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A Comparative Analysis of The Efficiency and Total Factor Productivity of Selected Food Processing Companies in Turkey

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Türkiye'de Seçilmiş Gıda İşleme Firmalarının Etkinlik ve Toplam Faktör Verimliliğinin Karşılaştırmalı Analizi

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Abstract

The main purpose of the study is the efficiency and productivity analysis of selected firms that operating in the Turkey food processing industry in 2015-2019 period. In the study, two variables, namely the equity of the firms and the number of paid employees, are used as input, while the net sales values of the firms are used as output. Estimates were made in two stages using the Data Envelopment Analysis method and the Malmquist index approach as a method. The technical efficiency results of the firms in the first stage showed that all firms except one firm operate below the optimal scale. The results of the Malmquist index in the second stage of the study showed that the technical efficiency changes of all firms increased in the examined period, and there was an increase in productivity in all firms except for three firms. However, technological development changes in most of the companies decreased in the period under consideration. According to the results, the decrease in technological change was determined as the important factor causing the decrease in productivity of these companies.

***Keywords**: Efficiency, productivity, Malmquist Index, data envelopment analysis, food industry.*

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Öz

Bu çalışmanın temel amacı 2015-2019 dönemi Türkiye gıda işleme sektöründeki firmaların etkinlik ve verimlilik analizidir. Çalışmada girdi olarak firmaların özkaynakları ve ücretli çalışan sayısı olmak üzere iki değişken kullanırken çıktı olarak firmaların net satış rakamları kullanılmıştır. Veri Zarflama Analizi yöntemi ile Malmquist endeksi yaklaşımı kullanarak iki aşamada tahminler yapılmıştır. İlk aşamadaki firmaların teknik etkinlik sonuçları, bir firma dışında diğer bütün firmaların optimal ölçeğin altında faaliyet yaptıklarını göstermiştir. Çalışmanın ikinci aşamasındaki Malmquist endeksi sonuçları ise incelenen dönemde bütün firmaların teknik etkinlik değişmelerinin arttığını ve ayrıca üç firma dışında diğer bütün firmalarda verimlilik artışı olduğunu göstermiştir. Ancak firmaların birçoğunda teknolojik gelişme değişmeleri ele alınan dönemde düşüş göstermiştir. Sonuçlara göre teknolojik değişmesindeki düşüş, bu firmaların verimlilik düşüşüne neden olan önemli etken olarak belirlenmiştir.

***Anahtar Kelimeler**: Etkinlik, verimlilik, Malmquist Endeksi, veri zarflama analizi, gıda endüstri.*

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Extended Abstract

Introduction and Research Questions & Purpose

Food safety is very important and practical item that has a special place in the world economy and food industry today and have attracted the attention of politicians, researchers and officials. Food security actually means that all members of a community have access to healthy and adequate food throughout their lives to have a healthy and active life. To achieve this goal, barriers such as water scarcity and limited agricultural land, high energy costs, increased food waste and lack of investment in agricultural research must be overcome. These cases indicate that more food should be produced for people around the world with fewer resources. This explains the necessity of examining the more efficient use of resources in the relevant sector and thus reaching the optimal production level. The food industry in Turkey has many importance and benefits due to the climatic conditions, diversity and favorable quality of agriculture. Accordingly, starting from the question of whether the resources are used optimally in the Turkish Food industry, the main purpose of the study is to evaluate the performance and productivity of the Turkish Food industry.

Literature Review

The necessary variables in line with the method of the study were obtained from the database of the Istanbul Chamber of Industry. Different bibliographies have been reached on the subject of the study, but Dızkırıcı (2014) is the only study that evaluates productivity in the Turkish food industry as a whole, and other studies have only taken a single sub-sector in the food industry. For this reason, since there are not many studies on the total performance of this sector, it has become important to conduct this research. The studies of Ibn Afzal (2018), Sultan and Bhat (2020) and Amin (2010) on the food industry of other countries can be mentioned. In all of the studies reached in the literature, Malmquist index, which is the total factor productivity index, was used in productivity measurement.

Methodology

Although this study is an applied study, it is an exploratory use of the Data Envelopment Analysis approach as a design. Accordingly, input and output variables are needed in the study. For this, the net sales value of the companies operating in the Turkish food sector for the period of 2015-2019 is considered as the only output variable, and the equity and number of employees of the companies are considered as input variables. The main statistical society of the study consists of companies operating in the Turkish food sector. However, the sample of the study consists of companies that are among the top 500 companies according to the Istanbul Chamber of Industry. The only problem encountered in the study was that some of the companies had incomplete information and therefore, these companies were necessarily excluded from the analysis. Therefore, a total of 19 companies were included in the analysis. The data required in the study were obtained from the annual reports of the Istanbul Chamber of Industry. In the research, estimations were made with the DEA method, which is based on linear programming, and Malmquist productivity index to examine the performance of the Turkish food sector and the productivity of the companies.

