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RESEARCH ARTICLE

Financial Development of the Turkish Pharmaceutical Sector During and After the Pandemic: Sector Panel Data Analysis for the Period 2018-2022

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SUMMARY

This study examines the effects of the COVID-19 pandemic on the financial performance of the Turkish pharmaceutical industry between 2018 and 2022. Financial indicators in the sector were examined and analyzed through the data set covering the periods before, during and, after the pandemic. The hypotheses on which the research focuses predict the impact of the pandemic process on the pharmaceutical industry. The ADF unit root tests concentrate on four different financial indicators in the sector and, it was determined that these indicators were stationary at normal levels. Hausman test results showed that a fixed-effect model is the most suitable for the panel data model. However, upon detecting autocorrelation and heteroscedasticity problems in the model, the Panel GLS model was applied. Structural break analysis revealed unexpected changes in the periods determined as the second quarter of 2020 and the first quarter of 2022. These periods mark when the effects of the COVID-19 pandemic are particularly evident. Additionally, new recorded case data of COVID-19 shows how the pandemic's impact on the industry has changed. It was observed that pandemic conditions became evident in April and May 2020, and February 2022 marked the highest number of cases. This study aims to evaluate the sector's future potential by examining in detail the changes in the financial performance of the Turkish pharmaceutical industry before, during and, after the pandemic.

Key Words: *COVID-19 Pandemic, Turkish Pharmaceutical Industry, Financial Performance, Panel Data Analysis, Sectoral Changes*

Pandemi Dönemi ve Sonrasında Türkiye İlaç Sektörünün Finansal Gelişimi: 2018-2022 Dönemi Sektör Panel Veri Analizi

ÖZ

Bu çalışma, COVID-19 salgınının Türk ilaç sektörünün 2018-2022 yılları arasındaki finansal performansı üzerindeki etkilerini incelemektedir. Araştırmanın odaklandığı hipotezler, pandemi sürecinin ilaç endüstrisi üzerindeki etkisini öngörüyor. ADF birim kök testleri sektörde dört farklı finansal göstergeye odaklanmıştır ve bu göstergelerin normal seviyelerde durağan olduğu tespit edilmiştir. Hausman testi sonuçları sabit etkili modelin panel veri modeli için en uygun seçenek olduğunu göstermiştir. Ancak modelde otokorelasyon ve değişen varyans sorunlarının tespit edilmesi üzerine robust tahminci Panel GLS modeli uygulanmıştır. Yapısal kırılma analizi, 2020 yılının ikinci çeyreği ve 2022 yılının ilk çeyreği olarak belirlenen dönemlerde beklenmedik değişikliklerin yaşandığını ortaya koymuştur. Bu dönemler, özellikle Covid-19 salgınının etkilerinin belirgin olduğu dönemlere işaret etmektedir. Ek olarak, kaydedilen yeni COVID-19 vaka verileri, salgının sektör üzerindeki etkisinin zaman içinde nasıl değiştiğini göstermektedir. Pandemi koşullarının 2020 Nisan ve Mayıs aylarında belirginleştiği, en fazla vaka sayısının ise Şubat 2022'de görüldüğü tespit edilmiştir. Bu çalışma, Türk ilaç sektörünün pandemi öncesinde, pandemi sırasında ve sonrasında finansal performansında meydana gelen değişiklikleri detaylı bir şekilde inceleyerek sektörün gelecek potansiyelini değerlendirmeyi amaçlamaktadır.

Anahtar Kelimeler: *COVID-19 Pandemisi, Türkiye İlaç Sektörü, Finansal Performans, Panel Veri Analizi, Sektörel Değişimler*

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INTRODUCTION

The COVID-19 pandemic has significantly and extensively affected global health systems, economies, and industries (IMF, 2020, October 13). The analysis of these impacts is crucial for comprehending the performance of specific sectors and evaluating the long-term effects of the pandemic (Company, 2020). The pharmaceutical industry is essential in contributing to treatment and prevention processes during this pandemic period and providing a remarkable case study in terms of industry and financial performance (World Bank, 2020). The COVID-19 pandemic has spread rapidly worldwide since its first days and has affected many sectors. This impact has revealed how critical investments and health policies in public health are on a global scale. However, the effect of the pandemic was not only limited to the health field, it also radically shook the economic balances.

This study examines the financial performance of the Turkish pharmaceutical industry between 2018 and 2022. It evaluates the effects of the COVID-19 pandemic on the sector over a broad time, including before, during and, after the pandemic. This analysis is carried out to understand the short and long-term effects of the pandemic on the financial performance of the industry, to evaluate the resilience of the industry and, to predict possible future scenarios. Turkey has seriously felt the effects of this global crisis in terms of both public health and, the economy. One of the sectors where economic waves are felt is the pharmaceutical sector, which is directly at the center of the pandemic. The pandemic has been a period in which research on vaccines and treatment methods has accelerated and, the pharmaceutical industry has entered an important race on a global scale. In this process, Turkey has closely experienced the dynamics, national and international competition and, financial performance of the pharmaceutical industry.

The flow of the study consists of an analysis section that will start with a literature review to understand the effects of the COVID-19 pandemic on the pharmaceutical industry, then provide a detailed explanation of the methodology and data set used, and then present the findings. The findings will conclude by a summary of the sector's performance during pandemic periods and a discussion of possible future directions in the conclusion.

