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Stock Market Response to Coronavirus (COVID-19) Pandemic

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Abstract
Since the first day of its emergence, the novel type of coronavirus (COVID-19) has affected many areas of life. The economic and financial effects of the virus were as devastating as the damage it caused to human health. Accordingly, the aim of this study is to investigate the impact of the COVID-19 Pandemic on selected stock markets. Panel Data Analysis with structural breaks was used to identify the relationship between new case/death numbers and stock market indices. According to the results of the Westerlund-Edgerton Cointegration test, a break was observed in each of the stock markets included in the sample. As the break dates caused either positive or negative results in different countries, the prospects for the reasons for breaks formed either positively or negatively. The results of the analyses reveal that a significant worldwide health problem does not only affect social life and real economy, but it also causes decrease in prices in financial markets. Therefore, it may be considered by countries to take early financial measures and form some funds for pandemics. Investors may also allocate a specific portion of their portfolios to safe harbors such as gold and exchanges in this kind of panics.

Keywords: Coronavirus; COVID-19; Stock markets; Financial markets

JEL Classification: G10, G15, C33, C58

1. Introduction

The novel type of coronavirus (COVID-19) emerged in Wuhan, China in December 2019, causing over 60 million deaths in 100 days (Ali et al., 2020: 1). The rapid increase in the number of infections and death caused the World Health Organization (WHO) to declare COVID-19 as a pandemic on March 11, 2020. The word pandemic originates from the Greek language, "pan" meaning "all" and "demos" meaning "people". WHO defines the pandemic as "an outbreak of a new pathogen that spreads easily from person to person worldwide" (Maital and Barzani, 2020: 2). It is not possible to compare the COVID-19 outbreak with other global crises such as the 2008 financial crisis. Coronavirus has a number of new challenges that prevent it from being compared simply to the past. These challenges can be summarized as follows (Fernandes, 2020: 5):

- It is a pandemic.
- It is not focused on low-middle income countries.
- Interest rates are historically low.
- The world is much more integrated.
- The current crisis creates spillover effects across supply chains.
- Supply and demand disruptions occur simultaneously.

These factors, which prevent the coronavirus from being compared with various crises, and the fact that mobility of both the information and the people is quite high, have made

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changes in the operation of the world in many respects in a very short time. Key dates related to the COVID-19 pandemic are summarized in Table 1 (Corbet et al., 2020: 2).

Table 1. Key dates in the Chinese COVID-2019 outbreak

Date	Event
Dec 31, 2019	Cases of pneumonia detected in Wuhan, China were first reported to the WHO. The virus was unknown during this period. According to Wuhan Municipal Health Commission, the cases emerged between December 12 and December 29.
Jan 1, 2020	Chinese health authorities closed the Huanan Seafood Wholesale Market after discovering that wild animals sold there could be the source of the virus.
Jan 5, 2020	China announced that unknown pneumonia cases in Wuhan are not SARS or MERS.
Jan 7, 2020	Chinese officials confirmed that they identified the virus as a new coronavirus, initially called 2019-nCoV by the WHO.
Jan 11, 2020	Wuhan Municipal Health Commission announced the first death caused by the coronavirus. A 61-year-old man exposed to the virus in the seafood market died on January 9 due to respiratory failure caused by severe pneumonia.
Jan 13, 2020	Thai authorities reported a case of infection caused by coronavirus (first cross-border case). The infected individual was a Chinese citizen who had come from Wuhan.
Jan 30, 2020	The WHO declared 2019-nCoV a “Public Health Emergency of International Concern”.
Feb 11, 2020	The WHO announced a new name for the virus: COVID-19.
Mar 11, 2020	The WHO declared COVID-19 a pandemic.

Restrictions were introduced in many countries to reduce/stop the rate of the spread of coronavirus. These restrictions were: suspending formal education and switching to remote education; postponing or canceling events such as concerts, sports competitions, arts activities; reduction of passenger numbers in public transportation; closure of shopping malls, restaurants, entertainment venues; use of masks and gloves; and curfews etc. These restrictions and prohibitions not only affected social life but also started to have profound effects on national economies. Karabag (2020: 1) states that although the coronavirus is generally described as a period of instability, uncertainty and danger, this crisis will also have beneficial contributions to accelerate the spread of digital technologies and micro-level initiatives.

Although the pandemic has a severe impact on the real economy, the real impact of the outbreak is not yet known. McKibbin and Fernando (2020: 49) estimated the effect of the pandemic on countries' GDP in seven different scenarios (Table 2). The values shown in Table 2 indicates the change in GDP in 2020 as a percentage change from the baseline. Scenarios 01-03 are reflections of the economic and financial impact of the situation on other countries due to the isolation of epidemiological events in China. Scenarios 04-06 constitute those in which epidemiological shocks occur to different degrees in all countries of the world. Scenario 07 assumes that the future is uncertain and that the pandemic will be repeated mildly each year. When the scenarios in question are analyzed, it is observed that there are significant decreases in GDP especially in Scenario 06; that is, when all the countries experience a high level of virus effect. The GDP loss in 2020 will be $2,330 billion according to Scenario 04, $5,305 billion according to Scenario 05 and $9,170 billion according to Scenario 06.

As of the end of March 2020, partial or full lockdowns have been carried out in more than 100 countries worldwide, and air and intercity travel, affecting billions of people in big cities worldwide, has decreased by 70-90% compared to March 2019 (Dunford et al., 2020). Baldwin and Weder di Mauro (2020: 1) state that COVID-19 has caused a global economic disruption, claiming that it can be economically contagious as much as it is medically so. The spread of the virus resulted in stock market crashes, increased financial volatility, decreased nominal interest rates, and caused shrinkage in real economic activities as reflected in real GDP (Barro et al., 2020: 2). In order to cope with the economic damage of the virus, governments, finance ministries and central banks have prepared support and incentive packages (Ashraf, 2020: 1).

