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Modelling the asymmetric effect of COVID-19 on REIT returns: A quantile-on-quantile regression analysis

Ahmed Bossman^a, Zaghum Umar^{b,*}, Tamara Teplova^c

^a Department of Finance, School of Business, University of Cape Coast, Cape Coast, Ghana

^b College of Business, Zayed University, P.O. Box 144534, Abu Dhabi, United Arab Emirates

^c National Research University Higher School of Economics, Russian Federation

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ABSTRACT

The COVID-19 pandemic has affected all sectors of the economy resulting in unprecedented challenges for market participants, policymakers, and practitioners. This study envisages this issue from the perspective of real estate investment trusts (REITs), which is a relatively less analysed segment. We examine the impact of the COVID-19 pandemic on REIT returns for 12 top REIT regimes spread across America, Asia, and Europe under the bullish, bearish, and normal market conditions over the COVID-19 period (specifically from February 02, 2020, to January 24, 2022). We employ the quantile-on-quantile regression and causality-in-quantiles approach. We document a strong (weak) predictive power of COVID-19 cases on REIT returns within the lower (upper) conditioned quantiles. Our findings are of importance to market participants, practitioners, and regulators across REIT regimes.

1. Introduction

The COVID-19 pandemic has a major impact on global economies across various sectors. The empirical assessment of the effect of this global catastrophe on various segments including equities, bonds, cryptocurrencies, commodities is widely documented.¹ However, the impact of COVID-19 on the real estate sector, which is an important segment of the economy and financial markets, is relatively less documented. Therefore, the purpose of this study is to investigate the impact of COVID-19 pandemic on this pivotal sector by employing real estate investment trusts (REITs) as a proxy for real estate sector. The pandemic induced uncertainty can affect the real estate sector through different channels. For instance, the escalation of number of COVID-19 cases coupled with the stringent measures to curb the pandemic spread would most likely affect real estate operations. Furthermore, the heightened financial uncertainty due to the onset of the pandemic and an exponential increase in the number of cases would have an impact on investments in REITs.

* Corresponding author.

E-mail addresses: ahmed.bossman@outlook.com (A. Bossman), zaghum.umar@gmail.com (Z. Umar), tteplova@hse.ru (T. Teplova).

¹ Please see [Asafo-Adjei et al., 2021](#); [Bossman, 2021](#); [Ji, Zhang, & Zhao, 2020](#); [Owusu Junior et al., 2021](#); [Umar & Olson, 2021](#); [2021a,b](#) among others.

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The spread of COVID-19 across the globe has been in multiple waves and it has a varied impacts on different countries. Therefore, in this study, we envisage to study this impact of COVID-19 on the real estate sector of different countries on a standalone basis. Theoretically, several factors can have a direct and indirect effect on the real estate sector. This study is specifically focused on the impact of the systemic crisis induced by the pandemic. Therefore, we use the number of cases in each of the counties as a proxy of the COVID-19 effect. Thus, enabling us to isolate the local market dynamics of the spread of COVID-19 on the real estate sector. We argue that the changes in the number of reported cases may have an impact on the operations and earnings of income-generating real estate properties. Thus, we envisage to isolate this impact for an in-depth analysis of the underlying impact of pandemic on real estate sector.

Our study adds to the existing literature in three major ways. To the best of our knowledge, this is the first study to focus specifically on twelve major real estate markets across America, Asia, and Europe to assess the extent and direction of the effect of the COVID-19 pandemic on the real estate sector. The analysis of the effect of pandemics would influence market participants' decisions and highlight the need for policymakers to streamline policy actions across different REIT markets in the future for similar exogenously driven meltdowns. Second, we employ novel quantile-based techniques of causality-in-quantiles and the quantile-on-quantile regression that allows us to quantify the relationship over the entire distribution, thus providing comprehensive estimates compared to techniques that provide mean based estimates. Despite the availability of these techniques, their application in empirical works on REITs has yet to be given attention in a period like the COVID-19 pandemic. Third, we incorporate the heterogeneous market hypothesis in our analysis, which implies that the findings of this study should serve as a guide to market participants and policymakers whose decisions are bounded by market conditions (normal, bearish, and bullish).² This may aid in a thorough assessment of market states for effective policy actions for investor classes, policymakers, and practitioners alike.