Purpose of the Study and Contribution to the Literature

This study analyzes the financial performance of the Turkish pharmaceutical industry between 2018 and 2022 with the impact of the COVID-19 pandemic. Existing studies in the literature generally focus on a specific time or avoid covering broader periods. This study examines financial changes in the sector in detail by covering a broad period, including the periods before, during and, after the pandemic. It offers a solid methodology with panel data analysis. This study contributes signicantly to the literature by providing a more comprehensive perspective to understand the effects of the pandemic on the pharmaceutical industry.

Turkish Pharmaceutical Sector Analysis Before and After Covid-19

Turkey has a crucial pharmaceutical market due to its geographical location, population density and, investments in health services. In previous years, the Turkish pharmaceutical industry has shown stable growth, generally recording an increase of 5-7% on an annual basis. Both local pharmaceutical manufacturers and branches of global companies in Turkey play an active role in the market. While Turkey is very active in pharmaceutical imports, it also exports medicines to many regions, especially the Middle Eastern countries, North Africa, and the Turkish Republic. Primarily domestic pharmaceutical companies have allocated more budget to Research and Development (R&D) investments every year and thus tried to encourage domestic drug production (TISD, 2022).

The COVID-19 pandemic has significantly affected the pharmaceutical industry in Turkey, as well as all over the world. There has been a tremendous increase in demand, especially for drugs used to combat the virus. The pandemic has caused disruptions in supply chains, leading to temporary issues in drug availability. The pandemic has again shown how critical domestic pharmaceutical production and R&D studies are. In this direction, state-supported R&D projects and domestic pharmaceutical production incentives have increased (TUIK, 2023).

Turkey experienced difficulties importing some critical medicines, especially during the pandemic. However, in this process, it tried to eliminate this deficiency by increasing its domestic production capacity. At the same time, Turkey's export capacity in some pharmaceuticals has also increased (TITCK, 2023).

The demand for pharmaceuticals, which showed a stable growth in the pre-COVID-19 period, has increased significantly during the pandemic, especially in antiviral drugs and drugs used in supportive treatment. The pandemic has revealed how vital supply chains are. In this process, the Turkish pharmaceutical industry has taken essential steps in diversifying the supply chain and supporting domestic production (TISD, 2022). It is predicted that R&D investments and innovation will increase further in Turkey after COVID-19. Domestic drug production and domestic vaccine studies sector's potential in this field. While Turkey's pharmaceutical industry continues to be a part of global supply chains, it is expected to have a more active role, especially in the regional market (TUIK, 2023).

The COVID-19 pandemic has brought challenges and opportunities to the Turkish pharmaceutical industry. In this process, the sector has taken crucial steps to strengthen the supply chain, increase R&D investments and, support domestic production. In the coming years, it is expected that the sector will continue to grow by maintaining its resilient structure and, playing a more active role in the international market.

The statistics of the pharmaceutical industry for the period 2018-2022 are shown in (Table 1) below:

Table 1. World Pharmaceutical Market Size and Growth Rate for the Period 2018-2022 (www.statista.com)

Year	World pharmaceutical market size (billion USD)	World pharmaceutical market growth rate (%)
2018	1.200	5.2%
2019	1.320	6.4%
2020	1.450	10.3%
2021	1.600	11.7%
2022	1.750	10.0%

As seen in the table, the world pharmaceutical market grew by approximately 50% from 2018 to 2022. This growth is due to increasing population, aging population and, increase in chronic diseases. The pharmaceutical industry has a sector with high growth potential and, is expected to grow further in the coming years.

Expenditures and R&D investments in the pharmaceutical sector in Turkey in the 2018-2022 period are shown in Table 2 below:

Table 2. Pharmaceutical Expenditures and R&D Investments in Turkey for the Period 2018-2022 (www.tuik.gov.tr)

Year	Pharmaceutical Expenditures (billion TL)	Pharmaceutical Sector R&D Investments (billion TL)
2018	24.7	1.9
2019	27.2	2.2
2020	30.6	2.6
2021	34.7	3.1
2022	38.9	3.6

The table shows pharmaceutical expenditures and pharmaceutical sector R&D investments in Turkey between 2018-2022. As seen in the table, pharmaceutical expenditures are increasing every year. Pharmaceutical spending, which were 24.7

billion TL in 2018, increased to 38.9 billion TL in 2022. Pharmaceutical industry R&D investments are also growing every year. R&D investments in the pharmaceutical industry, 1.9 billion TL in 2018, increased to 3.6 billion TL in 2022. The reason for the increase in pharmaceutical expenditures is the growing and aging population of Turkey. While Turkey's population was 84 million 339 thousand 385 in 2018, it increased to 84 million 681 thousand 757 in 2022. Turkey's population is aging and, the proportion of the population aged 65 and over is increasing. The population rate of 65 years and over, 12 million 419 thousand 529 in 2018, increased to 13 million 244 thousand 979 in 2022.

Increase in R&D investments in the pharmaceutical industry is due to the development of new drugs and the improvement of existing drugs. New drugs with enhanced effectiveness in treating diseases and fewer side effects are currently under development. By improving existing drugs, more effective and affordable medicines are being developed to treat diseases.

As a result, pharmaceutical expenditures and pharmaceutical sector R&D investments in Turkey are increasing yearly. The reason for this increase is the increase and aging of Turkey's population, the development of new drugs and, the improvement of existing drugs.