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Table 2. GDP loss in 2020 (% deviation from baseline)

Country/Region	S01	S02	S03	S04	S05	S06	S07
Australia	-0.3	-0.4	-0.7	-2.1	-4.6	-7.9	-2
Brazil	-0.3	-0.3	-0.5	-2.1	-4.7	-8	-1.9
China	-0.4	-1.9	-6	-1.6	-3.6	-6.2	-2.2
India	-0.2	-0.2	-0.4	-1.4	-3.1	-5.3	-1.3
France	-0.2	-0.3	-0.3	-2	-4.6	-8	-1.5
Germany	-0.2	-0.3	-0.5	-2.2	-5	-8.7	-1.7
South Africa	-0.2	-0.2	-0.4	-1.8	-4	-7	-1.5
Italy	-0.2	-0.3	-0.4	-2.1	-4.8	-8.3	-2.2
Japan	-0.3	-0.4	-0.5	-2.5	-5.7	-9.9	-2
United Kingdom	-0.2	-0.2	-0.3	-1.5	-3.5	-6	-1.2
Mexico	-0.1	-0.1	-0.1	-0.9	-2.2	-3.8	-0.9
Canada	-0.2	-0.2	-0.4	-1.8	-4.1	-7.1	-1.6
Argentina	-0.2	-0.3	-0.5	-1.6	-3.5	-6	-1.2
Russia	-0.2	-0.3	-0.5	-2	-4.6	-8	-1.9
Saudi Arabia	-0.2	-0.2	-0.3	-0.7	-1.4	-2.4	-1.3
Turkey	-0.1	-0.2	-0.2	-1.4	-3.2	-5.5	-1.2
USA	-0.1	-0.1	-0.2	-2	-4.8	-8.4	-1.5
Indonesia	-0.2	-0.2	-0.3	-1.3	-2.8	-4.7	-1.3
Republic of Korea	-0.1	-0.2	-0.3	-1.4	-3.3	-5.8	-1.3

Although the global economic effects of coronavirus have not been fully evident yet, financial markets have already responded to the virus with dramatic movements (Zhang et al., 2020: 1). In various countries, stock values have fallen excessively and market volatility has skyrocketed. The effect of the virus in the international capital markets was evident on March 9, 2020, with the value loss of about 10% of the important stock indices in one day. Such a decrease has been the highest daily decrease since September 11, 2001 (Daube, 2020: 2). Following the outbreak of the virus, an extraordinary decrease of 30% was observed in the EU and US stock markets (Gormsen and Koijen, 2020: 2). In the USA, market volatility in mid-March 2020 reached or exceeded the levels experienced in October 1987, December 2008, and 1929-1930 (Baker et al., 2020: 1; Sharif et al., 2020: 1). Figure 1 shows the volatility of the S&P 500 adjusted closing price series between 1900-2020 on the dates indicated.

Goodell (2020) provides comprehensive literature research on the economic effects of natural disasters such as nuclear wars, climate change or local disasters, and emphasizes that the COVID-19 outbreak has caused unprecedented devastating economic damage on global scale. He states that the pandemic can have a wide impact on financial markets, banking and insurance sector and is a promising area for future research. Liu et al. (2020) state that the WHO and public health officials play an intermediary role in communicating the pandemic risk to investors, and this has shaped investor behaviour towards the disease. Investor sentiment affects markets significantly. Investors behave in a more optimistic way when the market is up and the perceived risk is low. With the market downstream, investor sentiment becomes relatively pessimistic and investors wait to enter the market until a recovery begins. Such situations lead to the overreaction of the short-term investor (Liu et al., 2020: 2). Excessive and sudden reactions by investors in return cause events such as volatility increase and price changes in markets. Accordingly, in this study, the impact of the COVID-19 outbreak on financial markets was examined by considering the markets of the top ten countries where the virus was most intense for the period between February 12 and May 15, 2020. The introduction section discusses the importance and motivation of the study, and the current and potential effects of COVID-19. In the literature review section, studies examining the effect of the virus on assets and markets are provided in addition to a summary of the studies examining the relationship between COVID-19 and financial markets. In the analysis and method section, the data set, variables, hypothesis and research model of the study are introduced and the methods applied within the framework of econometric analysis are explained theoretically together with the reasons for using them. In the findings section, analysis results are explained and important dates are interpreted in detail on country basis. The study is concluded with the conclusion section where the findings are critiqued and policy recommendations are made.

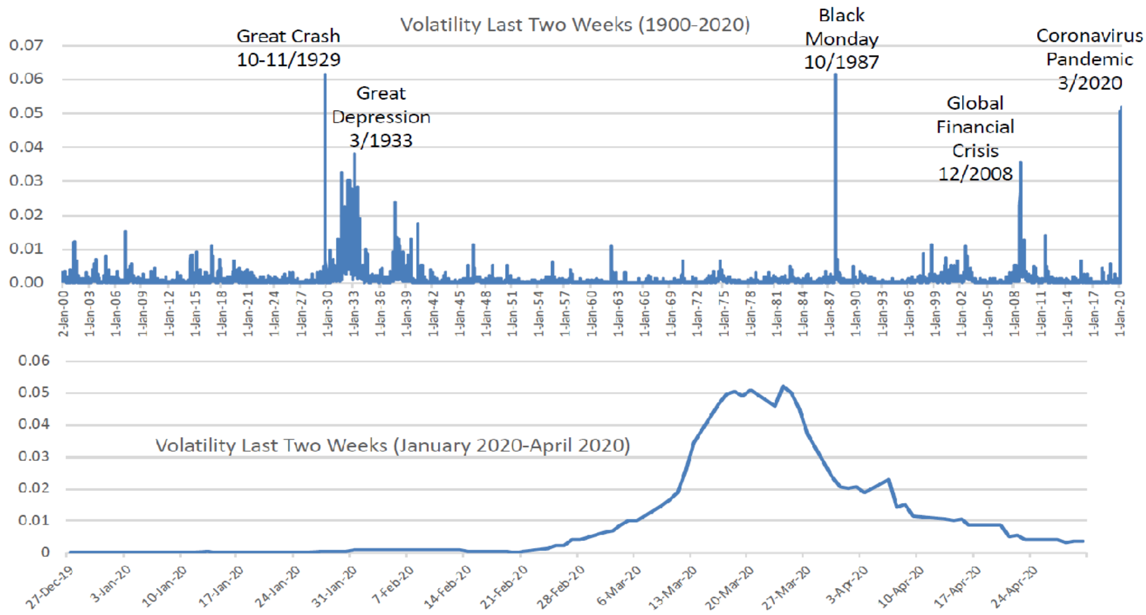

Figure 1. Realized U.S. Stock Market Volatility (Baker, 2020: 17)

