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Analyzing Efficiency and Productivity Changes of Turkish Textile Firms

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ABSTRACT

This study addresses the analyzing of efficiency and productivity change of 19 Turkish textile firms for the period 2014-2020 which are quoted to stock market. For the efficiency analysis super-efficiency DEA model is employed which contains three inputs and two outputs. The efficiency results are given in yearly base. For productivity analysis stage Malmquist Productivity Index is used including TECI, TCI and TFPI values. According to results, none of the firms increased their total factor productivity through 2014 to 2020. Furthermore, there isn't any significant difference between the average of efficiency, TECI, TCI and TFPI values before and during COVID-19 pandemic. This study contributes to the literature with covering seven-year period including COVID-19 pandemic period in the analyses.

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Data envelopment analysis, Malmquist productivity index, textile industry, Türkiye, COVID-19

1. INTRODUCTION

Turkish textile industry has grown and investments in this sector has increased with the aid of export-led development policies applied since 1980s. This sector has an important share in GDP, share in manufacturing industry, export, employment, and investments for Turkish economy. Today Turkish textile industry is commonly export-led and current capacity in the sector is greater than the domestic demand. Türkiye is in the third country among the leading countries in the world textile exports to EU countries after China and Bangladesh [1].

Especially for Türkiye, which supplies raw materials from China, there have been problems in the supply of intermediate goods with the pandemic, and the deceleration in demand for textile products in the world has led to a decrease in Türkiye's textile manufacturing capacities and exports [2]. In addition, social distancing and hygiene measures have led to an increase in retail prices due to additional costs [3] and, combined with the weakening caused by COVID-19 in people's purchasing power, have led to a further decrease in demand.

World Trade Organization's (WTO) agreement on textile and clothing (ATC) expired in 1 January 2005 and the competition in this sector is more intensive. To increase the competitiveness in such an environment, working with high productivity rate and using their resources efficiently is crucial. Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI) are widely used techniques to measure the efficiency and productivity changes of decision-making units.

Based on the theoretical approach in the study by Farrell [4], it was also put forward for the first time by Charnes et al. [5]. DEA allows more than one output to be produced by using more than one input aimed at determining the relative efficiency of the decision-making units enabled. The relative efficiency scores of the technical decision units are calculated with the distance to the efficiency boundary formed by the units with the best performance. In this way, efficient and in efficient units are determined, source of inefficiency for units not on the border can be investigated

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and the target for these units to reach the efficient limits can be determined [6]. To determine the most efficient decision-making unit super-efficiency DEA model can be used.

MPI uses only the quantity data of inputs and outputs in estimating the production frontier [7]. In other words, this approach does not require the use of market prices as inputs or outputs and this is situation is advantageous when prices are displayed incorrectly or data are not available [8].

This study evaluates the efficiency and productivity changes of 19 Turkish textile firms by using super-efficiency DEA and MPI respectively for the period 2014-2020. The firms considered in the study are quoted to Borsa Istanbul (stock market of Türkiye). To the best of our knowledge, there is no other study evaluates the efficiency and productivity performance of Turkish textile firms covering 2014-2020 period. Also, this study includes the period including the effect of COVID-19 pandemic on the textile firms.

The rest of the paper is organized as follows: After the introduction, literature review is given on the efficiency and productivity analysis of textile firms. In section 3 the details of super-efficiency DEA and MPI are mentioned as methodology. Section 4 is about the methodology and presents the details of data and variables used in the analysis In Section 5 empirical results are given and Section 6 concludes the study.

2. LITERATURE REVIEW

In this section of the paper, international and domestic studies on the efficiency and productivity analysis on textile firms are presented and the gap filled by this study is given at the end of the section.

