Cogent Economics & Finance

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/oaef20

Are all countries created the same? An asymmetric nexus between the COVID pandemic and G20 stock markets

Peterson Owusu Junior & Siva Kiran Guptha Kare

To cite this article: Peterson Owusu Junior & Siva Kiran Guptha Kare (2024) Are all countries created the same? An asymmetric nexus between the COVID pandemic and G20 stock markets, Cogent Economics & Finance, 12:1, 2430140, DOI: 10.1080/23322039.2024.2430140

To link to this article: https://doi.org/10.1080/23322039.2024.2430140

COGENT ECONOMICS & FINANCE
2024, VOL. 12, NO. 1, 2430140
https://doi.org/10.1080/23322039.2024.2430140

GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

OPEN ACCESS Check for updates

Are all countries created the same? An asymmetric nexus between the COVID pandemic and G20 stock markets

Peterson Owusu Junior[a,b] and Siva Kiran Guptha Kare[c]

[a]Department of Finance, School of Business, University of Cape Coast, Cape Coast, Ghana; [b]School of Construction Economics & Management, University of the Witwatersrand, South Africa; [c]Department of Humanities and Social Sciences, Sri Sathya Sai Institute of Higher Learning, AP, India

ABSTRACT

The impact from COVID is dire to economies, and G20 countries are no exception irrespective of how developed their market are. This is due to how investors respond to bad and good news alike. Using daily data, for the G20 countries and data on COVID, we employ quantile regression (QR) and quantile-on-quantile regression (QQR) to explore the asymmetric nexus between COVID cases and G20 stock indices returns. Our results show that the pandemic fundamentally has a significant negative effect on all G20 stock returns with a heterogeneous nature across portions of the returns. Also, at varying quantiles of the distribution of stock, we highlight the fact that COVID pandemic has rather occasioned an asymmetric effect on G20 stock returns. Conversely, we notice positive link between the COVID and stock returns at the upper quantiles when the market started to bounce back from the crash. While the pandemic has largely slowed down, it is not completely swept out and the impacts may linger for a little long, hence investors are recommended to be more particular in the stock indices they wish to invest as they observe the erratic dynamics across the G20.

IMPACT STATEMENT

The study is important to understand that for investors and policy-makers in the G20 countries, there are differences in how the COVID pandemic affected each country through their stock markets, and this is more complex than meets the eye. It should be noted that while concerted efforts are needed to address happenings like these, they should not be uniform. Investors need this information to spread their finances across the G20 markets to safeguard against losing it all.

ARTICLE HISTORY
Received 8 January 2023
Revised 6 October 2024
Accepted 12 November 2024

KEYWORDS
G20; quantile-on-quantile regression (QQR); asymmetric impact; COVID; pandemic

SUBJECTS
Economics; Finance; Industry & Industrial Studies

1. Introduction

Several studies suggest that any disruption in a country's economy can hurt its stock market performance. This phenomenon has been proven true on instances like the 1930s great depression (Fisher, 1933; Galbraith, 1955), the global financial crisis in 2008 (Reinhart & Rogoff, 2009; Brunnermeier, 2009), to the recent COVID pandemic (Baker et al. 2020; Gormsen & Koijen, 2020). However, the economic turmoil all over the world caused by the outbreak of COVID is the worst ever the world economy has witnessed since the great depression (Baldwin & Weder Di Mauro, 2020; Gita Gopinath, 2020; IMF (2020). Ever since it was traced in China on 31 December 2019, the spread of the virus was so much so that the confirmed cases and deaths were rising at a fast rate. As the world had never been exposed to such a health crisis, with increasing deaths, the World Health Organisation (WHO) declared the COVID outbreak a pandemic.

The world experienced economic crisis which erupted mainly due to measures taken by governments to contain the spread of the pandemic. In order to avoid the pandemic diffusion, world economies had

CONTACT Peterson Owusu Junior peterson.owusu@ucc.edu.gh Department of Finance, School of Business, University of Cape Coast, Cape Coast, Ghana

Supplemental data for this article can be accessed online at https://doi.org/10.1080/23322039.2024.2430140.
This article has been corrected with minor changes. These changes do not impact the academic content of the article.

considered stricter restrictions on human mobility; causing many to lose their jobs, halt production, resulting in a reduced per capita income in all regions across the globe. The OECD (2020) report stated that COVID pandemic had a far-reaching impact on the major sectors of the economies, leading to a downfall in gross domestic product across the world. Besides sectors of the economies, the stock markets were impacted due to mobility restriction policies to control the ongoing COVID (Hashmi et al., 2021). However, the developed and emerging stock markets reacted differently to the COVID shocks (Ashraf, 2020b; Liu et al., 2020; Harjoto et al., 2021a,b; Tabash et al., 2024). For instance, the largest economies in the world, the US and China suffered more directly from the aftermath of the first wave of the pandemic than the rest of the world. Irrespective, the magnitude of the effect from US and China markets' response to the outbreak are not the same (Doko Tchatoka et al., 2022). This asymmetric impact could be attributable to the strong regulatory mechanism in developed countries hence the ill effects of the pandemic on those countries' stock markets were short lived; these markets rebounded quickly. While in the case of emerging countries, the COVID impact is still being felt across the globe (Amewu et al., 2022; Mensi et al., 2022; Hashmi et al., 2021; Istiak et al., 2021; Nian et al., 2021; Owusu Junior et al., 2021a; Topcu & Gulal, 2020; Khan et al., 2020).

Several empirical studies have been carried out to gauge the impact of the pandemic on stock markets with reference to developing and developed economies. However, the shortcoming in several of these studies is that they used the standard linear regression (Alfaro et al., 2020), and event studies (He et al., 2020) to examine the impact of pandemic on markets. While Hashmi et al. (2021) and Doko Tchatoka et al. (2022) argued that the linear regression models have failed to capture the gyrations of stock market returns. Also, they argued that the stock market movements are captured well by examining the relationship between the distributions of COVID and stock returns series. Given the limitations of traditional regression methods, there is a need to employ modern methods that can uncover the complex nexus with the stock market that the pandemic engendered. These complexities border on asymmetry, non-linearity, non-stationarity, adaptability, and time- and time-horizon varying dynamics, among others. Most prominent among these techniques is the quantile regressions framework (Owusu Junior & Tweneboah, 2020).

Against this background, this study mainly intends to investigate the impact of COVID on the G20 stock markets. The purpose of considering the G20 is because the majority of developed and developing countries that were affected the most by the pandemic belong to the G20 economies. The G20 countries also house the largest global financial markets, not least the stock markets. These countries together accounted for 85% of the world stock market capitalisation and 95% of the world stock value traded in the year 2022. Changes in the stock market in this economic bloc or individual countries have far-reaching impacts on the global economic landscape. This has been revealed in recent history when the subprime crisis emanating from the US engendered a huge spillover to other parts of the world and turned it into a global economic downturn. Further, being the largest market, it affords investors the best opportunity to diversify, hedge, and find a safe haven for the capital as a matter of risk management during turbulent times. This is true given the different resilient levels of the markets and how the pandemic had varying impacts on the different economies making the G20.

From a methodological perspective, analysing the stock market's reaction to COVID with symmetric methods such as the ordinary least squares will not yield realistic results as stocks may react asymmetrically (see, Ma et al., 2021) to pandemic-related information. As a result, the effect of COVID on stocks may be heterogenous. Though there are studies (see, Cevik et al., 2022) that have applied quantile regression using control variables in the context of G20 stock markets, this does not fully capture the heterogeneity as would a quantile-on-quantile (QQR). Yet, hitherto, no study has been carried out employing QQR approach which combines non-parametric estimation and quantile regression. Further, this study adds value to the existing literature in two folds. Firstly, this study applies the QQR approach developed by Sim and Zhou (2015) to analyse the stock market reactions to the pandemic. This method is used to understand how one series quantile (predictor) affects another series across quantiles (response variable) and hence captures the two-way heterogeneous relationship between the pandemic and stock returns. This knowledge allows for insights into making specific tailor-made decisions in both policy and investments.

Second, the study considers the stock markets of G20 economies to examine the market reactions to COVID. The findings from our analysis show that COVID negatively affected economies and even more on strong economies like China, South Korea, Italy, Japan, the UK, France, and Canada when the

pandemic was at its peak. Theoretically, investors respond differently to bad news as compared to good news in an efficient market (Fama, 1965). Accentuated also from the modern portfolio theory where investors want the maximum returns at the least likely risk (Markowitz, 1952), our findings fully depict investors' behaviour. Primarily, the COVID pandemic has occasioned an asymmetric effect on G20 stock returns, and thus offers an opportunity for portfolio diversification across these markets, even in crisis. Further, we are able to determine areas of the conditional distribution where diversification, hedge, and safe haven are afforded the investor involved in the G20 marketplace. This equally helps policy actions to respond depending on the extremities of unusual market conditions instead of applying the same stringent rules across the board. The implications from the pandemic are essential due to its unexpected nature that resulted to halting various economies. Investors are thus, expected to look for stable investment avenues to cut unexpected losses in extreme situations such as the COVID pandemic.

