World Review of Science, Technology and Sustainable Development

ISSN online: 1741-2234 - ISSN print: 1741-2242
https://www.inderscience.com/wrstsd

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DOI: 10.1504/WRSTSD.2021.10038774

Article History:

Received:	20 July 2020
Accepted:	08 March 2021
Published online:	30 November 2022

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Abstract: This article aims to analyse and measure the impact of the COVID-19 daily fatality cases, along with the BRENT prices and the financial volatility index (VIX) on the global economy, proxied by MSCI global market index (MXWO) both in the long run and the short-run, and discuss policy responses using the ARDL methodology. The study contributes to the literature as it is one of the first studies aimed at measuring the impact and direction of COVID-19 daily fatality cases on the global markets investigated through financial contagion. The ARDL model estimates indicated a significant and negative effect of the coronavirus crisis on MXWO. BRENT prices seem to have no direct effect on the global economy proxied by MXMO index, both in the long and the short term. But, it is likely to have an indirect effect through financial volatility as BRENT prices reacted sharply to the rise in financial volatility.

Keywords: COVID-19; autoregressive distributed lag; ARDL; MSCI world index; BRENT; volatility index; financial contagion.

JEL codes: B17, F36, F38, G15.

Reference to this paper should be made as follows: Toğuç, N. (2023) 'Impact of the COVID-19 on MSCI world equity market index', *World Review of Science, Technology and Sustainable Development*, Vol. 19, Nos. 1/2, pp.4–19.

Biographical notes: Nurhan Toğuç completed her undergraduate at Istanbul University. She earned her Master's at Brooklyn College (CUNY), and her Doctorate at City University of New York (CUNY). She has worked as an investment banker in New York, London, Milan and Istanbul for nearly 15 years, served in the New York City Government. She has taught undergraduate and graduate courses at New York University, Hunter College and other universities in Turkey. Currently, she is teaching at Istanbul Esenyurt University. Her awards are Who is Who in the World 1999, Scholarship Albany University in 1993, Women in Public Policy award, Extraordinary Women in America award.

1 Introduction

Before the coronavirus (COVID-19) pandemic, global equity markets were testing historical highs financed by FED's quantitative easing, following the 2008 subprime mortgage crisis.

The coronavirus had catastrophic results on the lives of ordinary people since its outbreak in Wuhan, China. Following the first release of the virus data collected by the World Health Organization (WHO) on Jan. 21, 2020, daily cases of fatality were reported to be 15 on a global scale. Despite the low fatality rates early in the pandemic, the contagious aspects of the disease triggered a panic in financial markets as well as in oil prices with the expectation of a global economic shutdown. The initial reaction was recorded in oil prices, followed by a rise in volatility index (VIX), and finally in global equity markets as daily fatality cases reached 100, from initial cases of 15 daily on Feb. 21, 2020.

Unlike other pandemic cases such as SARS and the Spanish Flu, coronavirus proves to be highly contagious and therefore raises uncertainty on global economic dynamics as well as on international trade. The current uncertainty seemed greater than the cases associated with the subprime mortgage crisis of 2008 and the pandemics like Ebola and SARS in the early periods of the pandemic.

The anticipation of a sharp decline in global demand along with a sharp rise in unemployment rates on a global scale due to the virus, resulted in a 56% drop in oil prices between Feb. 2, 2020, to March 23, 2020, followed by 35% decline in MXWO index as VIX rose sharply by 252% during the same period.

The MXWO index captures mid and large-cap companies in 23 developed economies and created by Morgan Stanley Capital International (MSCI). Countries include 'Austria, Australia, Belgium, Canada, Denmark, France, Finland, Germany, Hong Kong, Israel, Ireland, Italy, Japan, New Zealand, Netherlands, Norway, Portugal, Spain, Singapore, Switzerland, Sweden, the UK and the USA'. The index excludes shares in emerging markets and covers about 85% of the free float in developed markets.

Studying the effect of a pandemic on the share markets helps to understand the current situation in the global economy, as the market indices are considered to be early indicators of the economic outlook. US jobless claims have skyrocketed to all-time highs while consumer confidence declined sharply, signalling recession. Meanwhile, the global demand took a sharp downturn while the purchasing power is likely to decline further if the virus causes a second economic shutdown. As of now, the global macroeconomic outlook is uncertain.

The theory of financial contagion refers to the downside risks in financial markets, co-movements of the financial instruments including the stock prices and capital flows due mainly to market disturbances. Financial contagion may take place at the domestic level as well as on the international level. In regards to the domestic level, mainly a failure of a local financial institution may trigger transmission through the defaults and pushes to liquidate assets. International financial contagion takes place in global markets. Concerns about the financial and economic implications of a global pandemic shaped the theory of financial contagion since the 1990s.