You and Yan [9] compared the four types of eco-DEA models and proposed ratio model with undesirable outputs with the data of textile industry of China. Researchers concluded that ratio model gives better information about the impact of the textile industry on China's environment. Zhao et al. [10] used Analytic Hierarchy Process (AHP) and in DEA together to enhance the calculation efficiency of AHP by putting every efficiency value as decision-making threshold value. Authors used China's textile industry data including variables economic condition, social environment, natural ecology, and scientific technology. Kapelko and Lansink [11], analyzed the productivity change of the textile and clothing industry worldwide during the period 1995–2004 using bootstrapped MPI. The researchers compared the differences of the results according to countries that benefited and did not benefit from the quotas' elimination, and for firms in different regions. Ho [12], analyzed the operating performance of 12 textile firms in Taiwan for period 2010-2012 using DEA and slack variable analysis. Gambhir and Sharma [13] analyzed the productivity changes of 160 Indian textile firms using MPI. Researchers found out that exporting firms had better productivity performance and resource utilization. Furthermore, technology change and scale efficiency were the major sources of productivity gain of exporting firms. Yenilmez and Girginer [14] examined the efficiency of Turkish textile firms' exports in Eskisehir Organized Industrial Zone for the period of 2008-2009 using a CCR DEA model. Zhu et al. [15], used common weights to aggregate weights of undesirable outputs in DEA model using data on China's textile industry. This approach reduced the efficiency scores of DMUs. Erdumlu [16] compared the profitability and marketability efficiency of Turkish textile, apparel and leather sector with food, beverages and tobacco, and chemicals, petroleum, rubber and plastics using DEA. Lin and Yahalom [17] used DEA with Slacks-Based Measure (SBM) model to analyze the efficiency of 46 textile firms trading in the Taiwan stock market before the 2007 financial crisis firms' operating performance and they offered about improvement areas for the firms. Kapelko and Lansink [18] examined the impact of intangible assets on technical efficiency of textile and clothing industry over the period 1995-2004 using double bootstrap DEA approach. Jiang et al. [19], examined the interaction between environmental efficiency and output efficiency using DEA and structural model using data of textile industry in Jiangsu Province, China. They concluded that environmental efficiency has a positive impact on output efficiency. Goyal et al. [20], analyzed the efficiency levels of the Indian textile industry and also its sub-sectors using meta-frontier data envelopment analysis and the researchers found out that the Indian textile industry is inefficient and needed to be improved in terms of efficiency. Gambhir and Sharma [21] studied productivity performance of Indian textile manufacturing industry using Malmquist productivity index. They used the panel data of 160 firms for the period 2007-2008 to 2012-2013. Jahanshahloo and Khodabakhshi [22], proposed a new approach for the input congestion in DEA models considering textile industry of China. Khodabakhshi [23] developed super-efficiency issue based on input relaxation model in stochastic DEA considering the data of textile industry of China. Lucato et al. [24], investigated the relationship between environmental performance and financial performance of small and medium textile manufacturing companies in Brazil and they didn't conclude a statistically significant relationship between environmental and financial performances of the companies surveyed.

There are also some studies on the Turkish textile firms. Öztürk and Girginer [25], analyzed the export efficiency of 30 textile and apparel firms with complete data for 2012 using DEA and AHP. DEA was used to calculate the efficiency of the firms and AHP was used to understand the qualitative and quantitative factors affecting the export efficiency of efficient firms. Kıllı and Uludağ [26] measured the cost performance of Turkish textile firms using DEA for 2017-2019 period.

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Çetin [27] analyzed the efficiency of Turkish textile firms quoted to the stock market for 2004. Kayalıdere and Kargın [28], evaluated the efficiency of textile and cement sector firms listed in Istanbul Stock Exchange by DEA. Perçin and Ustasüleyman [29], examined the efficiency of textile, apparel and leather industries (textile) and food, beverage and tobacco (food) industries in Istanbul Stock Exchange National Market for 2000-2002 period using DEA and MPI approaches. Kahveci [30] used two-stage DEA to analyze the export performance of Turkish textile firms for 2006-2008 period. Apan et al. [31], financial performance of 19 Turkish textile firms being traded on Borsa Istanbul (BIST) for the period 2008-2017 are examined using DEA-Window Analysis.

This study fills the gap in analyzing the efficiency and productivity changes for Turkish textile industry firms for 2014-2020 period including the effect of COVID-19 pandemic.

3. METHODOLOGY

In this paper to analyze the efficiency and productivity change of the textile and apparel firms, super-efficiency DEA and MPI methods are used. In this section the theorical frame of the methods are presented.

3.1. Super-efficiency DEA

DEA is a non-parametric linear programming approach to evaluate the relative efficiency of the homogenous decision-making units (DMUs). This approach was first proposed by Farrel [4] with multiple inputs and outputs and developed by Charnes et al. [5]. Any DEA model can be assumed as Constant Returns to Scale (CCR model) or Variable Returns to Scale (BCC model) and these models are most popular DEA models. If the DEA model aims to minimize the level of inputs and maintains the level of outputs, this type of model called as input-oriented. On the contrary, if the DEA model aims to maximize the level of outputs and maintains the level of inputs, this type of model called as output-oriented.

