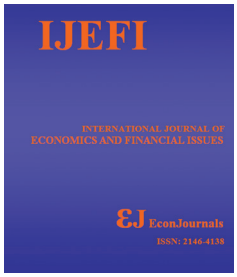

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Analyzing the Effects of Covid-19 Pandemic on the Financial Performance of Turkish Listed Companies on Borsa Istanbul using the Entropy-based Grey Relational Analysis

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ABSTRACT

The purpose of this study is to use financial performance indicators to reveal how Covid-19 affects different sectors of companies operating in Turkey compared to their financial performance in previous years. The financial performance of 210 companies operating in manufacturing, construction, and technology sectors was explored through ratio analysis, using four main and 15 sub-financial performance ratios. The effects of Covid-19 on their financial performance were investigated with the entropy-based grey relational analysis technique. The results of the study show that Covid-19 positively affected the manufacturing and technology sectors in Turkey, whereas it negatively affected the construction sector. In light of the results, this study contributes to manufacturing, construction, and technology companies to take measures against possible global crises that may arise in the future based on the effects of the Covid-19 period.

Keywords: Covid-19, Financial Performance, Manufacturing Sector, Construction Sector, Technology Sector, Entropy, Grey Relational Analysis
JEL Classifications: F62; M21; M40

1. INTRODUCTION

Covid-19, one of the most critical problems of the present century, has seriously affected the economy, transportation, and many other areas, particularly the health sector. At the macro level, it had caused the most severe global recession since 1930, when the economy completely collapsed (Rababah et al., 2020; Shen et al., 2020). The impacts of this recession vary from country to country or company to company, depending on the countries' healthcare systems, financial systems, the severity of uncertainties, and the balance between public health and economic cost (Hu and Zhang, 2021; Atayah et al., 2022). Also, country-specific characteristics of Covid-19 are essential, including countries' economic development levels and institutional governance infrastructure (Golubeva, 2021). Examining these country-specific characteristics from a financial perspective, it is imperative to conduct firm-based and sectoral-based studies to reveal the situation regarding the effects of Covid-19. Indeed, according to Atayah et al. (2022), who conducted research in G20 countries, Covid-19 on financial performance varies from country to country. For companies and sector-based studies, there are various studies on different sectors in different countries, including China (He et al., 2020; Al-Awadhi et al., 2020; Shen et al., 2020; Rababah et al., 2020), India (Alsamhi et al., 2022), Gulf Arab States (Umar, 2022), Vietnam (Anh and Gan, 2021), USA (Clampit et al., 2021), Greece (Polemis and Soursou, 2020), Romania (Achim et al., 2022), Poland (Kubiczek and Derej, 2021), and Indonesia (Devi et al., 2020). There are studies on the effects of Covid-19 on companies' performances in Turkey (Kılıç Karamahmutoğlu, 2022; Yücel and Durak, 2021). However, there

are no studies on the subject in Turkey in the journals scanned in the web of science database.

Furthermore, it was seen that studies on a single sector (Atayah et al., 2022; Clampit et al., 2021; Polemis and Soursou, 2020; Song et al., 2021; Qadri et al., 2022) could not be utilized to compare different sectors. As stated by Kubiczek and Derej (2021), the Covid-19 crisis affected different sectors in different ways, and according to Shen et al. (2020), the pandemic affected supply and demand in different sectors in different ways. Therefore, comparing multiple sectors would be extremely useful (Qadri et al., 2022). However, some studies employ only one variable, such as profitability as a measure of financial performance (Zhang et al., 2022; Kubiczek and Derej, 2021; He et al., 2022); Delen et al. (2013), using profitability ratios along with operating, financial structure, and liquidity ratios to measure financial performance is a powerful tool for decision-makers, and by using these financial ratios, comparisons can be made between companies within an industry, across industries or within a firm itself. Therefore, the present study fills the gap in the literature in terms of comparing listed companies operating in more than one sector in Turkey using entropy-based grey relational analysis techniques for different financial performance parameters. Also, studies conducted in 2020, when Covid-19 emerged, will contribute to the literature in terms of having data limitations in terms of seeing the effects in the following years, while this study will contribute to the literature in terms of taking into account the effects in the following years since the data for 2021 are also obtained in this study.

In this manner, the present study aims to reveal how the Covid-19 pandemic has affected different sectors of listed companies operating in Turkey using an entropy-based grey relational analysis technique. To measure these effects, financial performance indicators (operating ratios, profitability ratios, liquidity ratios, financial structure ratios) in the manufacturing, construction, and technology sectors before the pandemic (2016Q2-2019Q4) and during the pandemic period (2020Q1-2021Q3) were utilized. Thus, it was aimed to observe the long-term effects of Covid-19 on the financial performance of different sectors due to the limited availability of data.

2. LITERATURE REVIEW

It is possible to come across many studies examining the effects of the Covid-19 pandemic on companies and sectors at the micro level. Liu et al. (2023), in their research on 40 country or regional stock markets operating in the tourism and hospitality sector, found that COVID-19 significantly affects the volatility of tourism and accommodation stock markets in all countries and that government interventions have a positive effect on stock returns. Chen and Yeh (2021), in their research examining the effects of the 2008 global economic crisis and Covid 19 on stock returns, stated that investor confidence increased after the FED's quantitative easing announcement and had significant effects on sectors that were more affected by the pandemic. Carter et al. (2022), who examined the effects of Covid 19 on stock prices in travel-related sectors (airlines, restaurants and hotels) in the US, concluded that firms with high cash reserves and high market to book ratios were less affected. Analyzing the response of markets in China to the Covid-19 pandemic, He et al. (2020) stated that the markets reacted positively in the manufacturing and information technology sectors and negatively in the construction sector. Anh and Gan (2021), examining companies in the energy sector, a sub-sector of the manufacturing sector, concluded that stock returns were negatively affected in the early periods of the Covid-19 pandemic. However, stock returns increased in periods of lockdowns.

In the construction sector, companies have suffered severe financial damage worldwide. Addressing the financial performance of companies in the construction sector in India after the Covid-19 period, Alsamhi et al. (2022) showed the negative effect of the Covid-19 pandemic in terms of total revenue and net sales in this sector. Similarly, Xiong et al. (2020) have stated that companies in the construction sector, which they included in vulnerable sectors, were worse affected regarding stock returns. Umar (2022) conducted interviews with senior executives of construction companies operating in the member countries of the Gulf Cooperation Council for the Arab States and reported that the Covid-19 pandemic negatively affected the sector due to delays in supply, decreases in labor motivation, occupational safety, and legal sanctions. Regarding the performance of technology companies during the Covid-19 period, Levy (2021) argued that the restrictions imposed during the Covid-19 pandemic increased the revenues of large technology-based companies. Supporting this claim, Sierotowicz (2022) argues that International Business Machines (IBM), Samsung Electronics Co. Ltd. (Samsung), and Canon Kabushiki Kaisha (Canon) during the Covid-19 period, the pandemic did not have a negative impact on the performance of technology companies. Similarly, Al-Awadhi et al. (2020) examined the companies in the Shanghai Composite Index in China, and Mazur et al. (2021) examined the companies in the S&P500 Index and showed that companies in the information technologies/software sector increased their performance during the Covid-19 period and showed that companies in the information technology/software sector increased their performance during the Covid-19 period. In addition to these studies, Elhini and Hammam (2021), similar to Anh and Gan (2021) in the technology sector, stated that the shock experienced in the first period was short-lived and the effect progressed positively in the later stages of the Covid-19 period.

Examining the studies conducted in Turkey, similar results have been reported. Koyuncu and Meçik (2020) stated that the manufacturing sector is the sector that responds the fastest to shocks during the Covid-19 period, while the construction sector is the sector that reacts the slowest. Kılıç Karamahmutoğlu (2022) showed that the financial performance of companies operating in the manufacturing sector, such as leather, paper and paper products, primary metal industry, and metal goods production companies, increased during the Covid-19 period. Similarly, Yücel and Durak (2021) stated that during the Covid-19 period, companies in the manufacturing sector that produce products such as pharmaceuticals, disinfectants, basic food, and packaging, whose demand increased during the pandemic, increased their financial performance. Özdemir (2020) analyzed the market reactions in the technology sector and reported that the Covid-19 pandemic positively affected the BIST Technology Index (XUTEK).

