real estate investment partnership firms included in the analysis (2019–2020–2021), 3-year period efficiency change (effch), technological change (techch), pure efficiency (pech), scale efficiency change (sech), and total factor productivity change (tfpch) values were calculated. The average Malmquist indices for each year are provided in the tables below.

Table 9: 2019-2020 Malmquist Index Summary

Company	Malmquist Index Summary 2019-2020				
	Efficiency change	Technological change	Pure Efficiency change	Scale Efficiency change	Total Factor Productivity Change
AKMGYO	1.00	0.63	1.00	1.00	0.63
ALGYO	1.00	1.07	1.00	1.00	1.07
AGYO	1.00	0.79	1.00	1.00	0.79
AVGYO	1.00	0.67	1.00	1.00	0.67
DZGYO	0.43	0.60	1.00	0.43	0.26
EKGYO	1.29	0.68	1.60	0.80	0.88
HLGYO	1.00	0.54	1.00	1.00	0.54
ISGYO	2.03	0.90	2.02	1.00	1.82
KGYO	0.92	0.99	0.27	3.44	0.91
KRGYO	0.67	1.04	1.00	0.67	0.70
MRGYO	1.00	0.52	1.00	1.00	0.52
MSGYO	1.00	0.66	1.00	1.00	0.66
OZKGYO	0.93	1.05	1.00	0.93	0.98
PAGYO	1.00	1.14	1.00	1.00	1.14
RYGYO	1.00	0.60	1.00	1.00	0.60
SRVGYO	1.15	0.14	1.00	1.15	1.57
SNGYO	1.00	1.05	1.00	1.00	1.05
TRGYO	0.93	0.99	0.76	1.23	0.92
VKGYO	0.99	0.48	1.00	0.99	0.47
YGGYO	1.00	0.69	1.00	1.00	0.69
Ort.	0.98	0.79	0.98	1.00	0.77

When the Malmquist Index (2019-2020) table is examined, it is seen that there is an increase in Malmquist total factor productivity in 2020 compared to 2019 for ALGYO, ISGYO, PAGYO, SRVGYO, SNGYO companies for 2019-2020. On the other hand, it has been determined that the companies AKMGYO, AGYO, AVGYO, DZGYO, EKGYO, HLGYO, KGYO, KRGYO, MRGYO, MSGYO, OZKGYO, RYGYO, TRGYO, VKGYO, YGGYO have decreased in Malmquist total factor productivity in 2020 compared to 2019. If we look at the change in technical efficiency for 2019-2020, since the technical efficiency change of AKMGYO, ALGYO, AGYO, AVGYO, EKGYO, HLGYO, ISGYO, MRGYO, MSGYO, PAGYO, RYGYO, SRVGYO, SNGYO, YGGYO is 1 and above, it can be said that these companies have reached the production limit. The most technically efficient company is ISGYO. When it comes to technological efficiency change in 2019-2020, it can be said that ALGYO, KRGYO, OZKGYO, PAGYO, and SNGYO companies use it more effectively. The company that uses the technological efficiency change most effectively is PAGYO.

If we look at the scale efficiency change for the years 2019-2020, the company that reached the most effective production size was determined to be KGYO (3.44). It is followed by TRGYO (1.23) and SRVGYO (1.15).

Table 10: 2020-2021 Malmquist Index Summary

Company	Malmquist Index Summary 2020-2021				
	Efficiency change	Technological change	Pure Efficiency change	Scale Efficiency change	Total Factor Productivity Change
AKMGYO	0.86	2.04	0.86	1.00	1.76
ALGYO	1.00	1.69	1.00	1.00	1.69

AGYO	0.73	1.50	0.73	1.00	1.09
AVGYO	1.00	1.42	1.00	1.00	1.42
DZGYO	1.33	1.95	1.00	1.33	2.60
EKGYO	1.29	1.22	1.95	0.66	1.57
HLGYO	1.00	1.07	1.00	1.00	1.07
ISGYO	1.60	1.33	1.54	1.04	2.12
KGYO	1.83	1.577	1.85	0.99	2.89
KRGYO	1.15	1.01	0.78	1.49	1.16
MRGYO	1.00	3.04	1.00	1.00	3.04
MSGYO	1.00	3.06	1.00	1.00	3.06
OZKGYO	1.74	1.24	0.92	1.89	2.15
PAGYO	1.00	1.83	1.00	1.00	1.83
RYGYO	1.00	1.37	1.00	1.00	1.37
SRVGYO	0.63	1.19	1.00	0.63	0.75
SNGYO	1.00	0.81	1.00	1.00	0.81
TRGYO	1.33	1.42	1.32	1.01	1.88
VKGYO	1.005	1.66	1.00	1.005	1.67
YGGYO	0.90	2.00	0.90	1.00	1.80
Mean.	1.08	1.53	1.06	1.02	1.66