The CCR model is given in Eq.1 below.

$$
\begin{aligned}
&\max Eff_k = \sum_{r=1}^{s} u_{rk} y_{rk} && k = 1,2,3,\dots,n \\
&\sum_{r=1}^{s} u_{rk} y_{rj} - \sum_{i=1}^{m} v_{ik} x_{ij} \leq 0 && j = 1,2,3,\dots,n \\
&\sum_{i=1}^{m} v_{ik} x_{ik} = 1 && \\
&u_{rk} \geq 0 && r = 1,2,3,\dots,s \\
&v_{ik} \geq 0 && i = 1,2,3,\dots,m
\end{aligned}
\tag{1}
$$

where Eff_k is the relative efficiency value of each DMUs. m is the number of inputs, s is the number of outputs, n is number of DMUs, x_{ij} is amount of i^{th} input used by the j^{th} DMU, y_{rk} is amount of r^{th} output produced by the j^{th} DMU. The weights of i^{th} input and r^{th} output by DMUs are u_{rk} and v_{ik} respectively.
The BCC model is presented in Eq.2.

$$
\begin{aligned}
&\max Eff_k = \sum_{r=1}^{s} u_{rk} y_{rk} + c_0 && k = 1,2,3,\dots,n \\
&\sum_{r=1}^{s} u_{rk} y_{rj} - \sum_{i=1}^{m} v_{ik} x_{ij} \leq 0 && j = 1,2,3,\dots,n \\
&\sum_{i=1}^{m} v_{ik} x_{ik} = 1 && \\
&u_{rk} \geq 0 && r = 1,2,3,\dots,s \\
&v_{ik} \geq 0 && i = 1,2,3,\dots,m \\
&c_0 \ free &&
\end{aligned}
\tag{2}
$$

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Different from CCR model, BCC model includes a free variable c_0 and it indicates the variable returns of scale. CCR model provides Technical Efficiency (TE) and BCC model provides Pure Technical Efficiency (PTE). The ratio of TE to PTE is Scale Efficiency (SE).

In both CCR model and BCC models if Eff_k value of any DMU is 1 it is efficient, on the contrary if Eff_k value is lower than 1 it is inefficient. DEA analysis results can give us more than one efficient DMUs and the decision maker may need to know which DMU is more efficient. For this purpose, super-efficiency DEA model can be used to best DMU with input/output combination. Super-efficiency DEA eliminates the upper bound on the technical efficiency score and gives additional information regarding the relative performance of the efficient unit [32]. The mathematical model of super-efficiency DEA model is given in Eq. 3.

$$\begin{aligned}
&\max Eff_k = \sum_{r=1}^{s} u_{rk} y_{rk} && k = 1,2,3,\dots,n \\
&\sum_{\substack{r=1 \\ j\neq k}}^{s} u_{rk} y_{rj} - \sum_{\substack{i=1 \\ j\neq k}}^{m} v_{ik} x_{ij} \leq 0 && j = 1,2,3,\dots,n \\
&\sum_{i=1}^{m} v_{ik} x_{ik} = 1 && \\
&u_{rk} \geq 0 && r = 1,2,3,\dots,s \\
&v_{ik} \geq 0 && i = 1,2,3,\dots,m
\end{aligned} \tag{3}$$

The model given above produces continuous technical efficiency without upper bound and the main difference in super-efficiency DEA model is exclusion of unit k from the constraint set [32].

3.2. Malmquist Productivity Index

Malmquist Productivity Index (MPI) measures the change in total factor productivity of DMUs in time based on output distance. The idea of using distance functions was proposed by Caves et al. [33] based on the study by Malmquist [34]. MPI is constructed using radial distance of input and output vectors observed in *s* and *t* periods and these distances can be constructed input-oriented or output-oriented. If MPI is bigger than 1 it means there is an increase in total factor productivity (TFP), if there is no change in MPI there is no change in TFP and if MPI is lower than 1 there is decrease in TFP according to previous period. Fare et al. [35], defined MPI between period t and period t+1 as in Eq. 4.

where d denotes the distance function and M denotes the MPI. MPI can be decomposed into two components as technology change (frontier-shift effect) and technical efficiency change (catch-up effect). Technology Change Index (TCI) and Technical Efficiency Change Index (TECI) can be calculated as in Eq.5 and Eq.6. The MPI can be defined as $MPI = TCI(frontier-shift\ effect) \times TECI(catch-up\ effect)$.

$$M(x_{t+1}, y_{t+1}, x_t, y_t) = \left[\frac{d^t(x_{t+1}, y_{t+1})}{d^t(x_t, y_t)} \times \frac{d^{t+1}(x_{t+1}, y_{t+1})}{d^{t+1}(x_t, y_t)}\right]^{\frac{1}{2}} \tag{4}$$

$$TCI = \left[\frac{d^t(x_{t+1}, y_{t+1})}{d^{t+1}(x_{t+1}, y_{t+1})} \times \frac{d^t(x_t, y_t)}{d^{t+1}(x_t, y_t)}\right]^{\frac{1}{2}} \tag{5}$$

$$TECI = \frac{d^{t+1}(x_{t+1}, y_{t+1})}{d^t(x_t, y_t)} \tag{6}$$

4. DATA AND VARIABLES

Data of the textile firms were obtained from Türkiye Public Disclosure Platform (PDP). PDP is an electronic system through which electronically signed notifications required by the capital markets and Borsa Istanbul (stock market) regulations are publicly disclosed. The system covers over 600 companies and 3000 users all over Türkiye.

