Pamukkale Üniversitesi

Sosyal Bilimler Enstitüsü Dergisi

Pamukkale University Journal of Social Sciences Institute

ISSN 1308-2922 E-ISSN 2147-6985

Article Info/Makale Bilgisi
√Received/Geliş:23.01.2022 **√Accepted/Kabul:**20.04.2022
DOİ:10.30794/pausbed.1061965
Research Article/Araştırma Makalesi

Çelik, A., Nergiz, E. ve Akdağ, N. (2022). "Effects of Coronavirus Pandemic on Stock Markets in The European Union", *Pamukkale University Journal of Social Sciences Institute*, Issue 52, Denizli, ss. 1-15.

EFFECTS OF CORONAVIRUS PANDEMIC ON STOCK MARKETS IN THE EUROPEAN UNION

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Abstract

The world is undergoing one of the biggest economic crises since the 1929 Great Depression with the coronavirus pandemic. The emergence of the COVID pandemic, before the effects of the 2008 global economic crisis had not evaded, triggered the dynamics of the economic crisis again. The European Union (EU) economy is also profoundly affected by the crisis. This paper explores the relationship between the number of coronavirus disease 2019 (COVID-19) cases and Europe's most important stock market indices by using time series analysis. While performing the analysis, three different models were created. In this context, the number of cases of COVID-19 has been used as independent variables, while DAX Index, CAC 40 Index, and Euronext 100 Index have been tested as dependent variables, respectively. The analysis results prove that there is a long-run cointegration relationship between variables. We also found that the Error Correction Model results are statistically significant. Consequently, the estimator results determine that the COVID-19 negatively affected the European stock markets.

Key Words: *COVID-19, EU Stock Markets, Time Series Analysis, Cointegration Tests.*

KORONAVİRÜS PANDEMİSİNİN AVRUPA BİRLİĞİ BORSALARINA ETKİLERİ

Öz

Dünya, koronavirüs pandemisi ile 1929 Büyük Buhranı'ndan bu yana en büyük ekonomik krizinden birini yaşıyor. 2008 küresel ekonomik krizinin etkileri tam olarak savuşturulmadan KOVİD-19 pandemisinin ortaya çıkmış olması ekonomik kriz dinamiklerini yeniden tetiklemiştir. Avrupa Birliği ekonomisini de bu krizden derin bir şekilde etkilenmektedir. Çalışmanın amacı, 2019 koronavirüs vaka sayısı ile Avrupa'nın en önemli borsa endeksleri arasındaki ilişkiyi zaman serisi analizi kullanarak incelemektir. Analiz yapılırken üç farklı model oluşturulmuştur. Bu kapsamda COVID-19 vaka sayısı bağımsız değişken olarak kullanılmakta, bağımlı değişkenler ise sırasıyla DAX, CAC 40 ve Euronext 100 endeksleri şeklinde olmaktadır. Analiz sonuçları, değişkenler arasında uzun dönemli bir eşbütünleşme ilişkisi olduğunu kanıtlamaktadır. Ayrıca Hata Düzeltme Modeli sonuçlarının istatistiksel olarak anlamlı olduğu görülmektedir. Nihai olarak, tahmin sonuçları KOVİD-19 pandemisinin Avrupa borsalarını olumsuz etkilediği kanıtlamaktadır.

Anahtar Kelimeler: *KOVİD-19, Avrupa Birliği Borsaları, Zaman Serisi Analizi, Eşbütünleşme Testleri.*

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1. INTRODUCTION

The coronavirus disease 2019 (COVID-19) emerged in Wuhan, China's seventh-largest city, at the end of December 2019. The first death from this virus, which spread from China to many countries in a short time, occurred in Wuhan on January 11. COVID-19 spread rapidly in Europe in March, especially in Spain and Italy. As a result of the spread of the virus worldwide, the increasing number of cases and deaths, the World Health Organization (WHO) declared a new type of coronavirus-related pandemic, also called SARS-CoV-2, on March 11, 2020. With the pandemic, social and economic life restrictions started in many countries. Measures and prohibitions have begun to prevent people from coming together: In many countries, education was suspended, and distance education started; In business life, many businesses have switched from home to work; domestic and international travels have been canceled; shopping centers, restaurants, and entertainment venues have been closed; concerts and sports events have been postponed; Obligation to use masks and curfews have been introduced. All these bans and restrictions started to impact the world economies quickly. The world has been going through one of the biggest crises since the 1929 Great Depression because of the pandemic. The world is also facing a similar global epidemic a century after the Spanish flu of 1918-1920. While countries are trying to combat the disease, on the one hand, they are trying to overcome the adverse economic effects of the epidemic on the other hand.