3. METHODS

Since the first studies on the impact of the Covid-19 pandemic on financial performance started immediately after the pandemic, they mainly focused on stock returns and volatility (Xiong et al., 2020; Sharma et al., 2021; Sun et al., 2021). Therefore, relatively few firm-level studies have been conducted (Hu and Zhang, 2021; Alsamhi et al., 2022). In addition, Clampit et al. (2021) stated that in these few studies, firm performance variables in the Covid-19 period are generally compared with the performances of the pre-Covid-19 period (Rababah et al., 2020; Song et al., 2021).

Within the scope of the study, to measure Covid-19 effects, financial performance indicators (operating ratios, profitability ratios, liquidity ratios, financial structure ratios) in the manufacturing, construction, and technology sectors before the pandemic (2016Q2-2019Q4) and during the pandemic period (2020Q1-2021Q3) were utilized. The manufacturing sector has contributed significantly to global GDP and employment since 1970 (Haraguchi et al., 2017). Developing Turkey's manufacturing sector development has followed a similar path. According to the Turkish Statistical Institute (TurkStat), the share of manufacturing in Turkey's GDP increased from 17.8% in 1998 to 20.4% in the third quarter of 2022. The manufacturing sector's performance during the Covid-19 pandemic is analyzed in the present study as it is crucial in ensuring economic development. Similarly, the construction sector is essential to national economies, accounting for approximately 13% of the global GDP (Araya, 2021). This is undoubtedly the case for Turkey as well. According to the Turkish Statistical Institute (TurkStat), the construction sector's share in Turkey's GDP in 2022Q3 is 4.5%. In the construction sector, which has such an important place, the reflection of any crisis is seen very quickly due to the unique characteristics of the sector (Tekin, 2022). Therefore, it was deemed appropriate to select the construction sector as another sector in the study. With the Covid-19 pandemic, many sectors have switched to applications such as remote working, online ordering, etc. Therefore, business activities and business models have transformed digitally due to the Covid-19 pandemic (Stalmachova et al., 2022).

Along with the digital transformation, Turkey's technology sector has shown significant development, as is the case worldwide. Digital transformation in other sectors, especially e-sales applications, dramatically impacts the development of the technology sector. According to TurkStat data, the e-sales rate in the manufacturing sector, which was 10.3% in 2020, reached 16.8% in 2021. Similarly, the e-sales rate in the construction sector, which was 4.1% in 2020, reached 10.4% in 2021. With these indicators, it is possible to state that the technology sector is not on the rise alone but also contributes to the growth of other sectors. As a result, it is a fact that the manufacturing, construction, and technology sectors are among the locomotive sectors in economic growth both globally and in Turkey.

Financial ratios are generally preferred for firm performance variables. Therefore, financial ratios such as Return on Assets (ROA), Return on Equity (ROE), and Tobin's Q are frequently used in studies examining the impact of the Covid-19 pandemic on firm performance with firm performance variables. In the experimental phases of these studies, quarterly data on financial ratios were mainly included (Rababah et al., 2020; Shen et al., 2020; Hu and Zhang, 2021; Atayah et al., 2022). Financial performances in the form of stock values or index returns change in reasonably close ranges, and quarterly periods are gradual (Atayah et al., 2022). Using profitability ratios in their studies, Alsamhi et al. (2022) suggested that leverage and liquidity ratios should also be evaluated for future studies.

Within the scope of the study, the financial performances of 210 companies, including 186 companies in the manufacturing sector, nine companies in the construction sector, and 15 companies in the technology sector, among the companies operating in Borsa Istanbul (BIST) in Turkey, were analyzed. Four fundamental ratios and 15 sub-ratios were analyzed separately to measure their financial performance. A detailed explanation of the financial ratios included in the analysis is explained in Table 1.

In financial analysis practice, financial ratios are mainly used for their simplicity and additional information value. These ratios enable the development of a firm's financial position (trend analysis), cross-sectional analysis and comparative analysis. Financial ratios can be categorized as productivity, profitability, cost, liquidity, solvency, capital structure and capital market indicators. Financial ratios are also the most popular and widely used methods of financial analysis because they can be used as input data for more complex mathematical models (Myšková and Hájek, 2017). Operating ratios measure the ability of assets to generate revenue or earnings. Operating ratios analysis is important and useful and allows us to understand the overall level of efficiency that a business realizes (Monea et al., 2010). Profitability ratios are used to measure whether companies are earning profits at an acceptable rate. These ratios are an indicator to attract investors and can be used as an important indicator when making decisions for long-term investment (Husain et al, 2020). Liquidity ratios are used to measure the short-term solvency of the entity and to assess liquidity risk. Financial structure ratios are used to determine that the company is financed in a measured manner and how much the financing risk is. These ratios give clues about the company's ability to fulfil its obligations. (Akgüç, 2011). In general terms, operating ratios are used to measure the intensity with which companies utilize their assets, profitability ratios measure the return on the firm's investments, financial structure ratios measure the indebtedness of companies, and liquidity ratios measure how easily companies can obtain cash (Brealey et al., 2019). The relevant data were obtained from the Central Registry Agency, the Data Analysis Platform of the Public Disclosure Platform (Data Analysis Platform, 2023).

The sub-ratios in Table 1 were used in performance calculations for the basic ratios they are included in. For example, Asset Turnover Ratio, Shareholders' Equity Turnover Ratio, Inventory Turnover Ratio, and Trade Receivables Turnover Ratio ratios under operating ratios are used in the calculation of operating performance by using CRM techniques. The calculation of the performances is based on a two-stage approach. In the first stage, the weights of the sub-ratios were determined using the Entropy method. Since entropy weight

Table 1: Basic and sub-financial ratios used in the study

Basic Ratios	Lower Ratios	Calculation
Activity Ratios	Asset Turnover	Net Sales/Total Assets
	Equity Turnover Rate	Net Sales/Average Equity
	Inventory Turnover	Short-Term Inventories/Current Assets
	Trade Receivables Turnover Rate	Revenue/Average Trade Receivables
Profitability Ratios	ROA	Net Profit/Average Assets
	ROE	Net Profit/Average Equity
	Net Profit Margin	Net Profit/Net Sales
	Operating Profit Margin	Operating Profit/Net Sales
Liquidity Ratios	Cash Rate	Cash and Cash Equivalents+Marketable Securities/ Short Term Liabilities
	Current Ratio	Current Assets/Short-Term Liabilities
	Liquidity Ratio	Current Assets - Inventories/Short-Term Liabilities
Financial Structure Ratios	Leverage Ratio	Total Liabilities/Total Resources
	Short-Term Liabilities Ratio	Short-Term Liabilities/Total Resources
	Equity Ratio	Equity/Assets
	Long-Term Liabilities Ratio	Long-Term Liabilities/Total Assets

determines the criteria weights without the subjective approaches of decision makers, the intervention of decision makers in criteria weighting is eliminated. Entropy weighting is a multi-criteria decision-making method used to determine the weight of a decision criterion by relating the weighting of a criterion directly to the information of that criterion (Bazzazi et al., 2011). The process steps and mathematical functions used to determine the objective weights by the entropy method are explained in detail by Deng et al., (2000).

1: Each criterion in the decision matrix in equation (1) is normalized as specified in equation (2).