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The system is designed to allow everyone to have access to correct, timely, fair and complete information about the Borsa Istanbul companies, over the world wide web simultaneously and at low costs. On PDP there are 26 firms in textile industry but 7 of them doesn't have all data for selected variables for 2014-2020 period. The balance sheets of these firms are examined for the period of 2014-2020 and data set contains 19 firms.

For the efficiency and productivity analysis it is required to define inputs and outputs. Definition of three inputs and four output variables and references of variables are given in Table 1. The value of Employees (EMP), Total Assets (TA), Paid-in capital (PIC) and Revenues (REV) were obtained from the balance sheets directly. Return on Equity (ROE) was calculated by dividing company's net income by its shareholders' equity. The descriptive statistics of input and output variables are given in Table 2 in yearly base. The monetary values for TA, PIC and REV are the proportion by 100,000.

Furthermore, ROE has negative values and DEA doesn't work with negative values. To eliminate negative values in ROE, the values were normalized using Equation 7 [36].

$$\frac{X_{rj} - X_{jmin}}{X_{jmax} - X_{jmin}} \quad (7)$$

where X_{rj} is r^{th} value for j^{th} decision making unit, X_{jmin} and X_{jmax} are the minimum and maximum value of the considered variables.

5. EMPIRICAL RESULTS

In this section, results of super-efficiency DEA model and MPI are presented and interpreted in detail. Results were obtained by EMS 1.3 for DEA models and the DEAP 2.1 program for the MPI.

5.1. Super-Efficiency DEA Results

As stated before, super-efficiency scores provide us to understand the most efficient DMUs. In Figure 1, average super-efficiency scores of the textile firms are given in yearly base. According to the results, average super-efficiency values are stable in 2014 and 2015 but there is decrease in 2016 and 2017. With 2018 super-efficiency values start to increase until 2020. In 2016-2018 period average efficiency values are under 1, in contrast in other years average efficiency values are over 1.

In Table 3 super-efficiency scores and efficiency frequencies are given in firm level. DERIM and RODRG are efficient in all years. DERIM is the most efficient firms in period 2014-2020. YATAS is efficient only in last six years, DESA and KORDS are efficient only in three years, YUNSA is efficient in two years and DIRIT is efficient only in one year. However, 12 of the textile firms are inefficient in all years.

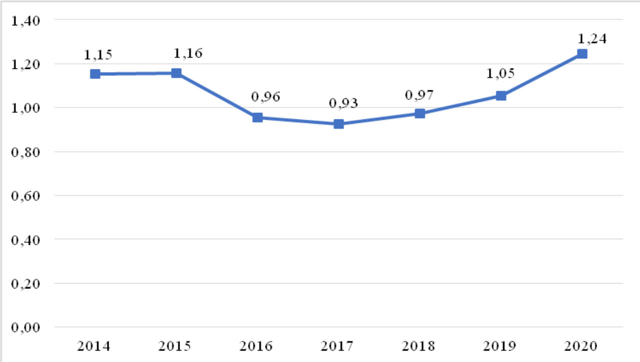

Figure 1. Average super-efficiency scores

Table 1. Definition of input and output variables

Variable name	Description	Type	References
Inputs			
Employees (EMP)	Number of employees in the firm	Numeric	You and Han [9], Kapelko and Lansink [11], Ho [12], Gambhir and Sharma [13], Zhu et al. [15]
Total Assets (TA)	Total amount of assets owned by the firm	Monetary	Ho [12], Kayalıdere and Kargın [28], Kahveci [30]
Paid-in capital (PIC)	The amount of capital paid in by investors during common or preferred stock issuances	Monetary	Jahanshahloo and Khodabakhshi [22], Khodabakhshi [23], Kahveci [30]
Outputs			
Revenues (REV)	Fees earned from providing services and the amounts of merchandise sold	Monetary	Kapelko and Lansink [11], Ho [12]
Return on Equity (ROE)	The ratio that measures the ability of a firm to generate profits from its shareholders investments in the company	Monetary	Kıllı and Uludağ [26], Çetin [27], Apan et al. [31],