The study is underpinned by the Heterogeneous Market Hypothesis (HMH) of Müller et al. (1993) and the Adaptive Market Hypothesis (AMH) of Lo (2004). These together describe the diversity among market participants in terms of risk and return preferences and well as responding to market dynamics differently as events in the market unfold. The quantile regression techniques we have employed have brought to bear that investor in G20 stocks responded differently to shocks from the COVID pandemic cases during the period.

Theoretically, this study extends the literature on stylised facts of stocks to include that of the COVID pandemic. It has been possible to apply asymmetry, non-linearity, and non-stationarity to the COVID cases as paired with the stock returns to achieve the objective of this study. In practical terms, this study proffer investment and risk management avenues for investors via safe haven, hedges, and diversifiers among the G20 stocks in the face of turbulent market times.

2. Literature review

A large body of literature has investigated the effect of COVID on various aspects of stock markets. In his seminal work, Goodell (2020) opined that COVID may have an impact on banks and stock markets. Subsequent empirical studies have since been conducted, further supporting this assertion.

Most existing literature focuses on the volatility of the stock markets as it is considered the market risk reflecting the impact of COVID. Baker et al. (2020) utilised text-based methods to investigate the impact of COVID on the volatility of the US stock market, concluding that the pandemic had a detrimental effect. Some studies use classical GARCH (Onali, 2020; Baig et al., 2021; Chaudhary et al., 2020; Apergis & Apergis, 2022; Tabash et al., 2024), GJR-GARCH (Jelilov et al., 2020; Bora & Basistha, 2021; Kayani et al., 2024), EGARCH (Osagie et al., 2020; Haroon & Rizvi, 2020; Liu, 2021; Amal & Fatma, 2023), Markov Switching Autoregression model (Baek et al., 2020; Just & Echaust, 2020), GARCH-MIDAS (Bai et al. (2021), TGARCH (Zhang et al., 2020; Khan et al., 2024; Tabash et al., 2024), DCC-GARCH (Akhtaruzzaman et al., 2021; Yousfi et al., 2021), APGARCH (Shehzad et al., 2020), FIGARCH (Lahmiri & Bekiros, 2021; Bentes, 2021), BEKK-GARCH (Baek & Yong Lee, 2021) to study the impact of COVID on the volatility of single and multiple stock markets. Some studies also employed wavelet-based analysis (Choi, 2020; Sharif et al., 2020; Hasan et al., 2021; Rehman et al., 2021; Amewu et al., 2022). Some scholars show a negative impact of COVID on stock markets (Pata, 2020; Hatmanu & Cautisanu, 2021; Yilmazkuday, 2023). Some studies use event study's methodology and find the effect of COVID on stock markets (Aldawsari & Alnagada, 2020; Bannigidadmath et al., 2022; He et al., 2020; Liu et al., 2020; Ledwani et al., 2021; Mazur et al., 2021). There are studies on contagion due to spillover among stock markets (Bossman et al., 2022a; Fu et al., 2021; He et al., 2020; Istiak et al., 2021; Malik et al., 2022). Some studies examined the impact of COVID on stock markets using OLS and quantile regression techniques (Alfaro et al., 2020; Harjoto et al., 2021a, 2021b; Hashmi et al., 2021; Narayan et al., 2021; Ijasan et al., 2021). These studies provide important insights. However, there are limitations bordering on the ability to track the relationship between along the conditional quantile of the distributions of the variables. This does not only ignore a complete capturing of the dynamics of the relations, but it does also not offer the opportunity decipher points for hedge, safe haven, and diversification. While QR does so, the QQR we employ fully captures this.

In addition to single-country analysis and multiple-country analysis using time series models, researchers have conducted studies using panel data models. The pioneering study by Al-Awadhi et al. (2020) used panel regression and found a negative impact of COVID on Chinese stock returns. Similar methodology was

used in Ashraf (2020a), Asli Azimli (2020), Bissoondoyal-Bheenick et al. (2021), Bossman et al. (2022b), Liu et al. (2020), Haroon and Rizvi (2020), Papadamou et al. (2020), Sun et al. (2021), Cevik et al. (2022), among others. While quantile regression has been frequently utilised in studies to examine the dependence structure between the pandemic and various financial variables, the quantile-on-quantile regression (QQR) technique has been largely absent in the context of stock markets. For example, Cevik et al. (2022) employed a panel QR approach to glean insight into the dynamic of investor sentiments on the stock markets of G20 countries during the COVID pandemic. However, the quantile-on-quantile regression technique provides a complete understanding of the dependence structure between COVID infections and G20 stock market returns, enabling the assessment of the impact on downside (lower quantile), upside (lower quantile), and normal market dynamics. This is a novelty proffered by this study, as it is missing in the G20-stock market nexus literature. This extended approach (QQR) from the QR condenses the nexus into an average across all quantiles (Bouoiyour et al., 2018) for a deeper understanding.

3. Methods and materials

3.1. Quantile-on-quantile regression (QQR)

The conditional quantile link between two or more variables is empirically justified using the QQR technique, which is a non-parametric variant of the traditional quantile regression (QR). The QQR is suited for studying bearish and/or bullish interrelations between the returns on G20 stock returns and COVID cases since quantiles can express asymmetry among high and low logarithmic price patterns. The relationship between the G20 stock returns and COVID cases are non-parametrically given as

$$SR_t = \beta^{\theta}(COVID_t) + u_t^{\theta} \tag{1}$$

where SR_t and $COVID_t$, respectively, represent the returns of G20 stock and COVID cases at period t, $\beta^{\theta}(\bullet)$ is the slope of the connection between the two assets at any conditional level, the θth quantile of SR_t in Eq. (1) that is conditionally distributed is denoted by θ, and u_t^{θ} is the quantile in error which is made to have a θth conditional quantile.

By a first-order Taylor approximation of a quantile of SR^{τ}, Eq. (1) is expanded to yield Eq. (2) as follows

$$\beta^{\theta}(SR_t) \approx \beta^{\theta}(COVID^{\tau}) + \beta^{\theta''}(COVID^{\tau})(COVID_T - COVID^{\tau}) \tag{2}$$

where the partial derivative of $\beta^{\theta}(SR^{\tau})$ is explained by $\beta^{\theta''}$, representative of a marginal effect as the slope. It is depicted that θ is the functional illustration of $\beta^{\theta}(SR^{\tau})$ and $\beta^{\theta''}(COVID^{\tau})$, from Eq. (1), while τ is the functional illustration of *COVID* and $COVID^{\tau}$ also in respect of Eq. (2). Therefore, θ and τ are the functional representations of $\beta^{\theta}(COVID^{\tau})$ and $\beta^{\theta''}(COVID^{\tau})$, is for Eq. (2). By substituting each of $\beta^{\theta}(COVID^{\tau})$ and $\beta^{\theta''}(COVID^{\tau})$ from Eq. (2) for $\beta_0(\theta,\tau)$ and $\beta_1(\theta,\tau)$, we deduce Eq. (3) as

$$\beta^{\theta}(SR_t) \approx \beta_0(\theta,\tau) + \beta_1(\theta,\tau)(COVD_T - COVID^{\tau}) \tag{3}$$

Eq. (2) can now be substituted into Eq. (1) to arrive at Eq. (4) as

$$SR_t = \beta_0(\theta,\tau) + \beta_1(\underbrace{\theta}_{(*)},\tau)(COVID_T - COVID^{\tau}) + u_t^{\theta} \tag{4}$$

$$\min_{b_0,b_1} \sum_{i=1}^{n} \rho_{\theta}\left[SR_t - b_0 - b_1\left(\widehat{COVID}_t - \widehat{COVID}^{\tau}\right)\right] K\left(\frac{F_n\left(\widehat{COVID}_t\right)\text{-}\tau}{h}\right) \tag{5}$$

where $(*)$ yields the conditional quantile of θth of returns on *COVID* in Eq. (4). It additionally portrays the true susceptibility of the SR (τth) to shocks from the quantile of the $COVID(\theta\text{th})$ in respect of Eq. (4), of the parameters β_0 and β_1 with indices represented by θ and τ. Similar to the case of OLS, we apply an analogous minimisation to produce Eq. (5).

where the quantile loss function, $\rho_{\theta}(u)$, is represented as $\rho_{\theta}(u) = u(\theta\text{-}I(u < 0))$, i is the function of indicator, the kernel density function (KDF) is denoted as $K(\bullet)$, and h is the bandwidth parameter of the KDF. The observations of $COVID^{\tau}$ is weighted by the KDF where the minimal weights are inversely connected to the distribution of $\widehat{COVID}_t$ in the form of $F_n\left(\widehat{COVID}_t\right) = \frac{1}{n}\sum_{k=1}^{n} I\left(\widehat{COVID}_k < \widehat{COVID}_t\right)$.