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1j} \\ x_{21} & x_{22} & \dots & x_{2j} \\ \dots & \dots & \dots & \dots \\ x_{i1} & x_{i2} & \dots & x_{ij} \end{bmatrix} \quad (1)$$

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \; i = 1,2,.,n; \; j = 1,2,.,m \quad (2)$$

In Equation (2), x_{ij} denotes the real value of each alternative, while p_{ij} denotes the normalized form values for each criterion. A normalized decision matrix in the shape of the equation specified below is obtained after solving Equation (2).

$$P = \begin{bmatrix} p_{11} & p_{12} & \dots & p_{1j} \\ p_{21} & p_{22} & \dots & p_{2j} \\ \dots & \dots & \dots & \dots \\ p_{i1} & p_{i2} & \dots & p_{ij} \end{bmatrix} \quad (3)$$

2: In the light of information contained in the normalized decision matrix in Equation (3), entropy values (ej) for each criterion are calculated using Equation (4) as specified as follows.

$$e_j = -k \sum_{i=1}^{n} p_{ij} \ln p_{ij} \quad (4)$$

In equation (4), k is calculated as $1/\ln(n)$ and is a constant which guarantees $0 \leq e_j \leq 1$. In Equation (4), e_j denotes the amount of information for a certain criterion. When the entropy value is smaller, then the importance of the criterion on decision making process becomes higher (Wu et al., 2011). In other words, entropy value shows the uncertainty of information on a criterion. The uncertainty decreases when the information values for the criteria are close to each other. Therefore, the entropy value takes a small value accordingly.

3: The degree of divergence (d_j) of the average information contained in each criterion can be calculated as follows:

$$d_j = 1 - e_j \quad (5)$$

The degree of differentiation (d_j) refers to the contrast intensity of the information in the criterion. Accordingly, as the value of the d_j criterion increases, the importance of the criterion in problem solving increases (Wang and Lee, 2009). In other words, it is the degree of difference between the information belonging to the criteria. It has an inverse relationship with its entropy value.

4: The last stage in the entropy method is where criterion weights are calculated. This calculation is done with the formula,

$$w_j = \frac{1 - e_j}{\sum_{i=1}^{n} 1 - e_j} \quad (6)$$

w_j in equation (6) above shows the weight values of the criteria.

The important point to be considered here is the rule that the sum of all w_j values ($w_1 + w_2 + \dots + w_n$) should be equal to 1.

In the second stage, baseline performances were calculated through sub-ratios using the Grey Relational Analysis (GRA) technique. "Grey relationship" refers to the measurement of changing relationships between two systems or between two elements in a system over time. The analysis method that measures the relationship between elements based on the difference in similarity or improvement trend between these elements is called

"grey relationship analysis" (Feng and Wang, 2000). Since the GRA process is based on point set topology, it makes a global comparison between two datasets instead of a local comparison by measuring the distance between two points (Chan and Tong, 2007). The study by Wu and Peng (2016) can be examined for the process steps of the grey relational analysis method.

1: After the decision matrix is created as in Equation (1), the series that make up the matrix in the decision problem with i rows (i = 1, 2,…., m) and j columns (j = 1, 2,…., n), according to the status of benefit, cost and nominality is normalized as follows.

a. Benefit-oriented criterion: If the criterion in the series has the property "the larger value is better", the i, rows (i = 1, 2,…., M) and j, the columns (j = 1, 2,…, n) the following normalization procedure is applied.

$$x_{ij}^{'} = \frac{x_{ij} - \min\limits_{i} x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}} \tag{7}$$

b. Cost-oriented criterion: If the criterion in the series has the property "the smaller value is better", i, rows (i = 1, 2,…., M) and j columns (j = 1, 2,…., n) the following normalization procedure is applied.

$$x_{ij}^{'} = \frac{\max\limits_{i} x_{ij} - x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}} \tag{8}$$

c. Nominality criterion: If the criterion in the series has a value such as x_{0b} (i.e. if it has the property "the nominal value is better") The following normalization procedure is applied to i lines (i = 1, 2,… columns, m) and j (j = 1, 2,…, n) columns.

$$x_{ij}^{'} = 1 - \frac{\left| x_{ij} - x_{0b} \right|}{\max\left\{ \max\limits_{i} x_{ij} - x_{0b}; x_{0b} - \min\limits_{i} x_{ij} \right\}} \tag{9}$$

At the end of the calculation processes and steps, a normalized matrix of the form specified below is obtained.

$$R^{'} = \begin{bmatrix} x_{11}^{'} & x_{12}^{'} & \dots & x_{1j}^{'} \\ x_{21}^{'} & x_{22}^{'} & \dots & x_{2j}^{'} \\ \dots & \dots & \dots & \dots \\ x_{i1}^{'} & x_{i2}^{'} & \dots & x_{ij}^{'} \end{bmatrix} \tag{10}$$

2: For each criterion, a reference is determined using the normalization matrix $x^{'}(0)$

$$x^{'}(0) = \left(x_{11}^{'}(0), x_{12}^{'}(0), x_{13}^{'}(0), .., x_{1j}^{'}(0) \right) \tag{11}$$

In equation (12), $x_{1j}^{'}(0)$ expresses the j[th] reference value and for each criteria it is obtained by by the largest normalization value.

3: The difference Δ_{ij} (0) between the reference series $x^{'}(0)$ and normalized values is calculated using equation (12) and as in equation (13), an absolute value matrix is created.

$$\Delta_{ij}(0) = \left| x^{'}(0) - x_{ij}^{'} \right| \tag{12}$$

$$\Delta = \begin{bmatrix} \Delta_{11}(0) & \Delta_{12}(0) & \dots & \Delta_{1j}(0) \\ \Delta_{21}(0) & \Delta_{22}(0) & \dots & \Delta_{2j}(0) \\ \dots & \dots & \dots & \dots \\ \Delta_{i1}(0) & \Delta_{i2}(0) & \dots & \Delta_{ij}(0) \end{bmatrix} \tag{13}$$

4: The grey relational coefficients γ_{ij} (0) are calculated with the help of the equation sepicified below in accordance to the absolute value matrix.

$$\gamma_{ij}(0) = \frac{\min\limits_{i}\min\limits_{j} \Delta_{ij}(0) + \delta \max\limits_{i}\max\limits_{j} \Delta_{ij}(0)}{\Delta_{ij}(0) + \delta \max\limits_{i}\max\limits_{j} \Delta_{ij}(0)} \tag{14}$$

where δ is expressed as the distinguished coefficient. δ∈ [0,1] bound, however, it is generally accepted to be 0, 5.

5: With the help of the equation (15), the grey relational degrees (Γ_i) are calculated.

$$\Gamma_i = \sum_{j=1}^{n} \left(w_j \times \gamma_{ij}(0) \right) subject\ to \sum_{j=1}^{n} w_j = 1 \tag{15}$$

w_j in Equation (15) indicates the weight of the jth criterion. The condition in the equation states that the sum of the weights of all criteria should be 1.

Therefore, four separate performance calculations were obtained in the present study: activity, profitability, liquidity, and financial structure. Then, according to these performance measures, the financial conditions of the sectors before and during the Covid-19 period are presented comparatively with graphs. Past research has generally used causal models and event studies to discern the impact of the pandemic. Therefore, from a methodological point of view, there needs to be a methodological gap in developing a CRM-based analytical framework (Biswas et al., 2022). There is a limited number of studies in the literature that examine financial performance during the Covid-19 period with CRM methods (Kehribar et al., 2021; Öndeş and Özkan, 2021; Biswas et al., 2022; Ertaş and Yetim, 2022; Özgüner et al., 2022). CRM techniques are very useful in using analytical models to comprehensively evaluate firm performance based on multiple factors.

4. RESULTS

The Entropy method, used in the first stage of calculating the performance of the sectors, is used to determine the weights of sub-financial ratios within the fundamental ratios for each sector. The calculation stages of the weights of the sub-ratios used in calculating financial performance for the manufacturing sector, obtained by the Entropy method, are briefly presented in Table 2.

