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Impact of Infectious Diseases on Stock Markets: Evidence from Developed Markets

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Abstract: *This study investigates the relationship between developed country market indices and the infectious disease stock market volatility index between March 11, 2020, and March 11, 2022. Thus, we seek an answer to the question of how global shocks will affect developed countries. In this context, indices such as S&P 500, CAC 40 and NIKKEI 225 are considered to represent developed country markets. The findings of the study indicate that the infectious disease stock market volatility index variable is significant, according to the GARCH model estimation for the CAC 40 index. In the EGARCH model estimation results for the NIKKEI 225 and S&P 500 indices, the infectious disease stock market volatility index variable is found to be significant. The results of this paper are important for policymaking by governments, investors, and the corporate sector in order to avoid future developments that could lead to financial shocks.*

Keywords: Covid-19; Advanced markets; Asymmetric relationship; GARCH; EGARCH

JEL Classification: D53, G01, G14, G15

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Introduction

The Covid-19 pandemic, declared by the World Health Organization on 11.03.2020, is responsible for approximately 512 million confirmed cases of the disease and has caused the death of approximately 6.3 million people as of April 30, 2022. The pandemic has adversely affected socio-economic activities across the world. It has caused a deficit of skilled and experienced workers, decreased labour supply, decreased productivity and negative economic growth (Abodunrin et al., 2020). In addition, considering its global effects, it has disrupted international trade, which has affected the logistics sector (Baker et al., 2020). In 2020, approximately 90% of countries experienced a decrease in economic activities and a 3.3% contraction in the world economy (World Economic Outlook, 2022). For this reason, countries had to take decisions quickly to minimize the economic effects of the pandemic. As such, they have developed policies in this direction (Ashraf, 2020).

Like many sectors, financial markets have been adversely affected by the pandemic. Covid-19, which created more severe effects than the 2008 global crisis, caused a 50% or more decline in global stock markets (Roubini, 2020). Many studies confirm significant fluctuations in stock, gold and cryptocurrency markets due to the pandemic (Haroon and Rizvi, 2020).

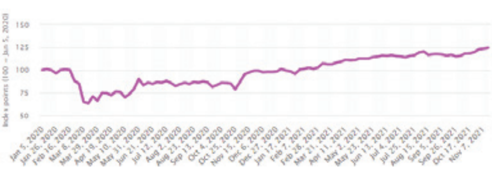
Figure 1: Impact of Covid-19 on MSCI World, S&P 500, NIKKEI 225 and CAC 40 Indices, (05.03.2020 – 07.11.2021)

MSCI World

S&P 50

NIKKEI 225

CAC 40



Source: Statista, 2022.

With the declaration of Covid-19 as a pandemic, the financial decline was the most acute in March 2020 as a result of risk and uncertainty in the markets. Figure 1 shows the impact of the pandemic on MSCI World, S&P 500, CAC 40 and NIKKEI 225 indices. The MSCI World represents global developed markets. The findings show that the market values of the various indices lost more than 30% at the end of March 2020, but there was a recovery in the following periods.

Due to the volatility experienced in the markets during this period, some indices were developed to reflect policymakers' and individual investors' uncertainty during the pandemic's progress and to be a leading indicator in this process. Baker et al. (2020) created an index by examining the frequency with which specified words appeared in US newspapers. In this context, they arranged the index to examine the effect of news about pandemics. The words and concepts used to create the index are specified in four separate clusters. In these word groups, there are concepts such as volatility, uncertainty and risk; as well as financially weighted words such as economy, economic, financial, stock markets and stocks. In addition, words related to infectious diseases and pandemics (such as 'virus', 'pandemic', 'epidemic', 'Mers', 'Sars', 'Ebola', 'H5N1' and 'H1N1') are another group considered in this context.

This study investigates the relationship between developed country market indices and the infectious disease stock market volatility index. In order to contribute to the literature, this study aims to investigate the effects of global pandemics on developed countries markets. The rest of the paper is organized as follows. Section 2 presents a summary of the literature. The third section presents the methodology and analysis. The last section presents the evaluation and conclusion.

