

Chapter 9

The Effects of COVID-19 Pandemic on International Trade and Production in the Age of Industry 4.0: New Evidence from European Countries

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Abstract

The COVID-19 outbreak occurred in Wuhan region of China has significantly affected the exports and production of countries. Digitalization and technological developments have increased with the Industry 4.0, and COVID-19 measures accelerated this process. In this study, the impacts of COVID-19 pandemic have been investigated on international trade and production in European countries and Turkey. Accordingly, the cointegration relations between variables were examined with Westerlund panel cointegration test. As a result of the cointegration test, it is determined that there are long-term relationships between variables. The causality relationships between variables are analyzed with the Dumitrescu–Hurlin panel causality test. Causality analyses show that there is a unidirectional causality relationship from COVID-19 cases and deaths to export, while there is a unidirectional causality relationship from COVID-19 cases to production. The empirical findings demonstrate that COVID-19 outbreak has a significant impact on production and export processes in European countries and Turkey.

Keywords: COVID-19 pandemic; Industry 4.0; production; international trade; global supply chain; Westerlund panel cointegration test; Dumitrescu–Hurlin panel causality test

Introduction

Coronavirus disease (COVID-19) emerged in the Wuhan region of China in late 2019 and spread all over the world in a short time. When the geographical spread of the COVID-19 virus is examined, it is seen that the first effects of COVID-19 virus were seen in Asian continent and then it spread to Europe and America. The World Health Organization declared COVID-19 disease as a global pandemic on March 11. In this direction, a process has been experienced all over the world, in which many businesses were closed and productions were decreased. This global pandemic has created an important shock in the economic processes. During pandemic periods, serious problems such as significant decreases in production and trade activities, supply problems of raw material, and product and price fluctuations may occur (Ivanov, 2020). In addition to protecting public health, the most important topics of the pandemic period were the ability of businesses to continue their activities, ensuring continuity in the global supply chain and creating solutions to economic problems (Petropoulos & Makridakis, 2020). In this context, after the globalization processes of the countries, the effects of COVID-19 virus on global supply chains, production and international trade will be discussed in order to understand the COVID-19 process in the age of the Industry 4.0.

It is seen that important structural transformations took place in the global economy after the 2008 global crisis. The West-centered globalization phenomenon has changed its focus nowadays. Developing countries, especially China ranking first in global exports, has started to take significant shares in production and global supply chain. Today, while the global capital intensity is under the control of Western countries, it is observed that production and international trade, which are important elements of real economy, have shifted to the Asia-Pacific region where developing economies, especially China, are located. In this process, China has started to produce high value-added products and has become the world's production factory (Baldwin & di Mauro, 2020).

China, an important production center, is at the center of global supply chain and international trade networks. The global COVID-19 pandemic started in China has created a large-scale economic crisis affecting the global supply chain and causing disruptions significantly. The Wuhan region, remarked as the origin of the virus, has an important position in the global supply chain, as it is one of the substantial production centers and many value-added products are produced in this region (Kilpatrick & Barter, 2020). Due to the COVID-19 pandemic, important economic problems such as quarantine processes, interruption of production and trade, and decrease in employment have emerged first in Wuhan and then in all regions where the coronavirus spread. This situation has created serious problems in production, supply chains, and international trade. While there was a high increase in the sales of some products, demands of some products decreased significantly. Consumer shopping forms have changed, and the level of shopping has increased through e-commerce. Naturally, these developments have caused significant changes in the international trade and logistics processes of the products.

The international trade volume, which has recently stalled, has started to decline significantly due to the disruption of global supply chain during the COVID-19 outbreak. According to the reports of the World Trade Organization (2020), it is stated that international commodity trade will shrink by 13%–32% due to COVID-19 pandemic in 2020. However, it is seen that the international service trade, consisting of tourism, transportation, and travel revenues, which are substantial for financing the current account deficit, has also been negatively affected by the COVID-19 pandemic, especially in developing countries. As a result of restrictions on international travel in line with quarantine applications, it has been inevitable that the tourism and transportation sector will be negatively affected by the pandemic process.