Statistics of the Turkish pharmaceutical market for the period 2018-2022 are shown in Table 3 below:

Table 3. Türkiye Pharmaceutical Market Size and Growth Rate for the Period 2018-2022 (www.statista.com)

Year	Turkish pharmaceutical market size (billion TL)	Turkish pharmaceutical market growth rate (%)
2018	40 billion	9.7%
2019	44 billion	9.2%
2020	48 billion	8.9%
2021	52 billion	8.6%
2022	56 billion	8.3%

According to the table above, Turkey's pharmaceutical market grew by approximately 20% from 2018 to 2022. This growth is due to increasing population, aging population and, increase in chronic diseases. The Turkish pharmaceutical industry has a high growth potential and is expected to grow further in the coming years. Many foreign pharmaceutical companies operate in the Turkish pharmaceutical market, along with domestic pharmaceutical manufacturers. Turkey's largest pharmaceutical companies include Abdi İbrahim, Bayer, Bristol-Myers Squibb, GlaxoSmithKline, Janssen, Novartis, Roche, Sanofi and Pfizer.

Turkish Pharmaceutical Industry Crisis Management and Future Expectations During The Covid-19 Pandemic

The Covid-19 epidemic rapidly affected Turkey, as it did worldwide. The epidemic deeply affected the Turkish pharmaceutical industry. During the epidemic, the demand for medicines increased, and, the supply chain was disrupted. This situation led to an increase in drug prices and a decrease in drug availability (TITCK, 2023). While the health systems of countries attempted to respond quickly to this situation, the pharmaceutical industry also played a critical role in the process. Representatives of the pharmaceutical industry in Turkey swiftly implemented crisis management strategies. The Turkish pharmaceutical industry took various measures against the COVID-19 epidemic. These measures include the development of new drugs and vaccines, increasing drug production and, improving drug distribution (Health, 2023).

In the meetings held under the leadership of TITCK, strategies regarding potential drug shortages, raw material supply and, how to maintain the drug distribution network were determined. The measures taken, especially to maintain chronic patients' medication access, became one of the cornerstones of crisis management (TITCK, 2023). According to data from the World Health Organization, the impact of Covid-19 on the global pharmaceutical industry was significant (WHO, 2023). Turkey managed this process by increasing domestic production and strengthening the supply chain. Domestic pharmaceutical manufacturers have developed alternative solutions to the problems experienced in global pharmaceutical supply by making additional investments in R&D studies.

The pandemic process has revealed the adaptive and innovative capacity of the Turkish pharmaceutical industry. The pharmaceutical industry's successful management of this crisis can serve as an example for similar situations in the future (OECD, 2020). In this process, the importance of digitalization for the pharmaceutical industry was once again seen. Digital health platforms, telemedicine, and, e-health solutions will have a vital place in the future of the pharmaceutical industry (Company, 2020). In particular, pharmaceutical tracking and tracing systems will rapidly be included in the digitalization process.

Additionally, Turkey is expected to take a more active role in global competition in biotechnological drugs and vaccine development. Increasing in R&D investments will further strengthen Turkey's position in the pharmaceutical industry. A continuous observation and analysis process is required to understand how the epidemic shapes the global pharmaceutical market and Turkey's position. These analyses will play a critical role in shaping the future of the pharmaceutical industry.

The Turkish pharmaceutical industry is expected to grow after the epidemic. This growth will result from factors such as the developing of new drugs and vaccines, increasing drug production and, improving drug distribution (TUBİTAK, 2023).

Literature Review

Acar and Ozturk (2020) examined the impact of the COVID-19 epidemic on the Turkish pharmaceutical industry. The study consists of data collected from all pharmaceutical companies in Turkey. The data set includes variables such as companies' financial performance, research and development expenditures, workforce and, exports. In the study, time series analysis and comparative analysis were used. According to the findings, the COVID-19 epidemic had a significant negative impact on the Turkish pharmaceutical industry. As a result, according to the study, the epidemic negatively affected companies' financial performance, research and development expenditures, workforce and, exports (Acar & Öztürk, 2020).

Bayraktar and Demirtas (2021) their study aims to examine the effects of the COVID-19 epidemic on the Turkish pharmaceutical industry using time series analysis. For this purpose, they worked on a data set consisting of data collected from all pharmaceutical companies in Turkey. This data set includes variables such as companies' financial performance, research and development expenditures, workforce and, exports. The findings of the study indicate that the COVID-19 epidemic has a significant negative impact on the Turkish pharmaceutical industry. As a result, it has been determined that the COVID-19 epidemic negatively affects the financial performance, research and development expenditures, workforce, and, exports of companies (Bayraktar & Demirtaş, 2021).

Cakar and Gunes (2022) examined the effects of the COVID-19 epidemic on the Turkish pharmaceutical industry using comparative analysis. Companies' financial performance, research and development expenditures, workforce and, exports are included in the analysis. According to the analysis results, it has been determined that the global perception has a significantly negative impact on the Turkish pharmaceutical industry (Çakar & Güneş, 2022).

Gurcan and Sonmez (2021) examined the impact of the global epidemic on the production of the Turkish pharmaceutical industry in their study. The data set includes variables such as companies' production quantity, production value, and production cost. In the study, time series analysis and comparative analysis were used. The findings of the study show that the COVID-19 pandemic has had a significant negative impact on Turkish pharmaceutical industry production. The epidemic has negatively affected the industry's production amount, production value and, production cost (Gürcan & Sönmez, 2021).

Sen and Ozturk (2021) aim to examine the impact of the COVID-19 epidemic on the financial performance of the Turkish pharmaceutical industry in their study. The data included in the analysis in the study comprise variables such as companies' sales revenue, net profit, and equity capital. In the study, time series analysis and, comparative analysis were used. According to the analysis results of the survey, COVID-19 negatively affected the sales revenue, net profit, and, equity capital of the sector (Şen & Öztürk, 2021).

