THE EFFECTS OF COVID-19 OUTBREAK ON FINANCIAL MARKETS

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Abstract

The purpose of this paper is to measure the risks posed by the COVID-19 outbreak on financial market indicators, which caused uncertainty and fear all over the world. In the paper, the Fourier KPSS unit root test, which helps to measure structural breaks more precisely by means of the Fourier transformations in time series, the Fourier-SHIN Cointegration Test to determine long-term relationships between time series, and the Fourier Granger Causality Test to determine causality relationships are used. As a result of these tests applied on the daily price series between 31.12.2019 and 01.05.2020, it has been found that in the long term, the COVID-19 outbreak has a significant effect on stock markets, crude oil representing oil markets, and fear index; but no significant effect on Bitcoin which represents money markets. In the short term, it is concluded that COVID-19 has had a significant effect on stock markets, crude oil, fear index, and Bitcoin.

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1. Introduction

Our world has experienced many diseases, wars, and disasters globally and regionally since its formation. Those kinds of events have had some direct and indirect effects on humanity in the short and long term. Although, humanity has tried to minimize the effects of such events with the precautions taken, the effects experienced have been removed to some extent. Even if these effects disappeared or are eliminated, this has taken a great time.

While the effects of regional disasters experienced in the past were felt particularly in that region, nowadays, the events and developments in any region of the world have direct and indirect global effects. Without a doubt, the fact that today's world has become globalized and integrated has a significant share in this. Today, we are fighting the epidemic of COVID-19, which has and will continue to have global effects similar to those in the past. It is useful to give brief information about the epidemic. The new generation coronavirus SARS COV 2 belongs to the same family of dangerous viruses such as MERS and SARS. However, the most crucial feature that distinguishes SARS COV 2 from these viruses is that it can be much more contagious and, therefore, much more deadly. While this virus is known to be widespread among animals, it has gained the feature of spreading between humans as it evolves, and the new disease that emerged with this evolution has been named COVID-19. The first case of the outbreak occurred on December 1, 2019, in Wuhan, the capital of China's Hubei region, and on December 31, this information was confirmed by the China office of the World Health Organization. From December 31, 2019 to January 3, 2020, the total number of cases reached 44, with the first death on January 11, 2020. The World Health Organization obtained information from the Chinese Health Commission indicating that the outbreak occurred in a seafood market in Wuhan city and declared a pandemic on March 11, 2020 as the outbreak turned into a global threat (WHO, 2020)

It is a fact that this epidemic will cause many economic problems, including financial markets. The epidemic continues to spread while this article is written. There is no continent in the world where the case is not seen, and the number of countries where the case is not seen is just a few. It is a mystery exactly how much the outbreak will spread in the future. However, the effects of the outbreak that has and will have on finance and other areas in the future will be of great interest to researchers.

This study considers only the process from the beginning of the outbreak to become a global crisis, until the completion of the study and aims to measure the impact of the outbreak on selected financial markets and to lead to more comprehensive studies on this subject.

It is thought that this globally threatening epidemic will have an impact on financial markets and lead to significant economic problems. Based on the developments in past outbreaks, it is possible to make predictions about the effects of this outbreak.

Even a non-global outbreak has adverse effects on trade, travel, and tourism activities in the regions affected by the epidemic considering the examples experienced in the past. For example, during the HIV and AIDS epidemic, there was a permanent change in consumer behavior, and a worldwide decline in expenditures and domestic demand posed an important challenge for the global economy (Haacker, 2004). Therefore, such long-term outbreaks discourage foreign investments directly and indirectly and negatively affect financial markets. Considering all these explanations, it is clear that global and regional outbreaks in the past brought along some problems. These problems are as follows (Bloom et al., 2018);

- Increase in the health system costs,
- The collapse of the health system as a result of excessive demand for it, and difficulty in dealing with even routine health problems,
- Employment losses,
- Retardation in the touristic activities
- Problems in transportation and education,
- Decreasing mobility in financial markets and experiencing financial losses,
- Slowdown in national and international trade

The adversities similar to those listed above and maybe, even more, will also be seen in the outbreak of COVID-19. Countries should always be prepared to prevent an epidemic and to overcome the problems mentioned above with minimal damage. On the bright side, countries do not have to invest considerable amounts in coping with these problems. (Fan et al., 2018).

COVID-19 has had and will have many possible effects on the financial markets included in this study. The outbreak is likely to pose risks to banks, which are an essential element of the money markets, during the period of the economic downturn due to the possibility of non-performing loans and excessive bank transactions. It is expected that the epidemic will have a long-term impact on companies related to financing and capital costs. As regards the impact of the outbreak on the financial markets, looking at what effects such recent terrorist attacks and disasters have had on the financial markets will help to understand the possible effects of the COVID-19 outbreak we are experiencing (Goodell, 2020). Because, from past to present, a limited number of studies investigated the effects of epidemic diseases on financial markets (Al-Awadhi et al., 2020). In recent studies, it has been determined that such disasters and terrorist events have a short-term impact on financial markets (Brounen and Derwall, 2010).

In the light of these explanations, GDP is expected to decrease by $130 billion in Turkey, and $9.170 billion throughout the world (McKibbin and Fernando, 2020). This situation shows that the global epidemic of COVID-19 harms the global economy on a scale not seen since the Great Depression and will continue to cause considerable damage to individual livelihoods, businesses, industries and the whole economy (Laing, 2020).