In a globalised financial system with large cross-regional cash flows, financial and economic implications of a global pandemic shaped the theory of financial contagion since the early 1990s.

The concept of financial contagion can be defined as the rapid and drastic consequences of a shocking event taking place in one country spreading to others in a short period. Theories regarding a pandemic can be discussed by:

1 ‘herding behaviour’ which is a spread of the crisis from a country to the global markets

2 ‘financial contagion’, which is the contagion caused by the interconnection between the markets

3 other theories including trade links, liquidity movements and competitive devaluations (Kaminsky et al., 2003).

The impact of pandemics such as SARS (2002), Swine Flu (2009), MERS (2015), and the COVID-19 on financial markets have significant social and economic outcomes and mainly investigated through financial contagion. During SARS (2002) and Ebola (2014–2026) pandemics in West Africa, World Bank established the Pandemic Emergency Financing Facility (PEF) in response to the outbreaks.

Due to the interconnected markets in a globalised world, COVID 19 pandemic turned into a global financial crisis with a contagion impact. The impact of contagion increases with the sharp decline in global economic outlook and herding behaviour caused by the COVID-19.

Autoregressive distributed lag (ARDL) model is employed in the article to investigate a long-term convergence and compare results with short-term outcomes due to the pandemic, ARDL model allows for the presence of stationarity as well as non-stationary series.

ARDL approach used in this study to determine whether there is a long-term relationship between the variables and to compare the findings with short-run outcomes due to the pandemic, hence allowing us to measure the effect of the pandemic mainly on developed markets.

The ARDL cointegration approach has three major advantages compared to traditional cointegration methods:

1 ARDL model is “straightforward and needs a single form of equation” (Bayer and Hanck, 2013).

2 The model does not demand all the variables to unify in the same order. The ARDL model can be used even if the model’s variables are unified at different orders.

3 ARDL test is more adequate in small sample size, and grants for the estimation of both the long-term and the short-term effects.

4 ARDL technique provides unbiased estimates (Harris and Sollis, 2003).

Considering the contagious nature of coronavirus, concerns of the global economic impact of a pandemic are effective in shaping public opinion. That in turn results in a financial contagion in an interconnected global financial environment. The core of this article is to measure the impact of a contagious disease resulting in a financial contagion in global markets and analyse empirical implications in the short-term as well as in the long-term and discuss policy responses.

This article is formulated as follows: introduction is followed by literature review, data and methodology, results and discussion and conclusions.

2 Literature review

The number of papers studying the effect of pandemics on financial markets through financial contagion is very rare.

Nippani and Washer (2004) investigated the SARS pandemic in Singapore, China, Canada, Thailand, the Philippines, Indonesia and Vietnam and found that SARS outbreak had an impact only in the equity markets of China and Vietnam.

The link between oil price shocks and financial stress was studied by Illing and Liu (2006) and found that financial stress has an impact on equity markets, as the share prices and oil prices are correlated.

The impact of SARS pandemic on the Taiwan equity market was investigated by employing an event study approach with the GARCH model and findings included that the SARS crisis did hurt tourism, wholesale and retail sectors (Chen et al., 2009).

Peckham (2013) studied the dynamics of infection spread by evaluating the influenza outbreak in 2009. He indicated that that biological and financial contagion is critical in understanding the global impact of the risk.

Wang et al. (2013) investigated the impact of contagious disease outbreaks and found that biotechnology stocks in Taiwan equity market had a major impact due to infectious diseases.

Macciocchi et al. (2016) analysed the short-run effect of the Zika pandemic in Argentina, Mexico and Brazil and results indicated that only Argentina and Mexico equity markets registered large negative returns following each shock.

Chen et al. (2018) studied the impact of the SARS pandemic on China, in relation to four Asian share markets in the long-run and they found a time-varying cointegration between the equity price indices.

Altan and Yıldırım (2019) examined the contagion effect of the financial markets through the ARDL model and concluded that there was a contagion effect on Borsa Istanbul from The New York Stock Exchange. They provided guidelines for portfolio diversification.

Recent additions to the growing literature relating to the dynamic impact of the coronavirus on share prices and economic activity are as follows.

Caballero and Simsek (2020) found that the overshooting of share prices during the pandemic is the main feature of the monetary policy. To close output gaps, central banks boost asset prices.

Chen and Spence (2020) argue that economic activity based on mobility aligns with the measures of the standard economic activity. They show that the immediate response of policymakers to the pandemic, enable countries in preventing economic damages.

Albulescu (2020) investigates the effect of pandemic on oil prices, at the same time controlling for the economic policy uncertainty of the USA and the VIX, using ARDL approach. The results show that the daily fatality cases due to COVID-19, have an indirect effect on oil prices in the short-term and a minor negative effect in the long-term.

