



# COVID-19 and stock exchange return variation: empirical evidences from econometric estimation

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## Abstract

This research looked at the effects of COVID-19 on a number of the world's most important stock exchanges, as well as the empirical relation between the COVID-19 wave and stock market volatility. In order to plan proper portfolio diversification in international financial markets, researchers must examine COVID-19 anxiety in relation to stock market volatility. The stock market volatility connected with the COVID-19 pandemic was measured using AR(1)-GARCH(1,1). COVID-19 fear, according to our research, is the ultimate driver of public attention and stock market volatility. The findings show that throughout the pandemic, stock market performance and GDP growth both declined significantly due to average increases. Furthermore, a 1% increase in COVID-19 causes a 0.8% and 0.56% decline in stock return and GDP, respectively. The stock market, on the other hand, showed a slight movement in GDP growth. Furthermore, the COVID-19 pandemic reported cases index, death index, and global panic index all influenced public perceptions of purchasing and selling. As a result, rather than investing in stocks, it is recommended that you invest in gold. The research also makes policy recommendations for important stakeholders. We look to examine how stock returns respond dynamically to unanticipated changes in the COVID-19 scenarios, as well as the uncertainty that comes with a pandemic. Using daily data from Canada and the USA, we conclude that a spike in COVID-19 instances has a negative impact on the stock market in general. Furthermore, in both the increase and decline scenarios in Canada, the stock return reactions are asymmetric. The disparity is due to the unfavorable impact of the pandemic's unpredictability. We also discovered that uncertainty had a negative impact on the US stock market. The magnitude, however, is insignificant.

**Keywords** Stock return · COVID-19 · Wavelet · Stock volatility

## Introduction

With the emergence of the COVID-19 pandemic, the world's stock markets have suffered unparalleled decreases in the face of great uncertainty. If a market is effective in a weak form, asset prices are, according to effective market expectations, all

available and relevant information on the market (Brodeur et al. 2021; Padhan and Prabheesh 2021). In financial theory, the efficient market hypothesis (EMH) has been regarded as mainstream. Furthermore, since the stock market is utilized to distribute resources, authorities should research weak-form efficiency in the stock market (Irfan et al. 2021a). On 11

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March 2020, a worldwide pandemic was declared by the World Health Organization. The 17,396,943 cases have been confirmed as of 1 August 2020, and internationally there have been 675,060 deaths (Razzaq et al. 2020; Irfan et al. 2021c). Furthermore, 4,456,389 confirmed cases and 151,265 deaths were reported in the USA. In other words, nearly 22% of COVID-19 deaths worldwide were in the USA. As a result, it's only natural that COVID-19's spread has had a significant influence on the US economy (Liu et al. 2020).

COVID-19 has recently been the subject of several investigations. The influence of the COVID-19 pandemic on the US stock market, for example, has been studied. These look at the economic consequences of the epidemic in the USA (Soofi et al. 2020; Lin et al. 2020). Its qualities are explored in particular in relation to the global financial crisis (GFC) of 2008. Several researchers investigated as well during the crisis at the market efficiency in the stock market. But many investors consider the decline, during a crisis, as an opportunity to earn a significant profit (Jan et al. 2021; Khan et al. 2021). Many professional investors also allocate portfolio assets using risk management (Susskind and Vines 2020). Because the EMH is linked to these, it is important looking at how this theory affects the stock market during a crisis.

This research has a twofold goal. First, we measure and evaluate the efficiency of each sector in the US stock market to determine its EMH. Depending on the nature of the company, the stock returns of various sectors may show varied reactions to the COVID-19 pandemic. Second, we look at how efficient the sector was during the COVID-19 outbreak and the Great Recession (62). According to our findings, some aspects of the COVID-19 pandemic differ from those of the GFC. As a result, investors and portfolio managers can use the efficiency of each industry to help them establish their investment strategy. Several things influence the stock market price (Mohsin et al. 2021b). These events have their individual qualities (Elavarasan et al.; Irfan et al. 2021b). Corporate actions such as stock splits, rights issues, and warrants have an impact on stock prices; however, the effect can be slow. Incidental events like the COVID-19 epidemic, boom fires, major unrest during a presidential changeover, and economic embargoes can all have an enormous one-time impact on stock values. The COVID-19 epidemic has had an impact on capital market practices in every country. Investors can make investing decisions based on the information contained in the event. The case's news can be regarded in three ways: positively, negatively, or neutrally (Mohsin et al. 2018b). The reaction of the capital market is shown by changes in stock price and stock exchange volume. The market began to react to concerns about the pandemic's economic repercussions (Irfan et al. 2021d). Consumer response to COVID-19 has been studied in a number of ways. A global COVID-19 death rate of more than 1%, according to Arfah et al. (62), will result in a 0.02% drop in the Standard and Poor's 500 after 1 day,

0.06% after 1 week, and 0.08% after a month in the Standard and Poor's 500. According to Hussain et al. (2021), daily unanticipated swings in projected cases based on traditional infectious disease models are referred to as stock sales. Their findings show that stock market volatility will reduce as the pandemic's progress becomes less unpredictable. From the perspective of stock market investors, Chachi (2021) proved that the COVID-19 health issue translated into a larger economic and financial disaster (Arfah et al. 2020; Elliott et al. 2020).

Previous studies on the effects of the COVID-19 epidemic on price exchange transactions had come up with different results. As a result, we wanted to give a more in-depth explanation of the COVID-19 and its consequences on international stock exchanges. This research aimed at testing COVID-19's positive and negative effects on stock exchange performance. Our input also includes a COVID-19 evaluation and inventory price remarks. The COVID-19 impact on stock return variation in the public was estimated using the AR(1)-GARCH(1,1) and wavelet coherence model. This study also looked at the intentions and actions of several industrialized countries, as well as the reasons for these methods and the efficacy of their recovery efforts. We emphasized the importance of economic recovery plans as the pandemic continues. The major goal of the study was to see if there was a significant variation in stock price and stock exchange value before and after the current pandemic.