2. Literature Review

There are several studies in the literature measuring the impact of diseases and outbreaks on the financial markets. These studies have mostly investigated the effects of outbreaks that arose in the past like SARS, MERS, Ebola, AIDS on financial markets. The number of studies evaluating the impact of COVID-19, which the world is encountering and suffering nowadays on financial markets, is not sufficient. The main reasons behind it are that the epidemic is brand new and the difficulties encountered in reaching enough data to do detailed analyzes. Accordingly, the studies about the current COVID-19 outbreak and past illnesses and outbreaks are stated below.

Nippani and Washer (2004) investigated the impact of the SARS outbreak on the financial markets of Thailand, Singapore, Hong Kong, the Philippines, Indonesia, Canada, Vietnam, and China. In the study, t-test and non-parametric Mann-Whitney tests were performed in order to compare the data obtained between June 1, 2002 and February 25, 2003 with the S&P 1200 global index. As a result of the analysis, it is concluded that SARS has an impact on the Chinese and Vietnamese stock markets and no negative impact on the stock markets of other countries.

Loh (2006) investigated to what extent the airline companies traded in the financial markets of Taylan, China, Canada, Hong Kong, and Singapore are affected by SARS. For this purpose, F-test, Siegel-Tukey, Bartlett, Levene, and Brown tests were performed by using the data obtained from December 1, 2002 to July 5, 2003. As a result of the analysis, it is indicated that the epidemic harmed airline companies.

Giudice and Paltrinieri (2017) examined monthly flows and performances of 78 equity mutual funds in African countries for the period of 2006-2015. As a result of the analyzes and examinations, it is concluded that two significant events, which are Ebola and the Arab Spring, have significantly affected the funds flows, fund performance, expenses, and market returns.

Chen et al. (2018) investigated the effects of SARS by examining the long-term relationship between the stock exchanges of Japan, Taiwan, Hong Kong, and Singapore, and the Chinese stock market. For the study, they conducted a cointegration test using the weekly data from 1998 to 2008 and concluded that the SARS outbreak weakened the long-term relationship between the four financial markets and China.

Goodell (2020) made comments and inferences about the economic effects of the COVID-19 outbreak considering past epidemics and disasters. He stated that this study will shed light on future studies on COVID-19.

Nemec and Špaček (2020) focused on the macro-socioeconomic effects of the COVID-19 pandemic. They qualitatively examined the information contained in the restrictive regulations of national governments, data published by government bodies, international statistics and media articles published before June 30, 2020 to investigate the impact of the pandemic on local budgets. The Czech Republic and Slovakia were included in the scope of the research and they concluded that the level of financial imbalance of the COVID-19 crisis was not proportional to the situation at the central level and that the municipal financial resources were not proportional to their responsibilities as stated in the constitution. They stated that the central administration in both countries is insufficient in combating the pandemic and this will cause problems in many areas, especially in culture and sports.

Ayittey et al. (2020) discussed the possible effects of coronavirus on China and the world. They stated that China is likely to lose 62 billion dollars in the first quarter of the year, and the world is expected to lose more than 280 billion dollars in the same period.

Laing (2020) examined the effect of coronavirus on certain precious metals. In order to measure the price changes, he compared the prices of aluminum, copper, gold, lead, nickel, and zinc for the period between March 4, 2020 and April 2, 2020. As a result of this comparison, it is found that the price of aluminum, copper, gold, lead, nickel, and zinc decreased by 15%, 14%, 2%, 10%, 11%, and 6% respectively in the period given.

Estrada et al. (2020b) investigated the impact on the performance of ten stock markets, including the FTSE to assess the determinants of capital market behavior in the event of an infectious disease outbreak, COVID-19's S&P 500, TWSE, Shanghai Stock Exchange, Nikkei 225, DAX, Hang Seng, UK-FTSE, KRX, SGX and Malaysia. As a result of the study, the researchers stated that the epidemic could be disastrous for all countries' economies and could cause similar damages to the 1929 Crisis on ten major stock markets worldwide.

Luo and Tsang (2020) investigated the impact of the COVID-19 outbreak on China and the global economy. For this purpose, in order to estimate output loss from labor loss by using a network approach, they looked at how the decline in the labor force in Hubei province affects production in China through input-output relations between states. As a result of the analysis, they concluded that the Chinese workforce had a production loss of about 4%, and global production decreased by 1% due to the economic contraction in China. With this result, they stated that approximately 40% of the impact is indirect, resulting from supply chain spreads inside and outside China.

Estrada et al. (2020a) investigated how the coronavirus outbreak affected China's economic performance. For the research, they developed a new model called "Massive Infections and Contagious Diseases Economic Simulator (IMICDE-Simulator)". In the analysis performed to investigate the effects of the coronavirus, they used the indicators given by the simulator and carried out the analysis in this framework. As a result of the analysis, they concluded that the epidemic reduced the potential growth of China by 2% compared to the previous year, and this is three times more negative compared to the one experienced in SARS. Besides, they mentioned that the epidemic could have more impact on other economies.