Liu et al. (2020) studied the short-term effect of the pandemic on the major equity markets employing an event study methodology and found that the consequences of the pandemic were considerable and had a direct impact on the major indices worldwide.

Claudiu (2020) paper searched the effect of COVID-19 official announcements and fatality ratio on the VIX and found that the fatality ratio had a positive impact on VIX. Also, financial volatility rises as the number of affected countries increases.

He et al. (2020) studied both the spill-over and direct impact of the COVID-19 on financial markets of China, Germany, France, Japan, Italy, Spain, South Korea, and the USA, by utilising non-parametric Mann-Whitney tests. Findings include that:

1. pandemic had a short-term negative impact on those share markets
2. the pandemic had bi-directional spill-over effects.

The study also provided a basis to assess trends in international share markets.

Khatatbeh et al. (2020) study analysed the early reaction of share market indices to the pandemic, using an event study methodology. Findings confirmed that there was significant negative effect on the returns of eleven share market indices. The results indicated evidence of underreaction to the COVID-19 announcement, through delayed response in terms of CARs of stock markets.

Zhang et al. (2020) measured the systematic risk as well as country-specific risk factors across global markets, following the COVID-19 outbreak, and found that the volatility and risk in global financial markets increased due to the uncertainty in a financial markets.

Erdoğan et al. (2020) investigated the impact of COVID-19 on Bourse Istanbul and Islamic stock markets using DCC-GARCH model and found that Islamic stock indices were more resistant to the pandemic, compared to the conventional share market in Turkey.

3 Data and methodology

3.1 Data

The data used in the article is daily data covering Jan. 21, 2020–Apr. 24, 2020 period. COVID-19 data is daily fatality figures obtained from the WHO database of official announcements. MXWO index data and BRENT data are the daily closing price indices while VIX data is the CBOE financial VIX and obtained from Matriks information data sources.

3.2 Methodology

The ARDL cointegration model originally developed by Pesaran and Shin (1999) and Pesaran et al. (2001). Compared to the traditional cointegration models, the model offers three advantages; the first advantage of the model is that there are no requirements for the variables under consideration to be unified in the same order. Hence, the model can be used even if the variables under study are integrated into $I(0)$ and $I(1)$ orders. The second advantage of the model is that the ARDL bound test is adequate in small data samples. The third advantage is that the application of the model provides impartial estimates of the long-term model (Harris and Sollis, 2003).

Initially, the unit root test is conducted to confirm stationary at $I(0)$ or $I(1)$ levels. Augmented Dickey-Fuller (ADF) test was used to assure that the variables were stationary at $I(0)$ or $I(1)$. Following the stationary test, ARDL bound test is performed in order to confirm the long-term cointegration. Subsequently, the estimates of both the short-term and the long-term coefficients are obtained, and residual diagnostics tests of normality, heteroscedasticity, serial correlation, and stability tests are performed. Lastly, the error correction model (ECM) was estimated to assess the speed of adjustment for the dependent variable, in case of a change in the independent variables.

Following ARDL model is estimated to analyse the relationship between MSCI world index (MXWO) and COVID-19 daily fatality cases, the financial VIX, and BRENT indices daily closing prices as proposed by Pesaran et al. (2001). The cointegration between the variables is expressed by the given linear estimation equation:

$$\ln MXWO_t = \alpha_0 + \alpha_1 \ln BRENT + \alpha_2 \ln VIX + \alpha_2 \ln COVID19 + \varepsilon_{it} \tag{1}$$

where $\ln MXWO$ is the natural log of the MSCI world index daily closing prices, $\ln BRENT$ and $\ln VIX$ are the log of closing prices of both indices explained above, $\ln COVID19$ is the natural log of the daily fatality figures and ε is the error term (white noise).

Initially, the cointegrating relationship between the variables is tested by the ARDL bound test to determine whether there is a long-term relationship. Results are evaluated by the F-test.

If a long-run cointegration is observed, then both the long and the short-term parameters can be estimated by equation (2) as follows (Pasaran and Shin, 1999; Pasaran et al., 2001):

$$\begin{aligned}\Delta \ln MXWO_t = \alpha_0 &+ \sum\nolimits_{i=1}^{n} \alpha_1 \Delta \ln BRENT_{t-j} + \sum\nolimits_{i=1}^{n} \alpha_2 \Delta \ln VIX_{t-j} \\ &+ \sum\nolimits_{i=1}^{n} \alpha_3 \Delta \ln COVID19_{t-j} + \beta_1 \ln MXWO_{t-1} + \beta_2 \ln BRENT_{t-1} \\ &+ \beta_3 \ln VIX_{t-1} + \beta_4 \ln COVID19_{t-1} + trend + \varepsilon_{it}\end{aligned} \tag{2}$$

Equation (2) represents the ARDL bound test model specified to the series used in the study, where α_0 and *trend* are the unrestricted constant and trend terms specified for the model respectively, and ε is the error term (white noise). The ARDL long-term coefficients are represented by β while the short-run coefficients are given by α.