The remainder of the paper is laid out as follows: The background and literature review are summarized in the “[Background and literature review](#)” section. The methodologies employed in this investigation are explained in the “[Data and methodology](#)” section. The “[Results and discussion](#)” section summarizes the findings and discusses them, while the “[Conclusion and policy implications](#)” section wraps up the discussion.

## Background and literature review

The impact of COVID-19 is important, in particular, since China, Asia's primary center for foreign capital investment, had the first outbreak of the virus (Hussain et al. 2021). Researchers assume the relationships between COVID-19 and SARS, although there are considerable distinctions between the two outbreaks. As we address the influence of COVID-19, we should refer to a number of previous studies on the economic effects of infectious virus epidemics. The prevailing literature focuses on the expenses of medical or economic repercussions of illness, as well as disease-related mortality. (Law et al. 2020) analyzed the spread of Hong Kong's SARS epidemic and its financial consequences, determining that the demand side had the most substantial negative consequences, with local consumption, tourism, and air

travel-related services exports having a short-term impact. The stock markets, according to researchers, are always influenced by large occurrences (Mohsin et al. 2018a). However, as the virus spreads globally, it begins to affect businesses, which is reflected in worldwide financial markets. The circuit brake mechanism struck the US market four times in 10 days in March. Similarly, the FTSE stock market index in the UK has declined by more than 12% since 1987. As a response to the COVID-19 pandemic, the global financial markets, dominated by advanced economies, have shown to lead to increased fear-led market risks, causing likely investment losses as investors were selling panic stock (see Phan and Narayan 2020; among others). Is this discovery possible for all pandemics and epidemics to be extrapolated? This is the important research issue raised in this work. We are also focusing on emerging stock markets, which seem to be less attentive to their developed counterparts during the COVID-19 pandemic (Shakouri et al. 2020). Usually, an integration of mature and emerging stock markets is used to calculate stock market hedging potential (Tiep et al. 2021). A research similar to this one was undertaken by Sun et al. (2020b) and Baloch et al. (2020), albeit their scope, measurements of uncertainty, methods, and analysis were different from this one.

According to the consensus, stock values plunged and market volatility surged after the pandemic influenza epidemic (Waheed et al. 2020) (Khokhar et al. 2020a). Those studies, on the other hand, did not investigate whether COVID-19 was to blame for the stock market's dramatic swings, presuming that no previous knowledge of the break position was accessible (Baloch et al. 2020) (Zhang et al. 2021c). Furthermore, they focused solely on price fluctuations and uncertainty, ignoring the role of return predictability in finance literature. Sansa studied the impacts of COVID-19 on stock markets in China and the USA. The authors discovered a positive and statistically relevant relationship between reported COVID-19 cases and the financial markets, both for the Shanghai Stock Exchange and the New York Dow Jones. Many studies have come up with similar results. COVID-19 has a positive and important impact on stock price trades and stock exchange rate (Nwosa 2021) (Iqbal et al. 2019b).

The stock exchanges are interconnected and interdependent. During the financial crisis, researchers discovered near cross-market correlations. Chiang, Nam, and Li from 1996 to 2003 looked at the regular stock returns for nine Asian markets and observed a strong link between the sample Asian countries throughout the crisis period (Chien et al. 2021b). According to (Iqbal et al. 2020), Malaysia, Vietnam, and Thailand are the Southeast Asian countries with the most financial ties to China. Investor sentiment has a more influence on stock markets in nations where herd-like behavior and overreaction are more prevalent (Anser et al. 2020), or in nations where institutional participation is limited. On 30 January 2020, the WHO announced the novel coronavirus

disease 2019 (COVID-19) an “emergency of international concern” and a pandemic on March 11. According to the WHO's Situation Report - 79, the disease has claimed the lives of 79,235 people worldwide as of April 8, 2020 (Khokhar et al. 2020a) (Siddiqui et al. 2020). Although it appears to be coming to an end in China, where it was first discovered, it continues to spread across Europe, the USA, and other parts of the world, including several low- and middle-income countries (LMICs) (Yumei et al. 2021). The pandemic has prompted unparalleled global responses. Travel bans, confinement, and lockout measures have been implemented in many countries. These responses have been implemented in an “emergency mode” and are primarily reactionary, to prevent the spread of the disease until a specific cure and/or vaccine is created (Elena 2020) and (Devi et al. 2020). During these lockdowns imposed by the government, the world economy suffered a considerable fall and remains the outcome of the suspension of big firms (Mishra et al. 2020) (Abbas et al. 2020). The documentary has been examined from two angles: (1) the transmission instability during the COVID-19 crisis and (2) the relationship between the COVID-19 indicators and stock market performance and economic uncertainty. We examined recent publications on the economic and financial effects of the COVID-19 pandemic (Iqbal et al. 2019a). Several new publications looked at COVID-19's financial and socioeconomic consequences (Tlemsani et al. 2020). There was significant growth on the conditional connections between financial and non-financial corporate equity returns (Mohsin et al. 2021a). This growth was far larger for financial enterprises, demonstrating that they played an important role in expanding the financial disparity between China and the G7 (Hou et al. 2019). They finally demonstrated that the optimum hedge ratios in most instances increased considerably during the COVID-19 crisis, signifying increasing hedge costs. According to Akbar et al. (2021), at the beginning of the COVID-19 epidemic, China's markets were the epicenter. The significant, detailed, and recent parallels between the words “corona” and “corona” were also demonstrated. Baloch et al. (2020) report that the fast expansion of COVID-19 has had a considerable impact on the stock market worldwide, which leads to major increases in global financial market volatility in the short term, and a huge loss to investors (Phan and Narayan et al. 2020).