It is seen that the digitalization process started in the twentieth century has gained momentum with the COVID-19 pandemic in the age of Industry 4.0. High technology activities such as digital applications, artificial intelligence, Internet of things, and autonomous vehicles in the global economy have developed rapidly in the age of Industry 4.0. Along with the COVID-19 pandemic, the widespread use of digital technologies in the economy and health sectors in line with different applications has shown the importance of the digitalization process in the pandemic period. In addition, it is seen that the fourth-generation industry and technology infrastructure has gained momentum in the pandemic process. The rapid digital transformations which are realized with the Industry 4.0 lead the world to a renewed economic system with the increasing level of digitalization after COVID-19 pandemic.

The Effects of COVID-19 Pandemic on International Trade and Production in the Age of Industry 4.0

The COVID-19 pandemic is a major economic crisis affecting both the production process and supply chain for the global economy. Accordingly, the international trade is affected significantly. There are important differences between the pandemic processes occurred in the past and during the COVID-19 pandemic that is experienced today. The first difference is that countries affected by the previous pandemics do not have an important role in the global economy (Baldwin & Tomiura, 2020). Today, the global economy has been deeply affected by the fact that China is considered as the origin of the virus and an important link in the global supply chain. While gross domestic product (GDP) of China was 4.31% of the world's total GDP in the early 2000s, this rate has reached to 16% today (Haren & Simchi-Levi, 2020). In other words, the effects of the COVID-19 pandemic on international trade and production are predicted to be greater than past pandemics.

While China, Japan, and Korea were significantly affected in the Asian continent due to the problems occurring in the production and supply chain, significant levels of production and trade volumes declined in France, Italy, England, and Germany, which are the production centers in Europe. As can be seen from [Fig. 9.1](#), while these countries constitute 37% of the world production

volume, they realize approximately 34% of the international trade volume. Accordingly, it is predicted that there are important impacts of the COVID-19 pandemic on the supply chain and international trade.

The impact of the COVID-19 virus in the Asian continent, especially in China, which has become the world's production center, has most adversely affected the production and supply chain. Due to the troubles in China's production processes, intermediate goods demand of many countries could not be met. Furthermore, the decrease in goods transportation and human movements in the logistics sector, the disruption of shipping trade, the increase of trade restrictions, and the closure of customs and ports have negatively affected international trade. The 20% decrease in China's maritime trade and the 30% decrease in France's maritime transport are the most important indicators of this economic shrinkage (Haren & Simchi-Levi, 2020).

During the pandemic period, there have been some attempts to eliminate the problems in international trade and production. At this point, it is seen that the volume of e-commerce, which increased with the development of information and communication technologies in the twentieth century, raised significantly during the pandemic process. In addition, there has been an increase in contactless trade practices and the level of digitalization in customs. In line with all these practices, it has aimed to remove the barriers to international trade in the COVID-19 pandemic.

In summary, the COVID-19 pandemic has caused vital problems such as the disruption of the supply chain, the decrease in demand levels, the inability to supply raw materials and intermediate products, the halt of production, the limitation of logistics activities, and the decline in imports and exports for countries. Within the scope of this study, the effects of the COVID-19 pandemic on international trade and production processes in the age of Industry 4.0 will be empirically examined, and policy recommendations will be made in line with the results.