Cepoi (2020) tried to measure the relationship between the news about COVID-19 and stock market returns in the six countries most affected by the pandemic (USA, UK, Germany, France, Spain and Italy) using a panel regression model. Stock market return (RET), The Panic Index (PI), The Media Hype Index (HY), The Fake News Index (FNI), The Country Sentiment Index (CSI), The Contagion Index (CTI), The Media Coverage Index (MCI), Sovereign CDS, Gold Price, Sentiment Index, Intercept, Lagged Returns and Observations were used. The analysis showed that exchanges offer asymmetric correlation with information about COVID-19, such as fake news, media coverage or contagion. In addition, it was observed that gold yield has a positive non-linear correlation with stock markets and gold is a “Safe Harbor” during the down-up periods. The results showed that more intensive use of appropriate communication channels is required to reduce the financial turmoil associated with COVID-19.

Zeren and Hizarcı (2020) conducted the Maki Cointegration Test using the daily data of death and case numbers between January 23, 2020 and March 13, 2020 to determine the possible effects of the COVID-19 outbreak on the stock markets. They found a parallel movement between the number of deaths and the financial markets included in the research, as well as a cointegration relationship between the daily number of cases and SSE, KOSPI, and IBEX35. As a result, they concluded that it would be much less risky for investors to invest in gold markets, virtual currencies, derivatives markets, or markets of countries where the epidemic is not observed during such crisis periods.

Wójcık and Ioannou (2020) conducted a study on the actual and potential impact of the pandemic on financial markets and sectors and the tendency of the epidemic to affect the financial environment. The study stated that a financial slowdown and a steady increase in financial-related business services are expected, but local and regional financial centers are likely to face greater challenges than leading international centers.

Zhang, Hu, and Ji (2020) investigated the country-specific and systematic risks COVID-19 poses to financial markets. For this purpose, they collected the daily data of 12 countries from February 7, 2020 to March 27, 2020, and made a correlation analysis. As a result of the correlation analysis, they concluded that the epidemic increased not only national risks but also systematic risks in the financial markets and stated that the epidemic caused uncertainty, risk, and economic losses on the financial markets of these countries.

Al-Awadhi et al. (2020) have investigated the effect of the coronavirus outbreak on financial markets. They included 82 companies operating in The Hang Seng Index and Shanghai Stock Exchange Composite Index and divided them into ten sectors according to their fields of activity. Then, they collected daily data of validated cases, deaths, and stock market values of companies from January 10, 2020 to March 16, 2020. By using panel data analysis, they concluded that the number of daily confirmed cases and daily death cases had significant negative effects on the financial markets of the countries included in the study.

3. Methodology

The fact that financial assets have unit roots causes permanent effects on the value of the financial asset due to some random shocks. Exposure of non-stationary series to shock causes high degree fluctuations to persist (Yılancı, 2017). Therefore, revealing the existence of the unit root gained importance, especially in the 1980s.

Failure to measure the stationary of financial time series in which short and long-term relationships are investigated, in the presence of structural breaks with sensitive tests may cause changes in analysis results and unsubstantial interpretations.

As the structural changes lead to large-scale changes in the prices of non-stationary financial assets, the need for developing unit root tests, taking into account a series of structural breaks pioneered by Perron (1989) has increased. Unlike Perron (1989) unit root test, based on the assumption that structural breaks are known, Zivot and Andrews (1992), Lumsdaine and Papell (1997), Lee and Strazicich (2003, 2004) developed unit root tests investigating the existence of unit root under the assumption of one or two structural breaks with an unknown date. In particular, Lee and Strazicich (2003, 2004) introduced the LM to eliminate the shortcomings of the ZA and LP unit root tests stating that in ZA and LP tests, the rejection of the H_0 hypothesis will not require rejecting the existence of the unit root (Yılancı, 2009).

Although the unit root tests mentioned above, which take into account the structural breaks, assume that the structural break dates are unknown, the structural breaks of the series which are tested for unit root existence, are determined in a preliminary form.

In ADF-type unit root tests, the null hypothesis suggests that the series has a unit root process while in KPSS-type tests, the null hypothesis states that the series is stationarity. KPSS type stationary test proposed by Kwiatkowski et al. (1992) has been developed by Becker et al. (2006). In this unit root test, structural changes are taken into account using the Fourier function. Thanks to the Fourier functions, changes in the series can be precisely estimated. Since the number, structure, and position of the structural changes are difficult to predict, the Fourier functions eliminate this imperative and allow getting better results. The unit root, cointegration and causality tests, which enable the coefficients to be transformed into trigonometric form with the help of the Fourier transformations, also take into account the effects of external shocks such as structural breaks that financial time series are exposed to. The tests applied in the Fourier form help to make accurate analyzes in financial time series where structural breaks are observed.

The data generation process for the stationary test developed by Becker et al. (2006) is as follows:

$$Y_t = X_t'\beta + Z_t'\gamma + r_t + \epsilon_t \tag{1}$$

$$r_t = r_{t-1} + u_t \tag{2}$$

where ϵ_t is a stationary process and u_t is a constant variance i.i.d. is a process.

In the first stage, in order to calculate the test statistics required to test the stationarity hypothesis, one of the following two models is estimated and residuals are obtained:

$$y_t = \delta_0 + \delta_1 sin\left(\frac{2\pi kt}{T}\right) + \delta_2 cos\left(\frac{2\pi kt}{T}\right) + v_t \tag{3}$$

$$y_t = \delta_0 + \beta_t + \delta_1 sin\left(\frac{2\pi kt}{T}\right) + \delta_2 cos\left(\frac{2\pi kt}{T}\right) + v_t \tag{4}$$

While the stationary at level hypothesis is tested with the model (3), the trend stationarity hypothesis is tested using the model (4).