Table 1. Data description.

Country	Stock Index	Date (MM-DD-YYYY)	Observations
Argentina	S&P MERVAL	03/04/2020–10/19/2021	391
Australia	ASX	01/28/2020–10/19/2021	441
Brazil	BOVESPA	02/27/2020–10/19/2021	409
Canada	CSX	01/28/2020–10/19/2021	434
China	SSE	01/23/2020–10/19/2021	418
France	CAC40	01/27/2020–10/18/2021	444
Germany	DAX	01/28/2020–10/19/2021	440
India	BSE-SENSEX	01/31/2020–10/19/2021	418
Indonesia	IDX	03/03/2020–10/19/2021	396
Italy	FTSE-MIB	02/03/2020–10/19/2021	438
Japan	NIKKEI	01/23/2020–10/19/2021	425
Mexico	MEXBOL	03/02/2020–10/19/2021	413
Russia	MICEX	02/03/2020–10/19/2021	434
South Africa	JSE	03/06/2020–10/19/2021	406
Saudi Arabia	TASI	03/03/2020–10/19/2021	405
South Korea	KOSPI	01/23/2020–10/19/2021	429
Turkey	BIST	03/12/2020–10/19/2021	399
United Kingdom	FTSE	02/03/2020–10/19/2021	438
United States of America	S&P500	01/23/2020–10/19/2021	440

Following the specifications of Sim and Zhou (2015), the bandwidth for the quantiles we employ in this study for the QQ breakdown is defined as $\theta = [0.05\ to\ 0.95]$ (see also Koenker, 2005). The smoothness of the estimated results is contingent on the bandwidth, which represents the divisions of the quantiles. Smaller bandwidths are recommended over larger bandwidths because larger bandwidths may lead to biased estimates of the coefficients. Estimations are based on the least-squares cross-validation (LSCV) kernel with lag 1, as described in Breslaw (1992). For more detailed descriptions see Koenker (2005), Koenker and Bassett (1978), Koenker and Hallock (2001), and Sim and Zhou (2015) among others. This article is also written in the spirit of the increasing importance of the quantile regressions in the extant literature to divulge asymmetric relationships (see, for example, Caporin et al., 2021).

3.2. Data sources and description

The study employed daily data on the stock returns of G20 and COVID cases of respective countries. The G20 countries include Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, South Africa, Saudi Arabia, South Korea, Turkey, United Kingdom, and United State of America. Due to time differences on the effect of the COVID pandemic on world economies, the daily observed data have country-specific start and end dates (as in Table 1). Nonetheless, the sample periods do not extremely differ among the countries, making it possible for effective comparison in the heat of the pandemic. The sampled period is based on the availability of consistent data during the COVID pandemic as of the time of writing. The start date in particular is based on the official dates when the WHO declared COVID as a pandemic on 11 March 2020[1]. The G20 stock returns data were obtained from investing.com and yahoofinance.com whereas data on COVID cases were gleaned from ourworldindata.org.

In Supplementary Table 4 (in the Appendices), we have presented the descriptive statistics of the returns. The values of skewness and kurtosis suggest asymmetry and leptokurtic as opposed to the normal distribution. The non-normality is confirmed by the Shapiro–Wilk test which rejects normality at all levels of conventional significance for all the data. The varying levels of these for the stock returns, in addition to the different means and standard deviations also tell of the asymmetry and in behaviour during the pandemic and the non-linearity in their relationships and responses. These preliminary findings provide justification for using the quantile regressions approach to portray the non-linear and asymmetric dynamics in stock returns with the pandemic.

4. Results and discussions

4.1. One-way asymmetric relationship between G20 stock returns and COVID (QR results)

The study presents an analysis of G20 stock returns and COVID pandemic cases for QR and OLS during the COVID pandemic. Particularly for the QR results, we show the extent of asymmetric relationship

Table 2. QR estimates of COVID and G20 stock market returns.

Quantile	South Korea	Saudi Arabia	South Africa	USA	UK	Canada	Russia	Japan	India	Indonesia
0.05	−2.0449*	−0.3197*	−0.7200*	−0.5854*	−0.6451*	−0.6643*	−0.6829*	−0.9521*	−0.9288*	−0.9863*
0.10	−0.7642	−0.2419*	−0.4627*	−0.3393*	−0.3608*	−0.3671*	−0.2483**	−0.5378*	−0.4800*	−0.6988*
0.15	−0.2497	−0.1102	−0.3473*	−0.2913*	−0.3010*	−0.2485*	−0.2299**	−0.3936*	−0.4584*	−0.4671*
0.20	−0.1510	−0.1102*	−0.2252*	−0.1555**	−0.2053*	−0.2476*	−0.1333*	−0.2474*	−0.3768*	−0.3742*
0.25	−0.0525	−0.0764	−0.2029*	−0.1308*	−0.1898*	−0.1488*	−0.0685	−0.1773*	−0.2635*	−0.3174*
0.30	−0.0375	−0.0397	−0.1398*	−0.1093*	−0.1338**	−0.1247**	−0.0548	−0.1255**	−0.1432	−0.1956**
0.35	−0.0375	−0.0397	−0.1398**	−0.0961*	−0.0897	−0.1090	−0.0463*	−0.0764**	−0.0729	−0.1201***
0.40	−0.0187	−0.0047	−0.0615	−0.0637**	−0.0287	−0.0542	−0.0312**	−0.0503***	−0.0596	−0.0787
0.45	−0.0187	−0.0047	−0.0293	−0.0621	0.0000	−0.0171	−0.0312	−0.0383***	−0.0363	−0.0787**
0.50	−0.0187**	−0.0047	0.0106	−0.0131	0.0040	−0.0143	−0.0286	−0.0223	−0.0314	−0.0685*
0.55	−0.0142	−0.0047	0.0356	0.0118	0.0040	0.0048	0.0052	−0.0098	0.0206	−0.0630***
0.60	−0.0142	0.0151	0.0356	0.0227	0.0275	0.0354	0.0440	−0.0035	0.0206	−0.0267
0.65	−0.0142	0.0385	0.0995	0.0831***	0.0430**	0.0852	0.1002**	0.0311	0.0206	−0.0208
0.70	−0.0121	0.0658	0.2228*	0.1121**	0.0546	0.1550*	0.1170*	0.0674	0.0549	0.0264
0.75	0.1139	0.1023**	0.2418*	0.1753*	0.0925**	0.1863*	0.1196*	0.1213**	0.1145***	0.1163
0.80	0.2345	0.1213**	0.2755*	0.2297*	0.1373*	0.2235*	0.1339*	0.2282**	0.1482***	0.3545**
0.85	0.3423	0.1923*	0.3434*	0.2644*	0.2634*	0.3043*	0.1627*	0.4901*	0.3224*	0.4824**
0.90	0.9452**	0.2574*	0.6323*	0.4771*	0.4659*	0.5265*	0.3246**	0.7089*	0.4756*	0.9041*
0.95	2.1928*	0.3178*	0.9607*	0.8090*	0.7641*	0.7983*	1.1738*	1.1704*	1.0908*	1.5814*
OLS	South Korea	Turkey	Saudi Arabia	South Africa	USA	UK	Canada	Russia	Japan	India
R^2	0.0068	0.0078	0.0242	0.0060	0.0049	0.0083	0.0110	0.0183	0.0030	−0.0018
COVID Cases	−0.0209**	−0.0150**	−0.0179*	−0.0250***	−0.0174***	−0.0174**	−0.0253**	−0.0261 *	−0.0205	−0.0051

Note. *, **, and *** indicate significance at 10%, 5% and 1% levels, respectively.

between the G20 stock returns and COVID pandemic cases at varying levels of market conditions. Hence, we are able to divulge diverse market conditions of stressed, normal and good market performance (see Baur & Lucey, 2010; Barson et al., 2022; Archer et al., 2022).