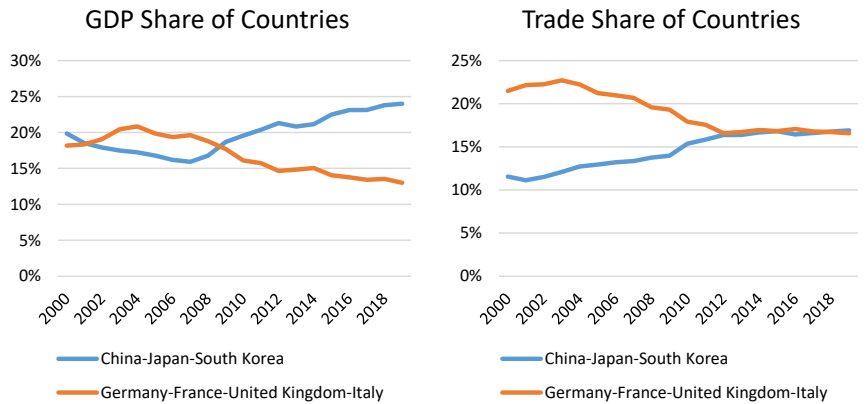


Fig. 9.1. Gross Domestic Product (GDP) and Trade Share of Asian and European Countries. *Source:* Data are obtained from WorldBank (2021).

Literature Review

The COVID-19 pandemic, which emerged in the age of Industry 4.0, affected the health policies of countries as well as international trade and production processes deeply. During this period, trade and production forms, as well as international trade and production volume have also changed. In this direction, a few studies have been carried out to examine how the economies of countries were affected during the COVID-19 process.

Wuest, Kusiak, Dai, and Tayur (2020), stating that the production and supply processes have undergone a digital transformation with Industry 4.0, have investigated the effects of digital technologies on future production and supply networks. Accordingly, it has been stated that the development process of digital technologies has experienced significant interruptions due to the COVID-19 pandemic, but digital technologies will make production and supply networks more durable in the future.

Vidya and Prabheesh (2020), measuring the interdependence of trade among the countries before and after the COVID-19 outbreak, have researched the future of international trade using Trade Network Analysis and Artificial Neural Networks. As a result of the study, it is seen that there was a great decrease in trade interdependence, connectivity and density between countries, and a noticeable change in the structure of the trade network after the COVID-19 outbreak. In addition, it has been reached that China's "center" position in the trade network continues despite the pandemic, and international trade will continue to decline sharply until the end of 2020.

Indicating that the COVID-19 pandemic also seriously restricted the economy and restrained production and logistics activities, Singh, Kumar, Panchal, and Tiwari (2020) have stated that the supply and demand of various products were affected as a result of the restrictions imposed. In the study, the developments in the food sector's supply chain were examined, and it was revealed that there were difficulties in meeting the supply and demand during the pandemic process. Accordingly, authors emphasized the importance of a strong production and supply chain during the pandemic process.

Song and Zhou (2020) aimed to analyze the impacts of the pandemic on the global economy and evaluate the effectiveness of policy measures in combating the pandemic and stimulating the global economy. In the study, it is suggested that COVID-19 will deepen the problems further in the global economy and delay the economic recovery. In this direction, they indicate that the main factors of economic recovery in the postpandemic period are structural reform, development of new technologies, and reintegration. Thus, it is claimed that the factors supported by strong public policies, especially at the national level, can provide the solution of the problems in the global economy after the pandemic.

Advocating for strengthening the digital economy during the COVID-19 pandemic, Lestari, Darma, Amalia, and Setini (2020) state that the digital economy is the important way out of restrictions of government in economic sectors. It is stated that the COVID-19 outbreak accelerated the sharp strengthening and transformation in the digitalized economic sector. After all, it is revealed that the

digital economy offers significant opportunities to support international trade, which experienced inconsistencies in growth tables during the pandemic.

Pal (2020) states that the COVID-19 crisis will seriously damage the world economy and international trade by suggesting the pandemic will lead to some changes in international trade and long-distance trade patterns. Accordingly, it is revealed that countries can eliminate the negative effects of the pandemic by adapting to new technologies in the age of Industry 4.0. In addition, it is emphasized that in order to overcome the negative effects of the pandemic, there will be significant economic costs, and global cooperation and trade policy coordination will be required.

Ozili and Arun (2020) express that the spread of COVID-19 encourages social distancing that leads to the closure of financial markets, corporate offices, businesses, and events, and the increasing uncertainty with the speed of the virus's spread has led to stagnation among consumers, investors, and international trading partners. As a result of empirical analysis, it has been determined that increasing international travel restrictions seriously affect the economic activities and stock prices. However, it has been observed that the increasing number of coronavirus cases does not have a significant effect on the economic activities within the country.