Test statistics can be calculated with the following formula:

$$\tau_{\mu}(k) \text{ or } \tau_{\tau}(k) = \frac{1}{T^2}\frac{\sum_{t=1}^{T}\tilde{S}_t(k)^2}{\tilde{\sigma}^2} \tag{5}$$

where $\tilde{S}_t(k) = \sum_{j=1}^{t}\tilde{e}_j$ and $\tilde{e}_j$ is the residuals from the model (3) or (4).

A non-parametric estimation of σ can be obtained by selecting lag parameter l and $w_j, j = 1,2,\ldots,l$ as follows:

$$\delta^2 = \tilde{\gamma}_0 + 2\sum_{j=1}^{l} w_1\tilde{\alpha_J} \tag{6}$$

where $\tilde{\alpha}_j$ is the j. sample autocovariance of the residuals from the model (3) or (4).

The significance of the Fourier function is tested using the F test statistic. The F test statistic for the Fourier model with K frequency is as follows:

$$F_i(k) = \frac{(SSR_0 - SSR_1(k))/2}{SSR_1(k)/(T-q)}, \quad i = \mu,\tau. \tag{7}$$

where $SSR_1(k)$ is the sum of the residual squares obtained from the regression equation (7), q is the number of explanatory variable and SSR_0 represents the sum of the residual squares obtained from the model in which trigonometric terms are not added. In order to use the F test, the stationary hypothesis must not be rejected. Suitable critical values for the F test and stationary test are included in the study of Becker et al. (2006) as a table.

In the literature, there are numerous cointegration tests developed by Engle-Granger (1987), Gregory-Hansen (1996), Johansen et al. (2000), Hatemi-J (2008) and so on. However, these tests require to determine the number and form of structural changes previously. The new cointegration test developed by Tsong et al. (2016) takes into account unknown form and number of structural breaks by using the Fourier trigonometric functions. This new method called Fourier-Shin Cointegration Test considers the cointegration regression equation as follows:

$$y_t = d_t + x_t'\beta + n_t, \qquad t = 1,2,\ldots,T \tag{8}$$

where $n_t = \gamma_t + v_{1t}$, $\gamma_t = \gamma_{t-1} + u_t$ with $\gamma_0 = 0$, and $x_t = x_{t-1} + v_{2t}$. Here u_t is an iid process with zero mean and variance σ_u^2. Therefore, γ_t is a random walk with mean zero. The deterministic component d_t in Eq. (8) can be defined as follows:

$$d_t = \sum_{i=0}^{m} \delta_i t^i + f_t\,, m = 0\ or\ m = 1 \tag{9}$$

$$f_t = \alpha_k sin\left(\frac{2k\pi t}{T}\right) + \beta_k cos\left(\frac{2k\pi t}{T}\right) \tag{10}$$

where (k) denotes the Fourier frequency value, t is trend, and T represents the sample size. The null hypothesis of cointegration against the alternative of non-cointegration could be expressed as:

$$H_0: \sigma_u^2 = 0\ versus\ \ H_1: \sigma_u^2 > 0 \tag{11}$$

In order to test the null hypothesis in Eq. (11), the model described in equation (9), (10) could be rephrased as:

$$y_t = \sum_{i=0}^{m} \delta_i t^i + \alpha_k sin\left(\frac{2k\pi t}{T}\right) + \beta_k cos\left(\frac{2k\pi t}{T}\right) + x_t'\beta + v_{1t} \tag{12}$$

The FSHIN Cointegration test statistic (denoted by CI_f^m) to test the null of cointegration with structural breaks against the alternative of non-cointegration is given by:

$$CI_f^m = T^{-2}\widehat{w}^{-2}\sum_{t=1}^{T} S_t^2 \tag{13}$$

where $S_t = \sum_{t=1}^{T} \hat{v}_{1t}$ is the partial sum of the ordinary least squares (OLS) residuals from Eq. (12) and w_1^2 denotes the consistent estimator for the long variance of v_{1t}.

In the study, the existence of the causality relationship between variables was investigated with the Fourier Granger causality test developed by Enders and Jones (2015). Enders and Jones (2015) introduced a flexible Fourier form to capture changes in multiple soft averages in a short-term VAR system. The authors limited the VAR model by forcing the limitations envisaged by the Granger causality test to take into account the effect of neglecting structural breaks in a linear VAR model on Granger causality tests. The findings of the authors showed that there was little interaction between the variables and that the significant responses are such that series tend to respond only to their own shocks.

The authors then defined the deterministic regressors as follows:

$$z_t = \delta(t) + \sum_{1}^{11} A_i z_{t-1} + e_t \quad (14)$$

$$\delta(t) = [\delta_1(t), \delta_2(t), \delta_3(t), \delta_4(t)]' \quad (15)$$

and each intercept δit depends on n Fourier frequencies such that:

$$\delta_i(t) = \alpha_i + b_i t + \sum_{k=1}^{n} \alpha_{ik} sin\left(\frac{2\pi kt}{T}\right) + b_{ik} cos\left(\frac{2\pi kt}{T}\right) \quad (16)$$

Unlike the Granger causality results obtained from the linear VAR model, Enders and Jones (2015) found stronger relationships and richer sets of interactions between the variables by adding trigonometric functions to the model.