Literature Review

At the beginning of the pandemic, developed countries' economies were greatly affected alongside all other economies (Rakshit and Neog, 2021). The effect of the pandemic on the stock markets has also led to daily jumps. Many studies have been carried out on countries' stock markets since the beginning of Covid-19. The studies used variables related to the pandemic, such as the number of cases and deaths. Gherghina et al. (2020) In a study that examined the effects of Covid-19 on Romanian stock markets for the period 31.12.2019–20.04.2020, as a result of the distributed lagged autoregressive model (ARDL) estimation, Covid-19 had both short- and long-term effects on the Romanian stock market. Khan et al. (2020), as a result of their pooled least squares estimation for 16 countries for the period 09.04.2019–03.04.2020, concluded that weekly new Covid-19 cases negatively affected returns in the stock markets. Ashraf (2020) examined the effect of Covid-19 cases and deaths on stock market returns from 22.01.2020–17.04.2020 using the daily Covid-19 case numbers and stock market returns of 64 countries. In the results of the analysis, it was found that the number of Covid-19 cases affected the stock markets negatively. However, the effect of the number of Covid-19 deaths on the markets was not statistically significant. Rehman et al. (2021), in the analysis of the study in which they examined the G7 countries, revealed that the number of Covid-19 cases and deaths have a long-term effect on the USA, Canada, and Germany's stock markets. Derbali et al. (2021), as a result of their analysis of China and some international financial markets, revealed that Covid-19 potentially explains the spillover effects of the Chinese stock market index in the international indices. In addition, the authors found that the volatility between the Chinese and international stock indices was more persistent. Table 1, below, summarizes the effects of the pandemic on the leading world indices and the variables studied.

Table 1: Literature Summary

Writer	Period and Method	Variables	Countries	Results
Shehzad et al., (2020)	30.06.2007–07.04.2020; APGARCH model	stock returns	USA (S&P 500, NASDAQ Composite), Germany (DAX 30), Italy (FTSE MIB), Japan (NIKKEI 225) and China (SSEC)	As a result of the analysis, it was concluded that Covid-19 had a negative effect on the S&P 500 and NIKKEI 225 stock returns but had an insignificant effect on the NASDAQ Composite index.
Wang et al., (2020)	Period 01.12.2019–25.03.2020; MCS test	VIX, EPU, RV	Stock index of 19 countries including USA (S&P 500), France (CAC 40) and Japan (NIKKEI 225)	For 19 stocks, VIX was found to be the stronger predictor of the future volatility of the pandemic's effect on all exchanges (except SSEC) compared to the EPU.
Albulescu (2021)	10.03.2020–15.05.2020; OLS method	RV, EPU, cases and deaths	USA (S&P 500)	It is concluded that cases increase financial volatility, death rates have a significant effect on volatility and the effect of EPU on financial volatility is insignificant.
Bai et al., (2021)	04.01.2005–30.04.2020; GARCH-MIDAS model	EMV-ID, RV (lagged realized volatility) and GEPU (global economic policy uncertainty)	USA (S&P 500), China (CSI 300), UK (FTSE 100) and Japan (NIKKEI 225)	It is concluded that Covid-19 has increased the volatility in international stock markets. However, this effect was small in the Chinese stock market. Moreover, the GEPU has a long-term effect on the volatility of international stock markets.
Baig et al., (2021)	13.01.2020–17.04.2020; OLS regression analysis	VIX, cases and deaths	USA (S&P 500)	According to the findings, it was determined that the increasing number of cases and deaths caused instability in the markets. It has been found that the markets were adversely affected as a result of the quarantines and restrictions applied.