2. Literature Review

It is incontestable that COVID-19 has not only health effects, but also economical and financial effects. While the vaccine/drug studies for the treatment of the pandemic by scientists gain steam, academic studies and literature in other branches of science are rapidly expanding. When studies on the effects of COVID-19 on economy and finance sector are analysed, it is observed that the effects of the pandemic on the banking sector (Cecchetti and Schoenholtz, 2020), monetary policy (Cochrane, 2020), oil prices (Arezki and Nguyen, 2020), gold and crypto coins (Corbet et al. ., 2020), world economy (Fernandes, 2020), supply and demand in trade (Baldwin and Tomiura, 2020), labor supply and GDP loss (McKibbin & Fernando, 2020), emerging market economies' exchange rates and bond markets (Hoffman et al. ., 2020), the petroleum and aviation industry (Mhalla, 2020), and market volatility (Papadamou et al., 2020) have been examined and estimates regarding the potential effects of the outbreak have been made.

As in the case of previous pandemics, financial markets immediately responded to coronavirus. The economic costs caused by the disease is the apparent indication that pandemics affect financial systems. There have been a number of articles examining the costs of past pandemics, such as the HIV/AIDS crisis, as well as the estimations on the costs of future pandemics (Goodell, 2020: 1). During pandemics, investors may tend to panic and display irrational behaviour. This trend may cause investors to move away from relatively risky exchanges and turn to assets that provide guaranteed returns. Therefore, escaping financial markets may cause excessive volatility in stock market indices. Studies examining the interaction of COVID-19 with financial markets have generally focused on the relationship between the number of cases and deaths caused by the virus, and the decline and volatility in exchanges. Ali et al. (2020) investigated the decline and volatility after COVID-19 and found that there were decreases in market indices in the later stages of the virus in China, which had been rather stable before the virus. It was determined that the markets were panic-stricken and the situation in the markets have worsened with the announcement of the pandemic. The authors provided evidence that negative returns were experienced even in safer commodities such as gold. Liu et al. (2020), which examined the short-term effect of COVID-19 in the world's leading stock exchanges, used the event study method in their studies. As a result of the analysis, they found that the effect of the disease is noteworthy, directly affecting world stock markets. It is among the findings that stock markets experienced rapid declines in the countries affected by the virus and the negative abnormal returns in Asian countries are higher than those in other countries. Papadamou et al. (2020) examined the impact of COVID-19-originated volatility in 13 world stock markets with the help of Google trend synthetic index. The authors concluded that increased search queries on Google have a direct impact on volatility, and this effect is stronger on the European stock markets than those in the rest of the world. The findings also showed that Google-based anxiety led to high risk avoidance in stock markets. Examining the effect of the COVID-19 pandemic on stock market risk, Zhang et al. (2020) argued that financial markets have followed an unprecedented dramatic move. Research findings have shown that global financial market risks have increased significantly in response to the pandemic. Individual market reactions have clearly demonstrated the severity of the outbreak in all countries. In addition, the uncertainty of the pandemic and the economic losses caused the markets to become quite volatile and unpredictable. Ashraf (2020), examining the impacts of COVID-19 cases and deaths on financial markets, included in his analysis the data from 64 countries for the January 22-April 17 period. The author, who proved that stock market returns decreased as the number of cases increased, revealed that stock markets reacted more intensely to the increasing number of cases than to the number of deaths. Baker et al. (2020) compared the effects of COVID-19 on the US stock market with the effects of outbreaks experienced in 1918-19, 1957-58 and 1968. The authors argued that the impact of COVID-19 on the stock market was greater than that in previous outbreaks, and that this was due to the government's restrictions on commercial activities as well as restrictions regarding voluntary social distance in a service-based economy.

Studies examining the impact of the pandemic on financial markets are increasing rapidly in the literature. Overall results of the studies reveal that the pandemic has caused great price decreases and volatility increases in world stock markets. To do best of our knowledge, unlike the other studies in the literature, the top 10 countries in which the pandemic was most commonly observed was determined as a sample and the effect of the pandemic on the stock exchanges was analyzed using the multiple structural breaks in panel data analysis method.

3. Methodology and Econometric Analysis

In the analysis section of the research, the relationship between the impact of COVID-19 and the stock market indices of countries will be examined for the top 10 countries (USA, Spain, Russia, Britain, Brazil, Italy, France, Germany, Turkey and Iran) where the virus is most commonly observed. In this section, the data set and model for the variables to be used within the scope of the hypothesis are introduced. Subsequently, following the presentation of the theoretical and conceptual framework of the tests used, analyses carried out are presented. The study is concluded with the interpretation of the findings obtained from the analyses and policy propositions.

3.1. Data Set and Model

In the study, the hypothesis “*There is a long-term relationship with structural breaks between COVID-19 and stock market indices*” is tested. In the analyses, 10 countries -USA, Spain, Russia, Britain, Brazil, Italy, France, Germany, Turkey and Iran- where the COVID-19 cases are the highest in number are included in the sample. Panel data analysis techniques that allow structural breaks are used as the analysis method. Daily data for the period between March 12 - May 15, 2020 were taken as a basis due to data constraints and common data creation purposes. The data on COVID-19 cases and deaths were taken from the Our World in Data website (https://ourworldindata.org/coronavirus-data), and Morgan Stanley Capital International (MSCI) indices were used as stock index data. Since MSCI index data of Iran is not calculated, it is excluded from the scope of the sample.

The model created to test the hypothesis of the study was constructed as in equation 1.

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$$LIND_t = \beta_0 + \beta_1 NC_{it} + \beta_2 ND_{it} + \varepsilon_{it} \quad (1)$$

i=1, 2, 3, ...N shown in the model indicates the cross sectional data, whereas t=1, 2, 3, …..T indicates the time dimension and ε refers to the disturbance term. In the study, stock market index (LIND) is modelled as a dependent variable. The number of new cases (New Cases-NC) and the number of new deaths (New Deaths-ND) identified in the countries as an indicator of the virus were used as independent variables in the model.