It can be observed from Tables 2 and 3 that the COVID pandemic has a significant negative effect on all G20 stock returns at stressed market outcome representing the lower quantiles of the distribution (quantiles 0.05 to 0.35). The impact of COVID becomes stronger at the lowest quantile and begins to submerge as the market becomes normal through to market boom. That is, susceptibility of the G20 stock returns to shocks from the Pandemic is mostly elicited at the lower tails of the distribution of the stock returns. This implies that in turbulent market conditions, the G20 stock returns are highly responsive to shocks, and even negative, from the COVID pandemic. Surprisingly, the lower quantiles (0.05–0.35) of the G20 stock-pandemic cases nexus revealed an adverse direction, indicating that the sample equities cannot act as a safe haven against the pandemic-based shocks. Thus, heightened levels of the pandemic coincided with adverse dynamics in the sample equity market. The summary of these patterns has been summarised in Table 4. The findings of Harjoto et al. (2021a, 2021b) on the significant negative impact of COVID cases on emerging as well as developed markets are also revealed in this study.

Conversely, we notice positive shocks transmission from the COVID to stock returns at market boom. Accordingly, in times of markets rebound, it is expected that a rise in the pandemic would rather correspond to a rise in stock performance which concurs the findings of Bai et al. (2021). This is not surprising because most economic agents such as investors, policy makers, businesses might have learned how to survive in the course of the pandemic (Asafo-Adjei et al., 2022; Owusu Junior et al., 2021b; Agyei et al., 2022).

Particularly for each G20 countries, the COVID impact on stock returns of South Korea at the extreme lower quantile (quantile 0.05) is the strongest. This is followed by the stock returns of Mexico, Brazil, Indonesia, and possibly Japan, India and Germany. However, the significant negative impact of the COVID pandemic cases on the diverse lower tails (quantiles 0.05-0.35) distribution of stock returns is severe for countries like South Africa, USA, UK, Canada, Japan, Indonesia, France, and Mexico. The remaining countries demonstrate heterogeneous significant (significant at particular lower quantiles) negative impact of COVID pandemic cases on stock returns. We find opposite outcomes of positive shocks from the COVID pandemic cases for almost all G20 economies for market boom (quantiles 0.75–0.95). Similar to the extreme lower quantile, at the extreme upper quantile (quantile 0.95), South Korea recorded significant impact of the COVID pandemic cases on stock returns, and its coefficient is considered to have the largest magnitude. Thereafter, countries such as Mexico, Indonesia, Brazil, Turkey,

Table 3. QR estimates of COVID and G20 stock market returns.

Quantiles	France	Germany	Australia	China	Brazil	Mexico	Turkey	Italy	Argentina
0.05	−0.4956*	−0.9244*	−0.4220*	−0.5447	−1.1204*	−1.3637*	−0.6868**	−0.9613*	−0.6201**
0.10	−0.3648*	−0.3127**	−0.4009*	−0.5447	−0.6696*	−0.9007*	−0.1548	−0.5433*	−0.4017***
0.15	−0.2138*	−0.1999*	−0.3144**	−0.4931**	−0.5925*	−0.8213*	−0.0898**	−0.2579	−0.2685
0.20	−0.1525*	−0.1085***	−0.2324***	−0.2068	−0.3786*	−0.5769*	−0.0898*	−0.1431	−0.0689
0.25	−0.1269*	−0.0662	−0.2208***	−0.2068	−0.2954**	−0.4293*	−0.0691**	−0.1196	−0.0461
0.30	−0.0902*	−0.0608***	−0.0927	−0.0310	−0.1330	−0.3778*	−0.0326	−0.0809***	−0.0487
0.35	−0.0652**	−0.0249	−0.0301	−0.0310	−0.0405	−0.3227**	−0.0326	−0.0731	−0.0531
0.40	−0.0490***	−0.0136	−0.0196	−0.0310	−0.0405	−0.1150	−0.0214	−0.0425	−0.0570
0.45	−0.0452	−0.0026	−0.0224	−0.0310	0.0107	−0.1014	−0.0184	−0.0065	−0.0300
0.50	−0.0227	0.0065	0.0285	−0.0024	0.0109	−0.0458	0.0002	−0.0065	0.0052
0.55	0.0088	0.0065	0.0299	0.0313	0.0287	0.0903	0.0094	−0.0065	−0.0004
0.60	0.0219	0.0065	0.0298	0.0899	0.0567	0.0903	0.0094	−0.0065	−0.0038
0.65	0.0261	0.0135	0.0286	0.0899***	0.1111***	0.1820	0.0094	−0.0012	0.0028
0.70	0.0384	0.0407	0.0244	0.1065***	0.1509**	0.3042**	0.0222	0.0208	0.0857
0.75	0.0431	0.0739**	0.0397	0.1086***	0.1509	0.4599*	0.0531	0.0430	0.1351***
0.80	0.1436**	0.0923***	0.0864	0.1086	0.3200*	0.6208*	0.0574	0.1247	0.1577**
0.85	0.2011*	0.1437	0.1668	0.1101	0.5654*	0.7223*	0.1679	0.2192**	0.1485*
0.90	0.3240*	0.3629**	0.2670*	0.1621	0.6888*	1.1079*	0.3237	0.4414*	0.1289***
0.95	0.7158*	0.8209*	0.3125*	1.1031	1.3017*	1.7219*	1.3004**	1.0429*	0.1017
OLS	Indonesia	France	Germany	Australia	China	Brazil	Mexico	Italy	Argentina
R^2	0.0657	0.0218	0.0012	0.0069	0.0108	−0.0024	0.0066	0.0186	−0.0012
COVID cases	−0.0649*	−0.0350*	−0.0101	−0.0377**	−0.0617**	0.0006	−0.0460***	−0.0248*	−0.0178

Note. *, **, and *** indicate significance at 10%, 5% and 1% levels, respectively.

Russia, Japan, China, India, and Italy respectively recorded the most impact of the COVID pandemic cases on stock returns.

Additionally, stock returns of South Korea (Wang & Park, 2021) and Indonesia (Utomo & Hanggraeni, 2021) respond negatively to shocks from the COVID pandemic cases at the median quantile (quantile 0.5). This implies that at normal market condition of the COVID pandemic period, the stock returns of South Korea and Indonesia could be an effective hedge. Accordingly, we find that the impact of COVID pandemic cases on stock returns of G20 has been heterogeneous across diverse distributions of the stock returns. The heterogeneous market hypothesis of Müller et al. (1993) comes to bear in this study revealing that investors of the G20 stocks responded differently to shocks from the COVID pandemic cases. The negative impact of the COVID pandemic cases is not startling because during the heat of the pandemic, representing market stress, sophisticated stock market investors price in the expected negative impact of the pandemic primarily from the progression in confirmed cases (Ashraf, 2020a).

Despite the consistent significant negative nexus between the COVID cases and most of the sample G20 stock returns, it is relevant to acknowledge that the median quantiles (0.40-0.65) exhibited a mixture of weak and moderate magnitude, with the majority characterised as bi-directional. As highlighted in Table 3, the weak and moderate (magnitude) and negative (direction) observed indicate the absence of hedge capacity of the sample G20 stocks against normal levels of shocks from the pandemic, with the reverse highlighted by the bi-directional nexus. The results indicate that only a few (Russia, USA, UK, Japan, France, China, and Brazil) among the G20 stocks could serve as hedge instruments, which should be considered by investors in these markets. A cursory observation of the nexus between the G20 and the pandemic cases at the higher quantile (0.70–0.95) revealed the diversification prospect among all the sample stocks across all quantiles, with the only deviation largely found in the magnitude of effect. Thus, except for South Korea, which recorded a bidirectional nexus with the pandemic cases at the higher quantile, the remaining stocks exhibited a positive response to variations in the pandemic cases, indicating the role of varying conditions in the dynamics of asset response to global shocks.

We confirm outcomes obtained by prior literature, but at varying levels of the distribution of stock returns to highlight the fact that COVID pandemic has occasioned an asymmetric effect on G20 stock returns. For instance, Sharif et al. (2020), Baker et al. (2020), Onali (2020), Albulescu (2020), Yilmazkuday (2023), Baek et al. (2020), Just and Echaust (2020), and Shahzad et al. (2022) found that COVID had a significant negative impact on the US stock market. However, we only confirm their findings at turbulent market outcome, and additionally find a significant positive effect at market boom. The asymmetric

Table 4. Summary of results in light of investment prospects.