The unrestricted ARDL model takes the following long-run form:

$$\begin{aligned}\ln MXWO_t = \beta_0 &+ \sum\nolimits_{i=1}^{n} \beta_1 \ln BRENT_{t-j} + \sum\nolimits_{i=1}^{n} \beta_2 \ln VIX_{t-j} \\ &+ \sum\nolimits_{i=1}^{n} \beta_3 \ln COVID19_{t-j} + trend + \varepsilon_{it}\end{aligned} \tag{3}$$

The variables are long-run variables as defined before and ε_{it} is the error term (white noise).

4 Results and discussion

In the results and discussion section, the findings of the study are discussed. The first stage in ARDL modelling is investigating unit-roots to ensure that none of the series used in the study are $I(2)$. The ADF test is applied to investigate unit roots in the series and to ensure the stationarity of variables at $I(0)$ or $I(1)$ levels. The second step involves investigating the long-term cointegration in ARDL model while estimating both the short-term and the long-term coefficients. Those stages are followed by residual diagnostics tests including heteroscedasticity in the residuals, normality, serial correlation, and a stability test – CUSUM. Eventually, the ECM is estimated to identify the speed of adjustment of the dependent variable, in case of a change in the independent variables.

4.1 Test of stationarity

The initial step in the ARDL methodology is to search for the unit root. The unit root analysis involves checking the degree of integration for variables to ensure stability. To ensure stability, the variables are not required to be integrated in the same order. They could be integrated either at $I(0)$ or the first difference $I(1)$ to satisfy the assumptions of the bounds test in the ARDL method. ADF test is utilised to check for unit roots. Following the unit root test, relationship between the variables is searched in the long-term using the ARDL model.

Table 1 gives the results of unit root analysis performed utilising the ADF test. The unit root test is used at both the $I(0)$ and $I(1)$ levels and for both constant and constant and trend for each variable.

Table 1 Unit root analysis

	Variables	*ADF*	
		Constant	*Constant and trend*
Level $I(0)$	*BRENT*	–0.76	–1.70
	*COVID*19*D*	–4.10*	–3.88*
	VIX	–1.56	–1.16
	MXWO	–1.25	–1.11
The first difference $I(1)$	*BRENT*	–7.65*	–7.59*
	*COVID*19*D*	–0.78	0.90
	VIX	–3.58*	–12.20*
	MXWO	–10.15*	–10.14*

Notes: ** and * denotes significance at 1% and 5% level, respectively. All variables are stationary at the 5% levels for both constant and cons and trend.

Table 1 gives the outcome of the ADF unit root test for the series. H0 hypothesis: ‘there is a unit root’ is tested against H1 hypothesis ‘series is stationary, no unit root’. The lag length is determined according to Akaike information criteria (AIC) during the unit root test. The calculated values are compared to critical values in absolute terms at 1% and 5% significance level in Table 1. ADF test results indicated that except the COVID-19 series, the remaining series contain unit roots both for constant and constant and trend on the level. On the contrary, the remaining series except COVID-19 are stationary at the first difference. Outcome of the unit root test indicates a mixed order of integration. ARDL model is convenient when time-series data is either stationary at $I(0)$, or at $I(1)$ levels (Pesaran et al., 2001) as given in Table 1.

4.2 Optimal lag structure

The ARDL model is used in this research since it is one of the most flexible models in studying periods with shocks and regime shifts, and the model allows for different lags for the variables, which helps capture the best data generating process.

The ARDL model includes lags of both dependent and independent variables. To determine whether there is cointegration in the model, the optimal lag number of the variables should be determined. The optimal lag length is estimated by the least squares (OLS) method using AIC. The maximum lag length for both independent and dependent variables set at 8. That provided 72 different model specifications. The model specification used in this study includes an unrestricted constant and trend as fixed regressors. The structure of the lag length in ARDL specification is determined by AIC since the lag structure selected by the Schwarz criterion tends to lead to a simpler model specification.

4.3 ARDL bound test

Following the determination of optimal lag length, cointegration among the variables is investigated using the bound test. The null hypothesis is: $\beta \ln MXWO = \beta \ln BRENT = \beta \ln VIX = \beta \ln COVID19 = 0$, representing no cointegration. The F-statistics is used as decision criteria and compared with Pesaran et al.'s (2001) critical values. A lower bound of $I(0)$ and an upper bound of $I(1)$ are assumed in the bound test. The outcome is given by Table 2.