Examining the weights of the sub-ratios in the calculation of the operating performance of the manufacturing sector, the criteria weights are Asset Turnover (25.6%), Equity Turnover (25.15%),

Table 2: Entropy weights of sub-ratios in calculating the operating performance of the manufacturing sector

Phase	Period	Criteria			
		Asset Turnover	Equity Turnover Rate	Inventory Turnover	Trade Receivables Turnover Rate
Decision Matrix	2016Q2	1.0495	0.815715	1.1559	0.940381
	2016Q3	1.8833	1.612713	2.166771	1.722281
	2016Q4	2.71152	2.434626	3.039214	2.661162
	2017Q1	0.045046	0.009991	0.132481	0.098211
	⋮	⋮	⋮	⋮	⋮
	2020Q4	2.69354	2.70055	2.72220	2.77090
	2021Q1	0.13828	0.16965	0.16821	0.11797
	2021Q2	1.15025	1.05785	1.07450	1.13272
	2021Q3	2.18933	2.06684	1.90798	2.13429
Normalized Decision Matrix	2016Q2	0033	0026	0037	0030
	2016Q3	0060	0051	0069	0055
	2016Q4	0086	0077	0097	0085
	2017Q1	0001	0000	0004	0003
	⋮	⋮	⋮	⋮	⋮
	2020Q4	0086	0086	0087	0088
	2021Q1	0004	0005	0005	0004
	2021Q2	0037	0034	0034	0036
	2021Q3	0070	0066	0061	0068
Entropy Weights (E_j)		0.9051	0.9068	0.9082	0.9093
Differentiation Degrees (d_j)		0.0949	0.0932	0.0918	0.0907
Entropy Weights (w_j)		0.2560	0.2515	0.2477	0.2448

Inventory Turnover (24.77%), and Trade Receivables Turnover (24.48%).

The entropy method calculates the weights in operating, profitability, liquidity, and financial structure performances based on sub-ratios for all sectors, as shown in Table 3.

In Table 3, examining the weights of the sub-ratios in the calculation of the financial performance rankings of the sub-sectors of all sectors, it is seen that they have different weights in sectoral terms. The ratio with the highest weight in each financial performance sub-ratio is indicated in bold. For instance, the highest weight in operating ratios is asset turnover in the manufacturing sector, equity turnover in the construction sector, and trade receivables turnover in the technology sector.

After determining the weights of the performance criteria using the Entropy method, the final performances were calculated using the GRA method. Calculations are evaluated separately for all sectors as in the Entropy method. The calculations' steps for the manufacturing sector's operating performance are briefly summarized in Table 4.

All sectors' final operating, profitability, liquidity, and financial structure performances were calculated by applying the steps in Table 4.

Before the Covid-19 pandemic, the best operating performances of sectors were realized in the 2018Q4 period in manufacturing and construction and the 2016Q4 period in technology. In the calculations for profitability performances, it was observed that the manufacturing sector reached the highest performance in 2017Q4, the construction sector in 2016Q4, and the technology sector in 2019Q4. When liquidity performances are analyzed, it is concluded that the manufacturing sector had the best performance in 2017Q1, the construction sector in 2018Q2, and the technology sector in 2018Q1 periods before Covid-19. Finally, considering the financial structure performances, it was observed that the best performance was realized in 2016Q2 in the manufacturing sector and 2019Q3 in the construction and technology sectors.

In the operating performances of the Covid-19 period, the best period in all sectors was 2020Q4. In terms of profitability performance, the manufacturing sector achieved the best performance in 2021Q3, the construction sector in 2020Q1, and the technology sector in 2020Q4. Regarding liquidity, in the Covid-19 period, the manufacturing and technology sectors had the best performance in 2021Q1, while the construction sector had the best performance in 2021Q2. Finally, all sectors obtained the best financial structure performances in the 2021Q3 period. The graphs of the performances calculated with GRA by sectors are presented in Figures 1-3.

It can be argued that the manufacturing sector experienced a decline in activities at the beginning of the Covid-19 period, but afterwards, it gave an image close to its pre-Covid-19 performance. Therefore, the Covid-19 pandemic did not have a significant positive or negative impact on the operating performance of the manufacturing sector. Considering the profitability performance, it was revealed that the manufacturing sector in Turkey followed a very positive course during the Covid-19 period. The 2020Q4 performance, the best performance during the Covid-19 period, was higher than the 2018Q4 performance, which was the best before Covid-19. Accordingly, manufacturing companies continued to increase their profitability during the Covid-19 period. Examining the manufacturing sector's performance in terms of liquidity, it is clear that there is a decline in the Covid-19 period, unlike the profitability performance. Although

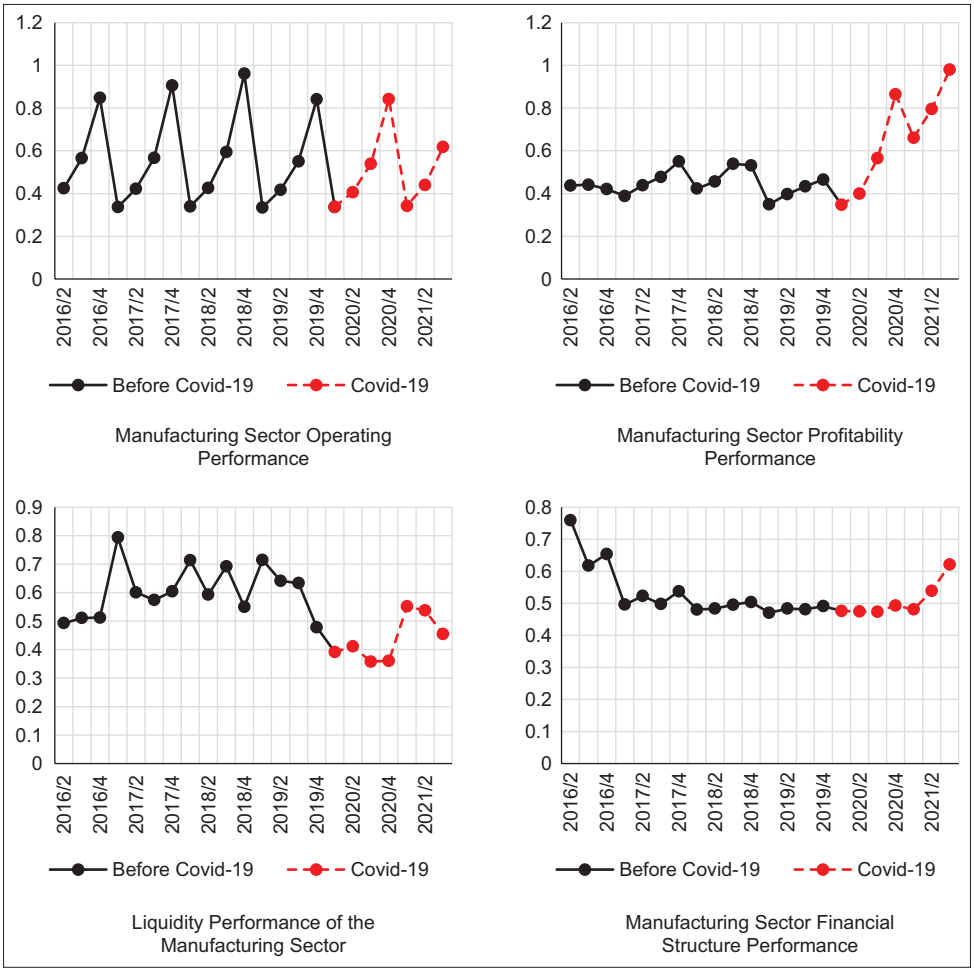
Table 3: Entropy weights of financial performance sub-ratios of all sectors