Countries	Quantiles	Direction	Magnitude	Diversification	Hedge	Safe haven
Indonesia, Germany, Japan, South Africa, UK, USA, Canada, Australia, Mexico, France	0.05–0.35	Negative	Strong	No	No	No
India, Saudi Arabia, Russia, Brazil, Italy, Turkey	0.05–0.35	Negative	Moderate	No	No	No
South Korea, China, Argentina	0.05–0.35	Negative	Weak	No	No	No
South Korea, Indonesia,	0.40–0.65	Negative	Moderate	No	No	No
Russia, UK, USA, Japan, France, China, Brazil,	0.40–0.65	Bidirectional	Moderate	No	Yes	No
Italy	0.40–0.65	Negative	Weak	No	No	No
Saudi Arabia, South Africa, Canada, India, Germany, Australia, Mexico, Turkey, Argentina	0.40–0.65	Bidirectional	Weak	No	Yes	No
Saudi Arabia, South Africa, USA, UK, Canada, Russia, Japan, India, France, Germany, Brazil, Mexico, Argentina	0.70–0.95	Positive	Strong	Yes	No	No
Indonesia, Australia, China, Turkey, Italy	0.70–0.95	Positive	Moderate	Yes	No	No
South Korea	0.70–0.95	Bidirectional	Moderate	Yes	No	No

Note. Directional and magnitude represent the pattern of relationship between the G20 stock indices and the pandemic cases and magnitude is the level of significance. A positive (negative) relationship between pandemic cases and G20 stocks in the normal quantile (0.40-0.65) indicate the existence (absence) of hedge while the same scenario in the lower quantile (0.05-0.35) indicate the existence (absence) of safe haven. A positive (+) or bidirectional (±) relationship at the higher quantiles (0.7-0.95) indicate a diversification.

impact of the COVID on the US stock returns deviates the stock market efficiency as also revealed by Ozkan (2021) on the US stock market. Although, our OLS results as a static model are in line with most prior studies outcomes, we explain differences with the QR estimates as a result of failure of prior studies to account for the effect of the COVID on diverse distribution of the US stock returns.

Moreover, in the Australian market, Rahman et al. (2021) revealed that stock returns responded negatively to COVID announcements as similarly found by Oliyide et al. (2022) in the Indian market. Moreover, Kotishwar (2020) found that US, Spain, France, Italy, China and Indian stock indices are susceptible to negative impact from COVID pandemic. Conversely, Bai et al. (2021) found that the pandemic had a positive impact on the volatility of the stock returns of US, China, UK and Japan. The outcome of Bai et al. (2021) is one of the few studies providing support at the upper quantile distribution of these stock returns from our findings. This highlights that indeed, on average, the impact of the pandemic on stock returns is mostly negative as found in our OLS estimates but becomes less profound at the upper quantile rather revealing positive outcomes. It is clear that outcomes generated from our study on the upper quantile departs significantly from extant literature on COVID pandemic and stock returns in general.

4.2. Two-way asymmetric relationship between G20 stock returns and COVID (QQR results)

This section presents the QQR estimates for the G20 countries covering the diverse distributions of both stock returns and COVID confimed cases. From Supplementary Figure 1 (in the Appendices), it can be observed that relationships with the COVID cases covers negative beta estimates for a majority of the distributions. Nonetheless, there are potential for positive relationships as revealed in the upper quantiles of stock returns in the case of the QR estimates. The negative relationships is severe for countries like China, Canada, France, South Korea, Italy, Japan, UK, etc., whose economy greatly responded negatively to shocks from the pandemic. This can be traced mainly to the lower quantile of stock returns representing stressed market condition in the heat of the pandemic. For China, we notice that at several distributions of stock returns, the relationship is still negative. This is not surprising because China experienced massive economic downturn during this period (Ashraf, 2020a; Apergis & Apergis, 2022; Liu et al., 2020; Sun et al., 2021).

To account for the adequacy of QQR estimates, the averages per quantile are plotted with those of QR estimates. We expect the two to be similar to prove QQR as a good technique to capture the dynamic non-linear and asymmetric nexus between COVID cases and G20 stock returns (Bouri et al., 2017; Ijasan et al., 2021). It is clear from Supplementary Figure 2 that the QR and QQR coefficients are similar for most of the G20 countries and for most of the quantiles. While they differ in magnitude at the lower and upper quantiles, the direction of the coefficients corresponds. We, therefore, find the QQR method also appropriate to decipher the relationship espoused in this study.

Based on the definitions of diversification, hedge, and safe haven by Baur and Lucey (2010), Baur and McDermott (2016), we summarise the findings of the study in Table 4. The surmise that assets that provide safety nets in the bad (bearish) market periods are referred to as safe havens, those which provide are hedge are uncorrelated or negatively correlated during normal or good (bullish) market conditions. Diversifiers are positively (but not perfectly correlated) in any market conditions. Thus, hedges and safe havens possess the specific property of risk reduction, unlike diversifiers, according to Baur and Lucey (2010). In this light, the quantile that correspond to diversifier, hedge, and safe haven are denoted by 0.70–0.95, 0.40–0.65, and 0.05–0.35, respectively.

5. Conclusion

In this study, we investigated the asymmetric relationship between COVID pandemic cases and stock returns of G20 countries. Hence, quantile regression approaches were adopted to execute this purpose. First, the quantile regression approach was utilised to ascertain the asymmetric relationship between COVID pandemic cases and different distributions of stock returns for G20 countries. Second, the quantile-on-quantile regression technique was employed to assess the asymmetric relationships between COVID pandemic cases and stock returns at their diverse quantile distributions. For the purpose of this

study, the OLS regression which provides response only at the median quantile was considered to contribute to the need of investigating the relationship rather through the quantile regression approaches.

It was found that stock returns of G20 economies react negatively to COVID pandemic cases during stressed market condition highlighting the heat of the pandemic. This implies that indeed, stock markets react with negative sentiments to the great number of confirmed COVID pandemic cases (Ashraf, 2020a). With such sentiments, investors may be more risk averse to investment, unless, the assets have been identified as a store of value during crises at respective frequencies. Conversely, there was a positive reaction of stock returns for countries such as South Korea, Mexico, Indonesia, Brazil, Turkey, Russia, Japan, China, India, and Italy. This is not overwhelming when the stock markets susceptibility to shocks from the pandemic have become saturated. Thus, the stock markets begin to experience a rebound with the declining adverse impact on markets dynamics depicting how adaptive investors are to news on a market (see Lo, 2004). The sophisticated stock market investors would rather price in the expected positive impact of the pandemic critically from the regression in confirmed cases.

Moreover, stock returns of South Korea and Indonesia responded negatively to shocks from the COVID pandemic cases at the median quantile. These findings are consistent with those of Wang and Park (2021) and Utomo and Hanggraeni (2021). We advocate that the impact of COVID pandemic cases on stock returns of G20 has been heterogeneous across accentuating the heterogeneous market hypothesis of Müller et al. (1993). Empirically, our results are consistent with those of Ashraf (2020a) Ashraf (2020b), Harjoto et al. (2021a), and Tabash et al. (2024). Accordingly, stock markets of most G20 nations quickly respond to COVID pandemic cases and this response varies over diverse market conditions depending on the stage of outbreak.

In this study, we have divulged the different responses of the G20 stock markets to the COVID pandemic which contributes to the growing body of literature of understand the non-linear and asymmetry in different relationships in line with the stylised facts of financial assets and well as the behaviour of market participants. The results in this paper proffer insights for bespoke investor decisions and policy responses which align with the gyrating market trends as captured in the various conditional distribution of returns. The asymmetric in the G20 stock return's reaction to the pandemic also suggests avenues for diversification and hedge for investors, even during hard market times. The study is limited by the different data periods for the G20 countries. Nonetheless, since the regressions are performed on country basis, this does not blight our results. In subsequent studies, the stock returns may be decomposed into different intrinsic times so that the asymmetry in responses may be analysed in time-horizons (i.e. short-, medium-, and long-terms). This presents the extra advantage of deeper insights into the problem. Further, control variables such as the government bond yield, foreign exchange rate, and gold price may be included to understand whether or not the impact of pandemic on the stock market is overstated (see Cevik et al., 2022). Furthermore, future studies can benefit from robustness tests with data of different periodicities such as weekly or monthly. This will foster an understanding of how the markets respond to shocks at different data generation intervals and this can also influence comparative investment and risk decision-making.

Note

1. https://www.who.int/emergencies/diseases/novel-coronavirus-2019.

Disclosure statement

No potential conflict of interest was reported by the author(s).

About the authors

Peterson Owusu Junior (PhD) is a Senior Lecturer in Finance in the School of Business, Ghana. He is also a Post-doctoral Fellow in the School of Constrction Economics, University of the Witwatersrand, South Africa.

Dr. Siva Kiran Gupta is Asst. Professor in Economics in Humanities and Social Sciences at SSSIHL, India.