Writer	Period and Method	Variables	Countries	Results
Belaid, (2021)	01.02.2019–12.05.2020; Diebold-Yılmaz methodology, Toda-Yamamoto, Dolado and Lütkepohl causality	Stock daily data (returns)	Stock indices of 22 emerging and developed countries including USA (S&P 500), France (CAC 40) and Japan (NIKKEI 225)	As a result of the analysis, it was concluded that the stress and economic uncertainty experienced during the pandemic period increased the transfer between financial markets.
Grima et al., (2021)	27.01.2020–29.05.2020; Johansen cointegration test, FMOLS method	VIX, daily cases and deaths	USA (DJIA), Germany (DAX), France (CAC 40), UK (FTSE 100), Italy (MIB), China (SSEC) and Japan (NIKKEI 225)	As a result of the analysis, it has been determined that the uncertainty and fear in the market due to cases and deaths have an effect on the VIX index. It has been shown that the VIX index is co-integrated with indices other than CAC 40 and MIB, thus the indirect effect of fear in the market.
Narayan et al., (2021)	01.07.2019–16.04.2020; regression models	Stock returns, crude oil price returns (WTI), quarantine days, travel bans, stimulus packages	G7 Countries: Canada (S&P/TSX), France (CAC 40), Germany (DAX 30), Italy (FTSE MIB), Japan (NIKKEI 225), United Kingdom (FTSE) and USA (S&P 500)	It was concluded that the policies implemented during the Covid-19 period positively affected the stock market returns in G7 countries. In addition, stimulus packages had a positive impact on Canadian, UK and US stock returns, while travel bans had a positive impact on Canadian and German stock returns.
Karamti and Belhassine, (2022)	22.01.2020–13.01.2021; Wavelet consistency analysis	EMVID, oil (WTI), bitcoin, Ethereum	USA (S&P 500), China (SSE), UK (FTSE), Japan (NIKKEI 225), Germany (DAX) and France (CAC 40)	It was concluded that the policies implemented during the Covid-19 period positively affected the stock market returns in G7 countries. In addition, stimulus packages positively impacted Canadian, UK and US stock returns, while travel bans positively impacted Canadian and German stock returns.
Chen et al., (2022)	01.2019–12.2019 and 01.2020–06.2021; QARDL model	EMVID, VIX, total commodity returns index (CCFI)	USA and China (S&P GSCI)	As a result of the analysis, the infectious disease index was found to be positively correlated between the two countries' stock markets during the pandemic period. Commodity shocks play an essential role for US stocks in the short and long term. The Chinese stock market is more sensitive to the EMVID index.
Wang et al., (2022)	01.01.2007–31.12.2019 and 01.01.2020–31.12.2020; GFEVD, VAR(p) model	Stock quotes (returns), WTI, GBP/USD	USA (S&P 500), China (SZSE 300), UK (FTSE 100), Japan (NIKKEI 225) and Hong Kong (Hang Seng)	It has been concluded that the spread between financial markets has increased significantly with the pandemic.

Since the US stock markets are at a leading point in the world economy, it is thought to have an impact on other countries' economies and stock markets. In this context, within the scope of the study, it will be examined whether the daily infectious disease stock market volatility index affects the stock market indices of developed countries during the pandemic period. Thus, it will be investigated whether the volatility index affects the German and Japanese stock markets and the US stock market. In this context, the study investigates the permanence of shocks and asymmetric effects throughout the pandemic. As such, it aims to provide information on the evaluation of the infectious disease stock market volatility index within the volatility dynamics in developed markets to be an advisory to investors. When the study is considered in this context, it is anticipated that it will make an essential contribution to the literature.

Data and Method

This study examined the relationship between developed country markets and the infectious disease stock market volatility index (INDEX) during the 11.03.2020–11.03.2022 pandemic period. Within the scope of the study, data from the S&P 500, CAC 40 and NIKKEI 225 stock market indices were taken from the 'Yahoo Finance' website. The infectious disease stock market volatility index was obtained from the site named 'policyuncertainty.com'. Table 2 below provides detailed information about the data used in the study.

Table 2: Data Used in the Study

Variables	Sources
S&P 500	Yahoo Finance' website[1]
CAC 40	Yahoo Finance' website
NIKKEI 225	Yahoo Finance' website
infectious disease stock market volatility index	policyuncertainty.com

Note: [1]finance.yahoo.com

Autoregressive conditional variable variance (ARCH) or generalized ARCH-type (GARCH) models are used to explain the volatility of stock markets (Ali, 2013). The GARCH(1,1) model introduced by Bollerslev (1986) is given in equation (1).