## Data and methodology

Through a revised wavelet coherence methodology, the relationship between temperature and COVID-19 confirmed cases can be examined over time scales (regardless of the time series). Similar to classical correlation, wavelet coherence can discover specific locations in the time-frequency domain where big and sudden shifts in the observed time series co-

movement patterns occur, while most coronavirus positive cases incubate in incubation centers for about 14 days (Iqbal et al. 2021b). The highest number of hours in incubation centers, supported by the WHO decision for positive coronavirus infections, is 14 days. The pre-test study showed the stock index volatility pattern in numbers during the COVID-19 outbreak, based on International Market Index (Sohail et al. 2019) (Baloch et al. 2020). These graphs indicate how stock market volatility is linked to the COVID-19 outbreak’s global fear index, which is still present in global stock indexes. The results of the interconnected distribution were based on marginal distributions presenting asymmetric distributions AR(1)-GARCH(1,1). Glosten, Jagannathan, and Runkle had previously described and operationalized the AR(1)-GARCH(1,1) model (1993). The following is an explanation of the AR(1)-GARCH(1, 1) model, whereas similar econometric methodologies have been used in various applications (Fu et al. 2021; Sun et al. 2020b).

Because this is a new virus, there are still a lot of questions about it. As a result, traditional techniques of creating policy orientations may not be applicable. The employment of sophisticated techniques to illustrate the connection between temperature, exchange rates, and verified instances of COVID-19 seems considerable to represent this association at varied times and frequencies (Asbahi et al. 2019). It is critical to have a thorough grasp of the condition to take preventative actions that will save more lives. In multiple time series analysis, the wavelet approach has several advantages: it allows cross-analytics. It also simultaneously records bi-directional (lead-lag) interactions between various time-frequency combinations (Iqbal et al. 2021a).

In the vast majority of cases, our data reveal that the variables in Canada are in phase. A big island visible in 4–8-day bands between the 7th and 23rd of April implies significant coherence between 5 and 10%, with variables in-phase (0,2) and examples leading. In the bulk of China’s occurrences, the factors are in sync. Variables are in-phase (0,2) in most events in France (Khokhar et al. 2020b). The black area, which extends from short-run day to long-run day bands between 9 April and 19 April, exhibits the same results, with phase variables (0,2) and leading cases. A small circle of 8–16 days on the 5th–9th of April likewise shows that variables are out-of-phase (-2,-), but that the occurrences lead. The bulk of events in Germany have in-phase variables (0,2) with cases taking the lead. The variables are in-phase (0,2) with cases leading in 1–2-day bands, the set of dark sections. However, occurrences between March 10 and March 20 imply that the variables are out-of-phase (-2,-), with cases leading in the 8–16-day bands.

$$\sigma_f^2 = \omega + \sum_{e=1}^q \alpha_e \varepsilon_{f-1}^2 + \sum_{j=1}^p \beta_j \sigma_{f-j}^2 \tag{1}$$

$$V_{e,f} = \beta_0 + \beta_1 V_{e,f} + \beta_2 (V_{e,f-1}) + \beta_3 \sigma + \varepsilon_{e,f} \tag{2}$$

$\sigma_{ft}^2$  displays the conditional variance and  $f_3$  shows the remaining error. Equation (1) comprises three parameters (and), three parameters, and distributions which characterize the model of AR(1)-GARCH(1,1). The equation has 8 constructions representing parameter estimates. As the GARCH shows, in addition, the robustness of the latest model test is tested by proposed methodologies. Green loans are assessed by total green credit of banks/total banks’ banks and used as a variable predictor, while economic development is measured by economic development (Chandio et al. 2020; Baloch et al. 2020; Zhang et al. 2021b, and Alemzero et al. 2020). Finally, current spending on education and gross capital formation (percent of total expenses) (percentage of GDP) are utilized as predictors. It was determined that the AR(1)-GARCH model (1). It was applicable to the measurement by He et al. of the impact of the COVID-19 on stock market volatility (62). Ng and Chan employed this triaxial model, a multivariant case version in which the effects of all other variables are omitted from the coherence between X and Y (Sun et al. 2020a). The relation between two time series must be understood. For this purpose, the phase difference that can be utilized to characterize the phase relationship between two series. When the phase difference is zero, they move together at the frequency specified (0). The series is in-phase, when the time series is between [0,2] and leads the time series e. If it is between [-2,0], e is in front of f, on the other hand. If the difference is between phases [2,], x leads and time series f leads; if the difference between phases is between [-,-2], then the relation is anti-phase (analogous to negative covariance).

$$e, f = ge, f, \varepsilon e, f \sim RkT(u, \lambda) \tag{3}$$

$$H_{ef} = \omega_{ef} + \alpha \varepsilon_{2f-1} + \beta h e_{f-1} + \gamma e_{2f-1} - e e_{f-1} \tag{4}$$

Stock market volatility is crucial to both market practitioners and policymakers, particularly in emerging nations (Agyekum et al. 2021). Stock market volatility is a source of concern for practitioners because it has an impact on asset value and risk, while policymakers aim to decrease unnecessary volatility to maintain economic and fiscal stability (Iqbal et al. 2021b; Li et al. 2021). In together circumstances, a good quantitative strategy for modelling stock market volatility is required to limit the danger of erroneous calculations (Zhang et al. 2021a). Researchers are still working for the optimum volatility model that can capture a number of stylized aspects about market volatility in this regard (Chien et al. 2021a; Zhang et al. 2021a). Wavelets are a sort of function that is localized in both the time and frequency domains and is used to breakdown time series into more elementary functions that convey different information well about time series. Wavelets are one of many extensively used statistical signal extraction and filtering, as well as thresholding approaches.

The enormous global effect of the COVID-19 crisis on world economies, especially in emerging and developed



markets, is one of its first distinguishing features. In this regard, the International Monetary Fund and other multilateral institutions initially projected that the amount needed to cover these countries’ transitional financing deficits would be USD 2.5 trillion. The effects of this recession have been different from those of the previous economic crisis in 2008, impacting all levels of the labor market; as a result, Merkl and Weber predicted the emergence of a new COVID-19 generation of graduates who would be unable to find work, and that employment subsidies would be one of the few effective steps for labor market stability. Pak et al. suggested that concerted international policies be put in place to ensure the survival of humanity as well as the economic stability that existed prior to the emergence of COVID-19.

In general, the application of wavelets to the analysis of COVID-19’s impact on various financial markets revealed, according to Kumar et al., that the observed unexpected changes in the structure of the variability of returns were due to the variable structure of investors’ activities in a context of complete uncertainty, as COVID-19’s outcome was catastrophic in international financial markets.