4. Data and the Empirical Results

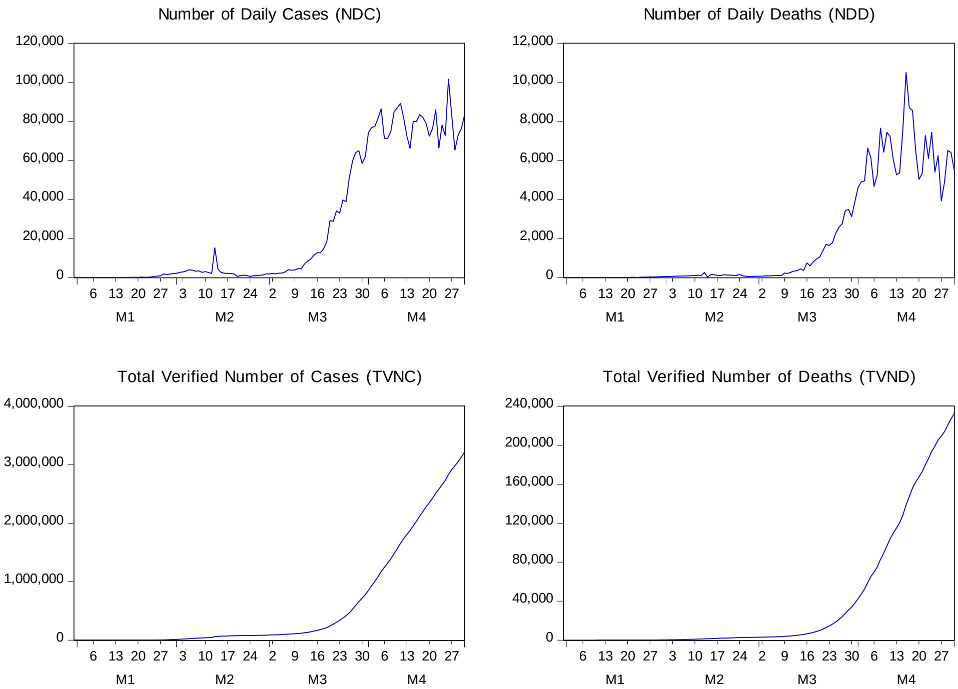
In this study, the effect of the COVID-19 outbreak on financial markets is evaluated. The results and findings obtained are important for people who play an active role in the stock market to understand and predict stock returns and movements during the pandemic.

For this purpose, the period between 31.12.2019 and 01.05.2020 is included in the study. Daily data are used for all price series included in the study. In order to evaluate the effects of coronavirus on financial markets, some financial markets are included in the research. These are; the Italian stock market (FTSE MIB), the French stock market (CAC 40), the British stock market (FTSE 100), the Chinese stock market (SHANGAI), and the Fear Index (VIX). In addition, ounces of gold (OUNCE) representing the precious metal market, crude oil (WTI) representing the energy market, and bitcoin (BTC) representing the cryptocurrency market are among the items to be examined in the study. All these elements mentioned above constitute the dependent variables of the study.

Total Verified Number of Cases (TVNC), Total Verified Number of Deaths (TVND), Number of Daily Cases (NDC), and Number of Daily Deaths (NDD) are chosen as independent variables of the study. Data on these variables are obtained from the website "ourworldindata.org". The line graphs of Number of Daily Cases (NDC), Number of Daily Deaths (NDD), Total Verified Number of Cases (TVNC), and Total Number of Verified Deaths (TNVD-), which are the independent variables of the study, are shown in Figure 1.

Figure 1

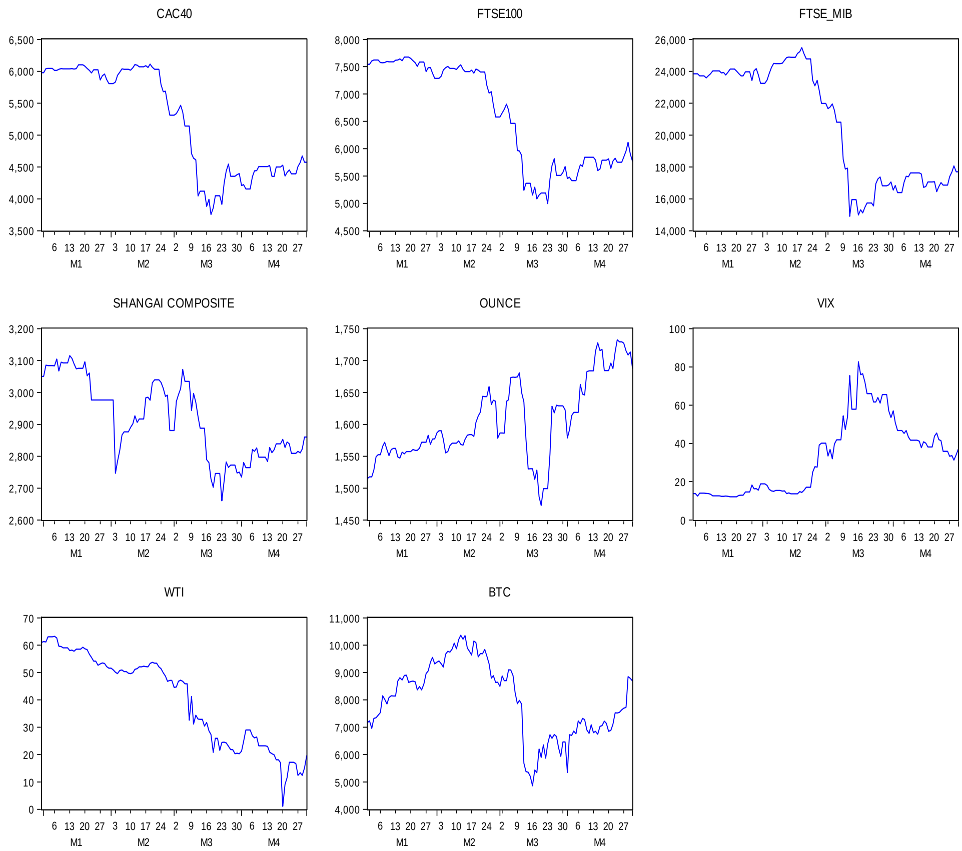
Daily price series regarding independent variables