ORCID

Peterson Owusu Junior http://orcid.org/0000-0001-6253-5770

References

Agyei, S. K., Adam, A. M., Bossman, A., Asiamah, O., Owusu Junior, P., Asafo-Adjei, R., & Asafo-Adjei, E. (2022). Does volatility in cryptocurrencies drive the interconnectedness between the cryptocurrencies market? Insights from wavelets. *Cogent Economics & Finance*, *10*(1), 2061682. https://doi.org/10.1080/23322039.2022.2061682

Akhtaruzzaman, M., Boubaker, S., & Sensoy, A. (2021). Financial contagion during COVID–19 crisis. *Finance Research Letters*, *38*, 101604. https://doi.org/10.1016/j.frl.2020.101604

Al-Awadhi, A. M., Alsaifi, K., Al-Awadhi, A., & Alhammadi, S. (2020). Death and contagious infectious diseases: Impact of the COVID-19 virus on stock market returns. *Journal of Behavioral and Experimental Finance*, *27*, 100326. https://doi.org/10.1016/j.jbef.2020.100326

Albulescu, C. (2020). Coronavirus and financial volatility: 40 days of fasting and fear. *arXiv Preprint*, arXiv 200304005. https://doi.org/10.48550/arXiv.2003.04005

Aldawsari, H., & Alnagada, A. (2020). Coronavirus economic effects on the seven largest advanced economies in the World (G7). *Available at SSRN 3613725*, https://doi.org/10.2139/ssrn.3613725

Alfaro, L., Chari, A., Greenland, A. N., & Schott, P. K. (2020). *Aggregate and firm-level stock returns during pandemics in real time.* (No. w26950). National Bureau of Economic Research. http://www.nber.org/papers/w26950

Amal, B., & Fatma, A. A. (2023). Stock market response to the COVID-19 lockdown: The case of Dow Jones, CAC 40, DAX, FTSE 100. *International Journal of Business and Emerging Markets*, *15*(4), 380–395. https://doi.org/10.1504/IJBEM.2023.134076

Amewu, G., Owusu Junior, P., & Amenyitor, E. A. (2022). Co-movement between equity index and exchange rate: Fresh evidence from COVID-19 era. *Scientific African*, *16*, e01146. e01146. https://doi.org/10.1016/j.sciaf.2022.e01146

Apergis, N., & Apergis, E. (2022). The role of COVID-19 for Chinese stock returns: Evidence from a GARCHX model. *Asia-Pacific Journal of Accounting & Economics, 29*(5), 1175–1183. https://doi.org/10.1080/16081625.2020.1816185

Archer, C., Owusu Junior, P., Adam, A. M., Asafo-Adjei, E., & Baffoe, S. (2022). Asymmetric dependence between exchange rate and commodity prices in Ghana. *Annals of Financial Economics*, *17*(02), 2250012. https://doi.org/10.1142/S2010495222500129

Asafo-Adjei, E., Frimpong, S., Owusu Junior, P., Adam, A. M., Boateng, E., & Ofori Abosompim, R. (2022). Multi-frequency information flows between global commodities and uncertainties: evidence from COVID-19 pandemic. *Complexity*, *2022*(1), 2022. https://doi.org/10.1155/2022/6499876

Ashraf, B. N. (2020a). Stock markets' reaction to COVID-19: Cases or fatalities. ?*Research in International Business and Finance*, *54*, 101249. https://doi.org/10.1016/j.ribaf.2020.101249

Ashraf, B. N. (2020b). Economic impact of government interventions during the COVID-19 pandemic: International evidence from financial markets. *Journal of Behavioral and Experimental Finance*, *27*, 100371. https://doi.org/10.1016/j.jbef.2020.100371

Asli Azimli. (2020). The impact of COVID-19 on the degree of dependence and structure of risk-return relationship: A quantile regression approach. *Finance Research Letters*, *36*, 1–5. https://doi.org/10.1016/j.frl.2020.101648

Baek, S., Mohanty, S. K., & Glambosky, M. (2020). COVID-19 and stock market volatility: An industry level analysis. *Finance Research Letters*, *37*, 101748. https://doi.org/10.1016/j.frl.2020.101748

Baek, S., & Yong Lee, K. (2021). The risk transmission of COVID-19 in the US stock market. *Applied Economics*, *53*(17), 1976–1990. https://doi.org/10.1080/00036846.2020.1854668

Bai, L., Wei, Y., Wei, G., Li, X., & Zhang, S. (2021). Infectious disease pandemic and permanent volatility of international stock markets: A long-term perspective. *Finance Research Letters*, *40*, 101709. https://doi.org/10.1016/j.frl.2020.101709

Baig, A. S., Butt, H. A., Haroon, O., & Rizvi, S. A. R. (2021). Deaths, panic, lockdowns and US equity markets: The case of COVID-19 pandemic. *Finance Research Letters*, *38*, 101701. https://doi.org/10.1016/j.frl.2020.101701

Baker, S. R., Bloom, N., Davis, S. J., Kost, K., Sammon, M., & Viratyosin, T. (2020). The unprecedented stock market reaction to COVID-19. *The Review of Asset Pricing Studies*, *10*(4), 742–758. https://doi.org/10.1093/rapstu/raaa008

Baldwin, R., & Weder Di Mauro, B. (2020). (eds) Economics in the Time of COVID-19', CEPR Press. https://cepr.org/publications/books-and-reports/economics-time-covid-19

Bannigidadmath, D., Narayan, P. K., Phan, D. H. B., & Gong, Q. (2022). How stock markets reacted to COVID-19? Evidence from 25 countries. *Finance Research Letters*, *45*, 102161. https://doi.org/10.1016/j.frl.2021.102161

Barson, Z., Owusu Junior, P., Adam, A. M., & Asafo-Adjei, E. (2022). Connectedness between gold and cryptocurrencies in COVID-19 pandemic: A frequency-dependent asymmetric and causality analysis. *Complexity*, *2022*, e7648085. https://doi.org/10.1155/2022/7648085

Baur, D. G., & Lucey, B. M. (2010). Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. *Financial Review*, *45*(2), 217–229. https://doi.org/10.1111/j.1540-6288.2010.00244.x

Baur, D. G., & McDermott, T. K. (2010). Is gold a safe haven? International evidence. *Journal of Banking & Finance*, *34*(8), Article 8. https://doi.org/10.1016/j.jbankfin.2009.12.008

Bentes, S. R. (2021). How COVID-19 has affected stock market persistence? Evidence from the G7's. *Physica A: Statistical Mechanics and Its Applications*, *581*, 126210. https://doi.org/10.1016/j.physa.2021.126210

Bissoondoyal-Bheenick, E., Do, H., Hu, X., & Zhong, A. (2021). Learning from SARS: Return and volatility connectedness in COVID-19. *Finance Research Letters*, *41*, 101796. https://doi.org/10.1016/j.frl.2020.101796

Bora, D., & Basistha, D. (2021). The outbreak of COVID-19 pandemic and its impact on stock market volatility: Evidence from a worst-affected economy. *Journal of Public Affairs*, *21*(4), e2623. https://doi.org/10.1002/pa.2623

Bossman, A., Owusu, P. J., & Tiwari, A. V. (2022a). Dynamic connectedness and spillovers between Islamic and conventional stock markets: Time-and frequency-domain approach in COVID-19 era. *Heliyon*, *8*(4), e09215. https://doi.org/10.1016/j.heliyon.2022.e09215

Bossman, A., Umar, Z., & Teplova, T. (2022b). Modelling the asymmetric effect of COVID-19 on REIT returns: A quantile-on-quantile regression analysis. *The Journal of Economic Asymmetries*, *26*, e00257. https://doi.org/10.1016/j.jeca.2022.e00257

Bouoiyour, J., Selmi, R., & Wohar, M. E. (2018). Measuring the response of gold prices to uncertainty: An analysis beyond the mean. *Economic Modelling*, *75*, 105–116. https://doi.org/10.1016/j.econmod.2018.06.010

Bouri, E., Gupta, R., Tiwari, A. K., & Roubaud, D. (2017). Does Bitcoin hedge global uncertainty? Evidence from wavelet-based quantile-in-quantile regressions. *Finance Research Letters*, *23*, 87–95. https://doi.org/10.1016/j.frl.2017.02.009

Breslaw, J. A. (1992). Kernel estimation with cross-validation using the fast Fourier transform. *Economics Letters*, *38*(3), 285–289. https://doi.org/10.1016/0165-1765(92)90072-7

Brunnermeier, M. K. (2009). Deciphering the liquidity and credit crunch 2007–2008. *Journal of Economic Perspectives*, *23*(1), 77–100. https://doi.org/10.1257/jep.23.1.77

Caporin, M., Gupta, R., & Ravazzolo, F. (2021). Contagion between real estate and financial markets: A Bayesian quantile-on-quantile approach. *The North American Journal of Economics and Finance*, *55*, 101347. https://doi.org/10.1016/j.najef.2020.101347