Basic Ratios	Lower Ratios	Manufacturing Sector %	Construction Sector %	Technology Sector %
Activity Ratios	Asset Turnover	25.6	25.3	26.71
	Asset Turnover Rate	25.15	26.54	24.78
	Asset Turnover Rate	24.77	22.45	19.82
	Trade Receivables Turnover Rate	24.48	25.99	28.69
Profitability Ratios	ROA	25.13	17.75	24.01
	ROE	24.08	20.24	23.30
	Net Profit Margin	24.75	25.54	24.64
	Operating Profit Margin	26.04	36.46	28.05
Liquidity Ratios	Cash Rate	28.54	31.58	37.01
	Current Ratio	35.95	36.61	36.14
	Liquidity Ratio	35.51	31.81	26.85
Financial Structure Ratios	Leverage Ratio	25.93	23.63	22.70
	Short-Term Liabilities Ratio	25.47	27.65	22
	Equity Ratio	21.66	24.78	26
	Long-Term Liabilities Ratio	26.95	23.95	29.3

Table 4: Stages of manufacturing sector activity performance calculation with GRA

Phase	Period	Criteria				Final Performance (Γ_{0i})
		Asset Turnover	Asset Turnover Rate	Stock Turnover Rate	Trade Receivables Turnover Rate	
Raw Data	2016Q2	0.48	1.10	2.84	2.41	
	2016Q3	0.69	1.64	4.37	3.54	
	2016Q4	0.90	2.20	5.68	4.89	
	2017Q1	0.22	0.55	1.30	1.20	
	⋮	⋮	⋮	⋮	⋮	
	2020Q4	0.90	2.39	5.20	5.05	
	2021Q1	0.24	0.66	1.35	1.23	
	2021Q2	0.50	1.27	2.72	2.69	
	2021Q3	0.77	1.95	3.97	4.13	
Reference Series and Comparison Matrix	2016Q2	0.48	1.10	2.84	2.41	
	2016Q3	0.69	1.64	4.37	3.54	
	2016Q4	0.90	2.20	5.68	4.89	
	2017Q1	0.22	0.55	1.30	1.20	
	⋮	⋮	⋮	⋮	⋮	
	2020Q4	0.90	2.39	5.20	5.05	
	2021Q1	0.24	0.66	1.35	1.23	
	2021Q2	0.50	1.27	2.72	2.69	
	2021Q3	0.77	1.95	3.97	4.13	
Normalized Matrix	2016Q2	0349	0268	0380	0300	
	2016Q3	0633	0533	0713	0567	
	2016Q4	0915	0807	1000	0888	
	2017Q1	0007	0000	0043	0012	
	⋮	⋮	⋮	⋮	⋮	
	2020Q4	0909	0895	0896	0926	
	2021Q1	0039	0053	0055	0018	
	2021Q2	0383	0349	0353	0365	
	2021Q3	0737	0684	0628	0708	
Absolute Values	2016Q2	0651	0732	0620	0700	
	2016Q3	0367	0467	0287	0433	
	2016Q4	0085	0193	0000	0112	
	2017Q1	0993	1000	0957	0988	
	⋮	⋮	⋮	⋮	⋮	
	2020Q4	0091	0105	0104	0074	
	2021Q1	0961	0947	0945	0982	
	2021Q2	0617	0651	0647	0635	
	2021Q3	0263	0316	0372	0292	
Grey Relation Coefficient Matrix	2016Q2	0111	0102	0111	0102	0426
	2016Q3	0148	0130	0157	0131	0566
	2016Q4	0219	0181	0248	0200	0848
	2017Q1	0086	0084	0085	0082	0337
	⋮	⋮	⋮	⋮	⋮	⋮
	2020Q4	0217	0208	0205	0213	0843
	2021Q1	0088	0087	0086	0083	0343
	2021Q2	0115	0109	0108	0108	0440
	2021Q3	0168	0154	0142	0155	0619

Figure 1: Financial performance graphs of the manufacturing sector before and during Covid-19



there was an increase in the 2020Q4 period, the performance values before Covid-19 were not reached. Finally, analyzing the financial structure performance of the manufacturing sector, the performance in the Covid-19 period continued close to the previous period. After the 2020Q4 period of the Covid-19 pandemic, it is observed that the manufacturing sector started to increase in terms of financial structure.

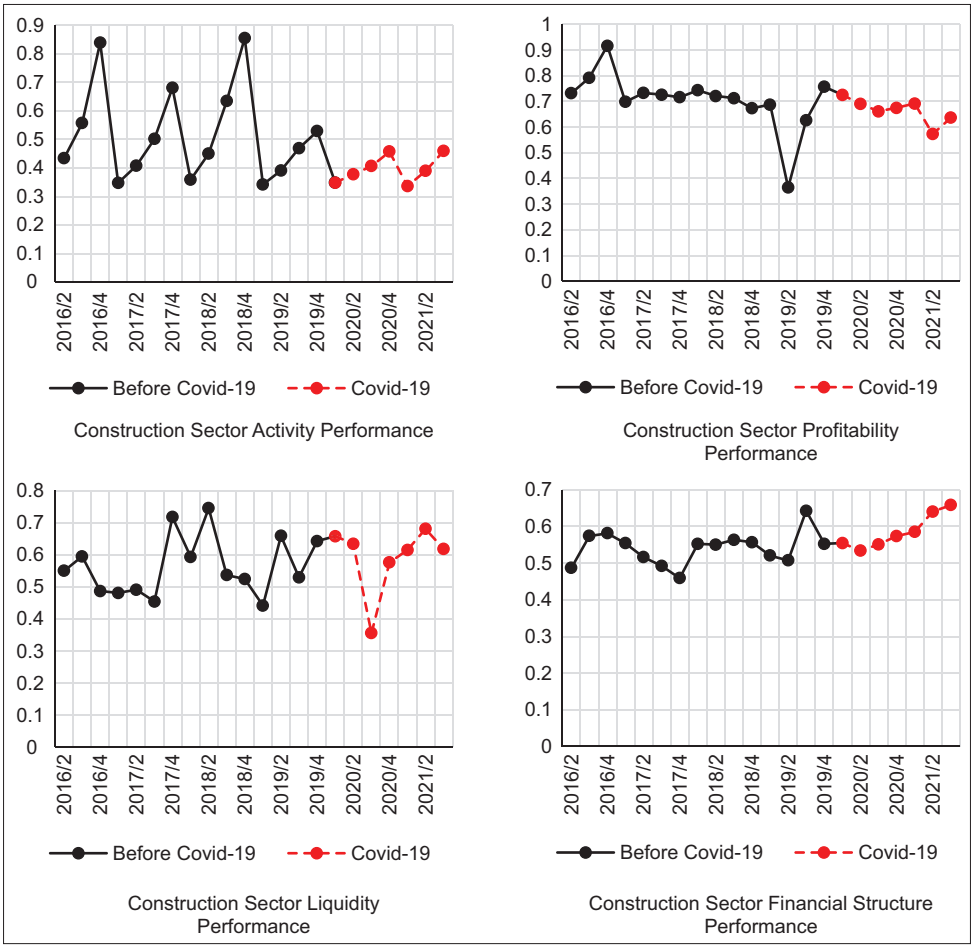
In the construction sector, another sector evaluated in the study, there has been a decline in the Covid-19 period compared to the previous performance in terms of operational performance. It was observed that the previous period's performance could not be reached during the Covid-19 period. Examining the profitability performance, it was concluded that the construction sector experienced a sharp decline just before the onset of the Covid-19 pandemic and then entered a downward trend again with the emergence of the Covid-19 pandemic while entering a recovery process. Considering the liquidity performance of the construction sector, the sector experienced the lowest performance during the Covid-19 period. Although there had been an increase after the 2020Q4 period, when the lowest performance was experienced, the previous period's performance was not fully achieved. Finally, only the financial structure performance of the construction sector was relatively better in the Covid-19 period compared to the previous period.

Considering Turkey's technology sector's performance during the Covid-19 period, the best performance was realized during this period. However, the technology sector was generally better in terms of operating performance in the Covid-19 period compared to the previous period. In terms of profitability performance, it was possible to state that the technology sector, just like the manufacturing sector, performed better than in the previous period. The technology sector showed a fluctuating and downward performance in terms of liquidity performance before Covid-19. However, albeit still fluctuating, it followed an upward trend in the Covid-19 period. Therefore, it can be argued that the liquidity performance of the technology sector has formed an increasing graph during the Covid-19 period. The financial structure performance of the technology sector exhibits a more stable outlook during the Covid-19 period. Although the financial structure performance of the technology sector in the Covid-19 period is stable within itself, it is in a better position than its performance before the pandemic.