Daily price series of the study's dependent variables which are the Italian stock market (FTSEMIB), the French stock market (CAC40), the British stock market (FTSE100), the Chinese stock market (SHANGAI), the Fear Index (VIX), Bitcoin (BT-C), Ounce of Gold (OUNCE) and Crude Oil (WTI) are shown in Figure 2.

Figure 2

Daily price series regarding dependent variables



When the charts of all financial assets as of March 2020 are analyzed, it can be seen that significant decreases occurred in all financial markets and the VIX index increased.

In order to evaluate the effect of COVID-19 outbreak on financial markets, the effects of changes in Number of Daily Cases (NDC), Number of Daily Deaths (NDD), Total Verified Number of Cases (TVNC) and Total Number of Verified Deaths (TNVD) on the Italian stock market (FTSE_MIB), the French stock exchange (CAC40), the British stock exchange (FTSE100), the Chinese stock exchange (SHANGAI), the Fear Index (VIX), Bitcoin (BTC), Ounce of Gold (OUNCE) and Crude Oil (WTI) are investigated.

First of all, it is necessary to conduct a stationarity test for the variables mentioned above. As mentioned in the methodology section, the FKPSS unit root test is implemented in the study. In the FKPSS unit root test, the null hypothesis is that the series is stationary. The test results are given in Table 1.

Table 1

Fourier KPSS Unit Root Test Results

Level	Frequency	Min SSR	FKPSS	KPSS	F Stat.
lnTVNC	1	1485558	0.511249***		60.32***
lnNDC	1	1647999	0.423009***		47.54***
lnNDD	1	9529202	0.470167***		77.38***
lnTVND	1	1746269	0.512016***		64.80***
lnBTC	1	0.241005	0.218039**		123.39***
lnCAC40	1	0.096856	0.196760**		308.32***
lnFTSE100	1	0.069726	0.235439**		347.18***
lnFTSEMIB	1	0.125325	0.175856**		289.71***
lnOUNCE	2	0.022441	0.754373***		33.14***
lnSHANGAI	1	0.021829	0.225168**		48.60***
lnVIX	1	1105033	0.172377**		422.29***
lnWTI	1	3823441	0.473817***		62.35***
1st Diff.	Frequency	Min SSR	FKPSS	KPSS	F Stat.
D(lnTVNC)	2	1647679	0.329952	0.387836	1.895
D(lnNDC)	2	2454385	0.072922	0.229203	2.935
D(lnNDD)	2	2207312	0.086305	0.084105	1.374
D(lnTVND)	2	1920076	0.300619	0.259411	1.906
D(lnBTC)	1	0.363565	0.035919	0.123260	1.906
D(lnCAC40)	1	0.066110	0.051429	0.124777	2.152
D(lnFTSE100)	2	0.056192	0.124419	0.132399	1.812
D(lnFTSEMIB)	2	0.087364	0.129699	0.125102	2.105
D(lnOUNCE)	3	0.015825	0.040886	0.035977	1.443
D(lnSHANGAI)	3	0.019820	0.138465	0.065277	1.352
D(lnVIX)	1	1140474	0.052856	0.182625	2.305
D(lnWTI)	3	0.561779	0.157658	0.331187	1.052

****, ** and * represent 1%, 5% and 10% significance levels respectively. Null Hypothesis "... is stationary".*

As can be seen in Table 1, according to the FKPSS Test results at the level, the test statistics for all series are greater than the critical values. Therefore, the null hypothesis stating that the series is stationary is rejected for all series. The ability to test the significance of trigonometric terms depends on the precondition that the null hypothesis cannot be rejected (Yılancı, 2017). Since the null hypothesis was rejected in level values for all series, both the FKPSS test statistics and the F test were applied for the differentiated series. It was determined that all series were stationary after taking the first difference. Since the test statistics are less than critical values for all series, the null hypotheses stating that the series is stationary are not rejected. Since it was found that trigonometric terms with the Fourier transformation are not significant, the series are found to be stationary at the first difference according to the standard KPSS test. In brief, according to the results of Table 1, all series are determined to be I[1].