Cevik, E., Kirci Altinkeski, B., Cevik, E. I., & Dibooglu, S. (2022). Investor sentiments and stock markets during the COVID-19 pandemic. *Financial Innovation*, *8*(1), 69. https://doi.org/10.1186/s40854-022-00375-0

Chaudhary, R., Bakhshi, P., & Gupta, H. (2020). Volatility in international stock markets: An empirical study during COVID-19. *Journal of Risk and Financial Management*, *13*(9), 208. https://doi.org/10.3390/jrfm13090208

Choi, S. Y. (2020). Industry volatility and economic uncertainty due to the COVID-19 pandemic: Evidence from wavelet coherence analysis. *Finance Research Letters*, *37*, 101783. https://doi.org/10.1016/j.frl.2020.101783

Doko Tchatoka, F., Puellbeck, J., & Masson, V. (2022). Stock returns in the time of COVID-19 pandemic. *Applied Economics*, *54*(9), 1071–1092. https://doi.org/10.1080/00036846.2021.1975028

Fama, E. F. (1965). The behavior of stock-market prices. *The Journal of Business*, *38*(1), 34–105. http://www.jstor.org/stable/2350752?origin=JSTOR-pdf https://doi.org/10.1086/294743

Fisher, I. (1933). The debt-deflation theory of great depressions. *Econometrica*, *1*(4), 337–357. http://www.jstor.org/stable/1907327 https://doi.org/10.2307/1907327

Fu, S., Liu, C., & Wei, X. (2021). Contagion in global stock markets during the COVID-19 crisis. *Global Challenges (Hoboken, NJ)*, *5*(10), 2000130. https://doi.org/10.1002/gch2.202000130

Galbraith, J. K. (1955). *The great crash 1929*. Houghton Mifflin.

Gita Gopinath. (2020). The Great Lockdown: Worst Economic Downturn Since the Great Depression. https://www.imf.org/en/Blogs/Articles/2020/04/14/blog-weo-the-great-lockdown-worst-economic-downturn-since-the-great-depression

Goodell, J. W. (2020). COVID-19 and finance: Agendas for future research. *Finance Research Letters*, *35*, 101512. https://doi.org/10.1016/2Fj.frl.2020.101512

Harjoto, M. A., Rossi, F., & Paglia, J. K. (2021a). COVID-19: Stock market reactions to the shock and the stimulus. *Applied Economics Letters*, *28*(10), 795–801. https://doi.org/10.1080/13504851.2020.1781767

Harjoto, M. A., Rossi, F., Lee, R., & Sergi, B. S. (2021b). How do equity markets react to COVID-19? Evidence from emerging and developed countries. *Journal of Economics and Business*, *115*, 105966. https://doi.org/10.1016/j.jeconbus.2020.105966

Haroon, O., & Rizvi, S. A. R. (2020). Flatten the curve and stock market liquidity – An inquiry into emerging economies. *Emerging Markets Finance and Trade*, *56*(10), 2151–2161. https://doi.org/10.1080/1540496X.2020.1784716

Hasan, M. B., Mahi, M., Hassan, M. K., & Bhuiyan, A. B. (2021). Impact of COVID-19 pandemic on stock markets: Conventional vs. Islamic indices using wavelet-based multi-timescales analysis. *The North American Journal of Economics and Finance*, *58*, 101504. https://doi.org/10.1016/j.najef.2021.101504

Hashmi, S. M., Chang, B. H., & Rong, L. (2021). Asymmetric effect of COVID-19 pandemic on E7 stock indices: Evidence from quantile-on-quantile regression approach. *Research in International Business and Finance*, *58*, 101485. https://doi.org/10.1016/2Fj.ribaf.2021.101485

Hatmanu, M., & Cautisanu, C. (2021). The impact of COVID-19 pandemic on stock market: evidence from Romania. *International Journal of Environmental Research and Public Health*, *18*(17), 9315. https://doi.org/10.3390/ijerph18179315

He, Q., Liu, J., Wang, S., & Yu, J. (2020). The impact of COVID-19 on stock markets. *Economic and Political Studies*, *8*(3), 275–288. https://doi.org/10.1080/20954816.2020.1757570

Ijasan, K., Owusu Junior, P., Tweneboah, G., Oyedokun, T., & Adam, A. M. (2021). Analyzing the relationship between global REITs and exchange rates: Fresh evidence from frequency-based quantile regressions. *Advances in Decision Sciences*, *25*(3), 58–91. https://doi.org/10.47654/V25Y2021I3P58-91

IMF. (2020). World Economic Outlook, April 2020: The Great Lockdown. https://www.imf.org/en/Publications/WEO/Issues/2020/04/14/weo-april-2020

Istiak, K., Tiwari, A. K., Husain, H., & Sohag, K. (2021). The Spillover of inflation among the G7 countries. *Journal of Risk and Financial Management*, *14*(8), 392. https://doi.org/10.3390/jrfm14080392

Jelilov, G., Iorember, P. T., Usman, O., & Yua, P. M. (2020). Testing the nexus between stock market returns and inflation in Nigeria: Does the effect of COVID-19 pandemic matter? *Journal of Public Affairs*, *20*(4), e2289. https://doi.org/10.1002/pa.2289

Just, M., & Echaust, K. (2020). Stock market returns, volatility, correlation and liquidity during the COVID-19 crisis: Evidence from the Markov switching approach. *Finance Research Letters*, *37*, 101775. https://doi.org/10.1016/j.frl.2020.101775

Kayani, U., Aysan, A. F., Khan, M. R., Khan, M. A., Mumtaz, R., & Irfan, M. (2024). Unleashing the pandemic volatility: A glimpse into the stock market performance of developed economies during COVID-19. *Heliyon*, *10*(4), e25202. https://www.cell.com/heliyon/pdf/S2405-8440(24)01233-7.pdf https://doi.org/10.1016/j.heliyon.2024.e25202

Liu, K. (2021). The effects of COVID-19 on Chinese stock markets: an EGARCH approach. *Economic and Political Studies*, *9*(2), 148–165. https://doi.org/10.1080/20954816.2020.1814548

Khan, K., Zhao, H., Zhang, H., Yang, H., Shah, M. H., & Jahanger, A, School of Finance, Zhongnan University of Economics and Law, China. (2020). The impact of COVID-19 pandemic on stock markets: An empirical analysis of world major stock indices. *The Journal of Asian Finance, Economics and Business*, *7*(7), 463–474. https://doi.org/10.13106/jafeb.2020.vol7.no7.463

Khan, M., Fifield, S., & Power, D. (2024). The impact of the COVID19 pandemic on stock market volatility: Evidence from a selection of developed and emerging stock markets. *SN Business & Economics*, *4*(6), 1–26. https://doi.org/10.1007/s43546-024-00659-w

Koenker, R. (2005). *Quantile regression* [Cambridge Books]. Cambridge University Press. https://econpapers.repec.org/bookchap/cupcbooks/9780521845731.htm

Koenker, R., & Bassett, G. (1978). Regression quantiles. *Econometrica*, *46*(1), 33–50. JSTOR https://doi.org/10.2307/1913643

Koenker, R., & Hallock, K. F. (2001). Quantile regression. *Journal of Economic Perspectives*, *15*(4), 143–156. https://doi.org/10.1257/jep.15.4.143

Kotishwar, A. (2020). Impact of COVID-19 pandemic on stock market with reference to select countries – A study. *Academy of Accounting and Financial Studies Journal*, *24*(4), 1–9.