4.1. Sensitivity Test

Sensitivity analysis is one of the critical stages of multi-criteria decision-making. Sensitivity analysis makes it possible to see whether small changes in input data or preferences change the decision-making outcome. This analysis is a tool to observe the variations in the obtained results due to changes in model

Figure 2: Financial performance graphs of the construction sector before and during Covid-19



parameters (Štreimikienė et al., 2016, p. 154). Using the grey relational analysis technique, which is one of the multi-criteria decision-making techniques, Kuo et al. (2008), Liu et al. (2019) applied sensitivity analysis using different values for discriminant coefficients (0.1, 0.3, 0.5; 0.5; 0.7; 0.9, etc.). Therefore, in the present study the changes realized with 0.1 and 0.9 values of the discriminant coefficient for GRA were analyzed and results presented in Figure 4.

For all values of the discriminant coefficient (0.1; 0.5; 0.9), it is possible to state that the graphs before and during the Covid-19 pandemic are parallel to each other. Therefore, the high similarities in the rankings according to the degree of grey correlation indicate that the solution to the decision problem is appropriate.

5. DISCUSSION

Even though manufacturing industries such as electronics and automobiles in China were initially closed for about 60 days, they immediately reopened, causing significant disruptions in the production process. The financial performance of the companies was severely negatively affected by Covid-19, especially in the first quarter of 2020 (Rababah et al., 2020). The manufacturing sector, especially the automotive sector, has been negatively affected by Covid-19 due to supply chain bottlenecks, fluctuations in credit markets, increased labor problems, increased production costs, and slowdown or stoppage in production (Özgüner et al., 2022). However, Koyuncu and Meçik (2020) show that the manufacturing sector was the sector that responded the fastest to the shocks experienced during the Covid-19 period. In a similar manner, He et al. (2020) stated that the manufacturing sector was positively affected by Covid-19 in China. Considering the manufacturing sector in terms of Turkey, the fact that the managers working in the manufacturing sector, which continued their activities with the exemption of manufacturing sector employees from lockdown restrictions, took action quickly, especially after the outbreak of the pandemic in China, had positive effects on their performance. Especially in sectors where raw materials and semi-finished products are supplied from outside Turkey, they decided to stock up on raw materials and semi-finished products with the anticipation that Covid-19 could spread worldwide. However, as the pandemic became widespread, there was an increase in demand, especially in the plastics and packaging sub-sectors. This was mainly associated with the increased production of cologne, disinfectants, and liquid hygiene materials. Therefore, employment and capacity increased in many sub-sectors of the manufacturing sector in Turkey. Turkey's short-time working allowance scheme for all employees has also significantly supported these companies, especially regarding employment growth.

According to the present study's findings, the manufacturing sector experienced a decline in activity rates at the beginning of the

Figure 3: Financial performance graphs of the technology sector before and during Covid-19

Covid-19 period. However, subsequently, it gave an image close to its pre-Covid-19 performance. Therefore, the Covid-19 pandemic did not significantly affect the manufacturing sector's operating performance. He et al. (2020) stated that the manufacturing sector is resilient against Covid-19. This result was inconsistent with Kılıç Karamahmutoğlu (2022), who showed that operating ratios decreased significantly in 2019 and 2020 before and after Covid-19 and that the pandemic process negatively affected the financial efficiency of sectors.

Considering the profitability performance, it was revealed that the manufacturing sector in Turkey followed a very positive course during the Covid-19 period. The 2020Q4 performance, which was the best performance during the Covid-19 period, was higher than the 2018Q4 performance, which was the best profitability performance before Covid-19. Accordingly, manufacturing companies continued to increase their profitability during the Covid-19 period. This result was in line with Atayah et al. (2022), who found that logistics companies, which are closely related to the manufacturing sector of G20 countries, increased their profitability during the Covid-19 period. Ergün and Üçoğlu (2022) found that companies working on textile, leather, and clothing manufacturing increased their profitability. On the other hand, Yücel and Durak (2021) and Demir (2020) found that profitability ratios were negatively affected by Covid-19, Kılıç Karamahmutoğlu (2022) concluded that the pandemic process in the manufacturing sector did not have a significant effect on the profitability of sectors in general.

Examining the manufacturing sector's performance in terms of liquidity, it is clear that there is a decline in the Covid-19 period, unlike the profitability performance. Even though there was an increase in the 2020Q4 period, the pre-Covid-19 performance values could not be reached. Similarly, Ergün and Üçoğlu (2022) found a decline in the liquidity performance of companies operating in the textile, leather, and apparel manufacturing sector during the Covid-19 period. Contrary to this result, Kılıç Karamahmutoğlu (2022) argued that the pandemic did not have a negative impact on the liquidity structure of the manufacturing sector in general and did not increase liquidity risk.

Finally, examining the financial structure performance of the manufacturing sector, the performance in the Covid-19 period remained close to the previous period. After the 2020Q4 period of the Covid-19 pandemic, it was observed that the manufacturing sector started to increase in terms of financial structure. In a similar vein, Devi et al. (2020) found an increase in the leverage ratios (considered in the financial structure) of the companies operating in the Indonesian stock exchange after Covid-19. Demir (2020), on the other hand, has reported that Covid-19 did not significantly affect the financial structure ratios of the manufacturing sector.