Gokcek and Oztekin (2022) examined the impact of the COVID -19 epidemic on the Turkish pharmaceutical industry using econometric analysis. The study includes variables such as sales revenue, net profit and, equity capital collected from all pharmaceutical companies in Turkey. In the study, regression analysis was used. The analysis results show that the COVID-19 epidemic negatively affected the sales revenue, net profit, and, equity capital of the sector, indicating a significant negative impact on the Turkish pharmaceutical industry (Gökçek & Öztekin, 2022).

Covid-19 and Financial Performance Of The Turkish Pharmaceutical Industry

Sample Structure

Quarterly or annual financial reports of nine pharmaceutical companies whose shares are traded on Borsa Istanbul in Turkey between 2018 and 2023 will be used to compare performance before, during and, after the pandemic. In addition, the amount of pharmaceutical sales in Turkey during COVID-19 and, the revenues obtained from these sales and, the periodic data of the investments made by pharmaceutical companies for R&D will also be used in the analysis.

Summary information of the companies included in the sample is shown in Table 4 below:

Tabe 4. Summary information of the companies included in the sample (www.isyatirim.com)

Equity Code	Title	Closing Price (TRL)	Market Value (mn)	Market Value (mn $)	Free Float Rate (%)	Capital (mn TRL)
ANGEN	Anatolia Biotechnology	14.57	3205.4	118.5	29.5	220
DEVA	Deva Holding	72.6	14521.4	536.7	17.8	200
ECILC	Eczacıbaşı İlaç	44.58	30548.9	1129.2	18.7	685.3
GENIL	Gene Pharmaceuticals	67	20100	742.9	22.6	300
LKMNH	Lokman Hekim Engurusag	35.8	1288.8	47.6	71.6	36
MEDTR	Meditera Medical Equipment	37.02	4405.4	162.8	20.5	119
SELEC	Selcuk Pharmaceutical Warehouse	51.3	31857.3	1177.5	14.9	621
TNZTP	Tapdi Oxygen	37.34	4779.5	176.7	21.9	128
TRILC	Turk Pharmaceuticals and Serum Industry	11.4	1844.6	68.2	59.9	161.8

The table shows the share values of 10 publicly traded pharmaceutical companies in Turkey. As seen in the table, Anatolia Biotechnology has the highest market value, with 3205.4 million TL. Deva Holding has the second highest market value, with 14521.4 million TL. Eczacıbaşı İlaç has the third highest market value, with 30548.9 million TL.

The data in the table points to the growth potential of the pharmaceutical industry in Turkey. The high market values of the companies operating in the sector show that the industry attracts attention from investors. It is expected that the sector's growth will continue as companies operating in the industry open up to foreign markets and develop new products.

MATERIAL and METHOD

The research aims to answer the hypotheses set below:

H_1: The financial performance of the pharmaceutical industry in Turkey was positively affected during the COVID-19 pandemic.

H_2: Financial growth expectations in the pharmaceutical industry are high after the Covid-19 pandemic.

Research data was conducted between 2018 and 2022 with a quarterly frequency. E-VIEWS 13 and STATA 17 statistical programs were used to analyze study's hypotheses.

A- Hypothesis-1

The study will consider the five most influential companies in the pharmaceutical industry in this research. The data of these companies were collected from the Public Disclosure Platform (www.kap.org.tr). The five companies researched are shown in Table 5.

Table 5. Pharmaceutical Industry Companies of the Study

Firm No	Title
1	Deva Holding (DEVA)
2	EIS Eczacibasi İlaç Industrial and Financial Investment Inc. (ECILC)
3	Lokman Hekim Engurusag Health Tourism Education Services and Construction Contracting Inc. (LKMNH)
4	Selçuk Pharmaceutical Inc. (SELEC)
5	Turkish Pharmaceuticals and Serum Industry Inc. (TRILC)

To analyze the first hypothesis, data will be utilized in quarterly and, cross-sectional forms for five companies. Since the data of the study are cross-sectional, the Panel Data model was used to investigate the effect of independent variables on the dependent variable (Baltagi, 2005). Before estimating the panel data model, a unit root test will be performed to determine whether the data is stationary. Hausman and LM tests will be used to select the method of the panel data model from common effect, fixed effect and, random effect methods. Panel data assumptions will be tested and, the final model will be estimated. The variables used in the first hypothesis are shown in Table 6 (Hausman, 1978).

Table 6. Variables

	Variables		Abbreviation
Independent Variable	Inventory Turnover Ratio	Inventory Turnover Ratio	SD
	Net Profit and Loss Margin %	Net Profit and Loss Margin %	NKZM
	ROA	Return on Asset	ROA
Dependent Variable	ROE	Return on Equity	ROE

For the first hypothesis, the financial performance measure ROE ratio was determined. Other variables were determined as independent variables. Structural break tests were conducted to answer the final panel model estimated hypothesis. Before the analysis, the series will be tested to be stationary.

RESULTS and DISCUSSION

Unit Root Test

First of all, since the data are quarterly, seasonal effects were investigated and, the seasonality effects of the series were eliminated in the residual and average values of the series (Levin, 2002). Dickey and Fuller (1979) ADF method was used for standard unit root tests (Dickey & Fuller, 1979). The results of the ADF test are shown in Figures 1 to 4.

```
. xtunitroot fisher SD, dfuller lags(1)

Fisher-type unit-root test for SD
Based on augmented Dickey-Fuller tests
--------------------------------------
H0: All panels contain unit roots           Number of panels  =     5
Ha: At least one panel is stationary        Number of periods =    20

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(10)   P        40.4624       0.0000
 Inverse normal            Z        -3.2793       0.0005
 Inverse logit t(29)       L*       -4.1940       0.0001
 Modified inv. chi-squared Pm        6.8116       0.0000
------------------------------------------------------------------------------
```