No control variable was used in the model, since the relationship of COVID-19 with financial markets was analysed in the study. Socio-economic developments in the economies of countries and global fluctuations can directly and indirectly affect stock indices. Investors invest in financial markets based on global developments and opportunities arising in countries. It is thought that global shocks like COVID-19 could affect these investments. Therefore, under the assumption that other variables are constant in the specified time interval, the impact of COVID-19 on stock market indices is analysed through structural breaks tests.

Logarithms are calculated for stock market index data that is used as the dependent variable in the model and they were used in the analyses. No logarithmic change was performed in the other variables. Taking the logarithms of the variables provides convenience in the interpretation of the analyses. Moreover, another reason for the logarithmic transformation is that the logarithms of the variables are reduced according to the specific base. Taking logarithms on the series does not cause any data loss. Logarithmic transformation also decreases autocorrelation problem and increases the normal distribution of the series (Dirican and Canoz, 2017: 383).

3.2. Econometric Method

Panel Data Analysis techniques, which take into account structural breaks, are employed in the study as an econometric method and below is the list of the tests used in chronological order:

- CD_{lm1} of Berusch-Pagan (1980) and LM_{adj} test of Pesaran et al. (2008) for the analysis of the existence of cross-sectional dependence of variables,
- Panel LM test developed by Im-Lee-Tieslau (2010) to determine whether the variables included in the model contain unit roots,
- Delta test developed by Pesaran and Yamagata (2008) to determine the homogeneity or heterogeneity of the variables,
- Cointegration Test with Multiple Structural Breaks, developed by Westerlund and Edgerton (2008) to determine the presence of cointegration relationship between the variables included in the model,
- For cointegration coefficients of variables, CCE estimator developed by Peseran (2006).

3.2.1. Cross Sectional Dependence Test

The dependency between countries has increased even more due to global effects. A positive or negative development in a country could affect other countries or commercial partners due to global effects. Due to the stated reasons, in econometric studies, cross sectional dependence tests are required to measure the impact of the shock in one country on other countries, making it possible to measure the interaction between countries.

When studies on cross sectional dependence are examined; Philips and Sul (2003), Andrews (2005) and Peseran (2006) stated that if the cross-sectional analysis is not performed, the findings in the studies will produce inconsistent and deviating results. According to Breusch-Pagan (1980) and Pesaran (2004), in studies where cross-sectional dependency is determined, all analyses should be carried out accordingly.

The tests used in determining the cross-sectional dependence can be shown as follows:

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- When the time dimension is greater than the cross section dimension (T> N); via Berusch-Pagan (1980) CD_{lm1} test
- When the time dimension is equal to cross section dimension (T=N); via Pesaran (2004) CD_{lm2} test,
- When the time dimension is less than the cross section dimension (T<N); via Pesaran (2004) CD_{lm} test,
- When the time dimension is greater (T>N) or less (T<N) than the cross section dimension, via the (LM_{adj}) test of Pesaran et al. (2008)

Since MSCI index data of the Iranian market has not been calculated, the analyses have been performed for 9 countries. For this reason, N, indicating the cross section dimension is taken as 9. The time dimension (T) is 47, as daily data for the periods between March 12 - May 15, 2020 are used. Since T>N, Berusch-Pagan (1980) CD_{lm1} test and the test (LM_{adj}) of Pesaran et al. (2008) are used in the analyses.

Table 3. Cross sectional dependence test results

Variables	CD Tests	CD_{lm1} (BP, 1980)	CD_{lm2} (Pesaran, 2004)	CD (Pesaran, 2004)	LM_{adj} (Pesaran et al., 2008)
LIND	T-statistics	749.8083*	83.06245*	24.60252*	82.96462*
	Probability Value	0.0000	0.0000	0.0000	0.0000
NC	T-statistics	516.3984*	55.55483*	5.466083*	55.45701*
	Probability Value	0.0000	0.0000	0.0000	0.0000
ND	T-statistics	514.1340*	55.28797*	14.36958*	55.19014*
	Probability Value	0.0000	0.0000	0.0000	0.0000

Notes: *, ** and *** indicate that there is a dependency between the sections at the significance level of 1%, 5% and 10%, respectively.

Considering the countries included in the model and the time dimension, a decision can be made according to the results of CD_{lm1} and LM_{adj} since it is T> N. In the cross-sectional dependency tests, the results of the LM_{adj} test are generally taken into account, since the CD_{lm1} test can yield deviating results. When Table 3 showing the results of the cross-sectional dependency test is examined, it is seen that the probability values of all variables are less than .01. Therefore, according to the results of LM_{adj}test, there is cross-sectional dependency between the countries.

This is compatible with today's global world and can be interpreted as an indication that a shock effect that may arise in one of the 9 countries where COVID-19 is most influential will take hold of other countries as well. Therefore, the leaders and decision-makers of the countries included in the analyses must steer into the future considering the status quo.

3.2.2. Panel Unit Root Test

In econometric studies, one of the main goals of unit root tests is to eliminate the spurious regression problem. Granger and Newbold (1974) state that no real results can be obtained from the analysis with unit rooted series. Gujarati (1999) measures the stationarity of the series as follows: if the variance and mean of a series does not change with time and if the covariance between two periods is not dependent on the period of this covariance but the interval between the two periods, it is considered stationary.

The main point to be considered in the stationary tests of panel data analysis is whether the countries included in the model are independent from each other. In this context, unit root tests of panel data analysis consist of first and second generation tests. While the first generation of unit root tests do not take into account cross-section dependency, the second generation tests perform their analysis according to cross-section dependency. In today's global world, the fact that the shock experienced in one of the countries that constitute the panel affects other countries as well is more realistic and the use of the second generation tests utilized in the literature is therefore interpreted as a more realistic approach.

In the second generation unit root tests, the use of unit root tests, which allows structural breaks due to the impact of global developments, yields much more effective results. Especially in series, which are very sensitive to changes in the economy such as foreign trade, exchange rate, stock market index, foreign capital etc., structural breaks are experienced from time to time. If static tests are performed without considering structural breaks, significant deficiencies in panel dimension and series can be observed (Im et al., 2010: 1). Therefore, panel unit root tests, which take into account structural breaks, were used to test the stationarity of variables that can be simply affected by cyclical fluctuations such as the stock index, which is the dependent variable of the study. Panel LM unit root tests with structural breaks were applied to the series of variables used through the model established in the study.