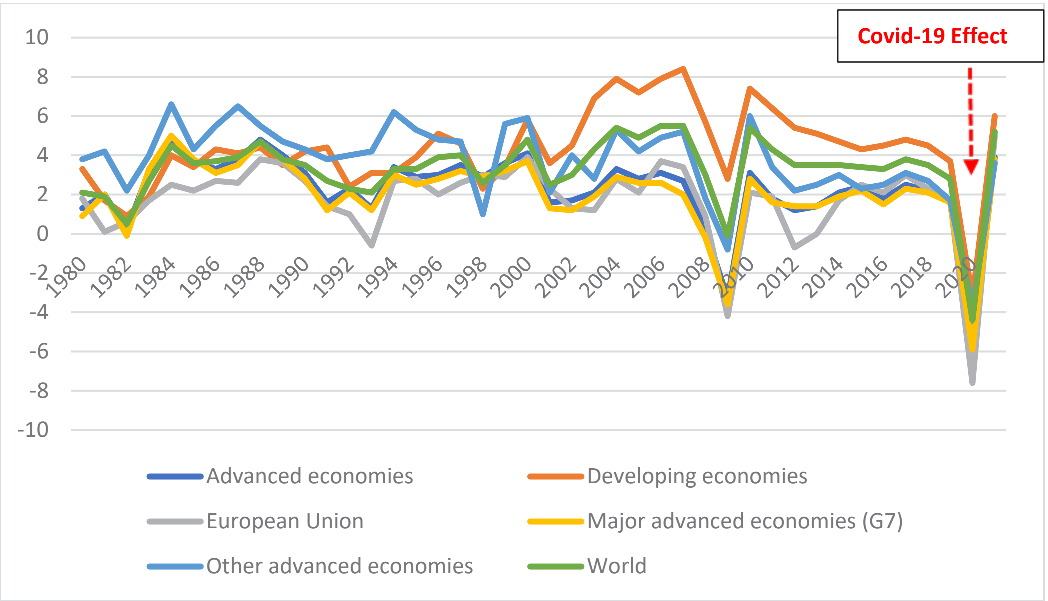
As the economy and finance experts and officials emphasized in their statements, the world economies were unprepared for this crisis, which emerged in a different dimension and had an unexpected significant impact (Tekin, 2020). There are different views about why the world economy turned upside down in the COVID-19 crisis. The world economy was already fragile and bottleneck economically, especially since the 2008 Global Crisis. The COVID-19 has deepened this crisis, which is already ready to explode due to geopolitical tension. Tensions such as the US-China trade war, the UK's exit from the EU, the possible conflict between the US and Iran, the risk of cyberattacks aimed at destabilizing the US public opinion before the US presidential elections, and North Korea's nuclear trials, have increased the effect of the economic crisis that may be caused by the coronavirus epidemic (Bremmer,2020).

According to another view, environmental problems such as global warming and the increase in input costs have affected the global economy badly for a long time (Schafer, 2020). COVID-19 has been developed based on all these conditions. This virus has several different effects on the economy. In general, the functioning of global supply chains has been disrupted due to the changing demand situation in the market. Many companies at the international level have come to an end. With the social panic attacks observed in countries where COVID -19 cases are seen, stock-keeping behaviors have occurred in unnecessary consumption, and home consumption products, chain markets, and supply sources have had great difficulty responding to this unexpected demand managing production resources in this direction. At the same time, the flow of goods in this area was also interrupted due to the insecurity in the products exported from abroad, and the demand decreased at the same rate. The sharp declines and volatility in the global financial markets followed a similar course to the 2008 and 2009 financial crises (Cinel, 2020). The economic effects of the pandemic have started to be seen a few months after the pandemic's start and have deepened in the forthcoming months. At the same time, the economic consequences of the epidemic are commonly referred to as coronanomics (Eichengreen, 2020). The International Monetary Fund has named the crisis that the covid outbreak caused 'A Crisis Like No Other, An Uncertain Recovery' (IMF,2020). Some describe it as 'Black Swan' (Barua, 2020). Baldwin and Weder di Mauro (2020) state that COVID-19 spreads economic suffering worldwide, stating that the virus can be economically contagious and medically. Measures and bans taken within the scope of the virus have affected many sectors.

The COVID-19 outbreak generates extensive and comprehensive economic cost burdens for all countries, especially China, the USA, and the European Union countries. Since the G7 countries realize 60% of the world supply and demand and 41% of the world production exports, the size and duration of the epidemic in these countries have become even more critical for the future of the global economy (Barua, 2020). China›s production and consumption contractions caused serious deadlocks (Fernandes, 2020). On the other hand, the epidemic changed the consumption patterns of consumers and caused a shortage of many consumer goods in the world, albeit for a short time (Tekin, 2020).

The world economy has been experiencing one of its biggest crises since the 1929 COVID-19 pandemic. The fact that such a pandemic has come to the fore before the wounds of the 2008 global economic crisis are healed pushes the world economy into a crisis whose impact is expanding day by day. National economies are also affected by this crisis in different dimensions. With the COVID-19, production has come to a halt. Numerous countries have faced negative economic growth rates due to decreased production. European Union countries are faced with the massive unemployment problem that has occurred since the 1929 Economic Depression. The basis of unemployment is the closure of workplaces by coronavirus measures and increased unemployment in many sectors. With the spread of the Coronavirus, disruptions occurred in the global supply chain, and auto manufacturers such as Volkswagen and Ferrari have suspended production in Europe. This situation has resulted in a decrease in employment due to the decline in production. When the sectoral effect of unemployment is examined, some sectors come to the fore. When the rates of the employees are concerned, 1.25 billion employees represent 38% of the world population. Two hundred four million people work in the supply chain services such as transportation and mail. The need for personnel to work in the cargo companies, e-commerce, and logistics sector has increased. People working in health, agriculture, and transportation services have also been paid additional overtime in the public sphere. Besides, many airlines at the international level went bankrupt, and there were layoffs. Travel agencies and many restaurants and shopping mall employees were subject to dismissal or indefinite leave.

The impact of Coronavirus on social life was limited to restrictions, but it also hurt many branches of art. The inability of artists to give concerts, closure of cinemas, theaters, and closure of art galleries have caused people working in these sectors to be unemployed. Unemployment is not only an economic issue, but it has also caused socio-cultural problems. This situation shows that COVID-19 is not limited to health restrictions but also the need for fast and coordinated policies at the national and international levels (ILO, 2020). As seen in Graph 1, there are two significant fluctuation periods from 1980 to the present, in which the growth rates decreased the most. The first fluctuation is the economic contraction experienced in 2008 due to the global financial crisis. In the second fluctuation, it is observed that the economic growth rates decreased significantly with the effect of the Coronavirus at the end of 2019 and the beginning of 2020. Global growth is estimated to reduce by 4.9 percent in 2020, 1.9 percentage points below the April 2020 World Economic Outlook (WEO) forecast.