Table 2 Bounds test results

F-statistics	*k*	*I(0)*	*I(1)*	*Result*
5.8523 *	3	4.01	5.07	Cointegration

Notes: F-stat. is compared to Pesaran critical values at 5% significance. Narayan (2005) critical values at 5% significance for $I(0)$ and $I(1)$ are 3.27 and 4.30, respectively.

Given the bound test results in Table 2, the value of F-statistic (5.85) is larger than the upper bound $I(1)$ of Pesaran critical value. To confirm the reliability of the long-run coefficients for smaller sample sizes (between 30–80), Narayan (2005) provides critical values in order to test the long-term cointegration. Both Pesaran and Narayan critical values affirm the existence of the long-term relationships among the MXWO and coronavirus, VIX, and BRENT series jointly and therefore the null hypothesis is not accepted.

Since the interrelation among the variables is proved in the long-term, it can be concluded that the connection between the variables is not only a short-run event, but it has long-run implications, which can be recovered following the short-term shock.

4.4 Diagnostic test results

The reliability of the model depends on the robustness of the estimation. To make sure that the estimated model is robust, diagnostic tests must be performed to investigate the existence of stability, functional form, parsimonality. The diagnostic tests include; the heteroscedasticity (Engle ARCH-LM test), functional form (Ramsey RESET test), normality (Jarque-Bera test), and the serial correlation of the residuals (Breusch-Godfrey LM test). All tests are performed following the estimation of the ARDL specification.

Diagnostic test results are given by Table 3 Breusch-Godfrey test results indicate that no serial correlation is observed between the error terms, Ramsey RESET test results show no functional form deficiency. Jarque-Bera test indicates that the error terms are distributed normality and ARCH LM tests show no heteroscedasticity as all p-values are greater than 5%. The diagnostic test results show that the model is consistent and does not suffer from defectiveness and the result of the research has economic significance.

Table 3 Diagnostic test results

R^2	0.89
Adjusted R^2	0.952
F-statistics	202 (0.000)
Breusch-Godfrey LM test	0.856 (0.438)
ARCH LM test	0.368 (0.546)
Jarque-Bera normality test	0.076 (0.962)
Ramsey RESET test	1.022 (0.356)

4.5 Long-run coefficient estimation

The long-term coefficients are given in Table 4 are obtained from the long-run ARDL (8, 7, 8, 7) model given by equation (3) indicates that 2 out of 3 long-run coefficients appeared to have negative signs and statistically significant. The long-run causal effects of variables are measured with the p-values of t-statistics of the coefficients for the long-run.

Table 4 Coefficients of long-run ARDL (8, 7, 8, 7)

Variable	*Coefficient*	*t-statistic*	*Prob.*
LN*BRENT*	0.036366	0.807014	0.4279
LN*COVID*19*D*	–0.060271	–5.489218	0.0000
LN*VIX*	–0.220109	–11.04343	0.0000

Note: Dep. variable: LN*MXMO*.

Table 4 indicates a negative long-term connection between the log of MSCI world index and coronavirus fatality cases and financial volatility. These findings are persistent with the theory. The negative effect of the log of coronavirus is marginal, while the negative effect of the log of VIX is stronger, implying that VIX has the most pronounced effect on the MXWO. On the other hand, the coefficient of the log of BRENT is insignificant, implying no long-run impact

4.6 Stability of the model

Both the short-term and the long-term results are checked for stability by cumulative amount (CUSUM) and square cumulative amount (CUSUMSQ) tests applied to the residuals of both long-run and ECM model (Pesaran and Pesaran, 1997). The long-run results are given in Figure 1 and Figure 2. Both indicate the stability of coefficients in the long-term as the plots remain within 5% critical bounds, confirming the stability of long-run coefficients.

Figure 1 CUSUM test (see online version for colours)