Kumar, Luthra, Mangla, and Kazançoğlu (2020) indicates that the global production and supply chain system has been severely disrupted due to the spread of the COVID-19 pandemic. It is emphasized that adequate strategies and policies should be established to renew production models and meet consumer demand. When the global supply chain is examined, it is stated that most of the raw materials are imported from China and other developing Asian countries. Together with the COVID-19 pandemic, it is indicated that the transportation networks and distribution mechanisms between suppliers, production facilities, and customers have been broken. Therefore, it is said that it is inevitable to create a sustainable production and consumption model in the age of Industry 4.0.

Hassani and Dost (2020), who conducted a comprehensive analysis in 42 countries using the computable general equilibrium (CGE) model to determine the effects of the COVID-19 outbreak on global trade, produced long- and short-term scenarios. In line with the results, it has been revealed that the global production and international trade volume will decrease significantly. In addition, it has been stated that China, which is the center of international trade, and the Asian continent will adversely affect international trade due to the COVID-19 outbreak.

Kimura, Thangavelu, Narjoko, and Findlay (2020) have investigated the economic shocks (financial crisis) on trade and global value chains in East Asia due to the COVID-19 outbreak. He suggests that the cost of pandemic and economic shocks will increase significantly when several countries in the region experience it simultaneously. Accordingly, it is revealed that countries should be in more economic coordination to reduce the pandemic effects. Thus, countries will be able to plan their international trade and production processes more efficiently.

Hayakawa and Mukunoki (2020) have investigated the effects of the COVID-19 outbreak on international trade using data from 186 countries in the first quarter of 2020. As a result of the analysis, it has been concluded that COVID-19 cases and deaths have negative effects in exporting countries. However, it has been determined that the negative effects of COVID-19 cases and deaths on exports are seen in developing countries.

Barua (2020) has investigated the effects of possible macroeconomic shocks of the COVID-19 pandemic. He states that the pandemic creates significant uncertainties in the economy, and the macroeconomic effects should be prevented from the deterioration in the national economies by supporting the supply side.

As can be seen, there are important studies in the literature revealing the uncertainty and negativity of the effects of the COVID-19 pandemic that broke out in the Industry 4.0 era on international trade and production. This study will analyze the effects of the COVID-19 pandemic on international trade and production in the age of Industry 4.0 that digitalization has accelerated and will make significant contributions to the literature.

Methodology

This study aims to analyze the relationships between COVID-19 cases, COVID-19 deaths, international trade, and production of European countries and Turkey in the age of Industry 4.0. Accordingly, it is going to bring out how COVID-19 cases and deaths have impacted the exports and production of European countries and Turkey.

The study examines the relationships between COVID-19 cases, COVID-19 deaths, international trade, and production of European countries and Turkey via panel data models as part of this chapter. While dependent variables are exports and productions of both European countries and Turkey, COVID-19 cases and deaths of both European countries and Turkey involved as independent variables in the research model.

Data of volume indexes of production are obtained from the database of EuroStat. Export data of countries are gained from the database of the World Bank. In addition, data of COVID-19 cases and deaths are obtained from the World Health Organization. Monthly series are used between 2020M01 and 2020M12 in the chapter. The variables used in the chapter are as follows:

ln(Case): COVID-19 cases of European countries and Turkey

ln(Death): COVID-19 deaths of European countries and Turkey

ln(Exp): Exports of European countries and Turkey

ln(Prod): Volume indexes of production of European countries and Turkey

Based on these information, the panel data models have been produced for European countries and Turkey to examine the relationships between COVID-19 cases, COVID-19 deaths, exports, and volume indexes of production (1, 2, 3, 4):

$$\ln(\text{Exp})_{it} = \beta_0 + \beta_1 \ln(\text{Case})_{it} + \varepsilon_{it} \quad (9.1)$$

$$\ln(\text{Exp})_{it} = \beta_0 + \beta_1 \ln(\text{Death})_{it} + \varepsilon_{it} \quad (9.2)$$

$$\ln(\text{Prod})_{it} = \beta_0 + \beta_1 \ln(\text{Case})_{it} + \varepsilon_{it} \quad (9.3)$$

$$\ln(\text{Prod})_{it} = \beta_0 + \beta_1 \ln(\text{Death})_{it} + \varepsilon_{it} \quad (9.4)$$