The heightened uncertainty in the global economy in recent periods signals the timeliness of this study, as it would influence policymaking and future arrangement on housing, hospitality and tourism, supply chain, and retirement planning, to mention a few, which have a direct bearing on REIT pricing and returns. Complementing the works on asset pricing and volatility of real estate assets (Chong & Phillips, 2022; Hoesli & Malle, 2021; Ling, Wang, & Zhou, 2020; Milcheva, 2021) through a holistic analysis of the systemic risk's impact on the conditional earnings from real estate is equally essential at this time. Our findings show a strong (weak) predictive power of COVID-19 cases on REIT returns within the lower (upper) conditioned quantiles. Thus, underscoring the market- and quantile-based significant causal effects between COVID-19 and REIT returns. Generally, upper (lower) quantiles of REIT returns, receive a considerable positive (negative) effect from COVID-19 cases' returns.

The remainder of the paper is outlined as follows. We review related works in Section 2. Section 3 interprets our methods and their relevance together with a description of the dataset employed in the study. Our results are analysed and discussed in Section 4. We summarise the results' practical implications in Section 5 and conclude in Section 6.

2. Literature review

We segregate our literature review into two subsections. First, we present a review of the literature on the effect of the pandemic on global markets and then we present a review of the literature specific to the real estate sector.

2.1. Financial markets' responses to the COVID-19 pandemic

Crises in the capital market typically influence investor behaviour by altering investor sentiment, which in turn influences asset prices (Gubareva & Umar, 2020). Consequently, we see a large strand of literature focused on the impact of COVID-19 induced sentiment on various financial markets and asset classes. For instance, please see for equities (Aharon et al., 2022; Akhtaruzzaman, Boubaker, & Umar, 2021; Umar, Trabelsi, & Alqahtani, 2021), bonds (Ali, Yousaf, & Umar, 2022; Gubareva, Umar, Sokolova, & Vo, 2021; Zaremba, Kizys, Aharon, & Umar, 2021), commodities (Balcilar, Gabauer, & Umar, 2021; Esparcia, Jareño, & Umar, 2022); digital assets (Umar & Gubareva, 2020; Umar, Trabelsi, & Alqahtani, 2021), and the references therein.

He, Sun, Zhang, and Li (2020) examined the market response tendencies of Chinese industries to the COVID-19 pandemic and found an unfavourable (favourable) influence on the environmental, electrical and heating, mining, and transportation (education, healthcare, information technology, and manufacturing) industries. Liu, Manzoor, Wang, Zhang, and Manzoor (2020) investigated the transitory impact of COVID-19 infections on the stock markets of 21 top affected countries and reported a negative influence of COVID-19 verified cases on stock indices' aberrant returns via an effective conduit that combines investors' pessimism about future returns and worries of uncertainty. In a similar study, Heyden and Heyden (2021) investigated the transitory market reactions to the COVID-19 pandemic in Europe and the US. The event analysis employed by the authors showed that markets react considerably unfavourably to the confirmation of the first death in a specific country. The authors further revealed that fiscal policy measures occasioned by the COVID-19 pandemic detrimentally impact asset returns whereas monetary policy announcements have potential favourable impacts on financial markets. It is important to note that these factors are all country-specific and, hence, a country-level analysis of the pandemic's impact on asset returns is not out of play. This initiated the second strand of works that analysed the impact of the COVID-19 pandemic on firm-level, national, and regional asset returns using several econometric approaches.

Real-time analysis of the US aggregate and firm-level stock returns by Alfaro, Chari, Greenland, and Schott (2020) revealed that sudden changes in the trend of COVID-19 cases have a strong predictive power on market value and returns. Under the effective

² The heterogenous market hypothesis was forwarded by Muller (1993).

transfer entropy approach, [Owusu Junior et al. \(2021\)](#) examined the information flow dynamics between COVID-19 cases and national and global stock returns and found a detrimental impact of COVID-19 on market returns. Their findings were similar to those revealed by [Bossman \(2021\)](#) who employed a similar technique but for Islamic and conventional stocks. As the literature on stock and other traditional assets kept growing, little is known about income-generating real estate, i.e., REITs, which have gained attention from investors in recent periods.