We were able to map the effect of COVID-19 by analyzing the coherence of the waves, and we discovered some stylized details that characterize its ramifications. For example, given a regular frequency of 32 days, the ACPS observed co-movements between the variance in cases of COVID-19 and the returns of stock indices (except for Germany), with a gradual decrease in volatility visible from the 18 March subperiod onwards. In each region, there were also relatively unique or differentiated relationships: the financial crisis caused by COVID-19 was more severe in the financial markets of South Africa (primarily), Brazil, and Australia than that in the USA, Japan, and Germany. The waves’ coherence allowed for the development of a chronogram that detailed the corresponding movements in or out of phase with the financial markets studied. The study of the financial assets included in CSR at the global level revealed that they were in-phase in each subperiod, with the USA following suit. The persistence of volatility in Brazil and Australia, which was not apparent in the rest, was notable from the 13 May subperiod onwards.

The variables’ co-movement was designed for conceptualization using these formulas, and the results were robust when using the GARCH approach. With the economy completely disrupted, the government should focus more on government spending to help the economy recuperate. It often encompasses increasing public spending, which will focus on improving cash flow and asset volatility, pouring more money in citizens’ hands and encouraging increased production of goods and services.

As a result, the economy’s supply levels or volumes will increase. The empirical framework of wavelet coherence is used to investigate the relationship between two or more variables.

$$W_{xyqr}(k, o) = W_q(k, o)W_r^*(k, o) \tag{5}$$

Where the transformations of the supplied wavelet  $x(t)$  and  $y(t)$  ensure, for example,  $W_x(k, o)$  and  $W_y(k, o)$ , the index of the wavelet should be evaluated by  $n^*$ .

$$x(t) = \frac{1}{C_\psi} \int_0^\infty \left[ \int_{-\infty}^\infty W_q(k, o)\psi_{k,o}(t)du \right] \frac{do}{N^2}, N > 0 \tag{6}$$

Whereas

$$\|x\|^2 = \frac{1}{C_\psi} \int_0^\infty \left[ \int_{-\infty}^\infty |W_q(k, o)|^2 dm \right] \frac{do}{N^2} \tag{7}$$

The wavelet transformation is thus used as an empirical tool for evaluating the underlying variables in non-fixed time series. The objective function can evaluate the correlation power between two variables in one series in cross-wavelet transformations. The updated wavelet coherence coefficients and the mathematical model are calculated as follows:

$$R^2(k, o) = \frac{|N(N^{-1}W_{qr}(k, o))|^2}{N(N^{-1}|W_q(k, o)|^2)N(N^{-1}|W_r(k, o)|^2)} \tag{8}$$

R means the wavelet compression smoothing method, while  $0 < R_2(m, n) < 1$  squared coefficients provide in the bracket of wavelet coherence. Values of consistency below the threshold are removed by threshing the estimated parameter and an estimate of 1 point to show a better correlation of values between the variables to be evaluated. The objective function for the reduction of hard thresholds is as follows:

$$x_{ht} = \begin{cases} 0 & \text{if } |x| \leq \lambda \\ x & \text{if } |x| > \lambda \end{cases}, \tag{9}$$

And now

$$x_{ht} = \begin{cases} 0 & \text{if } |x| \leq \lambda \\ x - \frac{\lambda^2}{x} & \text{if } |x| > \lambda \end{cases}, \tag{10}$$

$$x_{yt} = \begin{cases} 0 & \text{if } |y| \leq \lambda \\ y - \frac{\lambda^2}{y} & \text{if } |y| > \lambda \end{cases}, \tag{11}$$

The transformer transforms are two-transforming features designed for X and Y wavelets, respectively.  $W_X$  and  $W_Y$ . The initial phase of the mixed debate ( $W_{xy}$ ) may be defined:

$$D\left(\frac{|W_o^X(s)W_o^{Y*}(S)|}{\sigma_X\sigma_Y} < p\right) = \frac{U\vartheta(p)}{\vartheta} \sqrt{P_k^X P_k^Y} \tag{12}$$

The degree of certainty associated with the probability  $p$  is denoted by  $U(p)$ , which is defined as the square root of multiplying two distributions. Basing upon this amazing

dependency, the Granger causality (GC) area has been determined to characterize the two series.

$$x = a_1x_{t-1} + \dots + a_px_{t-p} + \beta_1y_{t-1} + \dots + \beta_py_{t-p} + \beta_{1t} \quad (13)$$

By the test Geweke (1992) proposed in zero linear restriction, the null hypothesis was validated, which is:

$$H_0: My \rightarrow x(\omega) = 0.$$

## Results and discussion

### COVID-19 analysis

Table 1 presents the unit root analysis. COVID-19 is rearranging our culture, causing fear and concern about the novel coronavirus’s effect on Americans’ mental health. The current research looks at how COVID-19 terror, concerns, and perceived danger interact with social vulnerabilities and mental health outcomes, such as anxiety and depressive symptomatology. Unemployment increased dramatically during the pandemic for a variety of causes, most notably the shutdown of numerous unnecessary companies. This resulted in a rise in poverty rates, as people were unable to work and their discretionary income was drastically decreased, leaving them unable to pay their tax obligations.