Results and Conclusions

According to the total factor productivity results, except three firms, other companies experienced an increase in productivity. The highest productivity increase was seen in “Çamlı Yem Besicilik” company with 42.6%. In the period under consideration, the average productivity change achieved by all companies increased by 13.9%. In the analyzed period, productivity increased annually in all years. The results of the Turkish food industry total factor productivity analysis have shown that firms attach more importance to technical efficiency and therefore, the increase in productivity is due to increases in technical efficiency change. The increase in technological development resulting from the using new methods in production between periods will have a positive effect on the company’s productivity increases as well as the technical efficiency. Especially companies that experience a decrease in their productivity have the opportunity to close this gap by developing their technologies or replacing with the newest and uptodate technologies, and it is very important that they should pay attention to this in terms of increasing their productivity.

1. INTRODUCTION

Nutrition, clothing, and shelter are the basic needs people must meet in order to survive. Therefore, together with textile and housing, the food and beverage industry are one of the three most strategic sectors of a country's economy. The need for food and beverage items is vital, as well as an urgent need. Therefore, it is imperative that their supply be uninterrupted (Akın, 2012: 18).

The food industry sub-branch is one of the most beneficial communication methods between the two sectors of industry and agriculture and a prerequisite for the industrialization strategy and also provides food security in the country (Kohansal and Mahmoodi, 2020: 59). The food industry has always played a role in creating added value, increasing income levels, increasing productivity and increasing the share of industrial employment in active areas, as well as part of the economic development process. Also, these industries have a key role in the development process of the country and more attention to it will accelerate the agriculture and economic growth and development of the country (Nouri and Nilipour Tabatabaei, 2007: 163) About these industries, it can mention the food processing industry, which is one of the most important sectors of the industry in all countries and is directly related to food security (Pfitzer and Krishnaswamy, 2007). Also, food industry among different industries in terms of necessity and variety of production, low investment, rapid efficiency, increased productivity, waste reduction, job creation, direct or indirect participation in national income, currency, poverty reduction and health issues are also very important (Trienekens and Zuurbier, 2008).

The food industry, which has a very important place in the country's economy, is also the oldest industry branch. While contributing to the development of sectors such as transportation, retailing and food marketing, it processes agricultural raw materials taken from the soil into high quality, healthy products. It continues to develop in parallel with the agricultural industry, which is its main input. In Turkey, 45% of the total population located in the agricultural sector and this part realizes about 13% of the total production. For this reason, agriculture and food industries are of great importance for the country's economy in socioeconomic terms (Başer and Akgül, 2002).

On the other hand, food industries as industries dependent on agricultural products are among the most important industrial groups that can affect the economic growth of countries, especially in developing countries. The reasons for this are the cheapness of raw materials for agricultural products, the existence of cheap labor, investment, and the need for low currency of these products. The creation of these industries can have a special effect on increasing the value added of agricultural products and increase the export value of this sector. By increasing investment in the food industry, while purchasing agricultural products and eliminating seasonal fluctuations and reducing production surpluses, waste from these products can be prevented and seasonal supply can be turned into a permanent supply (Torkamani and Zoughipour, 2008: 24).

Considering the increasing need for food in the world, it can be stated that a food and beverage industry capable of producing products in accordance with international standards can be one of the leading sectors of the economy. Therefore, it is important for economic growth to increase the production of this sector and to produce more efficiently by using the existing limited opportunities effectively. Producer units or companies affect economic growth. For this reason, analyzing the productivity change of the food sector and analyzing the performance of the companies in the sector is of great importance. One of the ways to measure the performance of companies in the sector is to measure the technical efficiency of the companies operating in the sector and to monitor their change over time (Verma et al., 2015).

In this study, the efficiency and productivity analysis of selected firms that operating in the Turkey food processing industry in 2015-2019 period has examined and after obtaining the efficiency of each firm, their productivity has been compared.

2. THEORETICAL FRAMEWORK

According to economic growth theories, the increase in production is achieved in two ways: first by using more factors of production, but within the existing technology; Second, by using more advanced and efficient production methods and using more effective production factors. In the meantime, the second method is tied to the concept of productivity. The emphasis of economic growth theories in the first method is based on traditional theories on the accumulation of production factors, but in the second method, in addition to the accumulation of production factors, special attention has been paid to productivity growth as an important source of sustainable economic growth. In the Solow (1957) model, it is predicted that the per capita growth of production through the accumulation of production factors will not be sustainable due to the declining efficiency, and to achieve long-term growth of production factors must be accompanied by productivity. This is why today, most countries in the world in their long-term development plans, in order to achieve the goals of sustainable growth, improve productivity and efficiency (Coelli et al., 2005).

2.1. Efficiency

Efficiency shows how much input the firm has optimally used to produce the desired output. This means that the maximum product can be obtained from the minimum inputs. Accordingly, production efficiency can be considered as a comparison between actual performance and desired performance (Fathabadi and Soufi Majidpour, 2018: 29).

In microeconomics, the production function is defined based on the maximum amount of product that can be produced using a certain set of inputs according to the level of available technology. However, until the late 1960s, most experimental efficiency studies used the least squares method to estimate the production function, which could not show the relationship between maximum output and inputs.