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (1)$$

The equation that occurs when the INDEX variable is added to the GARCH(1,1) model is stated in (2). In this equation, while ω represents the constant parameter, the condition $\alpha+\beta<1$ must be valid. Thus, the effect of the infectious disease stock volatility index on volatility will be examined.

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \partial INDEX_t \tag{2}$$

The exponential GARCH (EGARCH) model introduced by Nelson (1991) is used because it satisfies the non-negative condition and reflects asymmetrical relationships. The EGARCH(1,1) model is shown in equation (3). According to equation (3), $\gamma<0$ means that negative news in the market affects volatility more than positive news. In equation (4), the equation formed when the INDEX variable is added is shown.

$$\ln(\sigma_t^2) = \omega + \beta\ln(\sigma_{t-1}^2) + \gamma\frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha\left[\frac{|\varepsilon_{t-1}|}{\sqrt{\sigma_{t-1}^2}}\right] \tag{3}$$

$$\ln(\sigma_t^2) = \omega + \beta\ln(\sigma_{t-1}^2) + \gamma\frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha\left[\frac{|\varepsilon_{t-1}|}{\sqrt{\sigma_{t-1}^2}}\right] + \mu INDEX_t \tag{4}$$

Result

Descriptive statistics of stock market indices are given in Table 3. These statistics contain information about returns. The return series of the stock exchanges were obtained as follows.

$$r_t = 100 \times (lnP_t - lnP_{t-1}) \tag{5}$$

Equation (5), P_t shows the closing price of the countries' stock market indices in the t period, and P_{t-1} shows the closing price of the countries' stock market indices in the t-1 period. The same transformation was applied for the INDEX variable regarding compliance with the stock market return series.

Table 3: Descriptive Statistics of Returns of Stock Indices

	Mean	Maximum	Minimum	Standard Deviation	Skewness	Kurtosis
S&P 500	0.1047	8.9683	-12.7652	1.4987	-0.5202	19.6576
CAC 40	0.0816	8.0561	-6.1192	1.4874	0.1208	8.2765
NIKKEI 225	0.0531	7.7314	-6.2736	1.4195	0.2204	6.6740

According to Table 3, the S&P 500 index has the highest average and standard deviation values in the 11.03.2020–11.03.2022 analysis period. According to the skewness values, since the S&P 500 index has a negative value, it is skewed to the left; CAC 40 and NIKKEI 225 indices are skewed to the right because they have positive values. When the kurtosis values are examined, it is found that all series have a value greater than three and have a sharp distribution. Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) unit root test results are given in Table 4. Both unit root test results show that the series is stationary at the 1% significance level. Stock market returns and INDEX series were obtained as stationary at the level.

Table 4: Unit Root Test Results

Series	**ADF**	**PP**
S&P 500	-33.1543*	-33.9902*
CAC 40	-24.7994*	-25.0805*
NIKKEI 225	-22.1087*	-22.4467*
INDEX	-18.3192*	-109.2817*

Note: * denotes significance at the 1% significance level.

Appropriate mean equations must be determined for GARCH-type models. Accordingly, ARMA(3,3) for NIKKEI 225, ARMA(1,1) for CAC 40 and ARMA(2,2) for S&P 500 were obtained. These equations were determined by estimating suitable different mean equations and selecting these equations according to the Akaike Information Criterion. After determining the appropriate mean equations, GARCH and EGARCH model estimates were made. Necessary tests have been made to test the autocorrelation and ARCH effect of the model estimations and are given in the estimation results. In the autocorrelation test, the null hypothesis is that there is no autocorrelation. In the ARCH Lagrange multiplier (LM) test, the null hypothesis states that there is no ARCH effect. Here, Q is the test statistic for the autocorrelation test, and LM is the test statistic used to test the ARCH effect.

