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Article

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

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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.

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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

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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.

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