Table 2. Descriptive statistics of the input and output variables in yearly base

Variables	Year	Mean	Std. dev.	Minimum	Maximum
EMP	2020	1066.263	1304.655	48.000	4499.000
	2019	1087.105	1289.977	22.000	4497.000
	2018	1089.789	1226.654	61.000	4415.000
	2017	1066.632	1174.961	61.000	3874.000
	2016	1074.947	1150.998	30.000	3782.000
	2015	1093.053	1194.896	21.000	4073.000
	2014	1161.105	1257.935	21.000	4284.000
TA	2020	9.583	17.223	0.174	76.047
	2019	8.076	15.847	0.130	71.706
	2018	6.277	10.664	0.221	48.302
	2017	4.667	6.370	0.194	28.666
	2016	4.030	5.547	0.169	25.437
	2015	3.635	4.805	0.153	21.740
	2014	3.326	4.414	0.123	19.715
PIC	2020	0.756	0.647	0.071	2.500
	2019	0.717	0.653	0.071	2.500
	2018	0.661	0.676	0.054	2.500
	2017	0.546	0.635	0.054	2.500
	2016	0.579	0.647	0.054	2.500
	2015	0.587	0.647	0.054	2.500
	2014	0.579	0.644	0.054	2.500
REV	2020	6.024	10.854	0.012	45.363
	2019	6.162	11.595	0.012	51.374
	2018	4.991	8.882	0.050	39.467
	2017	3.526	5.648	0.064	24.852
	2016	2.744	4.297	0.069	19.083
	2015	2.518	3.851	0.037	17.348
	2014	2.390	3.552	0.070	15.686
ROE	2020	-0.167	1.028	-4.347	0.575
	2019	0.123	0.296	-0.228	1.228
	2018	-0.146	0.889	-3.607	0.580
	2017	0.877	1.279	0.001	5.368
	2016	0.877	1.279	0.001	5.368
	2015	0.877	1.279	0.001	5.368
	2014	0.877	1.279	0.001	5.368

Table 3. Super-efficiency scores of textile firms

Firms	2014	2015	2016	2017	2018	2019	2020	Average	Efficiency frequency
ATEKS	0.32	0.34	0.39	0.44	0.63	0.81	0.77	0.53	0
ARSAN	0.33	0.39	0.38	0.39	0.36	0.42	0.39	0.38	0
BLCYT	0.43	0.42	0.33	0.52	0.60	0.69	0.40	0.48	0
BRKO	0.48	0.50	0.47	0.21	0.49	0.18	0.77	0.44	0
BOSSA	0.53	0.51	0.60	0.57	0.77	0.91	0.84	0.68	0
DAGI	0.52	0.77	0.42	0.48	0.66	0.57	0.42	0.55	0
DERIM	**4.80**	**5.92**	**6.23**	**5.12**	**3.99**	**2.87**	**3.05**	**4.57**	7
DESA	**1.05**	**1.02**	0.55	0.56	**1.00**	0.83	0.58	0.80	3
DIRIT	0.64	0.53	0.79	0.53	0.77	**2.70**	0.06	0.86	1
HATEK	0.63	0.68	0.34	0.56	0.66	0.66	0.83	0.62	0
KRTEK	0.44	0.52	0.60	0.77	0.78	0.80	0.77	0.67	0
KORDS	0.67	0.76	0.74	0.90	0.91	**1.58**	**1.93**	**1.07**	3
LUKSK	0.26	0.30	0.22	0.35	0.64	0.57	0.57	0.42	0
MNDRS	0.65	0.68	0.58	0.55	0.68	0.74	0.64	0.65	0
RODRG	**7.74**	**5.97**	**2.56**	**2.57**	**1.88**	**2.11**	**7.93**	**4.39**	7
SKTAS	0.46	0.51	0.45	0.43	0.61	0.50	0.35	0.47	0
SNPAM	0.24	0.27	0.32	0.38	0.68	0.59	0.95	0.49	0
YATAS	0.82	**1.03**	**1.49**	**1.42**	**1.21**	**1.01**	**1.44**	**1.20**	6
YUNSA	0.92	0.85	0.70	0.83	**1.13**	**1.46**	0.96	0.98	2

5.2. Results of Malmquist Productivity Index

MPI consists of technical efficiency change index (TECI), and technology change index (TCI). We calculated these components separately and then presented the results for each component. In Figure 2, average TFPI, TECI and TCI changes are given for period 2014-2020.

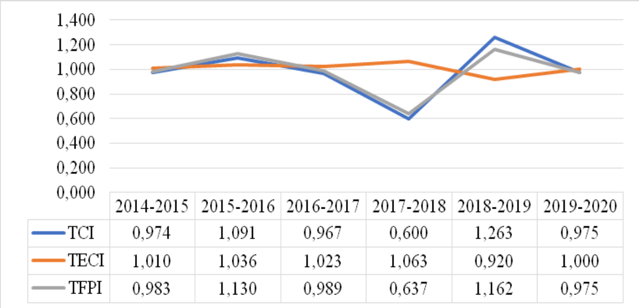

Figure 2. Average TFPI, TECI and TCI changes

According to the figure, average TFPI and TCI of textile firms increase in 2014-2015 period and they decrease until 2017-2018 period. There is an increment in 2018-2019 period and they decrease again in 2019-2020 period. However, TECI nearly remains in the same level in each period. We conclude that the source of change in TFPI is TCI for these companies.