Figure 4: Sensitivity analysis results

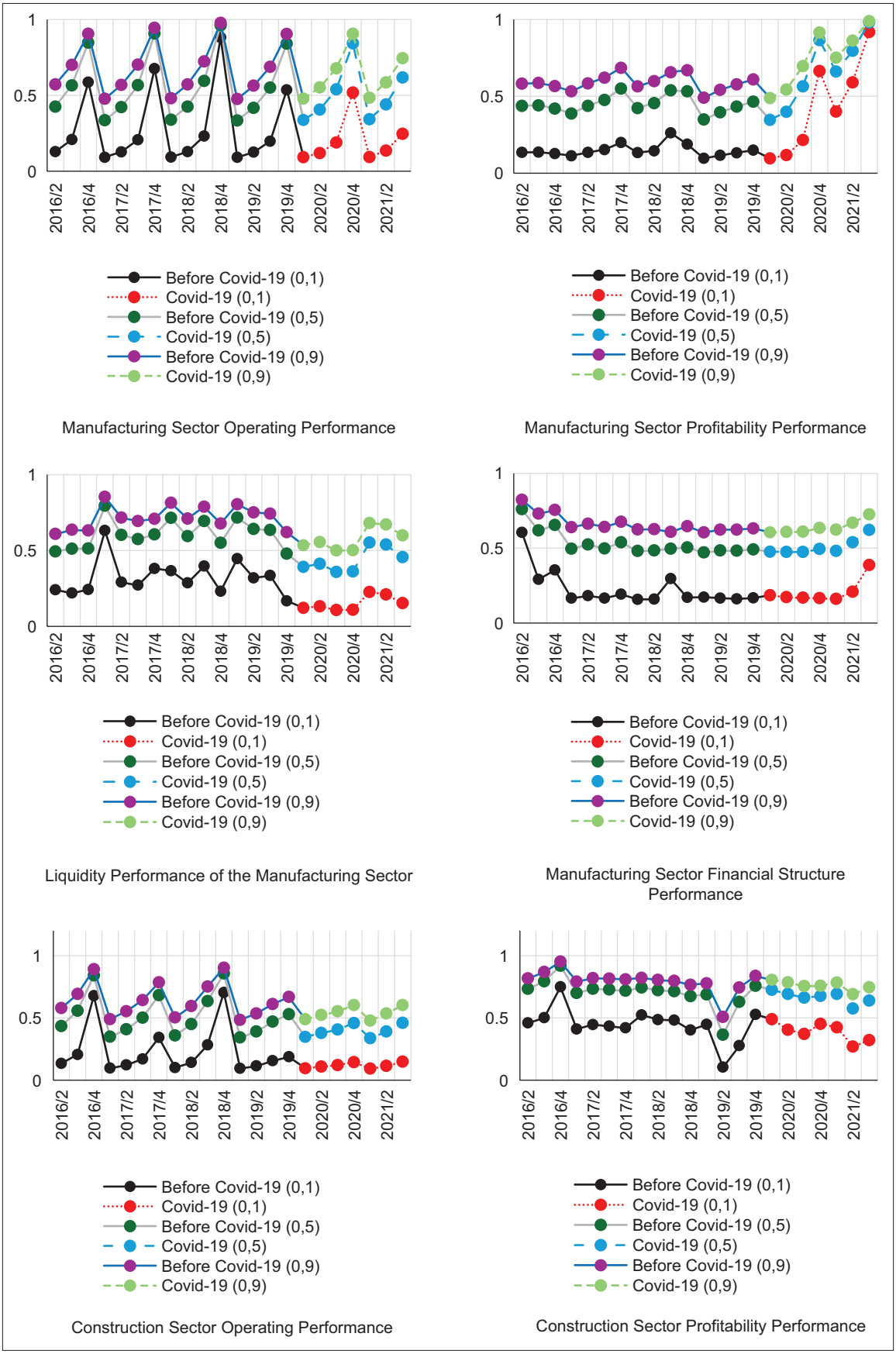


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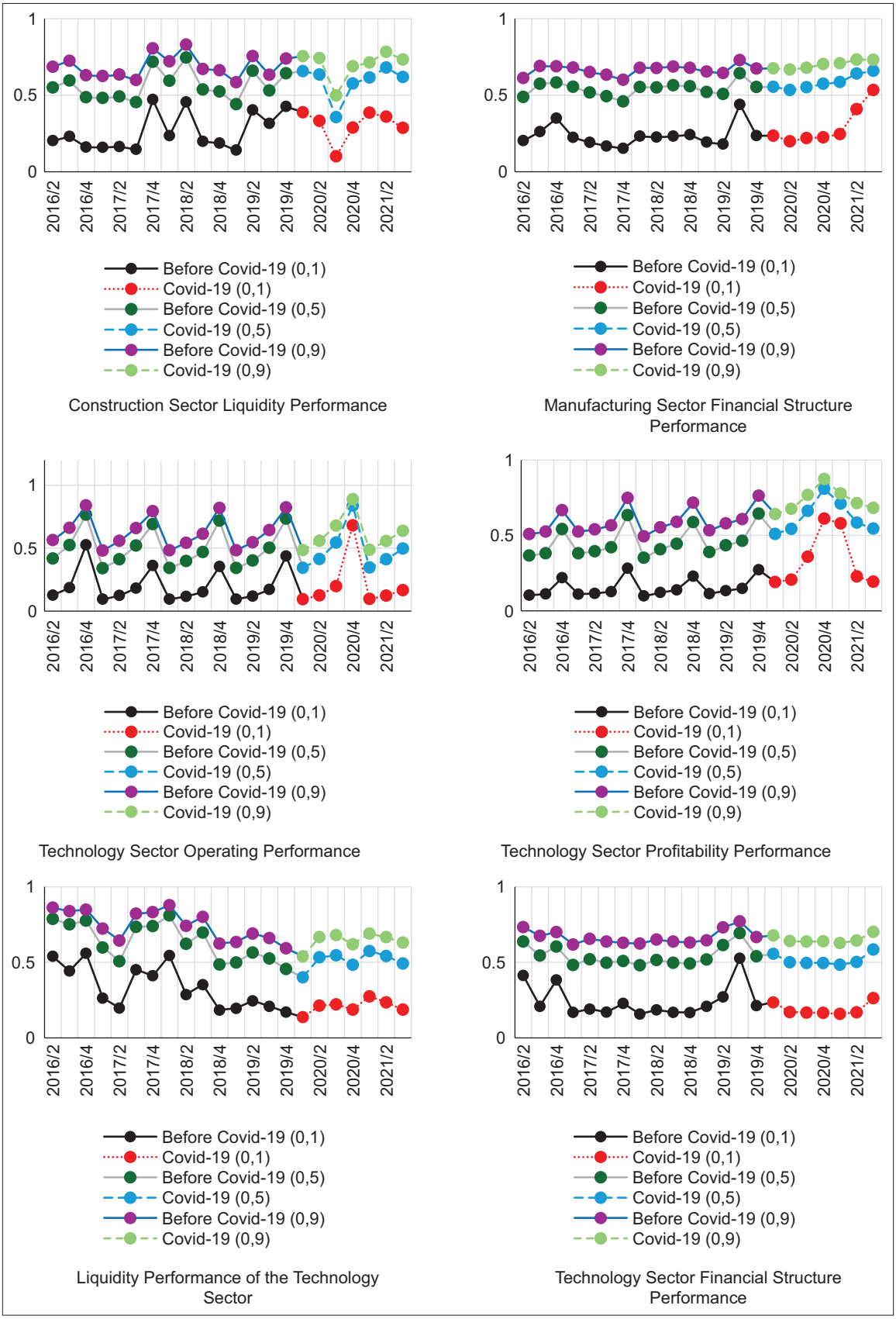
Figure 4: *(Continued)*



Examining the manufacturing sector, it was observed that the financial performance indicators (except liquidity) of companies in the manufacturing sector were not affected or increased during the Covid-19 period, and this result was consistent with the literature (Devi et al., 2020; He et al., 2020; Atayah et al., 2022; Ergün and Üçoğlu, 2022; Koyuncu and Meçik, 2020).

In Turkey's construction sector, which has an important place, there were decreases in all measurements except financial structure performance, especially in the first year of the pandemic. At the end of 2020, the increases in the cost input index in the construction sector can be considered as the reason for this situation. The construction cost input index increased by 25% in December 2020 compared to the same period of the previous year (Turkstat, 2023a). The change in turnover can explain the partial increase in the financial structure performance in the construction sector. The construction sector turnover index increased by 10.1% in 2020 compared to the previous year. However, considering the increase in the turnover index in the sector before Covid-19, it can be argued that the increase in the first year of the pandemic was relatively low (TurkStat, 2023b). The fact that the construction sector was not exempted from the restrictions imposed during the Covid-19 period also decreased the labor force. Parallel to all these developments, the construction sector's performance in the Covid-19 period followed an unfavorable course.

The construction sector, another sector evaluated in the study, experienced a decline in operating performance during the Covid-19 period compared to its previous performance. It was observed that the previous period's performance could not be reached in the Covid-19 period.

Examining the profitability performance, it was concluded that the construction sector experienced a sharp decline just before the onset of the Covid-19 pandemic and then entered a downward trend again with the emergence of the Covid-19 pandemic while entering a recovery process. Similar to this result, Devi et al. (2020) found a decrease in the profitability performance of the companies in the construction sector during the Covid-19 period.

Considering the liquidity performance of the construction sector, the sector experienced the lowest performance during the Covid-19 period. This result was consistent with what Devi et al. (2020) reported on the liquidity performance of the companies in the construction sector. Although there has been an increase after the 2020Q4 period, when the lowest performance was experienced, the previous period's performance has yet to be fully achieved.

Finally, only the financial structure performance of the construction sector is relatively better in the Covid-19 period compared to the previous period. Evaluating the construction sector, it is observed that there has been a decline in the financial performance indicators of companies in the construction sector during the Covid-19 period, and this result is consistent with the literature (Alsamhi et al., 2022; Xiong et al., 2020; Umar, 2022).

The technology sector has been positively affected by the increasing demand for specialized software that facilitates remote learning and working, such as Microsoft Teams and Zoom (Elhini and Hammam, 2021). Remote access applications have not only been used in education and working life. According to data from the Ministry of Trade, e-commerce volume in the first 6 months of 2020 increased by 64% compared to the same period in 2019. Therefore, it can be argued that the increase in e-commerce volume in Turkey was much faster during the pandemic period (Ministry of Trade, 2020).