Following the Debreu (1951) and Koopmans (1951), Farrell (1957) first proposed how to estimate the production function based on microeconomic relations. He suggested that the efficiency of a firm consists of two components: technical efficiency, which demonstrates the ability of a firm to achieve maximum output using its own amount of input. In other words, technical efficiency is related to the technological structure and is a relative concept. Because the comparison between firms is in the type and manner of using technology. Technical efficiency has nothing to do with the price of agents and can be used in cases of impossibility to determine the price of agents correctly (Alirezaee, 2003). Allocative efficiency, which demonstrates the firm's ability to use the optimal combination of inputs with Show attention to the relevant prices. The combination of these two functions is also called total economic efficiency.

2.2. Productivity

Productivity is an important and basic concept of economic knowledge that is an indicator to show the effective, useful, and efficient use of production resources to produce goods and services. Productivity is not a purely economic, financial measure, and does not necessarily mean more work. On the other hand, it is not just more production. Rather, it is the coordination of quantity, quality and cost in competition. Therefore, productivity is highly dependent on qualities. More precisely, productivity has two main components; The first is efficiency, which indicates more output versus less input. Second is effectiveness, which means choosing useful and principled activities to achieve a specific goal. In other words, productivity is about doing things right (efficiency) and do the right thing (effectiveness). Thus, efficiency is part of productivity and in terms of calculation is the optimal amount of resources consumed to produce a unit of product. For this reason, if one firm can achieve the goal with less resources compared to another firm, it is said to be more efficient (Bakhtiari et al. 2014: 52)

Efficiency and productivity are used in many texts in the same way or instead of each other, which is a big mistake. The two terms are not exactly the same. Because every point on the production frontier represents the maximum efficiency, but this does not mean maximum productivity. Only at a certain point in the production frontier is productivity at its maximum. For this reason, it can be said that efficiency is a part of productivity (Coelli et al., 2005). It should be noted that in dynamic conditions, a factor called technological changes is introduced, which causes the transfer of the frontier function and increases productivity. In other words, a change in technical efficiency follows an increase in productivity by measuring the movement of an economy toward the production frontier, and technological progress pursues productivity growth by measuring the rate of transfer of the production frontier over time. The distinction between these two factors can be seen in Figure (1).

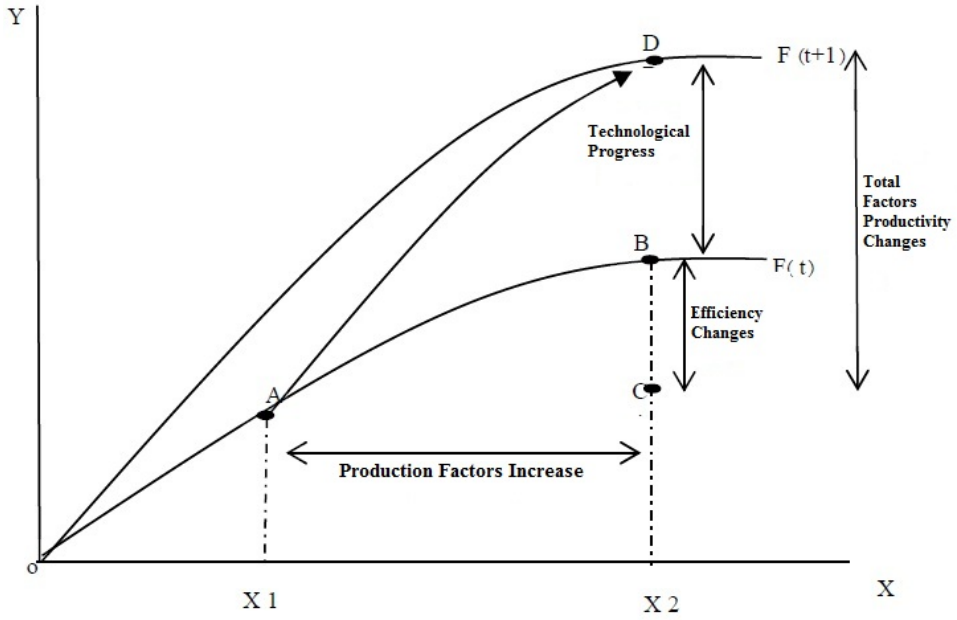

Figure 1: Production Factors Increase, Technological Progress, Technical Efficiency and Total Factors Productivity Changes

Source: Kumbhakar, 2004

According to Figure (1), the movement from A to B indicates an increase in production due to the accumulation of production factors in existing technology (frontier function $F(t)$) and this is assuming the existence of full technical efficiency in the production process (moving on the production frontier). The movement from C to D shows the increase in production due to the growth of total factor productivity at the level of factor X_2. This productivity growth includes increasing technical efficiency and technological progress (transferring production frontier and moving from B to D). Moving from a to d indicates an increase in production due to the total accumulation of production factors and productivity growth (Alirezaee and Afsharian, 2007).