The panel LM test, developed by Im et al. (2010), tests the series in level and trend models, as one break and two breaks. The LM test statistic is used to test the "unit root exists" hypothesis, which is formulated as $\phi i = 0$. What makes the test superior to other unit root tests is that it allows different break times from different countries. The asymptotic distribution of the test is the standard normal distribution and is not affected by the presence of structural breaks.

According to the model that allows two structural breaks, the stationarity analysis results of the series in the 9 countries are given in Table 4. When the data in the table is interpreted;

- It is observed that, while all variables for the overall panel are unit-root in level values for the model that allows breaks in the fixed, they become stationary when the difference is entered into the model. In other words, since the series is stationary at I (1) level for the overall panel, it can be said that the assumption for the cointegration test is met.
- When evaluated on a country basis, according to Table 4:
    - While the stock exchange index variable is only stationary in France in terms of level value, it is stationary in England and Italy in the series for which difference is taken.
    - While the number of new cases variable (NC) is stationary at level only in Italy, in US, Spain, Italy and Turkey, it is stationary in the series for which the difference is taken.
    - While the number of new deaths (NC) is stationary level at the US, Russia, Italy, France and Turkey, all countries are unit root in the series difference of which are taken.

3.2.3. Homogeneity Test for Cointegration Coefficients

In panel data studies, whether coefficients change between units, that is, homogeneity, is very important for determining the relationship between the variables included in the model. In addition, findings obtained as a result of homogeneity test will be an indicator in other stages of the analysis.

In the literature, Pesaran and Yamagata (2008) have developed the Delta test put forward by Swamy (1970) to determine whether the slope parameters of cross-sections are homogeneous. According to this test, the null hypothesis states that the "slope coefficients are homogeneous." Homogeneity indicates that the slope coefficients are the same for all units, while heterogeneity shows that the slope coefficient of at least one of the units is different.

According to the Delta test results related to the model established in the study, the slope coefficients among the units do not change in the long term because the probability values of both test statistics are greater than .05. In other words, it is concluded that the variables are homogeneous.

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Table 4. Results of panel LM unit root tests with structural breaks

Countries	LIND	ΔLIND	NC	ΔNC	ND	ΔND
United States	-1.533 (10) [9.04.2020 - 16.04.2020]	-3.661 (6) [7.04.2020 - 16.04.2020]	0.104 (9) [22.04.2020- 27.04.2020]	-8.229 (0)* [6.04.2020- 24.04.2020]	-6.797 (6)* [15.04.2020- 23.04.2020]	-3.185 (4) [9.04.2020- 30.04.2020]
Spain	-2.292 (10) [17.04.2020 - 4.05.2020]	-2.387 (10) [30.03.2020 - 5.05.2020]	-1.251 (10) [3.04.2020 - 14.04.2020]	-8.170 (0)* [9.04.2020- 28.04.2020]	-0.885 (9) [15.04.2020- 27.04.2020]	0.385 (7) [1.05.2020- 3.05.2020]
Russia	-0.991 (8) [2.04.2020- 10.04.2020]	-0.814 (6) [21.04.2020 - 27.04.2020]	-2.152 (7) [23.04.2020 - 1.05.2020]	--0.084 (10) [31.03.2020- 4.05.2020]	-6.035 (6)* [15.04.2020- 23.04.2020]	-3.937 (6) [30.04.2020- 4.05.2020]
United Kingdom	-2.079 (3) [20.04.2020 - 24.04.2020]	-16.933 (2)* [15.04.2020 - 17.04.2020]	-2.497 (10) [6.04.2020- 1.05.2020]	-1.621 (6) [15.04.2020- 20.04.2020]	-1.758 (4) [1.04.2020- 22.04.2020]	-1.591 (5) [3.04.2020- 29.04.2020]
Brazil	--0.730 (6) [15.04.2020 - 17.04.2020]	0.375 (6) [6.04.2020 - 8.04.2020]	-0.889 (9) [31.03.2020- 16.04.2020]	-1.769 (8) [13.04.2020- 27.04.2020]	-1.804 (9) [22.04.2020- 4.05.2020]	-1.320 (5) [20.04.2020- 29.04.2020]
Italy	-3.540 (6) [8.04.2020 - 30.04.2020]	-22.049 (1)* [21.04.2020 - 23.04.2020]	0.807 (10)* [6.04.2020- 13.04.2020]	-7.097 (0)* [30.03.2020- 14.04.2020]	-6.073 (6)* [15.04.2020- 23.04.2020]	-1.556 (5) [30.03.2020- 15.04.2020]
France	-6.446 (0)* [1.04.2020 - 15.04.2020]	0.381 (7) [1.04.2020 - 21.04.2020]	1.836 (7) [30.03.2020- 1.04.2020]	-1.667 (9) [1.04.2020- 28.04.2020]	-5.449 (0)* [16.04.2020- 28.04.2020]	-0.312 (6) [10.04.202 0-16.04.2020]
Germany	-2.466 (9) [10.04.2020 - 5.05.2020]	-1.828 (7) [14.04.2020 - 16.04.2020]	-4.154 (10) [31.03.2020- 24.04.2020]	0.946 (9) [7.04.2020- 28.04.2020]	-3.111 (10) [23.04.2020- 30.04.2020]	-1.864 (3) [15.04.2020- 18.04.2020]
Turkey	-2.908 (10) [2.04.2020 - 22.04.2020]	0.339 (10) [27.04.2020 - 1.05.2020]	-2.117 (10) [13.04.2020- 22.04.2020]	-6.325 (9)* [2.04.2020- 30.04.2020]	-5.897 (6)* [15.04.2020- 23.04.2020]	-2.489 (10) [2.04.2020- 17.04.2020]
	Panel CA - LM Test Statistics: 0.942 P-Value:0.827	Panel CA - LM Test Statistics: -7.799 P-Value:0.000*	Panel CA - LM Test Statistics: 2.964 P-Value:0.998	Panel CA - LM Test Statistics: 2.515 P-Value:0.006**	Panel CA - LM Test Statistics: -0.268 P-Value:0.394	Panel CA - LM Test Statistics: -6.680 P-Value:0.000*

Notes:
1. The critical values are taken from Im, Lee and Tieslau (2010).
2. Constant model critical values; two break models; T: 50: * -5.365 (1%); ** - 4.6613.950 (5%); *** - 4.338 (10%).
3. Maximum delay length was taken as 10 and optimal lag lengths were determined by the "t-stat significance" approach. Values in parentheses indicate lag lengths.
4. Values in square brackets indicate break dates.