The largest overflow was from SP500 (6.089%), the largest was from SP500 (30.795%), and the largest (21.428%) was from S&P500, and the biggest from SP500 were DAX returns (21.428%). A proportion of the entirety is 31.036%. This pandemic has had a significant effect on this business, leading to lower material costs and a shortage of manpower. Companies could obtain grants for long-term employers to help them sustain their economic activity, such as income tax savings

**Table 1** Unit root analysis

Constructs	Levin-Lin	FPP	FADF	IPS	Dicky-Fuller
COVID-19 RCI <sub>t</sub>	1.71	11.06	11.06	2.00	-
ΔCOVID-19 RCI <sub>t</sub>	-0.22*	32.15*	68.3*	-0.10	I(1)
COVID-19 RDI <sub>t</sub>	2.65	7.00	3.17	0.12	-
ΔCOVID-19 RDI <sub>t</sub>	-13.51*	61.65*	22.07*	-6.35*	I(1)
COVID-19 GFI <sub>t</sub>	5.66	3.20	5.57	0.77	-
ΔCOVID-19 GFI <sub>t</sub>	-1.00*	86.01*	35.27*	-1.38*	I(1)
MA <sub>t</sub>	5.07	5.80	5.63	1.20	-
Δ MA <sub>t</sub>	-2.16*	60.12*	25.5*	-2.26*	I(1)
MA-CC <sub>t</sub>	11.50	32.11*	57.50*	6.18	-
ΔMA-CC <sub>t</sub>	-3.07*	20.00*	26.12*	-3.13*	I(1)
MA-POL <sub>t</sub>	5.18	27.06	25.09	4.01	-
ΔMA-POL <sub>t</sub>	-0.04*	40.01*	79.35*	-4.75	I(1)

Note: \* indicates 1% significance level

or tax holiday periods. According to moving window research, COVID-19 had a greater impact on bond instability than the 2008 world financial crisis.

The autoregressive distributed lag (ARDL) test is presented in Table 2. As a result, 95% and 90% trustworthy, statistically significant estimates of the wavelet coefficient within the influence cone respectively are ignored in each area outside the cone. For the most part, variables in-phase (0,/2) are reported in Belgium. The Dark Island depicts the in-stage variable (0,/2), with COVID-19 cases resulting to 1–2-day bands, between 29 April and 5 May. Between March 25 and 30, the enormous island exhibits the same pattern in the 2 to 4-day bands, but another island displays in-phase (0,-/2) between April 9 and 17, but with temperatures beyond COVID-19.

Due to changes in US geopolitical risk, uncertainty about US economic policy has grown, generating COVID-19 volatility and price of oil. Therefore, the use of power will only increase by 3.1%. By the end of 2020, the energy industry will have a moderate effect. The average rate of return was 25.32%, less than the whole variance in the 40.11 correlation degree percent (for constant), demonstrating that stock exchange index volatility return rates around the world are strongly tied to their respective volatility. COVID-19 had an impact on industrial productivity, resulting in a significant reduction in China’s electricity usage.

The robustness test is shown in Table 3. Relative volatility transmission occurs in the dynamics of long, medium, and short frequencies, in opposite to the reappearance spillover influence in frequency dynamics. Furthermore, thanks to the COVID-19 pandemic, a substantial surge in stock market volatility was noted in mid-2020. Low-demand families who consume fewer than 24 barrels every billing cycle would be the most affected by this legislation. At the conclusion of week three after the initial outbreak notification, nations with significant individualism experienced a 12.71% smaller recession than nations with a low individualism. We also found that countries with a higher rate of evasion for uncertainty had decreased stock prices by 5.40% compared to countries with lower levels of avoidance for uncertainties in the same time

**Table 2** Autoregressive distributed lag (ARDL) test

Indicator	Value	Std. dev	T-sig	P-sig
COVID-19	50.23*	28.77	5.22	0.000
S&P500	7.57*	8.00	3.42	0.001
DOW	9.35*	28.31	7.77	0.000
DAX	18.43*	1.007	5.58	0.000
CRIA	27.87*	77.05	5.08	0.000
Cyprus	17.57*	0.201	2.77	0.000
MA-POL	19.28*	0.632	2.52	0.003

Note: \* indicates 1% significance level

**Table 3** Robustness test

Indicator	Value	Std. dev	T-sig	P-sig	R <sup>2</sup>	Sparsity
$\tau = 10\text{th}$						
COVID-19 RCI	4.24*	4.16	1.56	0.000	0.66	1045.12 (0.000)
COVID-19 RDI	1.74*	0.64	0.44	0.017		
COVID-19 GFI	1.57*	0.75	0.47	0.000		
MA-CC	0.77*	0.15	0.64	0.027		
MA-POL	0.44*	0.27	0.77	0.014		
C	107.44	111.64	0.75	0.011		
$\tau = 25\text{th}$						
COVID-19 RCI	4.04*	1.11	1.06	0.040	0.72	1424.05 (0.000)
COVID-19 RDI	1.05*	0.57	0.44	0.026		
COVID-19 GFI	0.46*	0.77	0.20	0.000		
MA-CC	0.77*	0.40	0.22	0.001		
MA-POL	0.64*	0.74	0.01	0.004		
C	124.74	217.01	0.65	0.000		
$\tau = 50\text{th}$						
COVID-19 RCI	4.16*	4.14	4.44	0.000	0.62	1077.64 (0.000)
COVID-19 RDI	4.44*	2.47	4.11	0.025		
COVID-19 GFI	2.02*	2.54	0.01	0.044		

Note: \* indicates 1% significance level

period. Stock price drops are connected with higher stock return volatility. Countries with low individualism and considerable ambiguity resistance, in particular, showed increased volatility and price declines in the early weeks of the pandemic. Our results are especially relevant when considering that as COVID-19 unfolds, there is increasing worry about future economic consequences, and presumably increasing economic uncertainty. As observed by Liu et al. (2021), the ongoing COVID-19 situation will have tremendous ongoing economic repercussions.