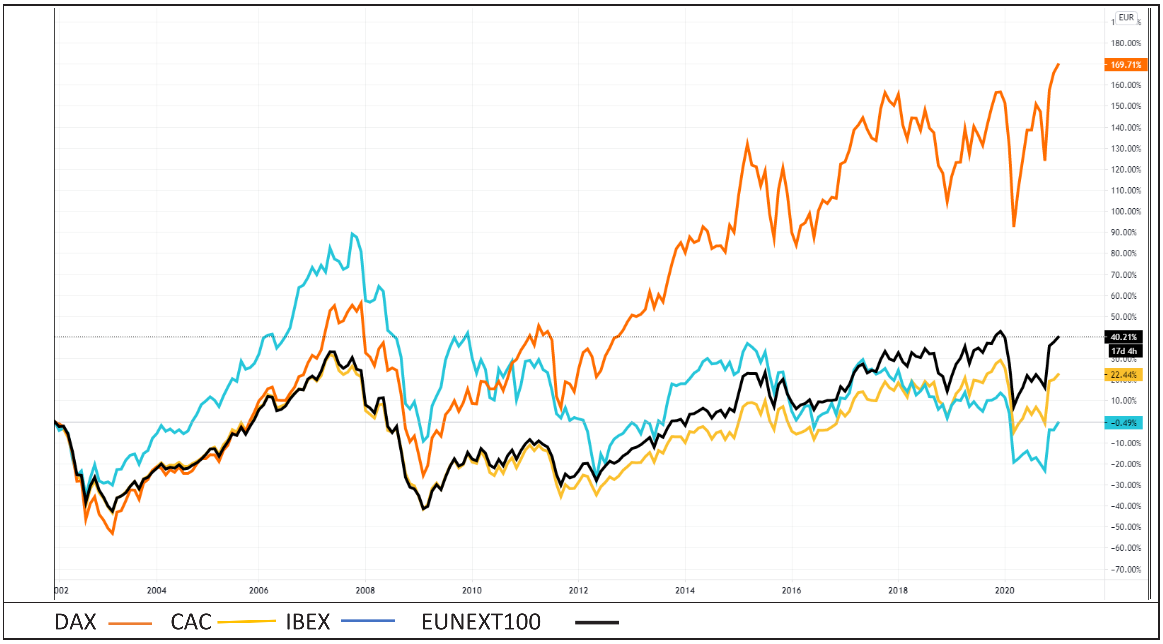
Graph 1: The World Economic Growth (%) Landscape After 1980

Source: IMF Database

The study examines how the European Union, the most critical economic union globally, was affected by this crisis. For this purpose, meaningful stock exchanges in the European Union analyzed the general structure. Another reason for choosing the European Union is that it is an important economic partner of Turkey. The difference between the study and similar studies is that the research subject was examined both with structural no break test methods and structural break test methods that they are more current techniques. It is thought that this aspect will make an essential contribution to the related literature. For this purpose, the relationship between the number of COVID-19 cases and Europe's most important stock market indexes was analyzed by time series analysis using daily data for the period of 01.02.2020-31.08.2020. After the theoretical information and the effects of the pandemic in the introduction part of the study, in the second part, the economic impact of the Coronavirus on the European Union is mentioned. In the third part, literature research is done. The fourth part includes empirical analysis. In the conclusion part, a holistic evaluation of the study is presented.

2. THE IMPACTS OF THE CORONAVIRUS PANDEMIC ON SELECTED EU STOCK MARKETS

With COVID-19, uncertainty has emerged in the financial markets. Due to the lack of drugs and vaccines for the COVID-19 virus, the rapid spread of the epidemic around the world, the lack of knowledge of the methods to prevent the outbreak, the decrease in production, the realization of inter-country trade restrictions, and the domestic bans, as well as shares in the US, China, and European stock markets. There has been a sharp decline in the prices of bills of exchange. At the same time, investors turned to cash demand instead of buying stocks. The sharp declines in the stock market increased the possibility of companies going bankrupt and reduced investors' need to buy shares. It turned towards the cash demand of investors as an alternative (Şenol, 2020). Graph-2 shows the correlation between the stock markets by period. It can be observed that until the 2002-2008 crisis, the four European stock exchanges were in close correlation and a rapid rise, especially DAX's and IBEX's upward trends are faster and in much higher correlation. In the USA, the decrease in interest rates and the increase in house prices in the US stock market increased the stock markets' purchases due to the mortgage fund's reflection and the high-risk appetite of hedge funds. The reasons behind the 2008 Sub-Prime Mortgage Crisis were the sharp rise in the US interest rate, a rapid decrease in real estate prices, and more: many mortgages backed securities suffered huge value loss, and the collapse confronted the US. Since mortgage funds and hedge funds have become more widespread in EU countries since the 2000s, the same risk has emerged. As markets are integrated with the effect of globalization, the collapse in the USA has also been reflected in them. In the 2008 global financial crisis, the US stock market was saved by purchasing assets. This situation caused quantitative easing. However, it was not reflected in all EU stock exchanges. The DAX stock market survived the 2008 crisis and reached a much higher level than the EU stock markets. Germany is above the level before 2008 due to its strong economic structure, being the largest producer and exporter of EU countries and a strong production economy, being among the largest exporting countries globally, and being financially strong.



Graph-2: The change in the values of major stock exchanges in the European Union between 2002-2020

Source: www.matriksdata.com, https://tr.tradingview.com/

Although the Euronext 100 Index recovered after the 2008 crisis, the coronavirus pandemic negatively affected the stock market value but recovered in the following process. The stock market value of CAC did not reach its highest level before the 2008 period, and it fell like other European stock markets in the 2019 pandemic period. In the 2019 pandemic period, it can be observed that the DAX stock market is on the rise. Thanks to the financial support that Germany gave to the public during the pandemic period, the stock market has recovered, and as seen in the graph, it is at its historical peak. The rise in the last 1-1.5 months is due to vaccine availability and positive news. Germany's better management of the process than other countries is attributed to its strong economic infrastructure. This situation indicates that the stock exchanges show the country's economy. In global financial crises, countries with solid macroeconomic indicators are decreasing simultaneously. It shows that countries with substantial equity financing (with a foreign trade surplus, economic infrastructure, and high national income) are affected by the global crisis due to excessive integration and foreign trade.

3. LITERATURE REVIEW

The Coronavirus, which has spread to seven continents of the world, has affected almost all segments of society at certain levels. Undoubtedly, a virus that affects social life should be carefully studied by social sciences and natural sciences. Therefore, the economic side of the COVID-19 pandemic should be considered. The economic effects of the coronavirus pandemic on different regions in the world are also discussed.