Research hypothesis of the chapter is that COVID-19 cases and deaths negatively affect the international trade and production processes of European countries and Turkey. The relationships between COVID-19 cases, COVID-19 deaths, exports, and volume indexes of production of both European countries and Turkey will be examined by the panel data analyses, but primarily, it is required to test the cross-sectional dependence and stationarity of the panel data series.

The fact that a shock, which occurs in one of the cross sections in the series, affects the other units indicates that there is a dependence between the cross-sections. This dependency relationship is not taken into account in traditional panel data analysis methods. Although there is an interdependence relationship between cross sections, ignoring this dependency makes the reliability of the panel data analysis results questionable. New generation panel data techniques take the cross-sectional dependence between the units into account. This provides empirical results to be more consistent and reliable. Accordingly, cross-sectional dependence tests developed by Breusch and Pagan (1980) (5), Pesaran (2004) (6, 7), and Pesaran, Ullah, and Yamagata (2008) (8) were used in the study.

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^N P_{ij}^2 \sim X_{\frac{N(N-1)}{2}}^2 \quad (9.5)$$

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^N P_{ij} \right) \sim N(0, 1) \quad (9.6)$$

$$CD_{LM} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^N P_{ij} (T \rho_{ij}^2 - 1) \sim N(0, 1) \quad (9.7)$$

$$LM_{adj} = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^N \frac{(T-k)P_{ij}^2 - \mu_{Tij}}{\sigma_{Tij}} \sim N(0, 1) \quad (9.8)$$

In case of cross-sectional dependence and variance problem in the model, Pesaran's (2007) Cross-Sectionally Augmented Dickey-Fuller (CADF) estimation method is recommended as the most appropriate unit root test, since this test method was developed according to both cross-sectional dependence and heteroscedasticity assumption (Lewandowski, 2007). In addition, Pesaran's CADF test is recommended for the analysis of macro panel and time series models. CADF test statistic is as follows:

$$y_{it} = (1 - \varphi) \mu_i + \varphi_i y_{i,t-1} + u_{it} \quad (9.9)$$

$$CIPS = N^{-1} \sum_{i=1}^N CADF_i \quad (9.10)$$

After determining the stationarity degrees of the variables, Westerlund (2007) cointegration test will be conducted to test the long-term relationships between variables. Westerlund (2007) cointegration test calculates test statistics using the model below.

$$\Delta y_{it} = \delta'_i d_t + \alpha_i y_{i,t-j} + \lambda'_i x_{i,t-1} + \sum_{j=0}^{p_i} \gamma_{ij} \Delta x_{i,t-j} + \sum_{j=1}^{p_i} \alpha_{ij} \Delta y_{i,t-j} + e_{it} \quad (9.11)$$

Causality relationships between variables will be tested by Dumitrescu and Hurlin's (2012) panel causality test. Dumitrescu and Hurlin (2012) state that the causality relationship is valid for any country as well as different countries within the scope of panel data, and it gives effective and reliable results with the increase in the number of observations. In addition, it provides consistent results even if the time dimension is larger or smaller than the unit size. Dumitrescu and Hurlin's panel causality test model is as follows (Dumitrescu & Hurlin, 2012, p. 1457):

$$Y_{i,t} = a_i + \sum_{k=1}^k Y_i^{(k)} Y_{i,t-k} + \sum_{k=1}^k \beta_i^{(k)} X_{i,t-k} + e_{i,t} \quad (9.12)$$

Dumitrescu and Hurlin (2012) examine the hypothesis that the homogeneous Granger causality relationship disappears in all units with the counter hypothesis that this relationship exists in at least one unit.