### COVID-19 index volatility of stock market

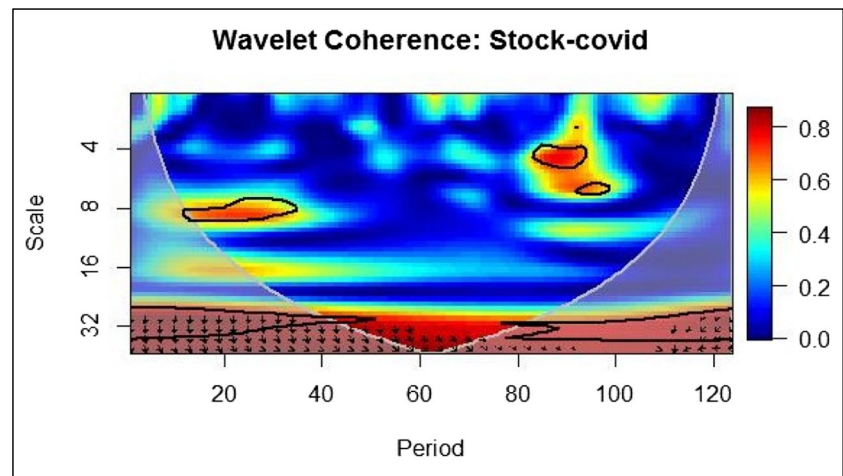
Globally, during COVID-19 outbreak, markets dropped so much value over such a short amount of time that the disease had a huge detrimental effect on communities. We show that some of the turmoil was induced at least by the investment sentiment–dread triggered by a pandemic of coronavirus. The pandemic of the coronavirus has been devastating the major economies in the world and has caused the most severe world recession over generations, with a declining per capita income in the largest proportion of countries since 1870. The IMF says that in 2020, the world economy will fall by 3%, with international economies in decades at their quickest pace. According to the fund, his death is the worst ever since the Great Depression. The epidemic will cut \$9 trillion off the world gross domestic product over the next 2 years, according to I MFI Chief Economist Gita Gopinath. In addition, the world GDP is set to contracted by 5.2% in accordance with the World Bank’s June 2020 Global Economic Perspective Report. In the following months, financial markets will fluctuate in various countries in response to COVID-19 findings and corresponding government control actions or stimulus packages, such as direct

financial aid or interest rate reductions (Ashraf, 2020). These profound developments have attracted many scholars from throughout the world. As a result, a number of researches are being carried out on different financial markets throughout the world to study the impact of the COVID-19 epidemic. Ashraf (62) utilizes a panel data study to analyze the effects of growth in reported cases of COVID-19 and mortality on stock exchange returns after adjustment of nation characteristics and systematic risk owing to external influences. He used the usual COVID-19 and stock return data from 64 nations between 22 January 2020 and 17 April 2020. The results reveal that stock markets react substantially in confirmed cases to negative growth returns, whereas the response to rise in mortality is statistically insignificant. Other data imply that stock markets react sharply in the initial days of the cases reported and then again 40 to 60 days later. However, due to government foreign exchange operations, even the people, investors, incur large losses on their gold market. Even after the outbreak, no substantial co-movement was detected between currencies, gold, and the stock markets. Investors in stock markets are likely to obtain a currency analysis. There was a negative connection between these in the near term and the affected economies of the COVID-19, while the recession allowed for long-term investors to invest more. The post-war scenario of the COVID-19 could lead to a robust bursary recovery, and investors can benefit from dividends and capital gains.

Figure 1 shows the first COVID-19 outbreak wavelet. We begin by examining the consistency of each pair of variables and then discover several significant correlations.

COVID-19 has also altered production and promotion processes because local physical touch is necessary. The fiscal ramification demonstrates that the long-term restricted associations suggest that there has been a

**Fig. 1** Wavelet coherence between stock return and COVID-19 cases



significant change between both markets, which suggests that during volatility, investors regularly adjust their portfolio structure. Subsequently, multiple risk spills between stock markets took place during the COVID-19 crisis. The market is changing over time and is unpredictable; thus, a portfolio manager is unable to adapt the portfolio erection during a crisis period. The component root test was done and stated data were determined to fit the initial difference in all the research constructions (see Table 4). The model AR(1)-GJR(1,1) gave some surprising insight. The intercept ( $\beta_0$ ) ( $\beta_1$ ) and mean stock volatility index coefficient are equal to each relative and close to zero sample market (Mohsin et al. 2018b; Muhammad Mohsin et al. 2021b).

Short-range and long co-motion between COVID-19 instances and temperature is shown by wavelet consistency between number and temperature of COVID-19 cases validated.

**Table 4** Individual stock return

Variable	Case(i)	Case(ii)
COVID-19		
S&P500	-0.177*	-0.235**
DOW	-0.051*	-0.032**
DAX	-0.162***	-0.112*
S&P500	-0.174*	-0.213*
NASDAQ	-0.246*	-0.334**
DOW	-0.475	-0.381*
DAX	-1.427*	-1.783*
CRIA	-0.424*	-0.332*
Cyprus	4.422*	3.321**
Constant	-2.444*	-1.552*
AR(2) p-value	0.462*	0.556**
Hansen p-value	0.442	0.332

Note: \*, \*\*, \*\*\* indicates 1%, 5% and 10% significance level

There is evidence that the variables are cyclical (in stage) in most cases, and temperature leads to linkage in most countries. This shows that a strong influence of temperature on COVID-19 disease propagation is demonstrated by an increase that contributes to the reduction in COVID-19 transmissions. This is consistent with previous findings.

As a result, our results highlight the negative relationship between the COVID-19 instances and the indices in question. This demonstrates that investors grew increasingly aware of the COVID-19 pandemic's long-term effects and were anticipating lengthier global in view of the escalating number of confirmed cases; lockdowns have been implemented, resulting in economic and social costs. The enactment of the global lockdown resulted in a huge reduction in stock market index points. The COVID-19 has contributed to the increased stock market volatility during the sample period, with several consequences, including countrywide lockdown, higher unemployment, and lowered levels of consumption.

Our findings however contradict those of who argue that the COVID-19 pandemic has constructive, short-term effect on stock markets in the countries affected. The findings of individual stock return verify the high negative impact on stock returns in all affected countries and regions of verified COVID-19 incidents. The results are also congruent with those of Sharif et al. (62) suggesting that all frequencies be investigated. Since late March 2020, stock prices have increased 37% since the US Federal Reserve and the expansionary policy of the government. Due to the COVID-19 virus that has swept the world, every major bond index lost value between 6 March and 18 March 2020. Investors' perspectives have been reflected in global stock markets since the 2008 financial crisis. UNCTAD (62) estimates global depression as a result of COVID-19 shocks, including losses of income and extensive unemployment, and negligent repercussions on financial markets, investor trust, global trade, and goods prices.