2.2. COVID-19's impact on REITs

The dynamism associated with the effect of the COVID-19 pandemic motivates the assessment of its impact on diverse sectors, industries, and economies of the global economy ([Agyei, Adam, et al., 2022](#)). This, in part, influenced the recent works on the real estate industry, but the main focus has been on situational analysis of selected companies or countries, pricing and volatility of real estate investments, big data analysis and sustainability concerns, and e-commerce growth in the COVID-19 era.

On the premise that the impact of pandemics or other health crises on real estate markets has received scanty attention in the global literature, [Del Giudice, De Paola, and Del Giudice \(2020\)](#), p. 114 probed into the short- and medium-term impacts of the COVID-19 pandemic on housing prices in Italy. The authors revealed a drop in housing prices by 4.16% and 6.49% in the short- and medium-term, respectively. In a situational assessment of the Turkish case, [Tanrıvermiş \(2020\)](#) investigated the plausible impact of COVID-19 on the development and management of the real estate. The authors identified a detrimental impact in respect of developmental projects associated with new real estate and the revenue of existing ones. They further reported that the measures (in particular, bans on local and international travels and restrictions on tourist and hospitality activities) taken to curb the spread of the coronavirus led to decreased volume of transactions and revenue whilst a significant increase in operating cost was recorded owing to additional measures employed to curb the pandemic. These findings were not different from those reported by [Toro, Nocca, and Buglione \(2021\)](#), p. 23 in the Italian context. By focusing on retail real estate only, [Nanda, Xu, and Zhang \(2021\)](#) explored the possibility of the COVID-19 pandemic reshaping the real estate industry through e-commerce and digitalisation. The conclusions in respect of the impact of the COVID-19 pandemic on the real estate operations corroborated those of [Tanrıvermiş \(2020\)](#) and [Toro et al. \(2021\)](#), p. 23.

By focusing on the European regime, [Hoesli and Malle \(2021\)](#) trajectoryally analysed COVID-19's impact on the prices of commercial real estate and revealed that the retail and hospitality sectors had experienced the most impact from the pandemic. [Ling et al. \(2020\)](#) examined the effect of GeoCOVID-19 cases on commercial real estate (CRE) portfolios and reported an inverse relationship between the risk of GeoCOVID-19 and excess CRE portfolio returns. The authors stressed that internal and national policy measures contributed to a reduction in the negative effect of marginal GeoCOVID-19 cases. [Milcheva \(2021\)](#) capitalised on the systemic shocks accompanying the COVID-19 to examine the risk-return nexus between self-developed regional pandemic risk factors and real estate equity indices from selected Asian and the US markets. The author reported a negative (positive) sensitivity of the Asian (US) markets to the COVID-19 risk factors, communicating a substantial heterogeneity between the real estate equities from the studied regions.

In a predictive big data analytics of the impact of the COVID-19 pandemic on real estate markets relative to the impact of the global financial crisis on real estate markets, [Grybauskas, Pilinkienė, and Stundžienė \(2021\)](#) reported corroborative findings for prior research, indicating that real estate is somewhat resistant to pandemics, as declines in prices were not as severe as initially thought. Meanwhile, [Chong and Phillips \(2022\)](#) examined the dollar effect of COVID-19 on the composite value of US commercial real estate and found that the intervention from the government caused a lesser impact of COVID-19 on commercial real estate values. The measures contained in the government intervention in the US were way dissimilar to those employed in other jurisdictions. It stands to reason, therefore, that the impact of the COVID-19 pandemic on REITs would be appropriately analysed based on regimes.