Empirical Findings

In order to analyze the effects of COVID-19 cases and deaths on exports and production of European countries and Turkey, cross-sectional dependence analyses of variables were conducted at first.

Table 9.1. Cross-sectional Dependence Test Results.

Variables	Test	Statistics	Prob.
ln(Case)	LM	4,595.264	0.0000
	CD _{LM}	141.046	0.0000
	LM _{adj}	139.546	0.0000
	CD	67.778	0.0000
ln(Death)	LM	4,369.233	0.0000
	CD _{LM}	133.383	0.0000
	LM _{adj}	131.883	0.0000
	CD	66.015	0.0000
ln(Exp)	LM	3,524.597	0.0000
	CD _{LM}	104.747	0.0000
	LM _{adj}	103.247	0.0000
	CD	58.868	0.0000
ln(Prod)	LM	2,576.275	0.0000
	CD _{LM}	72.596	0.0000
	LM _{adj}	71.096	0.0000
	CD	47.305	0.0000

According to the results in Table 9.1, the null hypothesis is rejected for $\ln(\text{Case})$, $\ln(\text{Death})$, $\ln(\text{Exp})$, and $\ln(\text{Prod})$. In this direction, cross-sectional dependence is valid for all panel data series. Due to the fact that the asymptotic properties of the first-generation unit root tests affect the cross-sectional section dependence, it is necessary to test the variables with second-generation unit root tests that take the correlation of the panel data series into account. The second-generation unit root test results are given in Table 9.2.

Table 9.2. Second-generation Panel Unit Root Test (PESCADF) Results.

Variables	Series in Level		Series in First Differences	
	<i>T</i> -Bar Stat.		<i>T</i> -Bar Stat.	
	<i>C</i>	<i>C</i> + <i>T</i>	<i>C</i>	<i>C</i> + <i>T</i>
$\ln(\text{Case})$	-1.826	1.700	-3.176***	-2.891**
$\ln(\text{Death})$	2.610	1.700	-3.414***	-4.079***
$\ln(\text{Exp})$	-1.881	-1.817	-2.116**	-2.641*
$\ln(\text{Prod})$	-1.815	-1.697	-2.221**	-2.718**

Note: “*C*” stands for constant term, “*I* + *T*” represents constant and trend. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively.

The second-generation panel unit root test (PESCADF) results demonstrate that variables are not stationary in level (Pesaran, 2007). In other words, variables are stationary in their first difference. After determining the stationarities of the variables, there will be Westerlund (2007) panel cointegration test in order to examine long-term relationships between variables.

Table 9.3. Westerlund (2007) Panel Cointegration Results.

Model	Statistics	
	Constant Model	Constant and Trend Model
$\ln(\text{Exp}) - \ln(\text{Case})$	-1.8894**	-2.0069**
$\ln(\text{Exp}) - \ln(\text{Death})$	-1.4255*	-3.2208***
$\ln(\text{Prod}) - \ln(\text{Case})$	-2.9999***	-2.1824**
$\ln(\text{Prod}) - \ln(\text{Death})$	-2.7597***	-2.8614***

Note: ***, **, and * indicate significance at 1%, 5%, and 10%, respectively.

Westerlund (2007) panel cointegration test results are shown in Table 9.3. When the results were examined, the H_0 hypothesis is rejected in constant and constant-trend models, and it is revealed that there are cointegration relationships between the variables. In this direction, there are long-term relationships between COVID-19 cases, COVID-19 deaths, exports, and production in European countries and Turkey.

Table 9.4. Dumitrescu and Hurlin (2012) Panel Causality Test Results.