Barro et al. (2020) stated that the spread of the COVID-19 induced stock market crashes boosted financial volatility in nominal interest rates and squeezed actual economic activity. These shocks also provoked many economists to express their worries about the forthcoming global recession.

Liu et al. (2020) explored the influence of the coronavirus pandemic on stock markets. They investigated the short-term effect of the coronavirus epidemic on 21 leading stock market indices in the most affected nations such as Italy, England, Japan, Korea, Singapore, the USA, and Germany. Their results verify that the primary affected countries and regions' stock markets have plunged after the virus outbreak.

Yetgin (2020) researched the effect of COVID-19 on the Borsa Istanbul Index 100 (BIST100). The study has concluded that the number of coronavirus cases has a substantial impact on BIST. According to another finding obtained from the research, the number of coronavirus cases explains 40.8% of the Borsa Istanbul index. When the research and stock market data of financial institutions were examined, it was seen that the world stock markets had a 35% fluctuation period and many stock market indexes encountered 10% or more decreases Jelilov et al. (2020) explored the effect of the COVID-19 on the stock market returns and inflation affinity by using the GARCH (1,1) models. Their analysis' consequences illustrate that COVID-19 ascends volatility and warps the positive affinity between inflation and stock market returns. Albulescu (2020) estimated the VIX, together with CBOE data, by ARDL modeling, considering the daily oil prices and the number of people caught in Coronavirus between January 21, 2020, and March 9, 2020. As a result of the findings obtained from the model, it was determined that the number of people caught in Coronavirus has a negative effect on oil prices. He also stated that although China reduces the effects of COVID-19, economic fluctuations will continue due to the virus worldwide. There are many studies on the impact of Covid 19 on financial markets. Syahri and Robiyanto (2020) examined the correlation of gold price, exchange rate, and stock markets using the DDC-GARCH method during the COVID-19 pandemic from January 2020 to June 2020. The consequences revealed that shifts in gold prices substantially impact stock price volatility. There is a clear, dynamic correlation between stock markets and gold and an adverse correlation between stock markets and exchange rates. Barro et al. (2020) state that the spread of the Coronavirus induced stock market collides boosted financial volatility in nominal interest rates and squeezed real economic activity. These shocks also provoked many economists to express their worries about the forthcoming global recession. Hacıevliyagil and Gümüş (2020) took the ten countries most affected by COVID-19 and analyzed the effect of the number of deaths and cases in these countries on the stock market indices of the countries. They analyzed whether there is a long-term relationship between the number of deaths and the stock market index with the Multiple Structural Break Model. As a result of the findings, it was determined that death rates rather than the number of cases were more effective on the stock market index. Compared with the other analyzed countries, they concluded that the USA and Turkey were most affected by the number of deaths and cases in the stock market index. Vurur and Özen (2020) examined the relationship between CDS premium and the stock market index of 5 European countries (Italy, France, Germany, England Spain) using daily data between February 22, 2019, and August 29, 2020 COVID-19. They analyzed the effect of CDS premiums on countries' stock market indices using the Structural Break Model and the causality relationship with the Toda Yamamoto method. Although CDS premiums did not affect the countries' stock market indices before the structural break, they found that CDS premiums had a significant effect on the countries' stock market indices after the break. In addition, they found a bidirectional causality relationship in other European countries, except Italy, after the break in the study. Li et al. (2020) investigated the effects of cumulative and new deaths, cumulative and new cases on stock markets due to COVID-19 between March 1, 2020, and April 10, 2020, in Germany, France, Italy, and China, Spain, and the USA. The analysis with the GMM model shows that while the stock market return is more effective than deaths in COVID-19 cases, it seems more sensitive to COVID-19 cumulative indicators than new ones. It also showed the negative impact of the spread of COVID-19 on stock market returns in China, France, Germany, and Spain but found no such finding for Italy and the United States. Al-Saifi et al. (2020) conducted panel data analysis using company data included in the Hang Seng Index and Shanghai Stock Exchange Composite Index between January 10 and March 16 to examine the effects of infectious diseases on the Chinese stock market. The analysis results indicated that the increase in the number of people with coronavirus disease and the occurrence of death rates negatively affected the Chinese stock market. Corvet et al. (2020) analyzed the effect of cryptocurrencies and gold on the Chinese stock market with the GARCH model before and after the pandemic, using hourly data between 11.03.2020-and 10.03.2020. GARCH model results show that COVID-19 has a strong and significant positive impact on each stock market, considering both Shanghai and Shenzhen Stock Exchanges. They also found that the epidemic impacted the volatility of cryptocurrencies and gold. Ünal (2020), in his analysis to measure the impact of the Coronavirus, which affects the whole world, on Borsa Istanbul, analyzed it with error correction and cointegration models using daily data between 31.12.2019 and 28.05.2020. The short-term catch-up rate has been evaluated by estimating the error correction model. In her analysis of the stock market index is used as the dependent variable, independent variables (the ratio of those who lost their lives in Turkey coronaviruses, US dollar exchange rate, the VIX (fear) index, volatility in capital markets and infectious diseases index, and international equity index) was statistically significant in the short term. In the long run, it determined that there is a significant relationship between the mortality rate and the international capital index among the independent variables (Ashraf, 2020; Topcu and Gulal, 2020; Liu et al., 2020; Sansa, 2020; Contuk, 2021; Çelik, 2021; Haldar and Sethi, 2021).

4. ECONOMETRIC ANALYSIS

This paper explores the relationship between the number of coronavirus disease 2019 (COVID-19) cases and Europe's most important stock market indices by time series analysis using daily data between 01.02.2020 and 31.08.2020. For this purpose, three different models were created. Therefore, the total number of COVID-19 daily cases in 27 EU countries has been used as the independent variable. In addition, the DAX Index, CAC 40 Index, and Euro Next 100 Index have been investigated as dependent variables, respectively. Moreover, the stock markets data were compiled from the www.investing.com website, while the number of COVID-19 cases was reached by World Health Organization (WHO). Table 1 indicates the definition of variables.