As it stands, knowledge and empirical assessments of the impact of COVID-19 on REIT investments have yet to investigate the extent to which regime-based COVID-19 trajectories affect returns on REITs. This is essential for asset allocation and portfolio management in systemic periods, particularly in an exogenously-driven market meltdown like in the era of the COVID-19 pandemic. [Liu et al. \(2020\)](#) noted that relative to other epidemics (e.g., Ebola, seasonal flu, the Middle East respiratory syndrome, the severe acute respiratory syndrome), the infection rate of COVID-19 is the highest in history so far. However, how the infection rates per jurisdiction affect the yields on assets operating in the jurisdiction is unknown to empirics.

As noted from the review, existing works have recorded the effect of the COVID-19 pandemic on financial markets through several techniques but failed to empirically show the effect across market conditions on asset returns. We contribute to these strands of work by analysing the effect of the COVID-19 pandemic on REITs – in a bivariate case – across conditional tails of both COVID-19 cases and REIT returns. Note that methodically, the quantile-on-quantile regression (QQR) technique, which is explained in the methodology section, helps to uncover the relationship between COVID-19 cases and REITs returns across conditional quantiles of both the dependent and independent variables. The quantile regression (QR) approach falls short in this aspect, as it only offers the conditional relationship across the conditions of the dependent variable. This further adds to the motivation for the approach we employed in this study.

3. Methods and materials

3.1. Methodology

3.1.1. Quantile causality

To empirically prove quantile causality for the interaction between COVID-19 cases and REIT returns, we employ the causality-in-

quantiles test of Jeong, Härdle, and Song (2012). We follow Balcilar, Cerci, and Demirer (2016) to establish causality in means, using the non-parametric Granger-quantile-causality approach.

Let y_t be REIT returns and x_t be marginal COVID-19 cases. In line with Jeong et al. (2012), the study tests the hypothesis that in the presence of the lag vector $\{y_{t-1}, \dots, y_{t-p}, x_{t-1}, \dots, x_{t-p}\}$ in the θ^{th} quantile, x_t does not cause y_t if

$$Q_\theta(y_t|y_{t-1}, \dots, y_{t-p}, x_{t-1}, \dots, x_{t-p}) = Q_\theta(y_t|y_{t-1}, \dots, y_{t-p}). \tag{1}$$

Nevertheless, in the presence of the lag vector $\{y_{t-1}, \dots, y_{t-p}, x_{t-1}, \dots, x_{t-p}\}$ in the θ^{th} quantile, it is presumed that x_t causes y_t if

$$Q_\theta(y_t|y_{t-1}, \dots, y_{t-p}, x_{t-1}, \dots, x_{t-p}) \neq Q_\theta(y_t|y_{t-1}, \dots, y_{t-p}). \tag{2}$$

where $Q_\theta(y_t|\cdot)$ denotes the θ^{th} quantile of y_t . Note that t predicts the conditional quantiles, $Q_\theta(y_t|\cdot)$, of y_t with a restriction on the quantiles as $0 < \theta < 1$.

Next, we define $Z_t = X_t, Y_t$, which comprises the vectors $y_{t-1} = y_{t-1}, \dots, y_{t-p}$ and $x_{t-1} = x_{t-1}, \dots, x_{t-p}$. We can now deduce the conditional distribution functions $F_{y_t|z_{t-1}}(y_t|Z_{t-1})$ and $F_{y_t|y_{t-1}}(y_t|Y_{t-1})$, respectively conditioned on the vectors Z_{t-1} and Y_{t-1} . For virtually all Z_{t-1} , we presume $F_{y_t|z_{t-1}}(y_t|Z_{t-1})$ to be completely continuous in y_t .

When we define $Q_\theta(Z_{t-1}) \equiv Q_\theta(y_t|Z_{t-1})$ and $Q_\theta(Y_{t-1}) \equiv Q_\theta(y_t|Y_{t-1})$, we can now arrive at $F_{y_t|z_{t-1}}\{Q_\theta(Z_{t-1})|Z_{t-1}\} = \theta$, with probability $P = 1$.