Table 5. Homogeneity test results

Test Statistics	T-statistics	Probability Value
Delta_tilde	-0.869	0.807
Delta_tilde_adj	-0.897	0.815

Notes: *, ** and *** indicate that the coefficients of the panel are heterogeneous at 1%, 5% and 10% significance levels, respectively.

3.2.4. Testing for Panel Cointegration with Structural Breaks

In order to obtain significant results in econometric studies, the variables included in the model should be stationary at the same level, in other words, they need to be cointegrated. Different methods are used to determine the existence of the cointegration relationship between the variables. These can be categorized as first generation tests and second generation tests. While the first generation tests do not take into account cross sectional dependence, analyses in second generation tests are carried out according to cross sectional dependence. Second generation tests take into account cross-sectional dependence but do not include structural breaks in the model (Koç and Sarıca, 2016: 42). In cointegration analysis, it is crucial to carry out the tests taking into account structural breaks in order to avoid deviating results. Therefore, the panel cointegration test with multi-structural breaks developed by Westerlund and Edgerton (2008) was used as the series on the panel was stationary at level I (1).

The panel cointegration test of Westerlund and Edgerton (2008) was developed from unit root tests obtained by many repeats (bootstrap) on the basis of the Lagrange Multiplier (LM). The main strengths of this test can be summarized as follows:

- It takes into account cross-sectional dependence and structural breaks.
- It allows heteroscedasticity and autocorrelation.
- It shows the breaks in different dates for each country at fixed term and slope.
- With the totally corrected least squares estimators, the potential problems of internality in the model are solved.
- This test also yields effective results in small samples.

Westerlund and Edgerton Panel Cointegration tests were preferred due to their above-stated strengths and the limited number of countries included in the sample as well as the limited time interval.

When Table 6, which illustrates the results of Westerlund-Edgerton Cointegration Test, is examined, it is decided whether there is a cointegration relationship between the variables based on the significance level of the probability values. When the test results are examined, it is observed that the cointegration relationship between the variables included in the model is 1% in the model without breaks and 5% in the model with structural breaks where there is a change in the level. Breaks were seen in all countries over a period and their interpretations were made over these periods. In the regime change model, no cointegration relationship was found.

When the structural breaks in the countries included in the analysis within the scope of the cointegration relationship observed in the level change model are analyzed, it is seen that the developments experienced in local and global scales generally cause breaks. It is estimated that the effects of the developments seen on the break dates on the markets caused significant breaks. According to the information obtained from local press of the countries included in the sample, these break dates can be interpreted as follows:

- In the USA, on April 7th, 2020, the stock market had its day with highest premium since the outbreak due to the financial measures taken as a result of COVID-19 death rates falling in New York.
- On March 3, 2020 in Spain, Deputy Prime Minister Carmen Calvo was hospitalized due to COVID-19, revealing the seriousness of the virus and creating uneasiness in the markets.
- Russia closed its borders to the outside world as of the end of March.
- On April 15, 2020, the number of people who died in England due to COVID-19 exceeded 16,000 and it was revealed that the number of deaths in nursing homes had not been

included in the actual death toll. It was stated that the toll would have increased by 15% if the number of those who died in nursing homes were added.

- In Brazil, there was a sudden leap in the number of deaths on April 8, 2020, and with the increase in the number of cases, Brazil became one of the countries most affected by the virus. In the country where 881 people lost their lives in one day, the public protests against the head of the state started to increase on the specified date.
- After a long period of decrease in the number of cases and deaths in Italy, it is seen that the number of deaths caused by the mitigation of the measures increased and 474 people died in one day.
- In France, Prime Minister Edouard Philippe declared, on April 10, 2020 that the measures taken were insufficient and that stricter measures would be taken within the next 15 days. This situation created uneasiness and fear both in the markets and among the public.
- Wearing a mask was made obligatory in all states in Germany on April 27, 2020. Moreover, it was observed that the effects of the virus decreased on the date specified throughout the country.
- May 4, 2020 is the date that when the number of patients recovering exceeded the number of daily cases for the first time in Turkey, and this was interpreted as the success of the measures taken.

Table 6. Westerlund-Edgerton Cointegration Test

Definition	Test	Statistical Value	Asymptotic Probability Value
No-Break	LM_tau	-8.19266	0.0000*
	LM_phi	-14.52622	0.0000*
Change in Level	LM_tau	-2.47645	0.00663**
	LM_phi	-3.80577	0.00007*
Regime Change	LM_tau	1.06403	0.85634
	LM_phi	1.06410	0.85636
Countries	**Break Dates**		
United States	7.04.2020		
Spain	23.03.2020		
Russia	1.04.2020		
United Kingdom	15.04.2020		
Brazil	8.04.2020		
Italy	21.04.2020		
France	10.04.2020		
Germany	27.04.2020		
Turkey	4.05.2020		

- Notes:
- 1. The *, ** and *** symbols indicate significance levels at the 1%, 5% and 10%, respectively.
- 2. Break dates are determined by considering the Change in Level.

3.2.4. Panel Cointegration Coefficients Estimator: CCE and AMG

CCE and AMG estimators are generally used for estimating long-term coefficients of models in the analysis where cointegration relationship is observed in econometric studies. The CCE (Common Correlated Effects) estimator, developed by Peseran (2006), makes predictions considering cross-section dependency under the assumption of homogeneity and heterogeneity in which the variables included in the model are not stationary in their level values. In the AMG (Augmented Mean Group) estimator, the level of cointegration of the variables included in the model does not necessarily have to be the same, whereas horizontal cross-section dependency is taken into account and the estimation of different coefficients for cross-sectional equations is performed under the assumption of heterogeneity (Acaravcı et al., 2015: 125).