Table 5: GARCH(1,1) Model Estimation Results

Coefficients	**S&P 500**	**NIKKEI 225**	**CAC 40**
ω	0.0427**	0.2927**	0.0313*
α	0.1537***	0.1795***	0.0975***
β	0.8175***	0.6421***	0.8920***
$\alpha + \beta$	0.9712	0.8216	0.9895
Q(36)	36.113(0.282)	36.279(0.199)	34.610(0.439)
LM(36)	22.462(0.962)	26.325(0.881)	10.907(0.999)

Note: ***, **, * denote significance according to the critical value of 1%, 5%, 10%, respectively. Values in parentheses indicate probe values.

GARCH model estimation results are given in Table 5. It is demonstrated that the results obtained for all stock market indices are statistically significant. As a result of the model estimations, the α + β coefficient was obtained as 0.97 for the S&P 500 index, 0.8216 for the NIKKEI 225 and 0.9895 for the CAC 40. According to these coefficients, CAC 40 and S&P 500 indices were very close to 1. In this context, it has been concluded that there is no short-term effect within the analysis period, and the effect of shocks is significantly large. The estimation results of the GARCH models created by including the INDEX variable are given in Table 6. As a result of these estimations, it was shown that the INDEX variable was not statistically significant, except for the model created for the CAC 40 index. As a result of the autocorrelation tests tested as a result of the estimation of different GARCH models, it was found that the null hypothesis could not be rejected. Therefore, it was concluded that there was no autocorrelation.

Table 6: Estimation Results of GARCH(1,1) Model with INDEX Variable

Coefficients	S&P 500	NIKKEI 225	CAC 40
ω	0.0430**	0.2656**	0.0294*
α	0.1390***	0.1560***	0.0846***
β	0.8277***	0.6780***	0.9035***
∂	0.0001	0.0020	0.0022*
α + β	0.9667	0.8340	0.9881
Q(36)	35.941(0.289)	35.495(0.225)	35.447(0.400)
LM(36)	22.742(0.958)	28.207(0.820)	10.893(0.999)

Note: ***, **, * denote significance according to the critical value of 1%, 5%, 10%, respectively. Values in parentheses indicate probe values.

The existence of the asymmetric effect was investigated with the EGARCH model estimation. In Table 7, the estimation results of the EGARCH(1,1) model are given. As a result of the EGARCH model estimates created for all stock market indices, it was seen that the coefficients (except for the constant coefficient for NIKKEI 225) were statistically significant. In the EGARCH model, the γ coefficient represents the volatility asymmetry. This coefficient was negative and statistically significant at the 5% significance level, as expected in the S&P 500 and NIKKEI 225 estimations. In the estimation results obtained for CAC 40, the γ coefficient was found to be negative and statistically significant at the 1% significance level, similar to the other results. As a result of the autocorrelation test, it was seen that there was no autocorrelation in all models. In addition, according to the ARCH LM test results, it was concluded that the null hypothesis that there was no ARCH effect could not be rejected.

Table 7: Estimation Results of the EGARCH(1,1) Model

Coefficients	S&P 500	NIKKEI 225	CAC 40
ω	-0.1895***	-0.0480	0.0382**
β	0.2474***	0.0782*	-0.0669***
γ	-0.0844**	-0.0578**	-0.1595***
α	0.9557***	0.9632***	0.9904***
Q(36)	36.133(0.281)	24.479(0.750)	38.828(0.259)
LM(36)	17.605(0.996)	27.592(0.841)	29.841(0.756)

Note: ***, **, * denote significance according to the critical value of 1%, 5%, 10%, respectively. Values in parentheses indicate probe values.

The EGARCH model estimation results estimated by including the INDEX variable are given in Table 8. The coefficient expressing the volatility asymmetry in all model estimation results is negative and statistically significant. In the results obtained, the coefficient of the INDEX variable in the model created for the S&P 500 and NIKKEI 225 indices was statistically significant at the levels of 5% and 1%, respectively. As a result of the autocorrelation test, it was seen that the null hypothesis could not be rejected. As a result, no autocorrelation issue was encountered in these models. According to the ARCH LM test results, it was concluded that the ARCH effect disappeared.