Figure 1. SD ADF Unit Root Test

PM statistic values of the ADF test show the final ADF result. If the probability value of this statistic is less than 0.05, the test rejects the null hypothesis. The SD variable rejects the null hypothesis in the ADF test. Therefore, the SD series is stationary.

```
. xtunitroot fisher NKZM, dfuller lags(1)

Fisher-type unit-root test for NKZM
Based on augmented Dickey-Fuller tests
--------------------------------------
H0: All panels contain unit roots           Number of panels  =     5
Ha: At least one panel is stationary        Number of periods =    20

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(10)   P        28.6305       0.0014
 Inverse normal            Z        -2.1335       0.0164
 Inverse logit t(29)       L*       -2.7323       0.0053
 Modified inv. chi-squared Pm        4.1659       0.0000
------------------------------------------------------------------------------
```

Figure 2. NKZM % ADF Unit Root Test

Figure 2 shows the ADF test results of the NKZM. The NKZM variable rejects the null hypothesis in the ADF test. Therefore, the NKZM series is stationary.

```
. xtunitroot fisher ROE, dfuller lags(1)

Fisher-type unit-root test for ROE
Based on augmented Dickey-Fuller tests
--------------------------------------
H0: All panels contain unit roots           Number of panels  =     5
Ha: At least one panel is stationary        Number of periods =    20

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(10)   P        26.5194       0.0031
 Inverse normal            Z        -2.3066       0.0105
 Inverse logit t(29)       L*       -2.4297       0.0108
 Modified inv. chi-squared Pm        3.6939       0.0001
------------------------------------------------------------------------------
```

Figure 3. ROE ADF unit root test

Figure 3 shows the ADF test results of the ROE variable. The series of the ROE variable rejects the null hypothesis in the ADF test. Therefore, the ROE series is stationary.

```
. xtunitroot fisher ROA, dfuller lags(1)

Fisher-type unit-root test for ROA
Based on augmented Dickey-Fuller tests
--------------------------------------
H0: All panels contain unit roots           Number of panels  =     5
Ha: At least one panel is stationary        Number of periods =    20

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(10)   P        69.7479       0.0000
 Inverse normal            Z        -4.9131       0.0000
 Inverse logit t(29)       L*       -7.9865       0.0000
 Modified inv. chi-squared Pm       13.3600       0.0000
------------------------------------------------------------------------------
```

Figure 4. ROA ADF Unit Root Test

Figure 4 shows the ADF test results of the ROA variable. The series of the ROA variable rejects the null hypothesis in the ADF test. Therefore, the ROA series is stationary.

Hausman Test

After estimating the panel data model with random and fixed effect models, the Hausman test was used to select the most appropriate and safe model between these two models. The null hypothesis of the Hausman test is that the coefficient difference is not systematic, and this shows that the appropriate model is a random effect model. Figure 5 shows the Hausman test results.

```
. hausman fixed random, sigmamore

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference       Std. err.
-------------+----------------------------------------------------------------
        NKZM |   -.1268414    -.1342088        .0073674        .0079524
         ROA |   -1.000361    -.0044389       -.9959225        .2093532
          SD |    .0032511    -.0011773        .0044284         .001984
------------------------------------------------------------------------------
                          b = Consistent under H0 and Ha; obtained from xtreg.
           B = Inconsistent under Ha, efficient under H0; obtained from xtreg.

Test of H0: Difference in coefficients not systematic

    chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =  29.61
Prob > chi2 = 0.0000
```

Figure 5. Hausman Test

According to the continuation of the Hausman test, the null hypothesis is rejected. Therefore, the most suitable model is the fixed-effects panel data model. Tests for autocorrelation, heteroskedasticity, and multicollinearity were conducted to examine the identified panel data model.

Heteroskedasticity, Autocorrelation and, Multiple Linear Dependency Test

Heteroskedasticity refers to a situation where the variance of the residual term or error term in a regression model varies significantly. Wald test was used to detect heteroscedasticity. The null hypothesis of this test is that the model has no heteroskedasticity. Figure 6 shows Wald Heteroskedastic Test results.

```
. xttest3

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (5)  =       39.49
Prob>chi2 =      0.0000
```

Figure 6. Wald Heteroskedasticity Test

The probability values of the Wald Heteroskedastic test reject the null hypotheses. This result shows that the model has heteroscedasticity.

The Breusch-Godfrey test was used to determine the absence of autocorrelation in the model variables. The null hypothesis of this test is that there is no autocorrelation between the variables. Figure 7 shows the results of the Breusch Godfrey autocorrelation test (Breusch & Pagan, 1979).

```
. estat bgodfrey, lags(1)

Breusch–Godfrey LM test for autocorrelation
---------------------------------------------------------------------------
    lags(p)  |          chi2               df                 Prob > chi2
-------------+-------------------------------------------------------------
       1     |         34.658               1                   0.0000
---------------------------------------------------------------------------
                        H0: no serial correlation
```

Figure 7. Breusch-Godfrey Autocorrelation Test

The results of Breusch-Godfrey (1979) test reject the null hypothesis. Therefore, it was determined that there was autocorrelation between the series. The specified fixed-effect panel data model has autocorrelation and heteroskedasticity problems, and the fixed-effect Panel GLS model will be used to eliminate these problems.