Considering Turkey's technology sector's performance during the Covid-19 period, the best performance was during this period. However, the technology sector is generally better off in terms of operational performance in the Covid-19 period compared to the previous period. He et al. (2020) have reported that the technology sector has responded positively to the adverse effects of Covid-19 while showing resistance to its negative effects.

Regarding profitability performance, the technology sector, like the manufacturing sector, performed better than in the previous period. Similarly, Demir (2020) found that the technology sector increased profitability during the Covid-19 period.

The technology sector showed a fluctuating and downward performance in terms of liquidity performance before Covid-19. However, albeit still fluctuating, it followed an upward trend in the Covid-19 period. Therefore, it can be argued that the liquidity performance of the technology sector has formed an increasing graph during the Covid-19 period. On the contrary, Demir (2020) detected decreases in liquidity in the technology sector.

The financial structure performance of the technology sector exhibits a more stable outlook during the Covid-19 period. Although the financial structure performance of the technology sector in the Covid-19 period is stable within itself, it is in a better position than its performance before the pandemic.

Evaluating the technology sector, it was observed that the financial performance indicators of companies in the technology sector increased during the Covid-19 period, and this result was consistent with the literature (He et al., 2020; Levy, 2021; Sierotowicz, 2022; Al-Awadhi et al., 2020; Mazur et al., 2021; Elhini and Hammam, 2021; Anh and Gan, 2021).

Although the research results were in line with the literature for each sector, it was observed that they differed from some studies. This may be since the studies with different results have a limited analysis period (Yücel and Durak, 2021; Kılıç Karamahmutoğlu, 2022; Demir, 2020), while the present study analyzed longer-term periods and the data analysis methods are different. Kubiczek and Derej (2021) stated that if an industry is in a downtrend, any deterioration in performance may not necessarily be a direct consequence of the pandemic crisis. A longer-term analysis is needed to reach this conclusion.

6. CONCLUSION

It was concluded that, in Turkey, the manufacturing and technology sectors generally had a better performance during the Covid-19 period compared to the pre-pandemic period, while the construction sector was negatively affected by the pandemic. According to the Chaos Theory perspective, crises can render the previous situation invalid (or inadequate), as well as initiate an innovative process emerging from the "ruins" of chaos during the crisis period (Faulkner, 2001). Therefore, crises are not always negative but can have potential positive outcomes (Kraus et al., 2020). Previous studies show that external shocks trigger companies to innovate and adapt to digital workflows and technologies (Seeger et al., 2005; Archibugi et al., 2013).

Pandemics, one of the factors that cause crises for countries and companies, only recur occasionally. However, they can profoundly affect the period and the subsequent period in which they are experienced. Therefore, governments and companies must make some plans, take measures, and be prepared for such pandemics. In this context, governments can first identify vulnerable sectors outside the health system in the absence of a pandemic. Accordingly, cash reserves should be set aside, ready to be used for financial support to be provided to sectors and companies. Similarly, it is essential for companies, regardless of sector, to complete their reserve liquidity preparations to be used in case of a similar pandemic. Xiong et al. (2020) have stated that companies with larger scales, better profitability, leverage, and growth opportunities are less adversely affected by the Covid-19 pandemic than other companies. Kumar and Zbib (2022) explain this as decision makers with higher management skills had higher liquidity and financial flexibility before the pandemic. Therefore, it is vital that companies and even sectoral associations periodically maintain spare liquidity and constantly check all their direct or indirect financial assets. Also, governments should provide serious incentives, support, and subsidies to the companies, especially in terms of maximizing the technological infrastructure in all sectors. Thus, during a sudden pandemic, it may become possible to directly realize opportunities such as remote working and continuous workflows in sectors. In order for production to continue without interruption, artificial intelligence and digital production technologies, cloud computing, internet of things, big data analysis and robots, which are among the requirements of industry 4.0, should be spread and the need for human element should be reduced. As a result, with the transition to full automation, factories with almost no people, called dark factories, will become widespread, and people will be able to work remotely. Thus, disruptions in production will be minimised in situations such as pandemics that are likely to occur in the future. In addition to government support, it is also crucial for companies to invest in sector-specific technological infrastructures. For instance, it is not possible to eliminate the labor force in the construction industry. However, some aspects of the labor force can be automated so that remote access to this automation can be provided in the event of a sudden pandemic.

It has become relatively easy for a pandemic that starts anywhere in the world to reach a country on the other side of the world due to population mobility. Therefore, it is the first step for governments to take measures to prevent pandemics from reaching their countries. Anh and Gan (2021) emphasized that governments should be proactive in preventing virus outbreaks from increasing investor confidence in similar pandemic cases. At this point, Turkey took severe measures to prevent entry into the country until March 11, 2020, when the first Covid-19 case occurred. However, due to reasons such as the speed of the spread of the virus and the fact that this virus had not been encountered before, the pandemic was felt seriously in Turkey, as was the case worldwide. Just like the prevention of a pandemic, governments need to intervene proactively after the virus is identified. Based on the results obtained with data from 13 countries, Golubeva (2021) stated that state supports were not effective in the challenges brought by the Covid-19 pandemic. To prevent such a case, cash support should be provided to the previously identified risky sectors, with priority given to the healthcare system, as quickly as possible. These supports should not be distributed equally to all sectors and companies. However, they should be based on firm- and sector-specific characteristics such as companies' turnover, size, and employment opportunities in previous periods. Also, companies need to be proactive, like governments, in such pandemics that may develop suddenly. It has been stated that companies with entrepreneurial orientation, which is defined as the simultaneous display of innovation, proactivity, and risk-taking, have positive effects on firm performance (Miller, 1983; Stam and Elfring, 2008; George, 2011; Šlogar et al., 2023). Therefore, the companies need to prepare action plans financially and on critical issues such as raw material supply, production flows, psychological support to employees, and transportation of products to markets in case of a pandemic.

During the pandemic, compulsory closure measures were taken in many countries for health reasons. Within the scope of these measures, in some countries such as China, closures were applied for all sectors, even for a short period. It is a fact that the manufacturing sector is the locomotive for many other sectors. Therefore, it is imperative to take the necessary measures in critical sectors, especially in the manufacturing sector, to ensure that production continues to prevent this chain effect from having a negative impact. Also, regarding the resource-based approach, it is very beneficial for companies to cooperate during pandemic periods, regardless of whether they are in the same sector (Crick and Crick, 2020). In the manufacturing sector, the use of computerized production techniques in many sub-sectors, with the developments in the technology sector, has minimized the impact of the pandemic on the labor force on production. Realizing similar collaborations in the construction sector in a sector-specific manner can ensure that at least some construction activities can continue without labor intensity in sudden pandemic situations.

The financial performance ratios discussed in the present study were obtained from the Central Registry Agency, the Data Analysis Platform of the Public Disclosure Platform. In this system, the collection of analyzable data in Extensible Business Reporting Language (XBRL) format started in June 2016. Therefore, the pre-Covid-19 period is defined as the period between 2016Q2 and 2019Q4, which is the period before March 2020, the first Covid-19 case in Turkey.

The study compares the listed companies operating in Turkey before and during the Covid-19 pandemic. Therefore, the results obtained may differ due to different country-specific characteristics. To examine the effects of the pandemic, the pandemic period and its aftermath or, in a longer term, before, during, and after the pandemic should be compared. Also, it can be investigated how not only listed companies but also medium or small companies are affected together. These comparisons can be handled with grey theory or fuzzy-based MCDM techniques other than GRA due to the uncertainty of the effects. Furthermore, the study covers the manufacturing, construction, and technology sectors. The effects of the Covid-19 pandemic can be investigated by examining different sectors with similar approaches. Also, studies can be

carried out that include the knowledge of sector representatives and the financial ratios used for performance criteria.

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