When the Malmquist Index (2020-2021) table is examined, it is seen that AKMGYO, ALGYO, AGYO, AVGYO, DZGYO, EKGYO, HLGYO, ISGYO, KGYO, KRGYO, MRGYO, MSGYO, OZKGYO, PAGYO, RYGYO, TRGYO, VKGYO, YGGYO companies have increased Malmquist total factor productivity in 2021 compared to 2020. On the other hand, it has been determined that SRVGYO, SNGYO companies have a decrease in Malmquist total factor productivity in 2021 compared to 2020.

If we look at the change in technical efficiency for the year 2020-2021, since the technical efficiency change of ALGYO, AVGYO, DZGYO, EKGYO, HLGYO, ISGYO, KGYO, KRGYO, MRGYO, MSGYO, OZKGYO, PAGYO, RYGYO, SNGYO, TRGYO, VKGYO is 1 and above. It can be said that these companies have reached the production limit. The most technically efficient company is KGYO.

If we look at the technological efficiency change for the year 2020-2021, it can be said that AKMGYO, ALGYO, AGYO, AVGYO, DZGYO, EKGYO, HLGYO, ISGYO, KGYO, KRGYO, MRGYO, MSGYO, OZKGYO, PAGYO, RYGYO, SRVGYO, TRGYO, VKGYO and YGGYO companies use technological efficiency change more effectively. The company that uses the technological efficiency change most effectively is MSGYO.

If we examine the scale efficiency change for the years 2020–2021, OZKGYO was found to have attained the most efficient production size (1.89). Next are KRGYO (1.49) and DZGYO (1.33).

Table 11: Malmquist Index Summary of Company Means

Company	Malmquist Index Summary of Company Means				
	Efficiency change	**Technological change**	**Pure Efficiency change**	**Scale Efficiency change**	**Total Factor Productivity Change**
AKMGYO	0.93	1.13	0.93	1.00	1.05
ALGYO	1.00	1.35	1.00	1.00	1.35
AGYO	0.85	1.09	0.85	1.00	0.93
AVGYO	1.00	0.97	1.00	1.00	0.97
DZGYO	0.75	1.08	1.00	0.75	0.82
EKGYO	1.29	0.91	1.77	0.73	1.18
HLGYO	1.00	0.76	1.00	1.00	0.76

ISGYO	1.80	1.09	1.76	1.02	1.96
KGYO	1.30	1.253	0.70	1.85	1.63
KRGYO	0.88	1.02	0.88	1.00	0.90
MRGYO	1.00	1.26	1.00	1.00	1.26
MSGYO	1.00	1.42	1.00	1.00	1.42
OZKGYO	1.27	1.14	0.96	1.33	1.45
PAGYO	1.00	1.45	1.00	1.00	1.45
RYGYO	1.00	0.91	1.00	1.00	0.91
SRVGYO	0.85	1.27	1.00	0.85	1.08
SNGYO	1.00	0.92	1.00	1.00	0.92
TRGYO	1.11	1.18	1.00	1.11	1.32
VKGYO	1.000	0.89	1.00	1.000	0.89
YGGYO	0.95	1.17	0.95	1.00	1.11
Mean.	1.03	1.10	1.02	1.01	1.13

When the 3-year Malmquist Index table of the company averages is analyzed, it is seen that the Malmquist total factor productivity of the AKMGYO, ALGYO, EKGYO, ISGYO, KGYO, MRGYO, MSGYO, OZKGYO, PAGYO, SRVGYO, TRGYO, and YGGYO companies has increased. On the other hand, it was determined that the Malmquist total factor productivity of AGYO, AVGYO, DZGYO, HLGYO, KRGYO, RYGYO, SNGYO, and VKGYO companies decreased.

If we look at the change in the 3-year technical efficiency of the company averages, it can be said that the companies ALGYO, AVGYO, EKGYO, HLGYO, ISGYO, KGYO, MRGYO, MSGYO, OZKGYO, PAGYO, RYGYO, SNGYO, TRGYO and VKGYO have reached the production limit since their technical efficiency change is 1 and above. The most technically efficient company is ISGYO.

If we look at the 3-year technological efficiency change of the company, it can be said that AKMGYO, ALGYO, AGYO, DZGYO, ISGYO, KGYO, KRGYO, MRGYO, MSGYO, OZKGYO, PAGYO, SRVGYO, TRGYO, and YGGYO companies use technological efficiency change more effectively. The company that uses the technological efficiency change most effectively is PAGYO. If we look at the 3-year scale efficiency change of the company, the company that reached the most effective production size was determined to be KGYO (1.85). Next are OZKGYO (1.33) and TRGYO (1.11).