Belsley (1973), variance inflation factor (VIF) measures the amount of multicollinearity in regression analysis. Multicollinearity exists when there is a correlation between more than one independent variable in a multiple regression model. Figure 8 shows the results of the VIF test (Belsley, 1973).

```
. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
          SD |      1.00    0.999024
         ROA |      1.00    0.999048
        NKZM |      1.00    0.999976
-------------+----------------------
    Mean VIF |      1.00
```

Figure 8. VIF test

If the VIF test values are more than 3, it is determined that there is a variance inflation factor, but since the VIF test results of the study are less than 3, it is determined that there is no VIF problem in the model.

Panel GLS Model and Panel Structural Break Tests

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. xtgls ROE NKZM ROA SD, panels(correlated) corr(ar1)

Cross-sectional time-series FGLS regression

Coefficients:  generalized least squares
Panels:        heteroskedastic with cross-sectional correlation
Correlation:   common AR(1) coefficient for all panels  (0.5605)

Estimated covariances      =        15          Number of obs     =        100
Estimated autocorrelations =         1          Number of groups  =          5
Estimated coefficients     =         4          Time periods      =         20
                                                Wald chi2(3)      =      91.52
                                                Prob > chi2       =     0.0000
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ROE	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
NKZM	-.110125	.0135335	-8.14	0.000	-.1366501	-.0835998
ROA	-.6485697	.2194349	-2.96	0.003	-1.078654	-.2184852
SD	.0066564	.0026107	2.55	0.011	.0015395	.0117733
_cons	.1962587	.0199419	9.84	0.000	.1571734	.2353441

Figure 9. Panel GLS model

Figure 9 shows Greene's (1986) panel GLS results. Panel GLS results determined that the effects of the determined independent variables were significant, and, this result indicates that the variables in the future Structural Break tests were selected correctly (Greene, 1986).

In econometrics and statistics, a structural break is an unexpected change in the parameters of regression models over time that can lead to significant forecast errors and overall unreliability. This issue has been popularized that instability of coefficients often leads to prediction failure and, therefore we should routinely test for structural stability. Structural stability is a central issue in all applications of linear regression models.

Dvoretzky, Kiefer and Wolfowitz (1956) investigate the possibility of a structural break in the regression using the DKW test (Dvoretzky, Kiefer, & Wolfowitz, 1956). The null hypothesis of the DKW test is that there is no structural break. Additionally, this test will predict the date of the structural break. Figure 10 shows the results of the DKW test.

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. xtbreak test ROE NKZM ROA SD, breaks(2) hypothesis(1)

Test for multiple breaks at unknown breakdates
(Ditzen, Karavias & Westerlund. 2021)
H0: no break(s) vs. H1: 2 break(s)
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	Test Statistic	Bai & Perron Critical Values: 1% Critical Value	5% Critical Value	10% Critical Value
supW(tau)	4.43	4.82	4.00	3.58

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Estimated break points:  2020q2 2022q1
Trimming: 0.15
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Figure 10. DKW Structural Fracture Test

In the regression determined according to the results of the DKW test, structural breaks occurred in 2 data. These dates are determined as the second quarter data of 2020 and the first quarter data of 2022. This estimate was estimated at the 5% significance level.

KT test tests whether each series has a structural break at specified dates. This test is performed once on each series and makes predictions by observing only the data of the series. According to the KT test results, a structural break exists in the series on the dates determined in the DKW test results.

Figure 11 shows the data on recorded new cases of COVID-19.

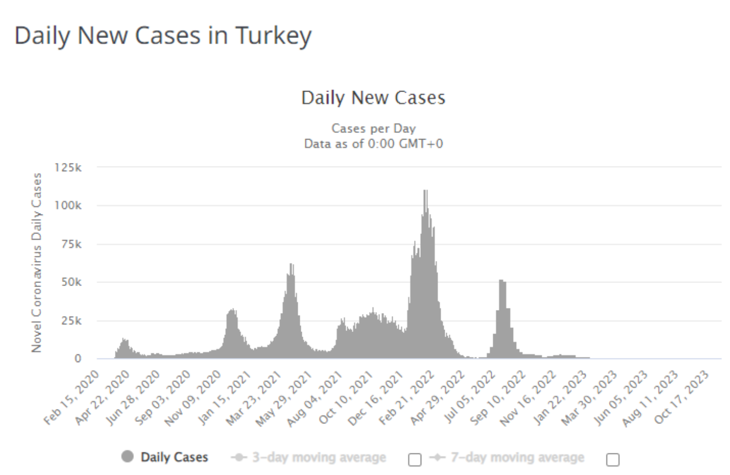

Figure 11. COVID-19 daily cases

According to the figure, COVID-19 reached pandemic conditions in April and May 2020. In addition, the COVID-19 pandemic was the cause of the highest number of cases in February 2022. These data confirm the result of the study.

B- Hypothesis 2

To analyze the second hypothesis of the study, data were collected in time series. Since time series models are used in this hypothesis, the financial growth variables will be the three variables determined in Table 7. The other variable was determined as the independent variable.

Table 7. Second hypotheses variables

Abbreviation	Variable	Frequency	
Snkzm	Net profit and loss margin	Quarter	Dependent
CCV	Covid-19 quarter cases	Quarter	Independent
sROE	Return on Equity	Quarter	Independent
sHSG	Stock returns of five companies in the pharmaceutical industry	Quarter	Independent

In the second hypothesis, the NKZM variable was determined as the financial growth rate in the pharmaceutical industry. After creating a VAR model in this hypothesis, the effects of the independent variables on the dependent variable will be investigated in the following eight quarters with the impact-response test. Since the series of this hypothesis are quarterly data, seasonal effects have been eliminated.