In Table 4 cumulative productivity changes of textile firms are given during 2014-2020 period. These values are obtained comparing data of year 2014 and 2020. According to the results, average TCI is 0.955, TECI is 1.008 and TFPI is 0.962. TECI of the firms increases from 2014 to 2020, but TCI and TFPI decrease. Source of the decrease in TFPI is decrease in TCI. There are 7 increases in TCI, 8 increases in TECI and 6 increases in TFPI. Number of decreases are 12, 6 and 13 successively.

5.2.1. Total Factor Productivity Index

In Table 5 TFPI changes of textile firms are presented. ATEKS and DIRIT increase their TFPI in all periods. Average TFPI decrease of the firms is 2,1% Highest mean of TFPI is in 2018-2019 period and lowest average TFPI is in 2017-2018 period. DIRIT has the highest average TFPI and MNDRS has the lowest average TFPI.

5.2.2. Technology Change Index

TCI changes of textile firms are given in Table 6. ATEKS, BRKO, DERIM, DIRIT and SNPAM increase their TCI in five periods. Average TCI decrease of the firms is 2.2%. Highest mean of TCI is in 2018-2019 period with 26.3% increase and lowest mean TCI is in 2017-2018 period with 40% decrease. DIRIT has the highest average TCI and MNDRS has the lowest average TCI as in TCI.

Table 4. Productivity changes of textile firms during 2014-2020

Firms	TCI (2014-2020)	TECI (2014-2020)	TFPI (2014-2020)
ATEKS	1.018	1.000	1.018
ARSAN	0.887	0.985	0.874
BLCYT	0.940	1.012	0.951
BRKO	1.138	0.979	1.114
BOSSA	0.897	1.001	0.898
DAGI	0.938	1.047	0.982
DERIM	1.090	0.896	0.976
DESA	0.895	1.009	0.903
DIRIT	1.279	1.000	1.279
HATEK	0.890	1.078	0.959
KRTEK	0.966	0.994	0.960
KORDS	0.981	1.049	1.029
LUKSK	1.037	0.899	0.932
MNDRS	0.765	1.048	0.801
RODRG	1.014	1.078	1.094
SKTAS	0.763	1.000	0.763
SNPAM	1.024	0.936	0.959
YATAS	0.783	1.097	0.859
YUNSA	0.990	1.063	1.052
Average	0.955	1.008	0.962
Number of increase	7	10	6
Number of decrease	12	6	13
Number of no change	0	3	0

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Table 5. Total factor productivity changes of textile firms

Firm	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	Average	Frequency of increase
ATEKS	1.138	1.164	1.071	0.612	1.167	1.100	1.042	5
ARSAN	0.942	0.921	0.882	0.582	1.102	0.908	0.890	1
BLCYT	1.042	1.172	0.667	0.668	1.007	1.354	0.985	4
BRKO	1.076	0.945	1.559	0.615	1.867	1.051	1.186	4
BOSSA	1.125	0.712	1.360	0.655	0.678	1.083	0.936	3
DAGI	0.688	1.650	0.871	0.581	1.281	1.216	1.048	3
DERIM	1.398	1.226	1.300	0.692	0.63	0.889	1.023	3
DESA	0.960	1.085	0.904	0.546	1.270	0.832	0.933	2
DIRIT	1.351	0.598	1.092	1.108	1.107	4.048	1.551	5
HATEK	0.987	1.562	0.78	0.621	1.204	0.867	1.004	2
KRTEK	0.956	0.819	0.816	1.201	0.917	1.114	0.971	2
KORDS	0.980	1.262	1.182	0.642	2.100	0.601	1.128	3
LUKSK	0.994	1.310	0.811	0.699	0.844	1.056	0.952	2
MNDRS	1.080	0.701	0.799	0.546	1.382	0.581	0.848	2
RODRG	0.924	1.339	1.250	0.938	1.029	1.148	1.105	4
SKTAS	0.477	1.398	1.131	0.411	1.620	0.393	0.905	3
SNPAM	1.035	1.014	1.031	0.598	1.238	0.972	0.981	4
YATAS	0.993	1.166	1.126	0.272	1.248	0.911	0.953	3
YUNSA	0.958	2.819	0.679	0.715	1.341	0.771	1.214	2
Average	0.983	1.130	0.989	0.637	1.162	0.975	0.979	