2.3. Productivity Measurement

Analyzing the productivity of all production factors is very important in terms of identifying innovations or selecting and applying new technologies. Accordingly, determining the criteria and indexes for measuring productivity change in such a way that it can be clearly determined whether the level of productivity in an economy improves through more efficient use of existing facilities and production factors or through technological progress is important. There are two distinct methods for measuring technical efficiency changes and total factor productivity changes: The first parametric method proposed by Nishimizu and Page (1982) is based on estimating the frontier function using econometric method. The second method, called the nonparametric method, is part of the data

envelopment analysis method, which is a linear programming method, and Farrell (1957) gave the first model. Charnes et al. (1978), Banker et al. (1984) and Färe et al. (1994) later provided additional information on this method. In this method, there are different units of measurement for production factors and products. Because this method covers all figures and information, it is called Data Envelopment Analysis (DEA). In this method, it is not necessary to determine the subsequent form of the production function. In addition to measuring the types of efficiency, the type of return to scale is also presented separately for firms in this method (Emami Maibodi and Izadi, 2008).

To calculate productivity changes using Data Envelopment Analysis (DEA), the Malmquist index is used, which is a non-parametric method for measuring the technical efficiency and productivity of economic units. In this method, after determining the efficient frontier, the units decide where this frontier should be located and what combination of input and output should be selected to reach the efficient frontier. One of the most important features of this index is the possibility of decomposing productivity changes into its components, changes in technical efficiency and technological changes. In Malmquist index, data envelopment analysis method is used to form a broken linear frontier production function. This index is introduced using distance functions, so that the production factor distance function determines the production technology by minimizing the production factor vector and considering the given product vector and the product distance function pays attention to the optimization problem by maximizing the outputs vector based on the given inputs vector (Fathabadi and Soufi Majidpour, 2018: 33).

Production technology is defined using the set of products P(X) as the representative of all output vectors Y that can be produced by the inputs vector X; it means:

$$P(X) = \{ Y: X \text{ can produce } Y. \} \quad (1)$$

The output distance function is defined using the product set P(X) as follows:

$$d_{\circ}(X,Y) = \min\{\partial : \frac{y}{\partial} \in P(X)\} \quad (2)$$

If the output vector Y is part of the product set P(X), the distance function $d_{\circ}(X,Y)$ will be less than or equal to 1. The distance function will be equal to 1 if Y is on the production frontier (production facilities curve).

The Malmquist Productivity Index (MPI) was first introduced by Malmquist (1953) and then expanded to studies such as Caves et al. (1982). With this index, changes in total productivity are measured over two time periods, which include changes in technical efficiency and technological changes. Changes in technical efficiency indicate the degree of efficiency of the economic unit in the process of converting data to output, while technological changes indicate the technological improvement of the firm between two consecutive time periods (Barros et al., 2005).

Figure (2) shows the relationship between output y and input x to explain the concept of the Malmquist productivity index. The technology frontiers for the two periods t and t + 1 are shown by the lines S^t and S^{t+1}, where the Malmquist Productivity Index (MPI) measures the distance from the input-to-output ratio of the firm between the technology frontiers. For example, the relative efficiency of producing a firm with the input value b and producing y^t is shown by the distance function $D^t(y^t, x^t) = oa/ob$. It is clear that in period t the firm is inefficient at the point Z^t Similarly, in the period t + 1, the firm is inefficient at the point Z^{t+1}, and in order to be efficient, it must use the input value c. In fact, the Malmquist Productivity Index is the geometric mean of two technology indices in periods t and t + 1. Therefore, according to Färe et al. (1994) the MPI index is calculated based on fixed scale returns as follows:

$$MPI(y^t, y^{t+1}, x^t, x^{t+1}) = \frac{D^{t+1}(y^{t+1},x^{t+1})}{D^t(y^t,x^t)} \times \left[\frac{D^t(y^{t+1},x^{t+1})}{D^{t+1}(y^{t+1},x^{t+1})} \times \frac{D^t(y^t,x^t)}{D^{t+1}(y^t,x^t)}\right]^{1/2} \quad (3)$$

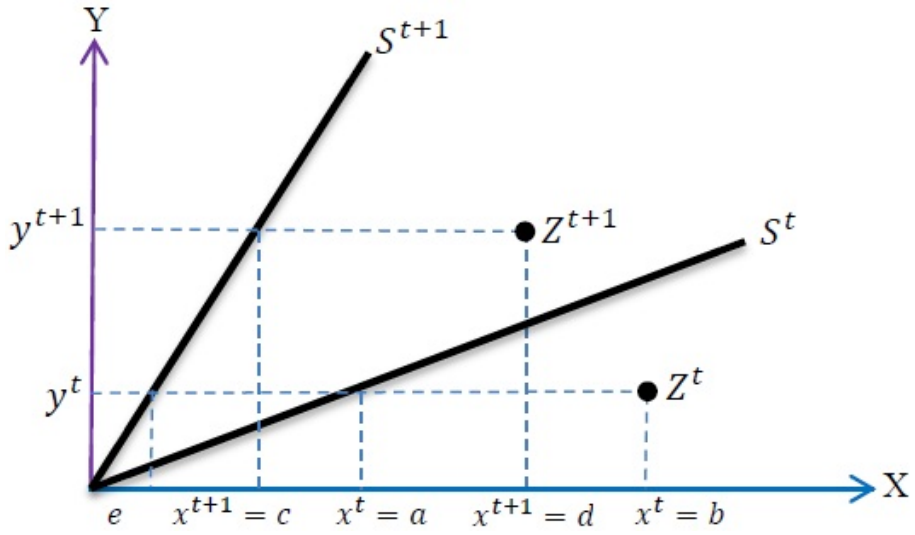

Figure 2: Malmquist Productivity Index (MPI)