Lahmiri, S., & Bekiros, S. (2021). The effect of COVID-19 on long memory in returns and volatility of cryptocurrency and stock markets. *Chaos, Solitons, and Fractals*, *151*, 111221. https://doi.org/10.1016/j.chaos.2021.111221

Ledwani, S., Chakraborty, S., & Shenoy, S. S. (2021). Spatial tale of G-7 and Brics stock markets during COVID-19: An event study. *Investment Management and Financial Innovations*, *18*(2), 20–36. https://doi.org/10.21511/imfi.18(2).2021.03

Liu, H., Wang, Y., He, D., & Wang, C. (2020). Short term response of Chinese stock markets to the outbreak of COVID-19. *Applied Economics*, *52*(53), 5859–5872. https://doi.org/10.1080/00036846.2020.1776837

Liu, H., Manzoor, A., Wang, C., Zhang, L., & Manzoor, Z. (2020). The COVID-19 outbreak and affected countries stock markets response. *International Journal of Environmental Research and Public Health*, *17*(8), 2800. https://doi.org/10.3390/ijerph17082800

Lo, A. W. (2004). The adaptive markets hypothesis. *The Journal of Portfolio Management*, *30*(5), 15–29. https://doi.org/10.3905/jpm.2004.442611

Malik, K., Sharma, S., & Kaur, M. (2022). Measuring contagion during COVID-19 through volatility spillovers of BRIC countries using diagonal BEKK approach. *Journal of Economic Studies*, *49*(2), 227–242. https://doi.org/10.1108/JES-05-2020-0246

Ma, R., Sun, B., Zhai, P., & Jin, Y. (2021). Hedging stock market risks: Can gold really beat bonds? *Finance Research Letters*, *42*, 101918. https://doi.org/10.1016/j.frl.2020.101918

Markowitz, H. (1952). The utility of wealth. *Journal of Political Economy*, *60*(2), 151–158. https://doi.org/10.1086/257177

Mazur, M., Dang, M., & Vega, M. (2021). COVID-19 and the march 2020 stock market crash. Evidence from S&P1500. *Finance Research Letters*, *38*, 101690. https://doi.org/10.1016/j.frl.2020.101690

Mensi, W., Vo, X. V., & Kang, S. H. (2022). COVID-19 pandemic's impact on intraday volatility spillover between oil, gold, and stock markets. *Economic Analysis and Policy*, *74*, 702–715. https://doi.org/10.1016/2Fj.eap.2022.04.001

Müller, U. A., Dacorogna, M. M., Davé, R. D., Pictet, O. V., Olsen, R. B., & Ward, J. R. (1993). Fractals and intrinsic time: A challenge to econometricians. Unpublished manuscript. SSRN: https://ssrn.com/abstract=5370

Narayan, P. K., Phan, D. H. B., & Liu, G. (2021). COVID-19 lockdowns, stimulus packages, travel bans, and stock returns. *Finance Research Letters*, *38*, 101732. https://doi.org/10.1016/j.frl.2020.101732

Nian, R., Xu, Y., Yuan, Q., Feng, C., & Lendasse, A. (2021). Quantifying time-frequency co-movement impact of COVID-19 on US and China stock market toward investor sentiment index. *Frontiers in Public Health*, *9*, 727047. https://doi.org/10.3389/2Ffpubh.2021.727047

Gormsen, N. J., & Koijen, R. S. J. (2020). Coronavirus: Impact on stock prices and growth expectations. *The Review of Asset Pricing Studies*, *10*(4), 574–597. https://doi.org/10.1093/rapstu/raaa013

OECD. (2020). COVID and the food and agriculture sector: Issues and policy responses. https://www.oecd.org/coronavirus/policyresponses/COVID-19-and-the-food-and-agriculture-sector-issues-and-policy-responses-a23f764b/

Oliyide, J. A., Adetokunbo, A. M., & Fasanya, I. O. (2022). How COVID-19 influences Indian sectoral stocks. *Asian Economics Letters*, *3*(2), 27111. https://doi.org/10.46557/001c.27111

Onali, E. (2020). COVID-19 and stock market volatility. *SSRN Electronic Journal*, https://doi.org/10.2139/ssrn.3571453

Osagie, M., Maijamaa, A. B., & John, D. O. (2020). *On the effect of COVID-19 outbreak on the Nigerian stock exchange performance: Evidence from GARCH models*. https://doi.org/10.20944/preprints202004.0444.v1

Owusu Junior, P., & Tweneboah, G. (2020). Are there asymmetric linkages between African stocks and exchange rates? *Research in International Business and Finance*, *54*, 101245. https://doi.org/10.1016/j.ribaf.2020.101245

Owusu Junior, P., Adam, A. M., Asafo-Adjei, E., Boateng, E., Hamidu, Z., & Awotwe, E. (2021b). Time-frequency domain analysis of investor fear and expectations in stock markets of BRIC economies. *Heliyon*, *7*(10), e08211. https://doi.org/10.1016/j.heliyon.2021.e08211

Owusu Junior, P., Frimpong, S., Adam, A. M., Agyei, S. K., Gyamfi, E. N., Agyapong, D., & Tweneboah, G. (2021a). COVID-19 as information transmitter to global equity markets: Evidence from CEEMDAN-based transfer entropy approach. *Mathematical Problems in Engineering*, *2021*, 1–19. https://doi.org/10.1155/2021/8258778

Ozkan, O. (2021). Impact of COVID-19 on stock market efficiency: Evidence from developed countries. *Research in International Business and Finance*, *58*, 101445. https://doi.org/10.1016/j.ribaf.2021.101445

Papadamou, S., Fassas, A., Kenourgios, D., & Dimitriou, D. (2020). Direct and indirect effects of COVID-19 pandemic on implied stock market volatility: Evidence from panel data analysis. https://mpra.ub.uni-muenchen.de/id/eprint/100020

Pata, U. K. (2020). Is the COVID-19 pandemic a financial disaster for G7 countries? Evidence from a fourier cointegration test. Evidence from a Fourier Cointegration Test. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3603068

Rahman, M. L., Amin, A., & Al Mamun, M. A. (2021). The COVID-19 outbreak and stock market reactions: Evidence from Australia. *Finance Research Letters*, *38*, 101832. https://doi.org/10.1016/j.frl.2020.101832

Rehman, M. U., Kang, S. H., Ahmad, N., & Vo, X. V. (2021). The impact of COVID-19 on the G7 stock markets: A time-frequency analysis. *The North American Journal of Economics and Finance*, *58*, 101526. https://doi.org/10.1016/j.najef.2021.101526

Reinhart, C. M., & Rogoff, K. S. (2009). The aftermath of financial crises. *American Economic Review*, *99*(2), 466–472. https://doi.org/10.1257/aer.99.2.466

Shahzad, S. J. H., Hoang, T. H. V., & Bouri, E. (2022). From pandemic to systemic risk: contagion in the US tourism sector. *Current Issues in Tourism*, *25*(1), 34–40. https://doi.org/10.1080/13683500.2021.1881050

Sharif, A., Aloui, C., & Yarovaya, L. (2020). COVID-19 pandemic, oil prices, stock market, geopolitical risk and policy uncertainty nexus in the US economy: Fresh evidence from the wavelet-based approach. *International Review of Financial Analysis*, *70*, 101496. https://doi.org/10.1016/j.irfa.2020.101496

Shehzad, K., Xiaoxing, L., & Kazouz, H. (2020). COVID-19's disasters are perilous than Global Financial Crisis: a rumor or fact? *Finance Research Letters*, *36*, 101669. https://doi.org/10.1016/j.frl.2020101669

Sim, N., & Zhou, H. (2015). Oil prices, US stock return, and the dependence between their quantiles. *Journal of Banking & Finance*, *55*, 1–8. https://doi.org/10.1016/j.jbankfin.2015.01.013

Sun, Y., Wu, M., Zeng, X., & Peng, Z. (2021). The impact of COVID-19 on the Chinese stock market: Sentimental or substantial? *Finance Research Letters*, *38*, 101838. https://doi.org/10.1016/j.frl.2020.101838

Tabash, M. I., Chalissery, N., Nishad, T. M., & Al-Absy, M. S. M. (2024). Market shocks and stock volatility: Evidence from emerging and developed markets. *International Journal of Financial Studies*, *12*(1), 2. https://doi.org/10.3390/ijfs12010002

Topcu, M., & Gulal, O. S. (2020). The impact of COVID-19 on emerging stock markets. *Finance Research Letters*, *36*, 101691. https://doi.org/10.1016/2Fj.frl.2020.101691

Utomo, C. D., & Hanggraeni, D. (2021). The impact of COVID-19 pandemic on stock market performance in Indonesia. *The Journal of Asian Finance, Economics and Business*, *8*(5), 777–784. https://doi.org/10.13106/JAFEB.2021.VOL8.NO5.0777

Wang, W., & Enilov, M. (2020). The global impact of COVID-19 on financial markets. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3588021

Wang, W., & Park, H. (2021). How vulnerable are financial markets to COVID-19? A comparative study of the US and South Korea. *Sustainability*, *13*(10), 5587. https://doi.org/10.3390/su13105587

Yilmazkuday, H. (2023). COVID-19 effects on the S&P 500 index. *Applied Economics Letters*, *30*(1), 7–13. https://doi.org/10.1080/13504851.2021.1971607

Yousfi, M., Dhaoui, A., & Bouzgarrou, H. (2021). Risk spillover during the COVID-19 global pandemic and Portfolio management. *Journal of Risk and Financial Management*, *14, 1*(5), 222. 29 https://doi.org/10.3390/jrfm14050222

Zhang, D., Hu, M., & Ji, Q. (2020). Financial markets under the global pandemic of COVID-19. *Finance Research Letters*, *36*, 101528. https://doi.org/10.1016/j.frl.2020.101528