UNCTAD (62) also estimates that impoverished countries will lose almost \$800 billion in export income in 2020 (excluding China). This is to add to the challenges that currency



**Table 5** First-order difference analysis

Paradigms	First-order differences	
FC	-1.43 (3)	-3.48 (2)*
FI	-1.29 (3)	-3.59 (1)*
$\varphi$	-1.33 (3)	-3.43 (2)*
$\omega$	-1.41 (3)	-3.33 (2)*

devaluation faces versus the dollar, as a result of the foreign exchange earnings.

As far as the Chinese currency is concerned, our results show a considerable (in-phase) joint move between the ERR and COVID-19, where the co-operation between exchange rate instances and COVID-19 is considerably offset phase. That implies that the foreign currency exchange rate of the COVID-19 instances has minimal impact on the exports of Chinese. Phan and Narayan (62) also investigated the response to the outbreak of currency epidemic from the USD/GBP and USD/TRY markets, showing a decreasing level of media stress over the epidemic expansion as of April 2020. The worst-hit nations in Europe, particularly Spain and Italy, suffer from their currency free fall and fewer investment into their systems—the severe economic effects. Due to the increase in COVID-19 cases in 1%, for example, in the S&P 500, the fall in the S&P 500 in -0.161 was 12.8%; the variance in NASDAQ from -0.188 to -0.054 and the variation in the DAX from -0.172 to -0.012 are shown in Table 5. CRIA’s stock exchange rate has the most significant impact on COVID-19. During the pandemic, the GDP logarithm has been utilized on account of control variable. The econometric assessment and findings of COVID-19 and the unpredictability of the stock market is presented. Almost all returns on the stock markets were associated negatively to COVID-19 cases, which meant that the COVID-19 timeframe is near to zero.

These data show that the volatility of markets through the whole pandemic has decreased as a result of the global COVID-19 outbreak. The GARCH coefficient (0.35) of the Shanghai SE is wide, while minor GARCH coefficients are available on the other markets. International exchange disruptions are predictable to have serious effects on stock markets. If today’s pattern continues, COVID-19 will cause stock exchange declines of between 14 and 32% and foreign investment declines of 30–40% by 2022. It is also projected that multinational companies will cut their investment abroad by 20–30% by 2020. These estimates should only be raised by government efforts to bring commercial networks back to the USA. While professional and political figures view COVID-19 as the highlight of globalization, the danger to rely heavily on other economies is also highlighted and the current effect of spillover intensification. Others say that the effects of the COVID-19 will be ephemeral and that it does not assist countries cope with the crisis to push commerce inward.

The study’s coefficients were significant at a p-value of 5%. Quite unexpectedly, there was a greater coefficient in the Shanghai Bourse and Dow Jones Industrial Average. At 5% level, all international stock exchanges have statistically important volatility coefficients (Table 6). That shows nevertheless queuing with the universal index of dread of the COVID-19 epidemic; the volatility index of global financial markets changed. Since stock indexes have shut down, the international economy has been exaggerated by the COVID-19 epidemic. The return on US Treasury Bonds for 10 years has likewise fallen to 0.67%. Several recent research studies have studied and demonstrated the detrimental impact on financial markets of the COVID-19 pandemic.

FC is the constant, FI the COVID-19 fear indexes, the equivalent is the variance coefficient for an index of stock

**Table 6** AR(1)-GJR(1,1) model estimates<sup>1</sup>

	S & P (500)	NASDAQ	DOW	DAX	CRIA	Cyprus
FC	-0.0214*	-0.0360*	-0.0214*	-0.0289*	-0.0241*	-0.0214*
FI	0.045*	0.245*	0.434*	0.665*	0.326*	0.675*
FI	0.0019*	0.0214*	0.0065*	0.0399*	0.0032*	0.0021*
$\emptyset$	-0.001	-0.002	-0.001	0.003	0.065	0.765
W	0.0004*	0.0002*	0.0022*	0.0060*	0.0029*	0.0000*
$\varphi$	0	0	-0.001	0	0	0
$\emptyset$	0.0410*	0.0532*	0.0301*	0.0458*	0.0501*	0.0199*
$\#$	0.676	0.324	0.546	0.765	0.324	0.344
$\cap$	0.4751*	0.149*	0.4156*	0.7635*	0.4876*	0.345*
AIC	0	0	0	0	0	0
$\varphi$	0.3014*	0.250000*	0.2141*	0.5012*	0.2965*	0.2145*

<sup>1</sup> Skewed t distribution regarding calculations was offered here as models about four marketplaces

Note: \* indicates 1% significance level

price volatility, and  $\beta$  is the variability of the dependent study. The autonomy parameter is equal to 2 with the exception of the S&P500 index. The German economy has also a “sharp-V” characteristic of recovery. It shows the economy has collapsed and rebounded rapidly. This form represents an economic loss and an increase in job patterns, GDP, and the rate of output in industry. Finally, the economy is subject to serious fines for people who do not comply with the rules on masks (50 euros). As a result of the abovementioned national measures, the Dutch economy is expected to fall first by 11% before expanding quickly and becoming stronger than before. Table 7 displays that the enduring volatility frequency is the lowest overall volatility spill, followed by the lowest volatility (0.049%), followed by the lowest volatility (0.297%) and the highest volatility frequency. More specifically, the NASDAQ (28.433%) had the most volatility spread. The S&P500 saw the largest volatility spillover of DAX (24.556%), the S&P500 had the highest volatility effect (38.195%), and the S&P500 had the largest volatility effect in Cyprus (38.195% and 56.9011%).

The epidemic saw strong economic growth in European countries. The Dutch economy was later revised, and favorable results in the fourth quarter of 2020 were attained. The economy was saved despite the losses caused by global fatalities.

Contrary to other countries, official lockouts and recommendations were enacted by the international community, including distances from the welfare system, labor at home, and protection of people. There are three sections of the economic recovery approach. The brief period of recovery is as follows: The initiative proposes to offer a stimulus grant of 130 billion euros. The aims of the COVID 19 conference are to ease the recession

and increase demand. By the end of 2022, if not sooner, the economy is expected to return to track with this scholarship. In addition, it provides German people optimism that they will recover.