Table 1. Definition of variable

Variables	Code	Unit	Source
The number of COVID-19 Cases	Covcase	Natural Logarithm	WHO
The Deutscher Aktien Index	DAX Index	Natural Logarithm	www.investing.com
The Continuous Assisted Trading Index	CAC Index	Natural Logarithm	www.investing.com
The blue chip index of the pan-European exchange	Eunext100 Index	Natural Logarithm	www.investing.com

These indices are chosen because they are the most influential indexes, consisting of the largest European Union companies. DAX Index is a stock index representing 30 of the largest and most liquid German companies traded on the Frankfurt Stock Exchange. CAC 40 Index consists of 40 of the largest multinational companies on the Paris Stock Exchange. The index is the main benchmark index of Euronext Paris, like the Dow Jones Industrial in the US, the DAX in Germany, and the Nikkei average in Japan. Two-thirds of the businesses and businesses of the companies included in the index are located outside France. Euro Next 100 Index consists of the largest and most liquid stocks traded on Euronext. The index is reviewed quarterly to analyze the size of the investment universe and liquidity. Euronext's members are 64 French companies, 19 Dutch companies, 11 Belgian companies, 5 Portuguese companies, and 2 Luxembourg companies. In this framework, the following four models will be investigated with the help of time series analysis. The mathematical form of these models is formulated as follows:

Model 1: DAX Index = f (Covcase) (1)

Model 2: CAC Index = f (Covcase) (2)

Model 3: Eunext100 Index = *f (Covcase)* (3)

The econometric form of the models with mathematical representation can be expressed as follows.

Model 2: $ln\text{DAX Index}_t = X_0 + X_1 \ln\text{Covcase}_t + z_t$ (4)

Model 3: $\ln\text{CAC Index}_t = Q_0 + Q_1 \ln\text{Covcase}_t + m_t$ (5)

Model 4: $\ln\text{Eunext100 Index}_t = k_0 + k_1 \ln\text{Covcase}_t + +v_t$ (6)

Where t denotes time series, $X_0 = Q_0 = k_0$ is the intercept while $z_t = m_t = vt$ is the error terms. Table 2 indicates the summary statistics of data.

Table 2. Summary Statistics

	Covcase	DAX Index	CAC Index	EUNEXT100 Index
Mean	7832,633	12017,99	5027,802	987,9792
Median	4774	12494,81	4952,46	982,55
Maximum	35080	13789	6111,24	1180,52
Minimum	0,000	8441,71	3754,84	749,91
Std. Dev.	8394,559	1363,385	617,6244	111,7922
Skewness	1,213997	-0,764957	0,395597	0,185808
Kurtosis	3,628547	2,519475	2,227796	2,209624
No of obs.	169	169	169	169

Note. In analysis, the natural logarithm of all data is taken to reduce scale differences.

4.1. Stationarity Analysis

This study was used both traditional unit root tests (no break) and unit root tests with structural break for stationarity analysis. In this direction, first, we employ the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) unit root tests. ADF unit root test procedure is as follows:

Simple form: $\Delta Y_t = \rho Y_{t-1} + \mu_t$ (7)

Constant form: $\Delta Y_t = a_0 + \rho Y_{t-1} + \mu_t$ (8)

Constant and trend form: $\Delta Y_t = a_0 + a_1 t + \rho Y_{t-1} + \mu t$ (9)

The test statistics of the series were compared with the critical values of MacKinnon (1996). In addition, the hypotheses of this test are as follows:

The null hypothesis (H_0: $\rho = 0$) demonstrates that the series have unit root, which means the series are not stationary while alternative hypothesis (H_1: $\rho \neq 0$) demonstrates that the series have not unit root, which means the series become stationary.

Phillips-Perron (PP) test is another unit root test used in the analysis. Phillips-Perron (PP) has developed some of the ADF's assumptions with error terms. In the stationary analysis of the trend series, it is revealed that the PP unit root test gives stronger results than ADF. The stationarity results for the PP test are determined by comparing their statistics with the critical values of MacKinnon (1996), just like the ADF unit root test. The Newey West error correction mechanism is used to eliminate the autocorrelation problem for the PP test. PP unit root test series are tested on the following equation.

$$\Delta Y_t = \beta_1 + \alpha Y_{t-1} + \beta_2 \left(t - \frac{T}{2}\right) + \mu_t \tag{10}$$

In Eq.10, T denotes the number of observations, while t denotes the trend, μ_t is error terms. When the hypotheses of the relevant test are applied to the series in the study, they are as follows:

The null hypothesis (H_0: $\alpha = 0$) demonstrates that the series have unit root, while the alternative hypothesis (H_1: $\alpha < 1$) demonstrates that the series have not unit root. Table 3 presents ADF and PP unit root tests.

Table 3: Unit Root Test Results

	Results of ADF Test				**Results of Phillips-Perron Test**				***Decision***
	Level Values		**First Difference Values**		**Level Values**		**First Difference Values**		
lnDax	(-1,42)	[0,85]	(-12,86)	[0,00*]	(-,59)	[0,79]	(-2,98)	[0,00*]	***I(1)***
lnCAC	(-1,44)	[0,84]	(-13,08)	[0,00*]	(-,61)	[0,78]	(-13,18)	[0,00*]	***I(1)***
lnEunext	(-1,38)	[0,86]	(-3,02)	[0,00*]	(-1,57)	[0,79]	(-13,13)	[0,00*]	***I(1)***
lnCovca	(-1,30)	[0,88]	(-14,09)	[0,00*]	(-1,34)	[0,87]	(-14,04)	[0,00*]	***I(1)***

Note. The data are analyzed within the framework of a fixed term and trend model. Parentheses ( ) indicate the t-statistics value of the data, while square brackets [ ] indicate probability values findings. The * sign indicates that the series is stationary at the 1% significance level. These critical values for ADF and PP are set forth by MacKinnon (1996).