As a consequence of Eq. (1) and Eq. (2), each hypothesis for causality-in-quantile can be deduced as

$$H_0 : P\{F_{y_t|z_{t-1}}\{Q_\theta(Y_{t-1})|Z_{t-1}\} = \theta\} = 1 \tag{3}$$

$$H_1 : P\{F_{y_t|z_{t-1}}\{Q_\theta(Y_{t-1})|Z_{t-1}\} = \theta\} < 1 \tag{4}$$

Note that a fat tail's causality differs from that of the distribution's centre (Jena, Tiwari, Hammoudeh, & Roubaud, 2019; T.-H.; Lee & Yang, 2007).³ The lag order, p , is calculated using the SIC criterion⁴ under the VAR that includes REIT and COVID-19 cases returns.

3.1.2. Quantile-on-quantile regression (QQR)

The QQR technique provided by Sim and Zhou (2015) is used to investigate the wholistic link between COVID-19 marginal cases and REIT indices of top-advanced REIT regimes. This model is a more advanced variant of the basic quantile regression (QR) that is created by mixing non-parametric estimations with basic QR. The influence of the regressors across multiple quantiles, and the conditional mean of the regressand, are investigated using conventional quantile regression (Ijasan, Owusu Junior, Tweneboah, Oyedokun, & Adam, 2021; Owusu Junior, Adam, & Tweneboah, 2020; Owusu Junior, Tiwari, Padhan, & Alagidede, 2020; Owusu Junior & Tweneboah, 2020; Tweneboah, Owusu Junior, & Kumah, 2020). As a consequence, the QR approach outperforms the ordinary least squares (OLS) approach. Traditional linear regression developed by Stone (1977) and Cleveland (1979) evaluates the influence of certain quantiles of the explanatory variable on the conditional average of the explained variable (Hashmi, Chang, & Rong, 2021). As a result, we can examine the influence on different quantiles of both the explanatory and explained variables by combining classic linear regression with basic quantile regression. This offers a better understanding of how the explanatory and explained variables interact.

Note that, whereas QR can reveal the impact of COVID-19 on the conditional distributions of REIT returns, we cannot observe how the various conditional tails of COVID-19 affect REIT returns. It is the QQR that aids to achieve this by regressing the conditional tails of COVID-19 on the conditional tails of REIT returns. This is needed because, the condition of COVID-19 can be observed for different conditions of asset returns and vice versa. Hence, the application of QQR relative to the QR becomes necessary in this study. Furthermore, as already indicated, the continuing adjustments in asset prices (Gormsen & Koijen, 2020) and household expectations (Hanspal, Weber, & Wohlfart, 2021) suggest that the pandemic's effect should not be considered short-lived (Heyden & Heyden, 2021). A long-term effect could most likely manifest across assets and the real estate industry is not decoupled from this. Therefore, in applying the QQR, a longer dataset would be advantageous to a shorter dataset. Despite the magnitude of short-term effects of every market crises, covering a long period is significant to unveil any inconsistent relationship between COVID-19 cases and REIT returns.

In this paper, we examine the impact of diverse COVID-19 quantiles on diverse quantiles of the REIT returns of top-advanced REIT regimes using an expanded method termed the QQR approach developed by Sim and Zhou (2015). The non-parametric QR model specified in Eq. (5) is used for this purpose.

$$RR_t = \beta^\theta(COVID_t) + u_t^\theta, \tag{5}$$

where RR_t is REIT returns for each REIT regime at time t , $COVID_t$ is the marginal cases of COVID-19 for each country at time t , β^θ is the slope of the relationship between RR_t and $COVID_t$, θ represents the θ^{th} quantile distribution of marginal COVID-19 cases, u_t^θ is the

³ We specify $h = 0.05$ as the bandwidth and use Gaussian as the kernel type for both $(\cdot)K$ and $(\cdot)L$.

⁴ Aimed at avoiding over-optimisation issues particularly with non-parametric techniques, we choose the lag order based on the sparse Schwarz Information Criterion (SIC) under the VAR consisting of REIT and COVID-19 returns. See detailed description from Balcilar et al. (2016).

quantile error term.