Table 2

The Fourier – Shin Cointegration Test Results

	Frequency	Min SSR	Fourier Cointeg. Test Stat.	Shin Test Stat.	F Stat.
NDC - BTC	2	9.805.982	0.4888***	0.8387***	13.590***
NDC - CAC40	2	3.710.850	0.2029	0.2966	11.3946***
NDC - FTSE100	2	3.296.216	0.1696	0.2656	14.334***
NDC - FTSEMIB	2	4.401.541	0.2460	0.3336**	9.593***
NDC - OUNCE	**1**	**1.090.769**	**0.1978****	**0.5562*****	**0.503**
NDC - SHANGAI	3	3.383.122	0.2512	0.2577	3.802***
NDC - VIX	2	2.382.989	0.0916	0.2628	35.229***
NDC - WTI	**1**	**5.230.376**	**0.0988**	**0.3046**	**2.667**
NDD - BTC	2	3.668.248	0.4804***	0.9504***	46.611***
NDD - CAC40	2	7.102.348	0.1651	0.3168**	114.448***
NDD - FTSE100	2	6.077.856	0.1045	0.2866	232.315***
NDD - FTSEMIB	2	1.105.621	0.2526	0.3691**	53.749***
NDD - OUNCE	1	5.262.592	0.2061***	0.6467***	4.170**
NDD - SHANGAI	2	1.870.958	0.3133**	0.5406***	22.030***
NDD - VIX	2	8.594.228	0.2088	0.4008**	244.647***
NDD - WTI	1	2.593.334	0.1129	0.3916**	4.555**
TVNC - BTC	1	7.333.911	0.2841***	0.9532***	12.836***
TVNC - CAC40	2	2.785.453	0.2619	0.3701**	20.072***
TVNC - FTSE100	2	2.273.288	0.2285	0.3354**	39.524***
TVNC - FTSEMIB	2	3.616.061	0.3035**	0.4101**	19.700***
TVNC - OUNCE	1	5.092.151	0.1856**	0.7075***	4.507**
TVNC - SHANGAI	2	2.737.019	0.2492	0.4403**	49.129***
TVNC - VIX	2	1.050.194	0.1130	0.3787**	151.003***
TVNC - WTI	1	3.176.993	0.1334**	0.4127**	10.721***
TVND - BTC	1	8.765.947	0.2903***	0.9691***	9.701***
TVND - CAC40	2	2.783.411	0.2372	0.3758**	36.160***
TVND - FTSE100	2	2.273.980	0.1964	0.3429**	68.761***
TVND - FTSEMIB	2	3.658.908	0.2877**	0.4136**	27.272***
TVND - OUNCE	1	5.805.349	0.1898**	0.7397***	4.775**
TVND - SHANGAI	2	3.491.393	0.2531	0.4679**	29.971***
TVND - VIX	2	1.119.943	0.1153	0.4013**	160.686***
TVND - WTI	1	3.664.198	0.1458**	0.4214**	9.383***

	Fourier Cointeg. Critical Values			F-Stat. Critical Values		SHIN Critical Value	
	k=1	*k=2*	*k=3*				
1%	0.198	0.473	0.507	*1%*	5.774	*1%*	0.533
5%	0.124	0.276	0.304	*5%*	4.066	*5%*	0.314
10%	0.095	0.200	0.225	*10%*	3.352	*10%*	0.231

****, ** and * represent 1%, 5% and 10% significance levels respectively. "null hypothesis; "There is a significant long-term relationship between variables."*

According to the degrees of freedom associated with the Fourier cointegration test statistics in Table 2, the results of the Fourier cointegration test statistics for NDC-CAC40, NDC-FTSE100, NDC FTSEMIB, NDC-SHANGAI, NDC-VIX, NDC-WTI, NDD-CAC40, NDD FTSE100, NDD-FTSEMIB, NDD-VIX, NDD-WTI, TVNC-CAC40, TVNC-FTSE100, TVNC-SHANGAI, TVNC-VIX, TVND-CAC40, TVND-FTSE100, TVND-SHANGAI and TVND-VIX are smaller than FSHIN critical values. For example, the Fourier cointegration test statistic for NDC-CAC40 (0.2029) is less than the FSHIN critical value of k=2 for 5% significance level (0,276). In this case, "H_0: There is a significant long-term relationship between variables" hypothesis could not be rejected. It is seen that all the financial stock markets mentioned above have a long-term relationship with daily cases/deaths (NDC and NDD) and total cases/deaths (TVNC and TVND).

Test statistics for NDC-BTC, NDC-OUNCE, NDD-BTC, NDD-OUNCE, NDD-SHANGAI, TVNC-BTC, TVNC-FTSEMIB, TVNC-OUNCE, TVNC-WTI, TVND-BTC, TVND-FTSEMIB, TVND-OUNCE, TVND-WTI are greater than the critical values with respect to degrees of freedom. For example, the Fourier cointegration test statistic for NDC-BTC (0.4888) is less than the FSHIN critical value of k=2 for 5% significance level (0,276). In this case, H_0 hypothesis is rejected. No relation has been found for the cointegration results in question. Also, according to the results of the F-statistic which shows the significance of the trigonometric coefficients, the F-Statistics values of NDC-OUNCE and NDC-WTI are smaller than the critical values. Therefore, the H_0 hypothesis of F-statistics could not be rejected, and it was concluded that the results were not significant. The F-Statistics values apart from NDC-OUNCE and NDC-WTI are greater than all of the critical values, so the results are meaningful. The results obtained with the F-Statistic are consistent with the results mentioned above, in which case, the results of the Fourier Cointegration test statistics are reliable. For NDC-OUNCE and NDC-WTI, whose F-statistic values are insignificant, the SHIN cointegration test was applied, and a significant relationship between NDC and OUNCE and insignificant relationship between NDC and WTI has been found.