First, we have employed the conventional unit root methods such as ADF and PP. The unit root test results indicate that all variables are stationary after taking first difference. However, these unit root tests might cause misleading findings as they neglect the structural break in the series. Subsequent, among these tests, it was commenced to be discussed whether the structural break dates should be added to the econometric model endogenously or exogenously. Zivot and Andrews (ZA, 1992) criticized Perron's (1989) exogenous breakpoint assumption. For this purpose, instead of the exogenous assumption, Zivot and Andrews developed a model that catches that the structural break appears endogenously. This model consists of 3 main equations. Model 1 allows for a single failure at the level, Model 2 allows for a single failure at the slope, and Model 3 allows for a single failure at both the slope and the level. The primary equations of the models are as follows (Zivot and Andrew,1992):

$$\text{Model 1: } \Delta yt = c + \alpha y_{t-1} + \beta t + dDU_t + \sum_{j=1}^{k} dj\, \Delta y_{t-j} + \mu t \tag{11}$$

$$\text{Model 2: } \Delta yt = c + \alpha y_{t-1} + \beta t + dDT_T + \sum_{j=1}^{k} dj\, \Delta y_{t-j} + \mu t \tag{12}$$

$$\text{Model 3: } \Delta yt = c + \alpha y_{t-1} + \beta t + dDU_t + dDT_T + \sum_{j=1}^{K} dj\, \Delta y_{t-j} + \mu t \tag{13}$$

In the models, DU level and DT are dummy variables expressing the break in the slope;

$$DU_t = \begin{cases} 1, if \;\; t > TB \\ 0, if \;\; t < TB \end{cases} \text{ and } DT_t = \begin{cases} t - TB & if\; t > TB \\ 0 & if\; t < TB \end{cases}$$

In this equation, time t=1,2,...,T gives the break point B = TB/T to express the TB break date. While applying the ZA unit root test, firstly, Model 3, which allows a single break in both slope and level, is estimated. Model 3 is preferred if both DU and DT dummy variables are statistically significant. If DU is significant from the three models, Model 1 is estimated, and if DT is significant, Model 2 is estimated. There is no consensus on which of these three models is superior, but Model 1 and Model 3 are generally preferred in practice. The ZA unit root test is sensitive to lag length as well as ADF and PP(Özcan, 2015).

Table 3 and Table 4 results can be shown that the series become stationary at the first differences for the ADF, PP and ZA unit roots. The chosen break dates show the time period when the virus commenced to spread rapidly throughout Europe. The result obtained in this respect is consistent. Table 4 presents ZA unit root test results.

Table 4. Zivot-Andrews Structural Break Unit Root Test Results

Variables	t-Statistics	Chosen Break Point
lnDax	-3.48 (0)	13 March 2020
lnCAC	-3.77 (2)	12 March 2020
lnEunext	-3.88 (3)	17 March 2020
lnCovca	-3.67 (4)	10 March 2020
ΔlnDax	-8.00 (1)*	-
ΔlnCAC	-7.90 (1)*	-
ΔlnEunext	-4.75 (4)**	-
ΔlnCovca	-4.17 (4)***	-

Note. Parentheses ( ) indicate chosen lag lenght. Considering the trend in Zivot Andrews Unit Root Analysis, the critical values for 1%, 5% and 10% are -4.80, -4.42, -4.11, respectively. The *, **, *** signs indicate that the series is stationary at the 1%, 5%, 10% significance level.

This result gives information about the tests to be used in the next stage of the analysis. The main condition of passing to cointegration analysis is that the series becomes stationary by taking their first differences. Accordingly, the Johansen Cointegration Analysis test, which determines the long-term relationship of the series, will be used in the next stage of the analysis.

4.2. Johensen and Maki Cointegration Tests

The condition of executing cointegration analysis is that the series examined are stationary after taking the first difference. Unit root tests proved that we could apply cointegration analysis. Therefore, in the study, we first performed cointegration analysis without a structural break (Johansen, 1988; Johansen and Juselius, 1990). Before testing the cointegration relationship between the series, the lag length must be determined. We determined that the suitable lag length was k = 1. Following that, Table 5 presents Johansen cointegration test results.

Table 5: Cointegration Test Results

Hypothesized No. of CE (s)	*Eigenvalue*	*Trace Statistic*	*0,05 Critical Value*	*Prob.***	*Max-Eigen Statistic*	*0,05 Critical Value*	*Prob.***
Model 1							
None *	0,2313	81,9649	24,2759	0,0000	42,8976	17,7973	0,0000
At most 1 *	0,1638	39,0673	12,3209	0,0000	29,1726	11,2248	0,0000
At most 2*	0,0588	9,8946	4,1299	0,0020	9,8946	4,1299	0,0020
Model 2							
None *	0,2367	83,7083	24,2759	0,0000	44,0289	17,7973	0,0000
At most 1 *	0,1705	39,6794	12,3209	0,0000	30,4871	11,2248	0,0000
At most 2*	0,0548	9,1922	4,1299	0,0029	9,1922	4,1299	0,0029
Model 3							
None*	0,2388	81,6825	24,2759	0,0000	44,4815	17,7973	0,0000
At most 1*	0,1553	37,2010	12,3209	0,0000	27,5194	11,2248	0,0000
At most 2*	0,0576	9,6816	4,1299	0,0022	9,6816	4,1299	0,0022

Not. Note. The * sign indicates that the series is at the 1% significance level. ** denotes Mackinnon-Haug-Michells (1999) p-values.

Table 5 illustrates the probability value is smaller than 5%, the null hypothesis was rejected for all models. This result proves the existence of a long term cointegration relationship between series. In addition, at least two cointegration vectors are determined. Table 6 presents normalized long-term cointegration results.

Table 6: Normalized Long-Term Cointegration Results

Dependent Variable	Cointegration coefficient for lnCovcase	Standard Error	t-statistic
lnDaxindex	-0,064*	0.018	-3,55
lnCacindex	-0,047*	0,015	3,13
lnEunext	-0,056*	0,016	3,5

Note. The * sign indicates that the series is at the 5% significance level.