Note that when using the non-parametric approach, selecting the appropriate bandwidth is critical. A large bandwidth h grows the estimate's deviation while the variance decreases, and vice versa. Following [Sim and Zhou \(2015\)](#), we stick to a bandwidth value of $h = 0.05$.

3.2. Data and descriptive statistics

We employ daily data from February 02, 2020, to January 24, 2022, to investigate the relationship between COVID-19 cases and REIT returns of 12 top-developed REIT regimes (Australia, Canada, China, France, Germany, Hong Kong, Japan, the Netherlands, New Zealand, Singapore, the UK, and the USA). We want to isolate the impact of COVID-19 induced specific uncertainty on the REITs. There are different COVID-19 proxies available such as number of cases, number of deaths, fear indices, media coverage, etc. A number of studies have used COVID-19 cases as proxy for COVID-19 effect ([Albulescu \(2020\)](#); [Hui and Chan \(2022\)](#) and references therein among others).⁵ In addition to the reasons for covering a longer period, we choose the daily frequency because it allows us to have a large number of observations, which allows us to gain deeper and more detailed insights ([Bouri, Cepni, Gabauer, & Gupta, 2020](#); [Umar, Gubareva, Teplova, & Tran, 2022](#)). The sample period was chosen based on the availability of matching data for the sample. DataStream provided the REIT indices while the COVID-19 confirmed cases for each country were retrieved from the OWID database (Our World in Data). After catering for missing values, 516 observations for each variable were available for estimations. The log returns of the daily REIT indices were computed as $r_t = \ln P_t - \ln P_{t-1}$, where r_t defines the continuously compounded returns, P_t represents REIT index or COVID-19 cases in period t , and P_{t-1} represents REIT index or COVID-19 in the previous period $t - 1$. Detailed in [Table 1](#) are the sample statistics.

The mean returns for REITs in China, France, Hong Kong, Japan, and the Netherlands are negative (see Panel I of [Table 1](#)), indicating that REIT markets have fared below average over the sampled COVID-19 period. All other REIT regimes experienced positive returns on average, with the USA recording the highest mean returns. This shows that American REITs have been the least impacted compared to other REITs regimes. This is unsurprising as a result of the substantial proportion of the global REIT capitalisation possessed by the USA. The lowest mean returns are seen in the Netherlands REITs (-0.0007), followed by the French REITs (-0.0003). Except for the Chinese and the Dutch REITs which had positive skewness statistics, all other REIT regimes had negative skewness, demonstrating that over the sample COVID-19 period, negative returns were mostly witnessed by most REIT regimes ([Akinsomi, 2021](#)). Normality test statistics are statistically significant, indicating that the returns in these REITs regimes are not normally distributed. This offers strong motivation for the chosen methodologies. Surprisingly, China had the lowest mean number of cases (see Panel II of [Table 1](#)), showing that it effectively coped with the COVID-19 pandemic, while other nations were severely impacted ([Hashmi et al., 2021](#)). The leptokurtic behaviour of all the return series cannot be side-lined.

4. Empirical results

In order of presentation, the results from causality-in-quantiles and the quantile regression methods are discussed and analysed. The quantile causality results set the pace for us to proceed with discussions on the quantile regression and quantile-on-quantile regression approaches.

4.1. Quantile causality-in-means

We test for the quantile causal relation between COVID-19 cases and REIT returns. This is needed to establish that indeed there is a causal relationship between COVID-19 and REIT markets across conditional distributions. The nonparametric causality-in-quantiles includes all quantiles in the distribution, as opposed to the basic Granger test that only examines the median ([Jena et al., 2019](#)). As a result, this method may demonstrate how causality works in both low and high marginal COVID-19 cases. Note that causality-in-quantiles enables the investigation of causation in the mean and variance, but in the context of our study, we stick to the causality in means.