Causality Relationship	Z_{NT}^{HNC}	Z_N^{HNC}
$\ln(\text{Exp}) \rightarrow \ln(\text{Case})$	-1.5617	-1.5712
$\ln(\text{Case}) \rightarrow \ln(\text{Exp})$	-2.3735**	-1.9812**
$\ln(\text{Exp}) \rightarrow \ln(\text{Death})$	0.8237	-0.3665
$\ln(\text{Death}) \rightarrow \ln(\text{Exp})$	-2.4905**	-2.0404**
$\ln(\text{Prod}) \rightarrow \ln(\text{Case})$	-1.5959	-1.5885
$\ln(\text{Case}) \rightarrow \ln(\text{Prod})$	-3.0756***	-2.3359**
$\ln(\text{Prod}) \rightarrow \ln(\text{Death})$	-1.0097	-1.2924
$\ln(\text{Death}) \rightarrow \ln(\text{Prod})$	-0.8982	-1.2361

Note: One lag length is chosen. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively.

In the presence of long-term relationships, causality relationships should also be tested between variables. When the Dumitrescu and Hurlin's (2012) panel causality test results are evaluated in Table 9.4, it is determined that there is a unidirectional causality relationship from COVID-19 cases and deaths to export in European countries and Turkey. Moreover, it is observed that there is a unidirectional causality relationship from COVID-19 cases to volume indexes of production in European countries and Turkey.

Conclusion and Discussion

COVID-19 cases and deaths have significant effects on international trade and production processes of countries. It is seen that business patterns are changed with the COVID-19 outbreak, and the use of technology has increased rapidly in the age of Industry 4.0, where digitalization accelerates. In this direction, it is crucial to analyze these important effects of COVID-19 on the economies of countries and develop policy recommendations to overcome this crisis. Along with this study, the effects of the COVID-19 pandemic on the international trade and production of European countries and Turkey in the age of Industry 4.0 are empirically investigated.

As part of the study, long-term relationships between variables were tested with Westerlund (2007) panel cointegration test in first. Based on the results, it is seen that there are cointegration relationships between variables. In other words, it is determined that there are long-term relationships between COVID-19 cases, COVID-19 deaths, exports, and volume indexes of production in European countries and Turkey. This result proves that the COVID-19 outbreak has affected the international trade and production processes of European countries and Turkey since the beginning of the process.

After determining the long-term relationship between the variables, it is necessary to determine the direction of this relationship between the variables. In

this context, causality relationships between variables were analyzed with Dumitrescu and Hurlin (2012) panel causality test. As a result of panel causality tests, it is observed that there is a unidirectional causality relationship from COVID-19 cases and deaths to export, while there is a unidirectional causality relationship from COVID-19 cases to volume indexes of production. The determination of causal relationships from COVID-19 cases and deaths to exports and production show that the COVID-19 pandemic has deeply affected the economies of the European countries and Turkey. The fact that exports are affected by both COVID-19 cases and COVID-19 deaths indicate that international trade has a crucial role in the economic activities of countries, and the ongoing export processes increase the contact. Therefore, exports are affected by the number of cases and deaths during the COVID-19 outbreak. For this reason, countries that develop contactless trade applications and encourage online commerce activities such as e-commerce will ensure to continue their export activities in line with the measures during the pandemic process. Nonetheless, it has emerged that there is a causal relationship from COVID-19 cases to production, while there is no causal relationship from COVID-19 deaths. This situation reveals that countries reduce or even halt their production processes during the COVID-19 pandemic. Based on reducing the effects of the COVID-19 pandemic, situations such as part-time work and job closure have negatively affected production processes. As the main solution to this situation, the development of telecommuting opportunities, increasing the online skills of employees, and increasing digitalization to meet the requirements of the Industry 4.0 age could prevent the spread of pandemic in the future.

It is observed that the COVID-19 outbreak has accelerated the digitalization processes with Industry 4.0, since organizations aimed to minimize contact among the people during pandemic periods. Accordingly, the COVID-19 outbreak and the Industry 4.0 age trigger each other. The COVID-19 pandemic crisis may reveal important opportunities for companies in the postpandemic period by increasing digitalization and use of technology.