Table 6 illustrates the normalized long-term cointegration results. It is found that a 1% increase in the number of cases of COVID -19 reduces the DAX Index by 0.06%, the CAC Index by 0.04%, the Euro Next 100 Index by 0.05%. Cointegration tests were employed to test the long-term relationship between time series. In cointegration tests, on the other hand, structural breaks occur due to economic shocks, political or social changes. To uncover the structural break dates, Gregory and Hansen (1996) developed the cointegration test, in which the structural break time is confined internally and allows a structural break. Hatemi J (2008) originated the structural break test and presented a model that permits two structural breaks. Maki (2012), on the other hand, developed the cointegration test in which the time of the break is determined endogenously to allow up to five breaks. The equations of the Maki (2012) model are as follows:

Model 0: $y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta' x_t + u_t,$ (14)

Model 1: $y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta' x_t + \sum_{i=1}^{k} \beta'_i x_t D_{i,t} + u_t,$ (15)

Model 2: $y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \beta' x_t + \sum_{i=1}^{k} \beta'_i x_t D_{i,t} + u_t,$ (16)

Model 3 : $y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \sum_{i=1}^{k} \gamma_i t D_{i,t} + \beta' x_t + \sum_{i=1}^{k} \beta'_i x_t D_{i,t} + u_t,$ (17)

Model 0; the trendless model with break in the constant term, Model 1; the trendless model with break in constant term and slope, Model 2; The model with a trend with a break at the constant term, and Model 3 the model with a trend with a break at the constant term and the slope. Here $D_{i,t}$ $(i = 1i \dots, k)$ denotes dummy variables and takes the value 1 when $t > TBi$, and takes the value 0 in other cases. TBi indicates the structural break period (Maki, 2012). Tablo 7 presents Maki (2012) cointegration test results.

Tablo 7: Maki (2012) Cointegration Test Under Multiple Structural Breaks Results

Cointegration Model 1: *LnDax= f (Covca)*		
Model 0	-5.08***	5 March 2020-20 March-25 May 2020
Model 1	-5.63**	10 March 2020-23 Apr. 2020- 28 May 2020
Model 2	-6.65*	15 Jan. 2020-31 March 2020-23 Apr. 2020
Model 3	-6.07	2 Apr. 2020-3 June 2020-24 June 2020
Cointegration Model 2: *LnCacindex= f (Covca)*		
Model 0	-7.36*	1 Jan. 2020-19 March 2020- 1 July 2020
Model 1	-7.74*	23 Jan. 2020-6 Feb. 2020- 19 March 2020
Model 2	-4.93	23 Jan. 2020-6 Feb 2020-19 March 2020
Model 3	-5.88	15 Jan. 2020-19 March.2020-15 June 2020
Cointegration Model 3: LnEunext= f (Covca)		
Model 0	-5.25***	9 March 2020-19 May 2020- 16 June 2020
Model 1	-5.31***	6 March 2020-30 March 2020- 27 May 2020
Model 2	-	-
Model 3	-	-

Note: *, ** and *** denote the rejection of the null hypothesis of "no cointegration" at the 1%, 5% and 10% significance levels, respectively. Table 1 in article of Maki (2012) presents Critical Value of the test. The critical values of this test are calculated by Monte Carlo simulation.

Table 7 illustrates the existence of a long term cointegration under multiple structural breaks relationship between series. It has been determined that the chosen break dates (points) are parallel to the peak periods of the COVID-19 pandemic. In traditional cointegration methods, while revealing the long-term relationships between the variables, there are problems of internality in the estimation process and interpretation problems of the long-term coefficients obtained. In order to solve these problems, "Fully Developed Least Squares" (FMOLS) developed by Hansen and Phillips (1990), "Canonical Cointegrated Regression" (CCR) developed by Park (1992), and "Dynamic Least Squares" developed by Stock and Watson (1993). Squares" (DOLS) methods were used. FMOLS, CCR and DOLS cointegration methods are based on the condition that the series used are stationary in difference, just like the Johansen cointegration method. However, the possibility of interpreting the coefficients in FMOLS, CCR and DOLS cointegration method offers a significant advantage (Erdoğan et al, 2018; Bulut and Yılmaz,2020). Table 8 shows that almost all results are close to each other. If we consider in order, FMOLS results illustrate that a 1% increase in the number of COVID-19 cases decreases the DAX index by 0.046%, the CAC index by 0.042% and the EUNEXT index by 0.041% while DOLS results prove that a 1% increase in the number of COVID-19 cases decreases the DAX index by 0.046%, the CAC index by 0.041% and the EUNEXT index by 0.040%. Lastly, CCR results show that a 1% increase in the number of COVID-19 cases decreases the DAX index by 0.042%, the CAC index by 0.043% and the EUNEXT index by 0.041%. To sum up, COVID-19 pandemic has adversely affected financial markets.

Tablo 8. FMOLS-DOLS-CCR Estimators

Panel A: Fully Modified Least Squares (FMOLS)		
Variables	**Coefficient**	**Prob.**
LnDax	-0.046*	0.000
LnCac	-0.042*	0.000
LnEunext	-0.041*	0.000
Panel B: Dynamic Least Squares (DOLS)		
LnDax	-0.046*	0.000
LnCac	-0.041*	0.000
LnEunext	-0.040*	
Panel C: Canonical Cointegrating Regression (CCR)		
LnDax	-0.042*	0.000
LnCac	-0.043*	0.000
LnEunext	-0.041*	0.000

Note. The * sign indicates that the series is at the 5% significance level.

4.3. Vector Error Correction Model (VECM)

While the long-term relationship is investigated with the cointegration method, the error correction model focuses on the short-term relationship between the series. This model examines the existence of divergences from equilibrium in the long run and how these deviations converge the mean in each period. It answers the questions of how much these deviations can decrease in each period and how long it will take to form the balance (Tarı et. al., 2019: 435). Accordingly, parameters in Models 18, 19, and 20 determine the deviations of the series. If these parameters are statistically significant, it can be said that there is a deviation. Various levels of deviations occur during the long-term dynamic movements of the series. There are short-term determinants confined in series with mostly long-term cointegration relationships. (Johnston ve Dinardo,1997). The Vector Error Correction model appears to solve this problem. The Vector Error Correction model equations used in the study are presented below.