VAR takes into account the lags of the variables of the model, so the optimal lag of the model must be determined (Akaike, 1974). VAR lag criteria were used to determine the optimal lag, and, the statistical values of these criteria are shown in Figure 12. Among the requirements in Figure 12, AIC, SC and, HQ, the most appropriate with the smallest value at zero lag. The values of the results show that the AIC information criterion is the most appropriate. The AIC shows that the most appropriate lag of the VAR model is only the first lag.

VAR Lag Order Selection Criteria
Endogenous variables: SNKZM CCV SROE SHSG
Exogenous variables: C
Date: 11/19/23 Time: 21:08
Sample: 2018Q1 2022Q4
Included observations: 18

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-222.8999	NA	1045547.	25.21110	25.40896	25.23838
1	-190.4253	46.90781*	177910.4	23.38059	24.36989*	23.51700
2	-168.4359	21.98938	127776.8*	22.71510*	24.49584	22.96064*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Figure 12. VAR Optimal Lag

The optimal lag of the VAR is the second lag determined in the AIC criterion, so that the VAR model will be estimated with lags of 1 and 2 for Hypothesis tests.

Roots of Characteristic Polynomial
Endogenous variables: SNKZM CCV SROE SHSG
Exogenous variables: C
Lag specification: 1 2
Date: 11/19/23 Time: 21:11

Root	Modulus
0.960772	0.960772
-0.871329	0.871329
-0.023143 - 0.811058i	0.811389
-0.023143 + 0.811058i	0.811389
0.387822 - 0.495514i	0.629238
0.387822 + 0.495514i	0.629238
-0.444113	0.444113
0.374113	0.374113

No root lies outside the unit circle.
VAR satisfies the stability condition.

Figure 13. VAR Stability Test

If the values of the VAR Stability test are less than 1, it will be determined that the VAR model is stable. Since the values of the results were less than 1, it was determined that the estimated VAR model was stable.

VAR serial correlation LM test checks whether the model passes with the LM test. The null hypothesis of this test is that the model has a serial correlation at the specified lag. The results of the LM test are shown in Figure 14.

VAR Residual Serial Correlation LM Tests
Date: 11/19/23 Time: 21:15
Sample: 2018Q1 2022Q4
Included observations: 18

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	16.62332	16	0.4104	0.991367	(16, 6.7)	0.5407
2	15.94837	16	0.4566	0.923666	(16, 6.7)	0.5829
3	61.68518	16	0.0000	37.04876	(16, 6.7)	0.0000

Figure 14. VAR Serial Correlation Test

According to the results of the LM test, the model accepts the null hypothesis at the first and second lags, but it was determined that the third lag had a serial correlation. Therefore, it was determined that there was no serial correlation with the estimated VAR model 1 and 2 lags.

The Johansen Co-integration approach uses maximum likelihood estimation to estimate the number of cointegration relationships and the parameters of these relationships (Johansen, 1991). It consists of VAR estimates that include the differences and levels of non-stationary series. Figure 15 shows the Johansen Co-integration test results. According to the Trace test statistics in Figure 15, it is seen that there is a long-term relationship between the variables examined. The null hypothesis of this test is the absence of a long-term relationship. As shown in the figure, rejecting at most one probability value, there are two cointegration equations in the model.

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.** Critical Value
None *	0.997660	140.2578	47.85613	0.0000
At most 1 *	0.822667	37.28095	29.79707	0.0057
At most 2	0.369454	7.875564	15.49471	0.4788
At most 3	0.002097	0.035681	3.841465	0.8501

Figure 15. Cointegrating Test

Figure 16 shows the estimated cointegration equation. To determine the significance of the estimate, which is the model of the study, in the cointegration equation, the coefficients of the equation will be divided by the standard error of the series. If the positive result is greater than two, it will be determined that the variable significantly affects the dependent variable in the long term.

1 Cointegrating Equation
Log-Likelihood: -108.9619

Normalized coitnegrating coefficients (standard error in parenth...

SNKZM	CCV	SROE	SHSG
1	-8.04237104...	6.731303407...	0.276394823...
	1.328705940...	0.121655790...	0.009158676...

Figure 16. Cointegration Equation

According to the results of dividing the coefficients by the standard error, CCV, SROE and, SHSG variables significantly affect the dependent variable in the long term.

After determining that the VAR model and cointegration equation are significant, we can be sure of the results of the impulse response model. Figure 17 shows the results of the impulse test.

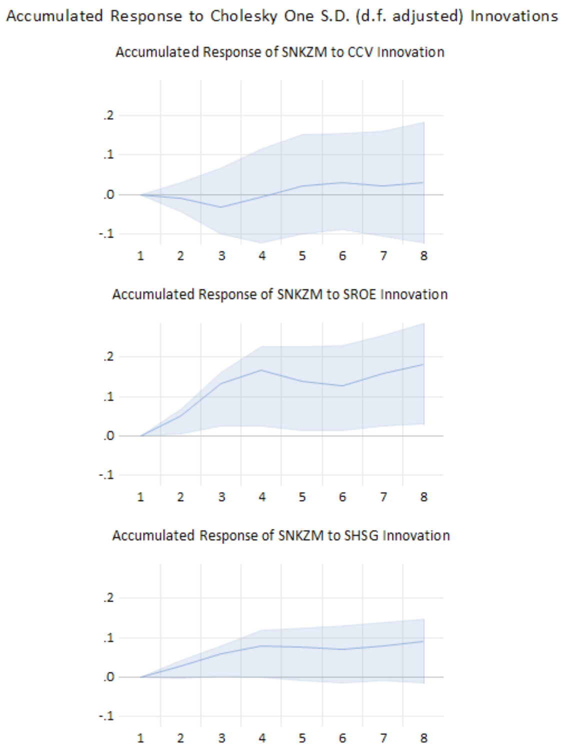

Figure 17. Impulse Test Results

According to the results of the impulse response test, a positive shock effect of the CCV variable negatively affects the NKZM value for up to three periods. After the third period, the shock will have a positive impact, and, this effect will continue until the eighth period.