Table 3

The Fourier Granger causality test results

	Enders Jones Single Frequency			
	Wald Stat.	Asymptotic p-value	Bootstrap p-value	Optimal Frequnecy
lnNDC→lnBTC	6.606	0.010***	0.010**	3
lnNDC→lnCAC40	4.141	0.042**	0.060*	2
lnNDC→lnFTSE100	4.173	0.041**	0.030**	2
lnNDC→lnFTSEMİB	3.998	0.046**	0.060*	2
lnNDC→lnOUNCE	4.613	0.032**	0.030**	2
lnNDC→lnSHANGAI	2.405	0.121	0.150	2
lnNDC→lnVIX	3.265	0.071*	0.090*	2
lnNDC→lnWTI	5.617	0.018**	0.010**	3
lnNDD→lnBTC	3.739	0.053*	0.050*	3
lnNDD→lnCAC40	0.611	0.434	0.420	3
lnNDD→lnFTSE100	0.382	0.536	0.530	3
lnNDD→lnFTSEMIB	0.638	0.424	0.350	3
lnNDD→lnOUNCE	2.604	0.107	0.110	3
lnNDD→lnSHANGAI	1.292	0.256	0.170	3
lnNDD→lnVIX	1.407	0.236	0.200	2
lnNDD→lnWTI	2.479	0.115	0.110	3
lnTVNC→lnBTC	5.577	0.018**	0.000***	3
lnTVNC→lnCAC40	7.142	0.008***	0.000***	2
lnTVNC→lnFTSE100	3.211	0.073*	0.110	3
lnTVNC→lnFTSEMIB	2.219	0.136	0.110	3
lnTVNC→lnOUNCE	4.617	0.032**	0.080*	3
lnTVNC→lnSHANGAI	1.987	0.159	0.100	3
lnTVNC→lnVIX	2.198	0.138	0.070	3
lnTVNC→lnWTI	4.480	0.034**	0.040**	3
lnTVND→lnBTC	4.516	0.034**	0.050*	1
lnTVND→lnCAC40	4.932	0.026**	0.020**	2
lnTVND→lnFTSE100	5.162	0.023**	0.030**	2
lnTVND→lnFTSEMIB	4.792	0.029**	0.050*	2
lnTVND→lnOUNCE	6.069	0.014**	0.020**	2
lnTVND→lnSHANGAI	3.514	0.061*	0.050*	1
lnTVND→lnVIX	3.939	0.047**	0.070*	2
lnTVND→lnWTI	4.160	0.041**	0.060*	1

*→ refers to causality. ***, ** and * represent 1%, 5% and 10% significance levels respectively. In this study, as T (number of samples) > 50, asymptotic p values are used in the analysis.*

According to the asymptotic p-values of the Fourier Granger Causality test given in Table 3, it has been found that there is causality from Number of Daily Cases (NDC) to BTC at 1% significance level, and to CAC40, FTSE100, FTSEMIB, OUNCE, WTI at 5% significance level; from Number of Daily Deaths (NDD) to BTC at 10% significance level; from Total Verified Number of Cases (TVNC) to CAC40 at 1% significance level, and to BTC, OUNCE, WTI at 5% significance level, and to FTSE100 at 10% significance level; and lastly, from Total Number of Verified Deaths (TNVD) to BTC, CAC40, FTSE100, FTSEMIB, OUNCE, VIX, WTI at 5% significance level, and to SHANGAI at 10% significance level.

5. Conclusions

The COVID-19 outbreak, which started in Wuhan, China, caused great panic and impact worldwide. The economic effects of the pandemic. which reached almost the whole world, has become more and more evident day by day. The COVID-19 epidemic caused a large interruption of production in the USA and China, which are seen as the largest economies in the world and competing with each other, as well as other countries, and price changes in oil, gold, cryptocurrencies and many other sectors and areas. The fact that the countries that have a big voice in the world economy are desperate against this threat affects and will continue to affect the whole world. It is a mystery what the effects of COVID-19, which we are currently living in, and do not know exactly what the effects and results will be on the financial markets in the short and long term.

Accordingly, in this study, the effects of COVID-19, which is accepted as a pandemic, on stock markets representing the financial markets, the gold ounce representing the precious metals, the crude oil representing the energy market, and Bitcoin representing the cryptocurrency markets were investigated separately. While performing these analyzes, in determining causal relationships or long-term relationships, the Fourier SHIN Cointegration Test and Ender and Jones Causality Tests were used for the Fourier transformation of the equations. As a result of the analysis, it has been found that the COVID-19 outbreak has a significant long-term effect on stock markets, crude oil representing the oil markets and the fear index, while has no long-term effect on bitcoin representing money markets. As for the short-term effects of COVID-19, it has been found that the pandemic has an effect on stock markets, crude oil, fear index, and bitcoin.

In light of all these explanations, it has been determined that COVID-19 has both the short and long-term effects on cryptocurrency markets, precious metal markets, the stock indices representing financial markets that will cause price movements.

The most important contribution of this study to the literature is that with a limited data set of the COVID 19 process, stationarity, cointegration, and causality relationships of the Fourier transformations, which is a new method considering the effects of structural shocks (smooth transition) on financial time series is used.

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