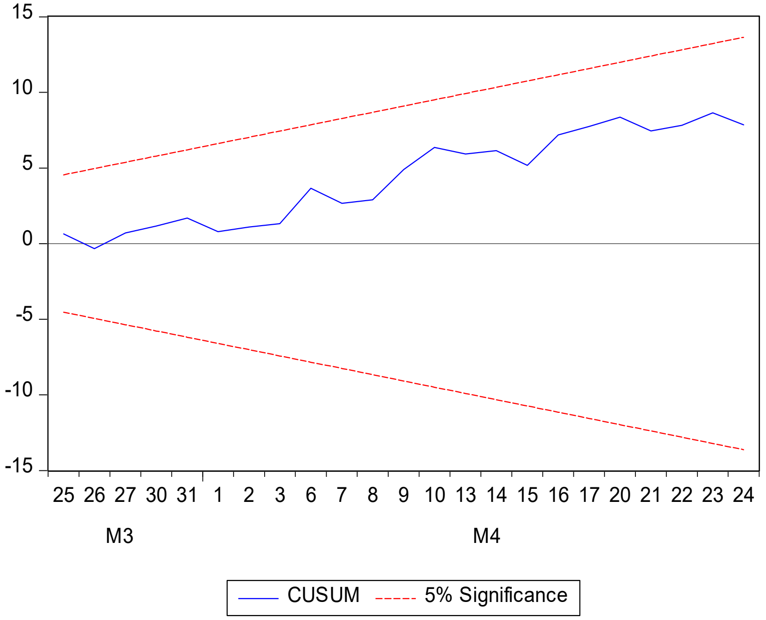
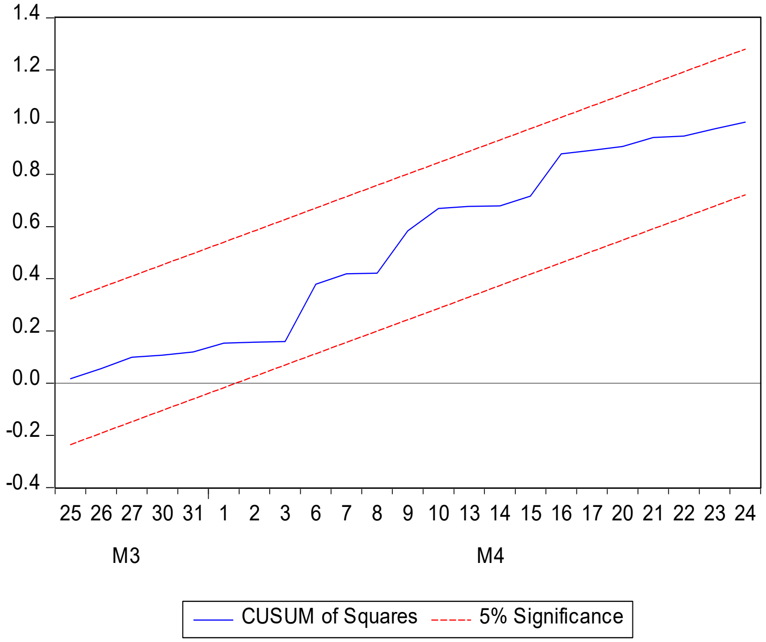


Figure 2 CUSUM square test (see online version for colours)



4.7 Estimation of short-run coefficients and the ECM model

Following the long-term prediction between the series, the short-term relationship for the unconstrained ECM is given by equation (4). The coefficients of the long-term equilibrium are linearly unified with the short-term through the ECM (Ali et al., 2017).

$$\begin{aligned}\Delta \ln MXWO_t &= \gamma_0 + \sum\nolimits_{i=1}^{n} \gamma_{1i} \Delta \ln MXWO_{t-j} + \sum\nolimits_{i=1}^{n} \gamma_{2i} \Delta \ln BRENT_{t-j} \\ &\quad + \sum\nolimits_{i=1}^{n} \gamma_{3i} \Delta \ln COVID19_{t-j} + \sum\nolimits_{i=1}^{n} \gamma_{4i} \Delta \ln VIX_{t-j} + \gamma_5 ECT_{t-1} \\ &\quad + trend + u_t\end{aligned} \tag{4}$$

ECM model for cointegrated time series shows that change in the dependent variable is not only a function of the previous changes in itself but also changes in independent variables. All variables are considered endogenous in the ECM model. Meanwhile, the error correction term (ECT) in the ECM equation is obtained from lagged OLS residuals of the long-run equation.

Table 5 ARDL short-run coefficients

Variable	*Coefficient*	*t-statistic*	*Prob.*
D(LN*MXWO*(–1))	0.637144	4.065383	0.0003
D(LN*MXWO*(–3))	–0.021845	–0.197056	0.8450
D(LN*MXWO*(–5))	–0.215412	–2.113079	0.0420
D(LN*MXWO*(–8))	–0.254087	–3.572285	0.0011
D(LN*BRENT*)	0.030479	0.813990	0.4213
D(LN*BRENT*(–2))	0.081478	2.625626	0.0129
D(LN*BRENT*(–6))	–0.171117	–4.738532	0.0000
D(LN*BRENT*(–7))	0.088110	2.215980	0.0335
D(LN*COVID*19*D*)	–0.017672	–2.086630	0.0445
D(LN*COVID*19*D*(–1))	0.000306	0.038898	0.9692
D(LN*COVID*19*D*(–2))	–0.019467	–2.110201	0.0423
D(LN*COVID*19*D*(–4))	–0.022276	–2.668885	0.0116
D(LN*COVID*19*D*(–5))	–0.022286	–2.848428	0.0074
D(LN*COVID*19*D*(–7))	0.016989	2.026764	0.0506
D(LN*COVID*19*D*(–8))	–0.024016	–2.716439	0.0103
D(LN*VIX*)	–0.174874	–7.450050	0.0000
D(LN*VIX*(–1))	0.089279	3.049666	0.0044
D(LN*VIX*(–3))	–0.034130	–1.177821	0.2470
D(LN*VIX*(–5))	–0.042116	–1.516303	0.1387
D(LN*VIX*(–7))	–0.063752	–2.882740	0.0068
C	0.021521	1.317614	0.1964
@TREND	0.000711	1.178709	0.2467
ECT(–1)	–1.242539	–5.151661	0.0000