The positive shock of the SROE variable affects the NKZM variable positively. This effect has a positive growth rate and will only have a negative growth rate in the fourth and sixth periods.

The positive shock of the SHSG variable affects the NKZM variable positively. This effect will continue at a constant growth rate.

This study has examined the financial performance of the Turkish pharmaceutical sector from 2018 to 2022 in the context of the impacts of the COVID-19 pandemic. Other studies have similarly investigated how the Turkish pharmaceutical sector was affected by the pandemic. These studies have emphasized the adverse effects of the pandemic on significant variables within the industry, such as financial performance, R&D expenditures, workforce, and exports.

Acar and Ozturk's study indicated a significant negative impact of the pandemic on the Turkish pharmaceutical industry, supporting the notion that it affected a broad spectrum of elements, including financial performance, R&D expenditures, workforce, and exports. Likewise, the studies conducted by Bayraktar and Demirtas, and Cakar and Gunes also supported these findings, highlighting the adverse effects of the pandemic on various facets of the sector.

Moreover, the studies by Gurcan and Sonmez, as well as Sen and Ozturk, yielded similar outcomes, demonstrating the adverse effects of the pandemic on the Turkish pharmaceutical industry. Gurcan and Sonmez delved into production-oriented elements like production quantity, value, and cost, indicating the sector's exposure to this unfavorable impact on production activities.

Additionally, the panel data analysis in this study revealed distinct fluctuations in the effects of the pandemic during specific periods. The structural break analysis emphasized the pronounced impact of the pandemic starting from the second quarter of 2020, showing significant alterations in sector performance during these periods. Furthermore, it observed how the relationship between COVID-19 case data and financial performance evolved.

These comparative analyses underscore the extensive and diverse adverse effects of the pandemic on the Turkish pharmaceutical industry. However, this study, in particular, provided a more detailed perspective by focusing on the evolution of pandemic effects over time.

CONCLUSION

In conclusion, these comparative analyses highlight the value of employing different analytical methods to understand the sector's response to the pandemic and the changes in its financial performance. Future studies could expand on these findings and deeply evaluate the sector's potential by utilizing larger datasets or employing different methodologies.

The COVID-19 pandemic has had profound social, economic and, health impacts in Turkey, as well as all over the world. As stated at the beginning of this study, we aim to analyze in depth how the pharmaceutical industry in Turkey responded to this unexpected and far-reaching crisis, and what the industry's future expectations are.

Throughout the pandemic, the Turkish pharmaceutical industry has faced a sudden increase in drug demand, disruptions in supply chains, and, fluctuations in drug prices. However, the sector has taken a series of strategic measures to overcome these difficulties, thus managing to keep supply continuity at the highest level and meet the pharmaceutical needs of the public.

With the active contributions of the Turkish Ministry of Health and TÜBİTAK, studies on new drugs and vaccines continue rapidly. At the same time, improvements in pharmaceutical production and distribution processes have increased the overall resilience of the sector and enabled it to respond to quickly changing needs.

This study examined in detail the financial performance of the Turkish pharmaceutical industry between 2018 and 2022 under the impact of the COVID-19 pandemic. Analyses conducted to understand the short and long-term effects of the pandemic on the sector have highlighted unexpected changes in financial indicators during specific periods. In particular, the financial resilience and volatility of the industry were observed in the periods ranging from before the pandemic to during and after the pandemic. The panel data analysis and structural break analysis showed that the pandemic had a substantial impact, especially from the second quarter of 2020, and that there were substantial changes in sector's performance during these periods. It was also observed how changes in the financial performance of the industry evolved in correlation with COVID-19 case data. The results of this study provide a significant perspective to understand the pharmaceutical industry's ability to adapt to pandemic conditions and the resilience of the sector. Future studies may expand on the findings of this study through analysis with larger data sets or the use of different methodologies and evaluate the future potential of the sector in more detail.

Limitations of the Study

This study has some limitations. For example, the data set used in the analysis covers a specific period, which may not allow long-term trends to be fully captured. Additionally, since the panel data analysis method is based on certain assumptions, the results may be affected if these assumptions are not met. However, since the study was limited to specific financial indicators, the impact of other variables in the sector may not have been thoroughly evaluated.

Future Directions

The findings of this study provide an essential basis for future research. In particular, more in-depth studies can be conducted on companies' strategies, international competition and, sectoral innovations in the post-pandemic period in the pharmaceutical industry. In addition, analyzing other variables such as labor force dynamics and R&D investments, in addition to the financial indicators on which this study focuses, may provide a vital breakthrough for future research.

Implications

The findings of this study may influence the decision-making processes of companies and regulators in the pharmaceutical industry. In particular, considering the uncertainties and changing trends in the sector during the pandemic is, crucial for companies to make their strategies flexible and adaptable. Additionally, the impact of these findings on regulations in the industry may shape future policy-making processes and contribute to the sustainable growth of the industry.

CONFLICT of INTEREST

The authors declare that there is no conflict of interest

AUTHOR CONTRIBUTION STATEMENT

Developing hypothesis (MÖ, HT), experimenting (MÖ, HT), preparing the study text (MÖ, HT), reviewing the text (MÖ, HT), statistics (MÖ, HT), analysis and interpretation of the data (MÖ, HT), literature research (MÖ, HT).

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