Table 12: Malmquist Index Means Summary

Malmquist Index Means Summary					
	Efficiency change	**Technological change**	**Pure Efficiency change**	**Scale Efficiency change**	**Total Factor Productivity Change**
2019-2020	0.98	0.79	0.98	1.00	0.77
2020-2021	1.08	1.53	1.06	1.02	1.66
Mean	1.03	1.10	1.02	1.01	1.13

Analyzing the efficiency values of 20 real estate investment partnership firms in the 2019–2021 period on the axis of Malmquist Index averages, it is seen that the period with the highest technical efficiency, technological efficiency, pure efficiency, scale efficiency, and total factor productivity change is the 2020–2021 period. In addition, for the years 2019–2020–2021, the average sector improved by 3% in technical efficiency change, 10% in technological efficiency change, 1% in scale efficiency change, and 13% in total factor productivity change.

Tablo 13: Malmquist Total Factor Productivity Ranking

Company	Teknik Efficiency change		Technological Efficiency change		Total factor productivity change	
	Productivity	Ranking	Productivity	Ranking	Productivity	Ranking
AKMGYO	0.93	16	1.13	10	1.05	12
ALGYO	1.00	6	1.35	3	1.35	6
AGYO	0.85	18	1.09	12	0.93	14
AVGYO	1.00	6	0.97	15	0.97	13
DZGYO	0.75	20	1.08	13	0.82	19
EKGYO	1.29	3	0.91	17	1.18	9
HLGYO	1.00	6	0.76	20	0.76	20
ISGYO	1.80	1	1.09	11	1.96	1
KGYO	1.30	2	1.25	6	1.63	2
KRGYO	0.88	17	1.02	14	0.90	17
MRGYO	1.00	6	1.26	5	1.26	8
MSGYO	1.00	6	1.42	2	1.42	5
OZKGYO	1.27	4	1.14	9	1.45	3
PAGYO	1.00	6	1.45	1	1.45	4
RYGYO	1.00	6	0.91	18	0.91	16
SRVGYO	0.85	19	1.27	4	1.08	11
SNGYO	1.00	6	0.92	16	0.92	15
TRGYO	1.11	5	1.18	7	1.32	7
VKGYO	1.00	6	0.89	19	0.89	18
YGGYO	0.95	15	1.17	8	1.11	10

5.CONCLUSION AND IMPLICATIONS

In the study, the Malmquist total factor productivity index is used to measure the efficiency of the companies, to determine the financial ratios, such as current ratio, leverage ratio, long-term debt-to-asset ratio, short-term debt-to-asset ratio, equity-to-asset ratio, return on assets, net profit margin, and gross profit margin, and to determine the efficiency and the importance level of these ratios in total factor productivity of 20 real estate investment trusts operating in 2019-2020-2021.

The results of the analysis show that 8 companies that are relatively efficient according to their CCR technical efficiency values have been identified; these are ALGYO, AVGYO, HLGYO, MRGYO, MSGYO, PAGYO, RYGYO, and SNGYO. It has been observed that these companies have been effective in an output-oriented way over the past three years.

Another result is that 11 companies were relatively active according to their BCC technical efficiency values. It has been observed that these companies, ALGYO, AVGYO, DZGYO, HLGYO, MRGYO, MSGYO, PAGYO, RYGYO, SRVGYO, SNGYO, and VKGYO, have been effective as output-oriented in the years observed. According to the CCR/BCC scale efficiency values, there are 10 companies that are relatively efficient; these are ALGYO, AGYO, AVGYO, HLGYO, MRGYO, MSGYO, PAGYO, RYGYO, SNGYO, and YGGYO. It has been observed that these companies are effective as output-oriented.

Another result is that ALGYO, ISGYO, PAGYO, SRVGYO and SNGYO companies increased their Malmquist total factor productivity in 2020 compared to 2019. On the other hand, the Malmquist total factor productivity of AKMGYO, AGYO, AVGYO, DZGYO, EKGYO, HLGYO, KGYO, KRGYO, MRGYO, MSGYO, OZKGYO, RYGYO, TRGYO, VKGYO and YGGYO companies decreased in 2020 compared to 2019. Finally, considering the 3-year scale efficiency change, KGYO is the company that reaches the most effective production size. OZKGYO and TRGYO follow.

The firms that are below the efficiency limit need to take a few things into account, according to the results. They need to alter a few input variables to reach a higher level of efficiency. It is anticipated that all these findings will support the decision-making of the companies and the investors who are considering investing in these companies.

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