Note: Dependent variable: LN*MXMO*.

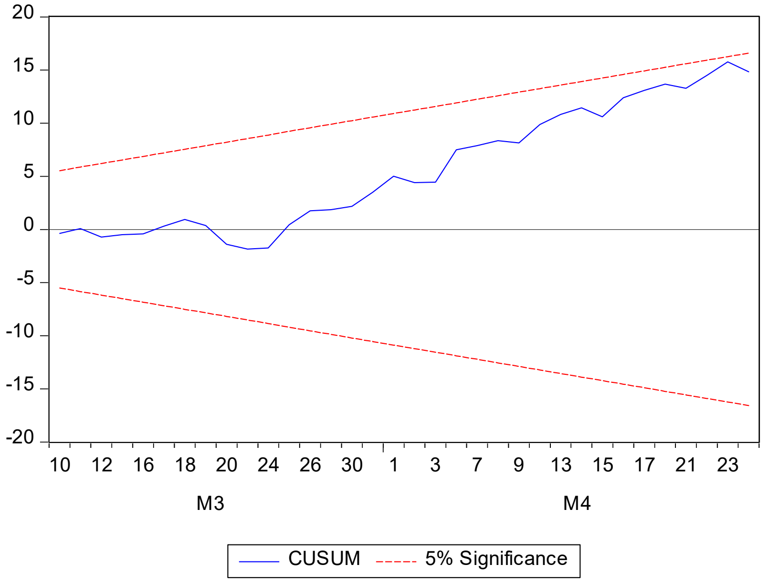
The ECT term indicates that deviation from the long-run equilibrium has an impact on the dependent variable in the short-term. Thus, the ECT term's coefficient provides the value for the speed of adjustment. ECT term measures the speed of the dependent variable returning to long-run equilibrium, following the change in the independent variables.

In the short-term, a joint F-test of the coefficients of the lagged values for each regressor is applied using the Wald test. Causal effects are measured with the t-statistics of the short-run coefficients. It appears that there are no short-run causal effects of BRENT prices on MXMO, similar to the result obtained in the long-run. However, it is likely to have an indirect causal impact through financial volatility.

Both the daily global fatality figure of COVID-19 and the financial VIX have significant short-term negative impact on MXMO. However, the direct causal impact of the virus was relatively small compared to the impact of VIX. The conclusion is that the coronavirus seems to have an indirect effect through the financial volatility, affecting first the financial market volatility (Albulescu, 2020).

To have meaningful results, the coefficient of the ECT term must have a negative sign and statistical significance. ECT coefficient gives information on how quickly/slowly short-term deviation adjusts to the long-run equilibrium levels. Coefficient of the ECT is estimated as –1.24, suggesting that divergence from the long-run equilibrium level is recovered by 1.24% over the following year. A significant ECT indicates that there exists a stable long-term relationship in the model as per Banerjee et al. (2001). The coefficient of determination given by R^2 is 0.89, indicating that 89% of the variance in the dependent variable is explained by independent variables, reflecting the significance of the model.

Figure 3 CUSUM test (see online version for colours)