Source: Färe et al., 1994

The first sentence from the right (sentence in bracket) in the equation (3) is the production due to technological improvement and the second sentence from the right is the production due to the development of technical efficiency. So,

$$TECH = \frac{D^{t+1}(y^{t+1},x^{t+1})}{D^t(y^t,x^t)} \tag{4}$$

$$TECHCH = \left[\frac{D^t(y^{t+1},x^{t+1})}{D^{t+1}(y^{t+1},x^{t+1})} \times \frac{D^t(y^t,x^t)}{D^{t+1}(y^t,x^t)}\right]^{1/2} \tag{5}$$

A value of MPI greater than 1 indicates a positive productivity growth and a value less than 1 indicates a negative productivity growth.

Using Figure (2) and Equation (3), also the interpretation of technical efficiency changes and technological changes will be as follows:

$$\text{Technological Changes} = \left[\frac{d/e}{d/c} \times \frac{b/a}{b/e}\right]^{1/2} \tag{6}$$

$$\text{Efficiency Changes} = \frac{d/c}{b/a} \tag{7}$$

Therefore, in practice and experimental mode, it is necessary to calculate four distance functions for each firm at any time, which is done using linear programming.

2.4. Literature Review

There is a very extensive theoretical and experimental literature on the application of Malmquist productivity index in estimating the productivity of various economic fields. Below are some of the most important studies done, especially in the food industry:

Ibne Afzal et al. (2018) discussed the change in efficiency and total factor productivity of 34 food processing industries in Malaysia between 2009-2010. According to the results of the study, although there was a difference in technical efficiency scores, positive technological development emerged in nearly all industries in the years examined. Voulgaris and Lemonakis (2013) analyzed the efficiency and productivity of 168 fishing companies in Greece in the period of 2002-2011. According to the results of the study, while the size of the firms affected their productivity, age did not have a

significant effect on the productivity of the firms. In addition, it has been revealed that the exports of companies have important effects on their productivity as well as their profitability. Madau et al. (2017) analyzed the changes in efficiency and productivity of dairy farming sectors of 22 European Union countries using the Data Envelopment Analysis method. The findings of the study showed that the increase in the efficiency of dairy farms was low and at the same time, the productivity of the European Union dairy sector decreased. In his study, Dizkırıcı (2014) handled the performance and comparative productivity of companies traded on the Borsa Istanbul Food and Beverage Index in the period 2010-2012, using the Malmquist index. According to the results of the study, both productive and non- productive firms were identified. Among these companies, Ülker has become the only company that has increased its productivity over the years and is the most productive company among other companies. Çakır and Perçin (2012) conducted the efficiency and productivity analysis of 25 Turkish sugar factories between 2002-2009 using the Data Envelopment Analysis method. According to the results of the study, while 12 factories were found efficient with the assumption of constant returns to scale, 16 factories were found efficient with the analysis performed under the assumption of variable returns to scale. According to the productivity analysis results, the average productivity increase of the factories in the period under consideration was 0.6%. In their study, Tatlı and Bayrak (2017) analyzed the changes in total factor productivity and efficiency of 22 companies that were in the food sector between 2011-2015 and are registered in the Borsa Istanbul (BIST). The results of the study showed that the technical efficiency of all firms decreased in the period under consideration, but technological changes and also their productivity increased. The highest productivity increase was 4.5%. In their study, Sultan and Bhat (2020) examined the total factor productivity of food processing firms in North India for the period of 2008-2016 using the Malmquist productivity index. The results of the study showed that all firms operate below the productivity limit. According to the researchers, one of the reasons for this is their inefficiency in companies. Baliyan et al. (2015) analyzed the total factor productivity of the food processing industry in India using the Malmquist index. According to the results of the study, the productivity of all firms examined has increased in the last 3 decades. Amin (2010) analyzed the total factor productivity of 55 industries operating in the Indonesian food manufacturing industry during the 2000-2006 period using the Malmquist index. The results of the study showed that while the annual technical efficiency average was 0.74, the annual average productivity increase was 1.25 in the period under consideration. Hui (2019) examined the total factor productivity of grain producers in China in the period of 1978-2018 using the Malmquist index. As a result of the study, the increase trend in the Chinese food sector productivity was negative (68.75%). Zrelli et al. (2020) tried to calculate the total factor productivity of the Tunisian manufacturing industry between 2002-2016. In the study, output oriented Malmquist index is used as a method. According to the results of the study, productivity increased in the period under consideration. The increase in productivity has also emerged as a result of technological changes rather than technical efficiency change.