Table 8: Estimation Results of the EGARCH(1,1) Model

Coefficients	S&P 500	NIKKEI 225	CAC 40
ω	0.0326**	-0.0250	0.0363**
β	-0.0479**	0.0437	-0.0641***
γ	-0.1299***	-0.0487**	-0.1399***
α	0.9946***	0.9715***	0.9924***
μ	0.0041**	0.0025*	0.0025
Q(36)	29.938(0.571)	25.006(0.725)	36.550(0.351)
LM(36)	33.162(0.604)	29.830(0.756)	25.686(0.899)

Note: ***, **, * denote significance according to the critical value of 1%, 5%, 10%, respectively. Values in parentheses indicate probe values.

Discussion

In this study, the state of the developed country markets and the effect of the infectious disease stock market volatility index on those markets during the scope of the pandemic period were examined. In this context, GARCH model predictions were made to demonstrate the shocks' permanence during the pandemic period. In addition, an asymmetric effect on financial markets in this period was investigated. It has been observed that the impact of shocks is high, especially in the CAC 40 index. In their study, Apergis and Apergis (2020) examined the effect of the Covid-19 pandemic on Chinese stock market returns and volatility using the GARCH model. They found that the pandemic had a severe negative impact on stock returns and volatility. As a result of the GARCH model estimates made by including the infectious disease stock market volatility index in the study, it is demonstrated that only the effect on the CAC 40 index returns is permanent.

As a result of the EGARCH model estimations, it was concluded that the asymmetric effect in volatility is significant. As a result of the EGARCH model estimates made by including the infectious disease stock market volatility index, significant results were obtained for the S&P 500 index. According to these results, it was observed that the adverse shocks in the S&P 500, NIKKEI 225 and CAC 40 indices had a more significant effect on the volatility of the three stock market indices than the positive shocks. It is concluded that the asymmetric effect on volatility is more significant when the infectious disease stock market volatility index is included. As a result of the general analysis, the effects of the infectious disease stock market volatility index on the stock market indices differ. This situation can be caused by the states taking different measures and decisions against the Covid-19 pandemic. Bai et al. (2021), as a result of their analysis of different international financial markets, such as those of USA, Japan, England and China, revealed that the pandemic had different effects on stock markets.

Conclusion

The study investigated the relationship between the developed country markets and the infectious disease stock market volatility index. In this context, 11.03.2020–11.03.2022 was analyzed with daily data using S&P 500, NIKKEI 225 and CAC 40 indices. After determining the appropriate mean equations, the GARCH and EGARCH models were estimated. As a result of the GARCH model predictions made for the pandemic period, it was seen that there was no short-term effect on the stock market indices. When the infectious stock market volatility index is included, as a result of the GARCH model estimations, significant findings were obtained only in the CAC 40 index. As a result of EGARCH model estimations, it is demonstrated that there is an asymmetric effect. In the estimations made by including the contagious stock market volatility index in the EGARCH model, significant findings were obtained in the S&P 500 and NIKKEI 225 indices. Similarly, it was observed that there was an asymmetric effect in these estimations.

The study attempted to reveal the effect of the infectious disease stock market volatility index on the developed country markets for the pandemic period. In this context, in future studies, the relationship of the index in question to different financial markets can be examined using different approaches. In addition, financial markets with different developed structures can be analyzed comparatively. The effect of the infectious disease stock market volatility index on stocks on a sectoral basis being a potential research subject.

Declarations

Funding

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Availability of Data and materials

The data that support the findings of this study are openly available in the website of Yahoo Finance (finance.yahoo.com) and Infectious disease stock market volatility index (policyuncertainty.com).

Code Availability

The computer program results are shared through the tables in the manuscript.

Competing Interest

The authors declare that they have no conflict of interest.

Authors' Contributions

Anıl LÖGÜN: Writing – review & editing, Investigation, Project administration.
Buket AYDIN: Writing – review & editing, Investigation, Visualization.
Rahman AYDIN: Writing – review & editing, Investigation.

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