Table 6. Technology changes of textile firms

Firm	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	Average	Frequency of increase
ATEKS	1.138	1.164	1.071	0.612	1.167	1.100	1.042	5
ARSAN	0.942	0.921	0.882	0.582	1.102	0.993	0.904	1
BLCYT	0.931	1.016	0.959	0.632	1.127	1.069	0.956	3
BRKO	1.037	1.035	1.150	0.615	1.867	1.528	1.205	5
BOSSA	0.983	1.062	0.849	0.654	1.024	0.88	0.909	2
DAGI	0.951	1.034	0.966	0.649	1.002	1.102	0.951	3
DERIM	1.398	1.226	1.300	0.692	1.003	1.081	1.117	5
DESA	0.925	1.066	0.904	0.546	1.270	0.832	0.924	2
DIRIT	1.351	0.598	1.092	1.108	1.107	4.048	1.551	5
HATEK	0.964	1.018	0.906	0.554	1.162	0.867	0.912	2
KRTEK	0.993	1.077	0.858	0.616	1.523	0.945	1.002	2
KORDS	0.736	1.621	0.986	0.599	2.100	0.601	1.107	2
LUKSK	0.994	1.310	0.811	0.699	1.192	1.411	1.070	3
MNDRS	0.814	0.885	0.813	0.425	1.654	0.486	0.846	1
RODRG	1.293	1.013	0.920	0.850	0.795	1.338	1.035	3
SKTAS	0.477	1.398	1.131	0.411	1.620	0.393	0.905	3
SNPAM	1.035	1.113	1.320	0.496	1.090	1.407	1.077	5
YATAS	0.945	0.930	0.795	0.382	1.707	0.508	0.878	1
YUNSA	1.041	1.798	0.874	0.608	1.226	0.771	1.053	3
Average	0.974	1.091	0.967	0.600	1.263	0.975	0.978	

In Table 7 TECI changes of textile firms are given. No firms increase its TECI in all periods. Average TECI decrease of the firms is 0.9%. Eleven firms increase their average TECI, five firms decrease their average TECI and three firm’s average TECI doesn’t change. TECI of textile firms increase in first four-periods, decrease in 2018-2019 period and doesn’t change in the last period. YATAS has the highest average TECI and DERIM and LUKSK has the lowest average TECI.

5.2.3. Effect of COVID-19 Pandemic on the Firms

The analyses period of this study covers the start of COVID-19 pandemic in 2020. For this reason, it is examined if there is a significant difference in efficiency values, TCI, TECI and MPI values between 2020 and the average of pre-2020 period. To answer this question Wilcoxon rank sum test is used. W_s statistic is calculated in the sign test process of Wilcoxon rank sum test. is compared to the expected value of this statistic in the test. The results of the test are presented in Table 8.

According to the results in Table 7, there isn’t any significant difference between pre-2020 and 2020 periods in terms of the efficiency, TCI, TECI and TFPI values of the textile firms.

Table 7. Technical efficiency changes of textile firms

Firm	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	Average	Frequency of increase
ATEKS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0
ARSAN	1.000	1.000	1.000	1.000	1.000	0.915	0.986	0
BLCYT	1.119	1.154	0.696	1.056	0.893	1.267	1.031	4
BRKO	1.038	0.912	1.356	1.000	1.000	0.688	0.999	2
BOSSA	1.144	0.67	1.602	1.002	0.663	1.231	1.052	4
DAGI	0.723	1.596	0.901	0.896	1.278	1.104	1.083	3
DERIM	1.000	1.000	1.000	1.000	0.628	0.823	0.909	0
DESA	1.038	1.017	1.000	1.000	1.000	1.000	1.009	2
DIRIT	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0
HATEK	1.023	1.534	0.861	1.121	1.036	1.000	1.096	4
KRTEK	0.964	0.761	0.951	1.95	0.602	1.18	1.068	2
KORDS	1.331	0.778	1.199	1.072	1.000	1.000	1.063	3
LUKSK	1.000	1.000	1.000	1.000	0.708	0.748	0.909	0
MNDRS	1.326	0.792	0.983	1.285	0.836	1.196	1.070	3
RODRG	0.714	1.321	1.359	1.104	1.294	0.858	1.108	4
SKTAS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0
SNPAM	1.000	0.911	0.781	1.206	1.136	0.691	0.954	2
YATAS	1.051	1.253	1.416	0.714	0.731	1.793	1.160	4
YUNSA	0.92	1.567	0.777	1.177	1.094	1.000	1.089	3
Average	1.010	1.036	1.023	1.063	0.920	1.000	1.009	

Table 8. Wilcoxon rank sum test results for efficiency, TCI, TECI and TFPI values

		Observation	Rank sum	Expected	p-value
Efficiency	2020	19	383	370.5	0.715
	Pre-2020	19	358	370.5	
TCI	2020	19	361	370.5	0.782
	Pre-2020	19	380	370.5	
TECI	2020	19	336	370.5	0.308
	Pre-2020	19	405	370.5	
TFPI	2020	19	353	370.5	0.609
	Pre-2020	19	388	370.5	

5.2.4. Grouping the Firms

The positions of textile firms which are grouped in terms of efficiency and TFPI values are presented in Figure 3. The horizontal axis of the figure contains average super-efficiency values and the vertical axis contains TFPI values. The threshold values for the groups is 1 for super efficiency and MPI values. By doing this we obtained for groups as A, B, C and D.