Paying attention to the method used by some important studies in the World and Turkey, Data Envelopment Analysis (DEA) and Malmquist productivity index were used in all of them. One possible reason for this may be to avoid some limiting econometric assumptions and also to see the cause of productivity changes. In this study, DEA and Malmquist productivity index approach based on linear programming method were used as methods.

3. RESEARCH FINDINGS

The main purpose of this study is to examine the efficiency and total factor productivity in the Turkish food products manufacturing industry between 2015-2019. Although there are some studies examining the efficiency in the food industry around the world, not many studies have been conducted in Turkey on this industry in recent years. For this reason, this study is important in terms of explaining the performance of companies in this industry in recent years and also evaluating the productivity developments in the period under consideration.

The required data for this study were achieved from the annual reports on the Istanbul Chamber of Industry (ISO) website and a total of 19 companies were included in the analysis. These companies consist of companies operating in the Turkish food manufacturing industry, which were among the top 500 industries between 2015-2019, for five consecutive years[1].

Firms' net sales values were used as the only output variable in this study. Equity of the firms and the number of employees with wages were taken into account as input variables. In the study, the Malmquist productivity index approach is handled by using Data Envelopment Analysis based on linear programming to make technical efficiency and total factor productivity estimates. The reason for choosing the non-parametric DEA method in the study is to avoid restrictive assumptions and hypothesis testing that are exist in SFA parametric methods. In addition, as in parametric methods, there is no obligation to determine an appropriate (Production or Cost) function form in the DEA method. DEA estimates were made with the DEAP 2.1 package program developed by Coelli (1996).

Input-Oriented DEA model under the Variable Return to Scale (VRS) assumption used in the study is as follows:

$$\min_{\theta,\lambda} \theta \tag{8}$$

$$\text{s.t.} \quad -q_i + Q\lambda \geq 0,$$

$$\theta x_i - X\lambda \geq 0,$$

$$I1'\lambda = 1,$$

$$\lambda > 0$$

The technical efficiencies estimation values of the companies using model (8) in the period under consideration are given in Table 1.

Considering the results of technical efficiency values of firms, while one firm (Özgün Gıda) in total reached full efficiency under the assumption of constant return to scale (CRS), under the assumption of variable return to scale (VRS), the number of fully efficient firms increased to six. The company that reached the lowest average technical efficiency under the assumption of CRS was the "Çay İşletmeleri Genel Müdürlüğü" company. However, this firm has reached full efficiency under the assumption of VRS. Under the assumption of VRS, "Gümüşdoğa Su Ürünleri" company had the lowest average technical efficiency value.

Since both CRS and VRS technical efficencies are equal to 1 in "Özgün Gıda" companies, full scale efficiency has been achieved in this company. In other words, this company do not have a scale problem and it operates at an optimal scale. When the scale efficiencies of other companies in the industry are examined, it is seen that most of them operate in a situation far from to the optimum scale. Accordingly, these companies have the scale problem and should pay more attention to reach the optimal scale or close to optimal scale. Summarizing the results of technical efficiency, the companies in Turkish food industry did not operate efficiently in terms of both technical efficiency and scale efficiency.

The results of Malmquist index analysis of firms under the CRS assumption between 2015-2019 are shown in Table 2. Considering the results in the table, there is an increase in technical

[1] Although some companies were in the top 500 organizations for five years, they were excluded from the analysis because they were found to be incomplete or inaccurate in their data. In addition, since the equity data in the "Türkiye Şeker Fabrikaları" company was negative and the productivity change value was 0 and thus affecting whole the results, this company was excluded from the analysis,

efficiency changes in all companies in the period examined. While the most technical efficiency changes increase was seen in "Çamlı Yem Besicilik" company with 47.3%, the lowest technical efficiency changes increase occurred in "Durak Fındık" company with 0.7%. On the other hand, there was no change in the "Özgün Gıda" company in this period, and the average technical efficiency of this company remained constant. The average change in technical efficiency of all firms during the period increased by 16.5%.

Technical efficiency changes consist of the changes in pure efficiency and scale efficiency. According to the results, the pure efficiency of four firms, did not change in the Turkish food industry, while pure efficiency increased in all other companies except for four companies (Çay İşletmeleri, Namet Gıda, Pınar Süt, and Beşler makarna). The highest increase belongs to "Gümüşdoğa Su" with 39.2%.