Model 1: $\Delta \text{lnDAX Index}_t = X_0 + X_1 ECT_{t-1} + X_2 \Delta \text{lnCovcase}_t + z_t$ (18)

Model 2: $\Delta \text{lnCAC Index}_t = Q_0 + Q_1 ECT_{t-1} + Q_2 \Delta \text{lnCovcase}_t + m_t$ (19)

Model 3: $\Delta \ln Eunext100\ Index_t = k_0 + k_1\ ECT_{t-1} + k_2\ \Delta \ln Covcase_t + +v_t$ (20)

Where refers to the one-period lag of the error terms series obtained from the long-term analysis. Tablo 9 presents Vector Error Correction Model test results.

Table 9. Vector Error Correction Model Test Results

Model 1	***Coefficient***	***t-statistics***	***Prob.***
D (Covcase)	-0,01*	-3,25	0,00
ECT (-1)	-0,02	-1,13	0,25
Constant Term (C)	0,00	0,31	0,75
Model 2			
D(Covcase)	-0,006	-1,60	0,11
ECT (-1)	-0,065*	-2,24	0,02
Constant Term (C)	-0,000	-0,46	0,63
Model 3			
D(Covcase)	-0,009*	-2,69	0,00
ECT (-1)	-0,005*	-2,00	0,04
Constant Term (C)	-0,0003	-0,21	0,83

Note. The * sign indicates that the series is at the 5% significance level.

Table 9 illustrates the Vector Error Correction Model results. The error correction coefficients are expected to be negative and the probability value to be significant. Error correction model coefficient used to eliminate the short-term deviations of the series moving together, in the long run, is substantial for Model 2 and Model 3. Accordingly, approximately 6% of one-unit deviation for Model 2 disappears in the next period; for Model 3, about 0,5% of one-unit deviation disappears in the next period. On the other hand, according to the results of short-term analysis between series for Model 1, it is found that a 1% increase in the number of COVID-19 cases reduces the DAX Index by 1%. Looking at Model 3, it is found that a 1% increase in the number of COVID-19 cases reduces the Euronext 100 Index by 0,5% in the short term. The COVID-19 pandemic has had a more negative impact on activity in the first half of 2020 than forecasted. The recovery is foreseen to be more step by step than previously indicated. In 2021 global growth is estimated at 5.4 percent. Overall, this means 2021 GDP will be 6,5 percentage points lower than in the pre-COVID-19 projections of January 2020 (IMF, 2020). Economic and socio-cultural problems experienced on a global scale significantly affect economic growth. In terms of financial markets, it has been determined that there is an average of 30% depreciation in stock markets in countries with the highest number of active cases worldwide. On the other hand, from the day of the first case of COVID-19 until the first 6-month period, severe losses began to be experienced in the stock markets of Germany, France, Italy, and Spain, which are among the leading countries in Europe. In short, in parallel with the analysis results, it can be said that the COVID-19 has severely affected the European stock markets.

5. CONCLUSION

The rapid spread of the new type of coronavirus, which emerged in China at the end of December 2019, has increased the number of cases from one million to over one hundred thousand in a short time since January. The prohibitions imposed by the states to prevent the virus have had a very rapid impact on the economies of the country and in general, many sectors have started to shrink. There were also sharp declines in the financial markets. Significant constrictions have occurred even in the world's largest stock markets.

In this study, the relationship between the number of COVID-19 cases and Europe's most important stock market indices was explored by time series analysis, using daily data for the European Union for the span between 01.02.2020 and 31.08.2020. In the unit root analysis executed in the first stage of the analysis, it was concluded that the series became stationary after taking the first differences. This result is accepted as a prerequisite for long-term cointegration analysis as well. The Johansen and Maki cointegration test results prove the existence of a long-term cointegration relationship between series. Whereas the probability value of the Trace statistic and the maximum eigenvalue statistic between the series is smaller than 5%, the null hypothesis was rejected. In addition, at least two cointegration vectors are determined. Looking at the cointegration coefficients, FMOLS results illustrate that a 1% increase in the number of COVID-19 cases reduces the DAX index by 0.046%, the CAC index by 0.042%, and the EUNEXT index by 0.041%. DOLS results demonstrate that a 1% increase in the number of COVID-19 cases declines the DAX index by 0.046%, the CAC index by 0.041%, and the EUNEXT index by 0.040%. Finally, CCR results show that a 1% upsurge in the number of COVID-19 cases reduces the DAX index by 0.042%, the CAC index by 0.043%, and the EUNEXT index by 0.041%.

Another noteworthy analysis that should be utilized for short-term analysis is the error correction model. This analysis tests the prevention of loss of information in differentiated series and in how many periods in which short-term deviations from series can disappear. The test results indicate that the error correction model coefficient used to eliminate the short-term deviations of the series moving together, in the long run, is significant for Model 1 and Model 2. Accordingly, approximately 6% of one-unit deviation for Model 3 disappears in the next period; for Model 3, approximately 0,5% of one-unit deviation disappears in the next period. On the other hand, according to the results of short-term analysis between series for Model 1, it is found that a 1% increase in the number of COVID-19 cases reduces the DAX Index by 1%. Looking at Model 3, it is found that a 1% upsurge in the number of COVID-19 cases reduces the Euro Next 100 Index by 0,5% in the short term.

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Beyan ve Açıklamalar (Disclosure Statements)

1. Bu çalışmanın yazarları, araştırma ve yayın etiği ilkelerine uyduklarını kabul etmektedirler (The authors of this article confirm that their work complies with the principles of research and publication ethics).

2. Yazarlar tarafından herhangi bir çıkar çatışması beyan edilmemiştir (No potential conflict of interest was reported by the authors).

3. Bu çalışma, intihal tarama programı kullanılarak intihal taramasından geçirilmiştir (This article was screened for potential plagiarism using a plagiarism screening program).