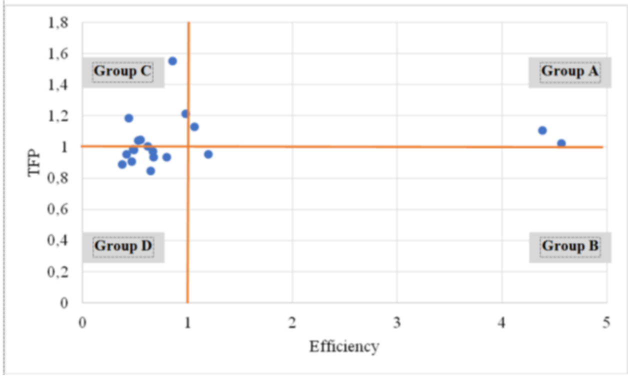

Figure 3. Positions of textile firms

Group A-High efficiency and positive productivity increase: Firms in this group are located on the upper right quadrant and these firms have an average super-efficiency values greater than 1 and an average TFPI values greater than 1 for the period 2014-2020. Firms in this group should preserve their position by implementing targeted business strategies. Firms in this group are DERIM, KORDS and RODRG.

Group B-High efficiency and negative productivity increase: Firms in this group are on the lower right quadrant and these firms have an average super-efficiency value greater than 1 but their average TFPI values are lower than 1. These firms manage their resources efficiently, but they can't gain positive productivity growth. Firms in this group should preserve their position in terms of efficiency but should gain positive technology change. The firm in this group is YATAS.

Group C-Low efficiency and positive productivity increase: This group contains the firms on the upper left quadrant with an average super-efficiency value lower than 1 and an average TFPI values greater than 1 for the examined period. Firms in this group will probably be located in the group with high efficiency if they resume their trend in productivity. Firms in this group are ATEKS, BRKO, DAGI, DIRIT, HATEK and YUNSA.

Group D-Low efficiency and negative productivity increase: These firms are the lowest performance firms and they are located on the lower left quadrant. Firms in this group don’t manage their resources efficiently and also, they decrease their productivity for 2014-2020 period. These firms must take some measures to stop their decrease in efficiency and productivity urgently to be able to continue to compete. The firms in this group are ARSAN, BLCYT, BOSSA, DESA, KRTEK, LUKSK, MNDRS, SKTAS and SNPAM.

CONCLUSION

In this study efficiency and productivity changes of 19 Turkish textile firms which are quoted to Borsa Istanbul are examined for 2014-2020 period. Super-efficiency DEA model is used for the efficiency analysis stage which provides us to know which unit is more efficient. For the productivity analysis stage MPI is used. In all analyses 3 input variables (employees, total assets, and paid-in capital) and 2 output variables (revenues, return on equity) are employed.

According to the results 2 of 19 textile firms are efficient in all period, 1 firm is efficient in seven periods and 6 firms are efficient in six periods. Twelve of the firms are inefficient in all periods. As for MPI results, average TCI is 0.955, TECI is 1.008 and TFPI is 0.962. Technical efficiency of textile firms increases from 2014 to 2020, but technology change and total factor productivity decrease. It is concluded that source of the decrease in TFPI is decrease in technical efficiency change.

To examine the COVID-19 pandemic on the efficiency, TECI, TCI and TFPI performance of the textile firms a Wilcoxon Rank Sum test was used. According to the results of the test, it was concluded that there isn’t any significance difference between before and during COVID-19 pandemic periods in terms of efficiency, TECI, TCI and TFPI values.

After these analyses the firms are grouped based on average super-efficiency and MPI values. By doing these four groups are obtained as A (high efficiency and positive productivity increase), B (high efficiency and negative productivity increase), C (low efficiency and positive productivity increase) and D (low efficiency and negative productivity increase). Three firms are included in Group A, one firm in Group B, six firms in Group C and nine firms in Group D. Comments are made for the performance of the firms in each group and recommendations are given to improve their performance.

For the future research our approach can be developed with other variations of the DEA models such as slack based model DEA or Network DEA and dynamic DEA models also can be used for further analyses.

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