Peseran (2006) developed two estimators: the average and pooled CCE estimators. The average estimator is an approach based on the mean of the coefficients of the units. Pooled CCE, on the other hand, was developed on the estimation of the coefficients of the explanatory variables of the units. It was concluded in the study that the variables were homogeneous since the slope coefficients did not vary among the units in the long run, according to the results of the Delta test. The CCE estimator achieves the results using the "pooled estimator" through the Stata program, assuming that the coefficients are homogeneous. This approach utilizes standard panel regression. In this type of regression, the cross-sectional means of the dependent variable and the explanatory variables of the units are taken as regressors. This has shown that the CCE estimators perform very well even in the case of small samples. Moreover, CCE is an estimator that can yield results providing consistent and asymptotic normal distribution, whether the time dimension is greater or smaller than the cross-sectional dimension, and can calculate long-term equilibrium values for the cross-section units separately.

Table 7. Estimation results for panel cointegration coefficients

Independent Variables	CCE Estimator Coefficient	Standard Error	Probability
NC	-3.3e+10	8.7e+10	0.708
ND	-9.1e+09	1.1e+12	0.993

Notes: *, ** and *** show that the coefficients are statistically significant at the 1%, 5% and 10% significance levels, respectively.

In the study, in which the relationship between COVID-19 and stock market indices is analysed, it is seen that the coefficients of the variables with long-term cointegration relationship are statistically insignificant according to CCE estimators. Therefore, estimations for the stock market index cannot be performed based on the coefficients of the variables of the number of new cases and the number of new deaths, which are among the indicators of COVID-19.

4. Conclusion

The novel coronavirus emerged in the Wuhan province of China through the end of 2019 and rapidly spread around many countries of the world. The rapid spread of the virus and the geometrical increase in the numbers of cases and deaths caused COVID-19 to be declared a pandemic by the WHO. The declaration of the pandemic led to a panic atmosphere in world economies and traumatic falls in stock markets. Compared to earlier financial crises, decreases similar to those experienced in 1929-1930, October 1987, and December 2008 were observed, and in some cases the decreases exceeded those in the mentioned crises. Besides the collapse experienced in financial markets, increases in financial volatility occurred. In this direction, this study tested the effect of the coronavirus on financial markets using panel data analysis with multiple structural breaks. The sample included data from the stock markets of the 10 countries most affected by the virus.

According to the results of the change in the level model of the Westerlund-Edgerton Cointegration Test, one break was observed in each of the stock markets included in the sample. When the break dates are analysed, it was observed that the decrease in death toll and financial measures caused the day with the highest return since the beginning of the pandemic in the USA; that Spanish markets experienced uneasiness due to the declaration of the infection of the vice prime minister; that Russia closed its borders; that the number of deaths in nursing homes in the UK was not added to the total death toll; that Brazil became one of the countries with the biggest number of deaths with the sudden increase in the number of cases and deaths; that the number of deaths increased once again in Italy with the decrease of measures; that the French prime minister announced harsher measures; that wearing masks was made compulsory in all the states of Germany; and that the number of discharged patients exceeded that of new cases for the first time in Turkey. According to the results of the cointegration test, there were separate break dates for the market of each country and the critical incidents on these dates were summarized above. As the break dates caused either positive or negative results in different countries, the prospects for the reasons for breaks formed either positively or negatively.

The findings from the current study hold significance for countries, regulators, and investors. The results of the analyses reveal that a significant worldwide health problem does not only affect social life and real economy, but it also causes panic, fear, increase in volatility and decrease in prices in financial markets. Therefore, it may be considered by countries to take early financial measures and form some funds for pandemics. As a matter of fact, many developed countries offered their citizens financial measure packages in the scope of a struggle against the pandemic. It may be aimed by market regulators to focus on solutions that may mitigate the panic atmosphere in markets, thereby decreasing the high volatility. In severe panic atmospheres in financial markets, it may help investors to direct their investment portfolios to sectors and companies operating in industries targeting solutions against the panic and basic needs, thereby transforming the crisis into an opportunity for themselves. Besides, international investors may avoid high financial loss by inclining towards the markets of developed countries where financial measures are strong and by leaning towards specific sectors. Investors may also allocate a specific portion of their portfolios to safe harbours such as gold and exchanges in this kind of panics.

In future research, analyses may be conducted using structural break tests based on country or sector. Furthermore, since the continuation of the pandemic means continuous update of data, similar research will also contribute to the existing literature.

References

Acaravcı, A., Bozkurt, C., Erdoğan, S. (2015), "MENA Ülkelerinde Demokrasi-Ekonomik Büyüme İlişkisi", *İşletme ve İktisat Çalışmaları Dergisi* 3(4): 119-129.

Ali, M., Alam, N., Rizvi, S.A.R. (2020), "Coronavirus (COVID-19) - An pandemic or pandemic for financial markets", *Journal of Behavioral and Experimental Fin*ance 27 (100341): 1-6.

Andrews, D.W.K. (2005), "Cross-Section Regression with Common Shocks", Econometrica, 73(5): 1551-1585.

Arezki, R., Nguyen, H. (2020), "Novel coronavirus hurts the Middle East and North Africa through many channels", Baldwin, R. and Weder di Mauro, B. (Ed.), *Economics in the Time of COVID-19,* London: CEPR (Centre for Economic Policy Research) Press, London, 53-58.

Ashraf, B.N. (2020), "Stock markets' reaction to COVID-19: Cases or fatalities?", *Research in International Business and Finance* 54 (101249): 1-7.

Baldwin, R., Tomiura, E. (2020), "Thinking ahead about the trade impact of COVID-19", Baldwin, R. and Weder di Mauro, B. (Ed.), *Economics in the Time of COVID-19,* London: CEPR (Centre for Economic Policy Research) Press, London, 59-71.

Baldwin, R., Weder di Mauro, B. (2020), *Economics in the Time of COVID-19,* CEPR (Centre for Economic Policy Research) Press, London.

Baker, S.R., Bloom, N., Davis, S.J., Kost, K.J., Sammon, M.C., Viratyosin, T. (2020), "The Unprecedented Stock Market Impact of COVID-19", working paper, National Bureau of Economic Research, April.

Barro, R. J., Ursua, J. F., Weng, J. (2020), "The coronavirus and the great influenza pandemic: lessons from the "Spanish Flu" for the coronavirus's potential effects on mortality and economic activity", working paper, National Bureau of Economic Research, April.