Table 1: Technical Efficiencies of Companies in the Turkish Food Industry

Companies	**CRS-TE**	**VRS-TE**	**SE**
SÜTAŞ Süt	0.146	1.000	0.146
Çay İşletmeleri Genel Müdürlüğü	0.056	1.000	0.056
Namet Gıda	0.194	0.956	0.203
Pınar Süt Mamulleri	0.173	0.771	0.224
Cargill Tarım ve Gıda	0.443	1.000	0.443
Gümüşdoğa Su Ürünleri	0.094	0.127	0.739
S.S. Trakya Yağlı Tohumlar	0.203	0.524	0.388
Başhan Tarımsal Ürünleri	0.350	0.400	0.875
Durak Fındık	0.610	1.000	0.610
Memişoğlu Tarım Ürünleri	0.243	0.306	0.796
Hastavuk Gıda Tarım Hayvancılık	0.159	0.192	0.824
Akyem Adana Yem Yağ Biodizel	0.120	0.189	0.638
Kent Gıda Maddeleri	0.095	0.132	0.720
Beşler Makarna Un İrmik Gıda	0.454	1.000	0.454
Göknur Gıda Maddeleri Enerji	0.230	0.295	0.781
Pınar Entegre Et ve Un	0.126	0.191	0.659
Nuh'un Ankara Makarnası	0.200	0.309	0.649
Özgün Gıda	1.000	1.000	1.000
Çamlı Yem Besicilik	0.212	0.327	0.649
Mean	**0.269**	**0.564**	**0.571**

Source: Author's Calculations

Considering the changes in scale efficiency, the scale efficiency of "Özgün Gıda" firm did not change during the period. At the same time, while the scale efficiency changes of four firms decreased in the analyzed period, the scale efficiency of other firms increased. The highest scale efficiency decrease was experienced in "Gümüşdoğa Su" company with 10.7%. Paying attention here, the decrease in the pure technical efficiency change in some companies has been compensated by the increase in the scale efficiency change, and as a result, an increase in the technical efficiency change of that company has emerged. The same can be said for companies that have a decrease in scale efficiency changes but an increase in pure technical efficiency changes.

As a result, for a firm to increase its technical efficiency changes over time, both pure efficiency and scale efficiency should increase. If any of these (pure efficiency or scale efficiency) have experienced a decrease, the other efficiency must have increased enough to compensate for it and consequently the technical efficiency changes to increase.

Table 2: Malmquist Index Analysis Results in Turkish Food Manufacturing Industry

Firm	EFFCH	TECHCH	PECH	SECH	TFPCH
SÜTAŞ Süt Ürünleri A.Ş.	1.087	0.901	1.000	1.087	0.980
Çay İşletmeleri Genel Müdürlüğü	1.302	0.923	0.931	1.399	1.202
Namet Gıda	1.078	1.007	0.996	1.082	1.085
Pınar Süt Mamulleri	1.215	0.931	0.995	1.221	1.131
Cargill Tarım ve Gıda	1.052	1.000	1.000	1.052	1.052
Gümüşdoğa Su Ürünleri	1.244	1.006	1.392	0.893	1.252
S.S. Trakya Yağlı Tohumlar Tarım Satış Kooperatifleri Birliği	1.211	1.007	1.175	1.030	1.219
Başhan Tarımsal Ürünleri Pazarlama	1.213	1.007	1.257	0.965	1.222
Durak Fındık	1.007	0.974	1.000	1.007	0.981
Memişoğlu Tarım Ürünleri	1.172	1.007	1.171	1.002	1.180
Hastavuk Gıda Tarım Hayvancılık	1.162	0.978	1.224	0.949	1.136
Akyem Adana Yem Yağ Biodizel	1.292	1.004	1.303	0.991	1.298
Kent Gıda Maddeleri	1.184	1.007	1.142	1.037	1.192
Beşler Makarna Un İrmik Gıda	1.093	0.940	0.952	1.149	1.028
Göknur Gıda Maddeleri Enerji İmalat	1.194	1.007	1.149	1.039	1.202
Pınar Entegre Et ve Un	1.110	0.967	1.004	1.105	1.073
Nuh'un Ankara Makarnası	1.145	1.007	1.034	1.108	1.153
Özgün Gıda	1.000	0.946	1.000	1.000	0.946
Çamlı Yem Besicilik	1.473	0.968	1.323	1.114	1.426
Mean	**1.165**	**0.978**	**1.100**	**1.060**	**1.139**

Source: Author's Calculations

Considering the results of technological changes in the Turkish food industry, while there is an increase in technological development in half of the companies, a decrease is observed in the other half. While the most increase in technological changes was seen in most companies with 0.7%, the most decrease of technological development occurred in "Sütaş Süt" company with 8.9%. The average technological change provided by all firms decreased by 2.2%. This shows that there are technological problems or obstacles in the companies of Turkish food industry.

Considering the results of the total factor productivity changes of the companies, productivity increases have been observed in all companies except for three companies (Sütaş, Durak Fındık and Özgün Gıda). The highest productivity increase is seen in "Çamlı Yem Besicilik" company with 42.6%, while the lowest productivity increase is seen in "Beşler Makarna" company with 2.8%. However, the most productivity decrease was seen in "Özgün Gıda" company with 5.4%. As a result, except three company, all other companies in the Turkish food industry experienced an increase in productivity and the decline in companies that experienced a decrease in productivity was not too much. Therefore, it can be concluded that this industry is operating productively in the 2015-2019 period. The average total factor productivity change that occurred by all firms also increased by 13.9%. This average value also proves that companies work productivity.