## Conclusion and policy implications

The purpose of this study was to observe the immediate effects on world stock markets of COVID-19. In addition, this research explores the unexpected impacts of a feared disease pandemic on financial markets. Coronavirus outbreak rapidly influenced worldwide supply and industry. The COVID-19 influence has resulted in new plans and methods in the future. The connection between production and consumption has been broken and the epidemic has developed. In order to quantify its impact on public consideration to stock exchange volatility, COVID-19 is dependable; based on wavelet methods, lead-lagging connections in the period-frequency field were classified to overcome certain intrinsic problems such as static and intermittence. The stock market of COVID-19 plummeted by 26% in the course of 4 days. During the first quarter of 2020, US GDP decreased respectively by approximately 4.8% and 20% because of a massive decline in the stock market index. According to our findings, stock market volatility has been reduced in nations with more cases of COVID-19. The results of the robustness test were true in univariate and multivariate models. In addition, the outbreak indirectly affected inventory performance. Following lockdowns by governments, stock returns seemed in a few weeks to be rather low. As a result of the pandemic, volatility in the stock market plummeted by 65% and 57% respectively for NASDAQ and CRIA; in addition, we discovered that the worldwide fear index of S&P500 was largely linked to the COVID-19 investor.

If COVID-19 spreads, we should examine not only how possible public health disasters could be prevented, but also how financial issues might be addressed. The virus expands and duplicates every 2 or 3 days, if not sooner, the number of new infections. Pandemic worry and regulations to limit the transfer of diseases resulted in a global supply shock, particularly in the manufacturing and labor-intensive industries. The operations close or decrease in order to protect personnel, factories, and offices, which results in a reduction in workforce, efficiency, and consequently business profitability. It would leave many enterprises in a condition of insolvency and would force firms to slash employees or to close down completely if they were not treated correctly by authorities. That's the main reason why worldwide financial markets are in turmoil. Investors see the pandemic as shrinking and are unclear about future sales, so stock prices reflect future income prospects. The traditional response of investors is to sell the equities before the deterioration becomes obvious.

**Table 7** GARCHX estimation analysis

	Mean equation	Variance equation
COVID-19	0.325*** (0.002) 0.384 (0.12)	-
S&P500	-0.6397*(0.323) 0.348*** (0.000)	-
DOW	-1.9982* 1.364***(0.000)	-
DAX	-	0.0050* (0.000)
S&P500	-	0.4571* (0.000)
NASDAQ	-	0.5124* (0.0000)
DOW	-	-0.201 (0.000) *
Diagnostics		
LM test for heteroscedasticity	(0.76)	(0.80)

Source: Authors' calculation

Note: \*,\*\*\* indicates 1% and 10% significance level

The implications for policymakers of our research are substantial. A combination of government officials and regulatory authorities for investment banks and the Central Bank is needed for tackling this challenge. If current debts were rolled over, bank regulators may be sympathetic to firms in economically seriously hit industries, including the manufacturing industry, travel, and tourism. Dealing with the COVID-19 situation calls for a pragmatic strategy, where officers can swiftly alert people without confusion of their plans and of the health care system.

This study presents an early evaluation of the problem of the pandemic, but further study in and between foreign markets on investor confidence is required. The analysis can be utilized as the foundation for future investor feeling and uncertainty research. We are using our findings in order to efficiently communicate the risk of infections, based on the practicality of our conclusions, to institutional and private investors, financial advisers, and financial and industrial professionals, and public health officials should also comprehend their communications' psychological and emotional consequences. An additional problem is that because of the lack of data, demographics such as age, gender, education, stock market experience, and kind of investor could not be investigated.

The results imply that investors have been dismayed and therefore regarded companies as unpredictable and encouraged investors to decide on investment. COVID-19 was utilized as a signal when stakeholders took investment decisions. Under the premise of an efficient market hypothesis, investors make decisions based on basic analysis that provides an indication of the importance of key stock price influences in the near term and technical analysis that includes regular stock price and the psychological aspects of the market. A productive market ensures that all market facts are contained in stock prices.

For each country's capital, the temperature statistics are recorded that may or may not precisely represent the climate patterns of the country. In the future study, this requirement will be solved. Strong co-movements can be detected and causes can be found to explain these co-movements. Therefore, the short-term and long-term consequences of the single COVID-19 pandemic may also be taken into account in the future study as well as in the sample size of larger data on other macroeconomic variables such as the GDP growth rate, PPI, employment rates, monetary policies, and other similar factors.

### Open innovation implications

The COVID-19 pandemic has had a huge impact on industry. As a result, organizations should react appropriately. To combat this pandemic, open creativity and innovation are needed. Because of its strategic position in organizations' development, open innovation has been one of the most hotly discussed subjects in management research in the last decade. Open innovation will prompt a company to make the necessary adjustments to ensure its long-term viability. An organization's survival can be accomplished by open innovation.

Furthermore, open innovation fosters a culture of innovation, learning, and information sharing. Organizations would have more options to react to challenges as a result of creativity. A learning culture encourages companies to develop their skills, while a knowledge-sharing culture increases human resource competence in the face of new challenges.

### Topics for future research and limitations

Despite these and other limitations, we believe that our findings are important for several reasons. Since the current study is limited only the global economic condition, its generalizability is limited. It is proposed that more global financial factors and mental health condition samples be taken for comparative studies. There may be parallels to pandemics as well. A longitudinal research may also be carried out to gather data for future applications and brand-new issues.

**Author contribution** Yousaf Latif: Conceptualization, data curation, methodology, and writing - original draft. Shunqi Ge: Data curation, visualization, and supervision. Muhammad Ramzan: Visualization and editing. Wasim Iqbal: review and editing. Salman Ali and Shahid Bashir: Writing - review and editing, and software acquisition.

**Data availability** The data can be available on request.

### Declarations

**Ethical approval and consent to participate** We declare that we have no human participants, human data, or human tissues.

**Consent for publication** N/A

**Competing interests** The authors declare no competing interests.

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