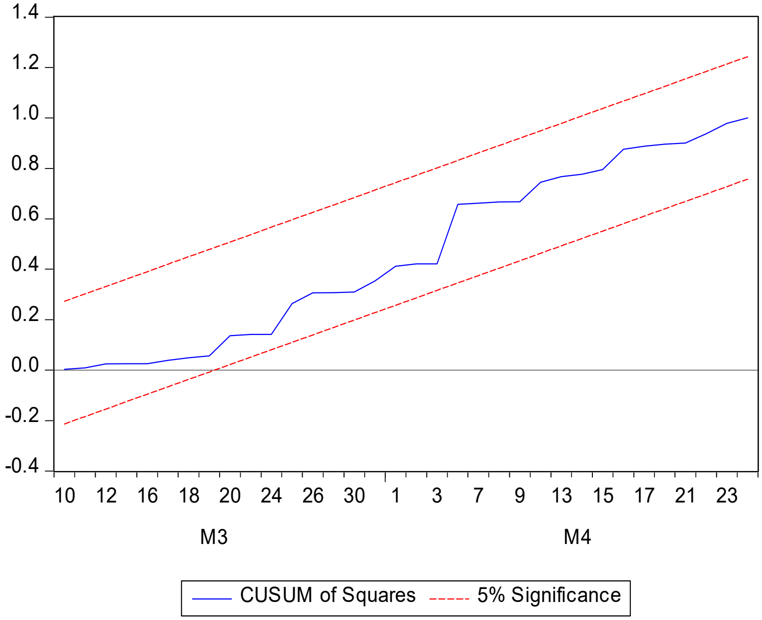


4.8 Robustness analysis

The results are confirmed through diagnostic test results and robustness analysis. The bound tests show the long-run relationship (cointegration) among variables at a 5% significance level, given in Table 2. The effect of BRENT prices on MXWO in the short-run, confirms the initial findings of 'no impact' in the long-run. Both COVID-19 daily fatality cases have rather reduced immediate negative impact on MXWO while the VIX has a significant negative effect on the MXWO in the short-term, reflecting similar findings in the long-run. Therefore, if necessary measures are not implemented timely against the pandemic, there exists a further risk of a downturn in the global economy. The ECM model's stability is given by CUSUM test result in Figure 3.

CUSUM square result is given in Figure 4. Both tests are given in Figures 3 and 4 indicate the stability of coefficients in the short-term as the plots remain within 5% critical bounds, confirming the stability of short-term coefficients.

Figure 4 CUSUM square test (see online version for colours)



5 Conclusions and policy recommendations

This article analyses the effect of COVID-19, in terms of daily fatality cases along with BRENT prices and financial volatility on the global economy, proxied by Morgan Stanley's global market index (MXWO). The ARDL model estimates indicated a significant and negative effect of the coronavirus crisis on MXWO.

BRENT prices seem to have no direct effect on the global economy proxied by MXMO index, both in the long and the short-term. But, it is likely to have an indirect effect through financial volatility as BRENT prices reacted sharply to the rise in financial volatility and the rise in COVID-19 daily fatality figures. Some other commodities, such as gold however gained value as the COVID-19 fatality figures rose, as investors searched for a safe heaven.

Both the daily global fatality figure of COVID-19 and the financial VIX has a significant short-term negative effect on MXMO. However, the direct causal impact of the virus was relatively small compared to the impact of VIX. That can be explained by the indirect impact of the virus through financial market volatility. This finding is similar to the study of Albulescu (2020). The conclusion is that the indirect impact of the coronavirus crisis seems to have a pass-through effect on financial volatility.

The exponential rise in the daily fatality rates risks a shutdown in the global economy and a sharp decline in BRENT prices in the short-term. The amplitude of the economic downturn is likely to be correlated with the persistence of the pandemic. However, recent developments indicate peaks have been reached in daily fatality rates and the decline has been evident. If that situation is sustainable, the recovery in the global economy is likely to be fast as indicated by the ECT term in the ECM model. Central banks have already cut interest rates sharply and provided liquidity in the markets. However, ECM coefficient of –1.24 also indicates that the correction mechanism is likely to be oscillatory, meaning that the speed of adjustment fluctuate further down before moving towards the long-run equilibrium.

Compared to Liu et al. (2020) and Albulescu (2020), this article has similar results; the consequences of the pandemic were considerable and had a direct impact on the global market indices.

Compared to papers by Chen and Spence (2020) and Caballero and Simsek (2020), this article contributes to the literature by identifying both the short-term and long-term impact of the pandemic along with oil prices and volatility on the MSCI world index. This paper is complementary to those studies in two respects:

1 this study focuses on MSCI world equity index rather than volatilities

2 considers the relationship of share prices to the oil prices and pandemic.

Manab et al. (2020) searched the importance of sustainability risk management and found that risk assessments and methods among others are critical components of the sustainability risk management in managing emerging risks. A rapid policy program must be developed in the short-run to safeguard businesses and households. Such a policy should be multidimensional and include the following to prevent global slowdown:

1 Provide central bank liquidity: Major central banks took actions to provide liquidity accommodation to ensure the normal functioning of markets. Central banks should consider risk monitoring to adapt to pandemic crises.

2 Fiscal burden on states and businesses affected by the pandemic should be shared by other states that are capable of extending lending facilities to other nations.

3 World Bank should setup PEF in response to the outbreaks.

4 Businesses should consider new models to include online solutions, make attempts to digitalise businesses.

5 Households should receive direct funding and be quarantined to prevent further waves of the pandemic.

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