The annual Malmquist index analysis results in the Turkish food industry are shown in Table (3). Considering the results in the table, there was an increase in average technical efficiencies change in all years. The greatest increase in average technical efficiency change occurred in 2016 with 48.6% and the lowest increase occurred in 2017 with 3.6%. Although the pure efficiency changes in 2017 year decreased by 1.8%, it could be compensated by significant increase in scale efficiency changes (5.5%), and consequently, there was an increase in technical efficiency changes. Similarly, although there was a 0.6% decrease in scale efficiency changes in 2018 year, this could be compensated by the 6.6% increase in pure efficiency changes and hence there was an increase in technical efficiency changes in this year as well.

Considering the annual average technological changes results, it has increased in all other years, except for 2016. While the most technological change increased in 2018 with 17%, the least technological changes increase (5.3%) occurred in 2017.

Considering the results of the annual average total factor productivity changes in Table (3), an increase in productivity was observed in all years in the period examined. While the highest productivity increase occurred in 2018 with 24%, the lowest productivity increase occurred in 2016 with 2%. However, although there was a serious decrease in the technological change in 2016, the resulting increase in technical efficiency change compensated this and consequently, it emerged as a result of the increase in productivity in this year. In other years, both of technical efficiency change and technological changes have increased, which normally can lead to an increase in productivity.

Tablo 3: Annual Malmquist Index Changes of Turkey's Food Industry During 2015-2019

Year	EFFCH	TECHCH	PECH	SECH	TFPCH
2015	-	-	-	-	-
2016	1.486	0.687	1.236	1.203	1.020
2017	1.036	1.053	0.982	1.055	1.091
2018	1.060	1.170	1.066	0.994	1.240
2019	1.131	1.080	1.131	1.000	1.221
Mean	**1.165**	**0.978**	**1.100**	**1.060**	**1.139**

Source: Author's Calculations

4. CONCLUSION

Nutrition is one of the most important needs that all people face. Accordingly, the food production industry is one of the most important production industries in countries.

The main purpose of this study is to analyze the productivity of companies operating in the Turkish food manufacturing industry between 2015-2019 using the Malmquist productivity index and Data Envelopment Analysis. Accordingly, in this period, companies that were included in the top 500 organizations for five consecutive years were selected and companies with missing data or errors were excluded from the analysis and a total of 19 firms were included in the analysis.

The data required in the study were obtained from the annual reports of the Istanbul Chamber of Industry. One output and two input variables were used for efficiency and productivity estimates. The firms' net sales value as the only output and the equity of the firms and the number of paid employees as input variables were taken into account. Two-stage estimation was made in the study. Firstly, after obtaining the technical efficiency values, the firms' technical efficiency changes, technological changes, and total factor productivity changes in the considered period in the second stage are revealed by using the Malmquist productivity index.

Considering the results of the firms' technical efficiency values, the technical efficiency values estimate made with the VRS assumption are higher than the estimated values made with the CRS assumption. The average VRS technical efficiency value was 0.564. This means that the firms in the analyzed period showed an average of 56.4% efficiency, in other words, 43.6% inefficiency. On the other hand, the average technical efficiency under the CRS assumption was 26.9%. This means that firms behave approximately 27% efficiently under the assumption of constant returns to scale. When the scale efficiency values of the companies are examined, it is seen that all other companies, except for a few companies, operate far below the optimum scale.

Looking at the Malmquist index analysis results of the companies, while the average technical efficiency change of one firm is constant and does not change, there was an increase in technical efficiency changes in all other companies during the analyzed period. The change in technical efficiency provided by all companies increased by 16.5% on average in 2015-2019 period.

Considering the results of the technological changes of the companies, while this value remained constant in "Cargill Tarım" company and decreased in half of companies, it has increased in other half companies in the period under consideration. The firm with the most decrease in technological changes was "Sütaş süt" company with 9.9%. In the period under consideration, the average technological change provided by all companies decreased by 2.2%.

According to the total factor productivity results, except three firms, other companies experienced an increase in productivity. The highest productivity increase was seen in "Çamlı Yem Besicilik" company with 42.6%. In the period under consideration, the average productivity change achieved by all companies increased by 13.9%. In the analyzed period, productivity increased annually in all years.

The results of the Turkish food industry total factor productivity analysis have shown that firms attach more importance to technical efficiency and therefore, the increase in productivity is due to increases in technical efficiency change. In other words, companies in this industry have made the necessary effort to use resources more efficiently and only realized the increase in production by using resources optimally. For this reason, companies in the Turkish food industry can increase their production by using newer technologies with the reallocation and use of resources more efficient and also with changes in their scales. The increase in technological development resulting from the using new methods in production between periods will have a positive effect on the company's productivity increases as well as the technical efficiency. Especially companies that experience a decrease in their productivity have the opportunity to close this gap by developing their technologies or replacing with the newest and uptodate technologies, and it is very important that they should pay attention to this in terms of increasing their productivity.

By considering the method used in the study and using other different variables, it is recommended to carry out similar studies in the same industry or to conduct different studies in different industries in the future and therefore to compare the results.

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