Breusch, T.S., Pagan, A.R. (1980), "The Lagrange Multiplier Test and Its Applications to Model Specification in Econometrics", *Review of Economic Studies* 47(1): 239-253.

Cecchetti, S.G., Schoenholtz, K.L. (2020), "Contagion: Bank runs and COVID-19", Baldwin, R. and Weder di Mauro, B. (Ed.), *Economics in the Time of COVID-19,* London: CEPR (Centre for Economic Policy Research) Press, London, 77-80.

Cochrane, J.H. (2020), "Coronavirus monetary policy", Baldwin, R. and Weder di Mauro, B. (Ed.), *Economics in the Time of COVID-19,* London: CEPR (Centre for Economic Policy Research) Press, London, 105-108.

Corbet, S., Larkin, C., Lucey, B. (2020), "The contagion effects of the COVID-19 pandemic: Evidence from gold and cryptocurrencies", *Finance Research Letters* 35(101554): 1-7.

Daube, C.H. (2020), "The Corona Virus Stock Exchange Crash", working paper, ZBW – Leibniz Information Centre for Economics, Kiel, Hamburg.

Dirican, C., Canöz, İ. (2017), "Bitcoin Fiyatları İle Dünyadaki Başlıca Borsa Endeksleri Arasındaki Eşbütünleşme İlişkisi: ARDL Modeli Yaklaşımı İle Analiz", *Journal of Economics, Finance and Accounting* 4(4): 377-392.

Dunford, D., Dale, B., Stylianou, N., Lowther, E., Ahmed, M., Arenas, Idl.T. (2020), "Coronavirus: The World in Lockdown in Maps and Charts." *BBC News*, 7 April, https://www.bbc.com/news/world-52103747.

Fernandes, N. (2020), "Economic Effects of Coronavirus Outbreak (COVID-19) on the World Economy", Available at SSRN 3557504.

Goodell, J.W. (2020), "COVID-19 and finance: Agendas for future research", *Finance Research Letters* 35(101512): 1-5.

Gormsen, N.J., Koijen, R.S.J. (2020), "The Corona Virus, the Stock Market's Response, and Growth Expectations", working paper, Becker Friedman Institute, March.

Granger, C.W.J., Newbold, P. (1974), "Spurious Regressions In Econometrics", *Journal of Econometrics*, 2(2): 111-120.

Gujarati, D.N. (1999), *Temel Ekonometri*, Şenesen, Ü., Şenesen, G.G. (translated), Literatür Yayınları, İstanbul.

Hofmann, B., Shim, I., Shin, H.S. (2020), "Emerging Market Economy Exchange Rates and Local Currency Bond Markets Amid the Covid-19 Pandemic." BIS Bulletin No. 5, Bank for International Settlements, Basel.

Im, K.S., Lee, J., Tieslau, M. (2010), "Panel LM Unit Root Tests with Trend Shifts", working paper, FDIC Center for Financial Research, No. 2010-1.

Karabag, S. F. (2020), "An Unprecedented Global Crisis! The Global, Regional, National, Political, Economic and Commercial Impact of the Coronavirus Pandemic", *Journal of Applied Economics and Business Research* 10(1): 1-6.

Koç, A., Sarıca, D. (2016), "Seçilmiş OECD Ülkelerinde Neo-Liberal Dönemde Emek Gelirlerinin Payı ile Sendikal Örgütlenme Düzeyi Arasındaki İlişkinin Analizi", *Journal of Current Researches on Business and Economics* 6(2): 29-56.

Liu, H.Y., Manzoor, A., Wang, C.Y., Zhang, L., Manzoor, Z. (2020), "The COVID-19 Outbreak and Affected Countries Stock Markets Response", *International Journal of Environmental Research and Public Health* 17(2800): 1-19.

Maital, S., Barzani, E. (2020), "The global economic impact of COVID-19: Summary of research", Haifa, Israel: Samuel Neaman Institute for National Policy Research.

McKibbin, W., Fernando, R. (2020), "The Global Macroeconomic Impacts of COVID-19: Seven Scenarios", CAMA working paper, The Australian National University, February.

Mhalla, M. (2020), "The Impact of Novel Coronavirus (COVID-19) on the Global Oil and Aviation Markets," *Journal of Asian Scientific Research* 10(2): 96-104.

Papadamou, S., Fassas, A.P., Kenourgios, D., Dimitriou, D. (2020), "Direct and Indirect Effects of COVID-19 Pandemic on Implied Stock Market Volatility: Evidence from Panel Data Analysis", MPRA working paper, Munich Personal RePEc Archive, 2 May.

Pesaran, M.H. (2004), "General Diagnostic Tests for Cross Section Dependence in Panels", working paper, CESifo Working Paper Series No. 1229, IZA Discussion Paper No. 1240.

Pesaran, M.H. (2006), "Estimation and Inference in Large Heterogeneous Panels with a Multifactor Error Structure", *Econometrica* 74(4): 967-1012.

Pesaran, M.H., Ullah, A. and Yamagata, T. (2008), "A Bias-Adjusted LM Test of Error Cross-Section Independence", *Econometrics Journal* 11: 105-127.

Pesaran, M.H., Yamagata, T. (2008), "Testing Slope Homogeneity in Large Panels", *Journal of Econometrics* 142: 50-93.

Phillips, P.C.B., Sul, D. (2003), "Dynamic Panel Estimation and Homogeneity Testing Under Cross Section Dependence", *Econometrics Journal* 6(1): 217-259.

Sharif, A., Aloui, C., Yarovaya, L. (2020), "COVID-19 pandemic, oil prices, stock market, geopolitical risk and policy uncertainty nexus in the US economy: Fresh evidence from the wavelet-based approach", *International Review of Financial Analysis* Vol 70(101496): 1-9.

Swamy, P.A.V.B. (1970), "Efficient Inference in a Random Coefficient Regression Model", *Econometrica* 38(2): 311-323.

Westerlund, J., Edgerton, D.L. (2008), "A Simple Test for Cointegration in Dependent Panels with Structural Breaks", *Oxford Bulletin of Economics and Statistics* 70: 665-704.

Zhang, D., Hu, M., Ji, Q. (2020), "Financial markets under the global pandemic of COVID-19", *Finance Research Letters,* Article in Press.

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