The quantile causality tests among the COVID-19 cases and REIT returns in mean for daily data are shown in [Fig. 1](#) and supported numerically by the test statistics reported in [Table 2](#) for all REIT regimes at all quantiles. In each plot, test statistics are shown (the vertical axis) against the matching quantiles on the horizontal axis. The horizontal solid line corresponds to a crucial value (CV) of 1.96 at the 5% significance level. The null hypothesis, in this case, holds that a change in marginal COVID-19 cases does not Granger-cause a change in REIT returns. For instance, the null hypothesis – that COVID-19 does not Granger-cause REIT returns – is rejected ($p < 0.05$) spanning the quantile ranges of 0.05–0.25 in the causality test for COVID-19 to the Canadian, Japanese, New Zealander, the British, and the American REITs in [Fig. 1](#). Over the quantile range of 0.05–0.35, the causality in the quantile test rejects the null hypothesis for most REIT regimes ($CV > 1.96$; $p < 0.05$). Exceptional countries are China, Germany, Hong Kong, and Singapore. Thus, aside from China, Germany, Hong Kong, and Singapore, we reject the null hypothesis for all other REIT regimes such that changes in their marginal COVID-19 cases have a strong predictive power on changes in their REIT returns. The differences may be ascribed to jurisdictional peculiarities and variations in the measures taken against the containment of the COVID-19 pandemic ([Agyei et al.,](#)

⁵ We acknowledge useful comments of an anonymous referee for this point.

Table 1
Sample statistics of REITs and COVID-19 cases' returns.

Country	Min	Max	Mean	Std. Dev	Skewness	Kurtosis	Normtest.W
Panel I: REIT returns							
Australia	-0.1549	0.0779	0.0002	0.0191	-2.1892	17.1138	0.7961***
Canada	-0.1540	0.0966	0.0002	0.0177	-2.8528	29.2284	0.6752***
China	-0.0981	0.0838	-0.0002	0.0178	0.5206	4.1427	0.9449***
France	-0.1336	0.1253	-0.0003	0.0187	-0.0472	14.2908	0.8410***
Germany	-0.0845	0.0580	0.0000	0.0122	-0.9743	9.7521	0.8802***
Hong Kong	-0.0677	0.0562	-0.0002	0.0159	-0.0956	2.9061	0.9524***
Japan	-0.1168	0.1086	-0.0002	0.0160	-0.5015	17.1483	0.7818***
Netherlands	-0.2221	0.1884	-0.0007	0.0367	0.0397	8.1625	0.8634***
New Zealand	-0.1597	0.0654	0.0000	0.0129	-3.8585	50.3013	0.7050***
Singapore	-0.0844	0.0747	0.0000	0.0123	-0.9128	13.5752	0.8037***
UK	-0.1006	0.0734	0.0000	0.0154	-0.5522	6.9119	0.9193***
USA	-0.1947	0.0850	0.0004	0.0197	-2.0915	22.6959	0.7851***
Panel II: COVID-19 cases returns							
Australia	0.0000	0.4463	0.0162	0.0408	5.1652	35.2409	0.4167***
Canada	0.0000	0.4189	0.0197	0.0507	4.7072	25.1094	0.3774***
China	0.0000	0.2916	0.0030	0.0200	9.9433	112.2405	0.1202***
France	-0.0712	0.7472	0.0200	0.0633	6.2652	49.3463	0.3290***
Germany	0.0000	0.6096	0.0201	0.0619	6.1743	44.4339	0.3030***
Hong Kong	-0.0001	0.2703	0.0100	0.0281	5.4151	36.5347	0.3795***
Japan	0.0000	0.2647	0.0160	0.0281	3.7579	18.5653	0.5456***
Netherlands	0.0000	0.7691	0.0176	0.0554	8.2469	85.4664	0.2658***
New Zealand	-0.0009	0.6737	0.0133	0.0507	7.4121	69.6642	0.2523***
Singapore	0.0000	0.2877	0.0137	0.0322	3.8256	17.9420	0.4727***
UK	-0.0011	1.3863	0.0234	0.0784	11.2940	177.6106	0.2552***
USA	0.0000	0.5421	0.0230	0.0669	4.8862	25.5497	0.3288***

Notes: This table presents the descriptive statistics of the sample. [***] $p < 0.001$.

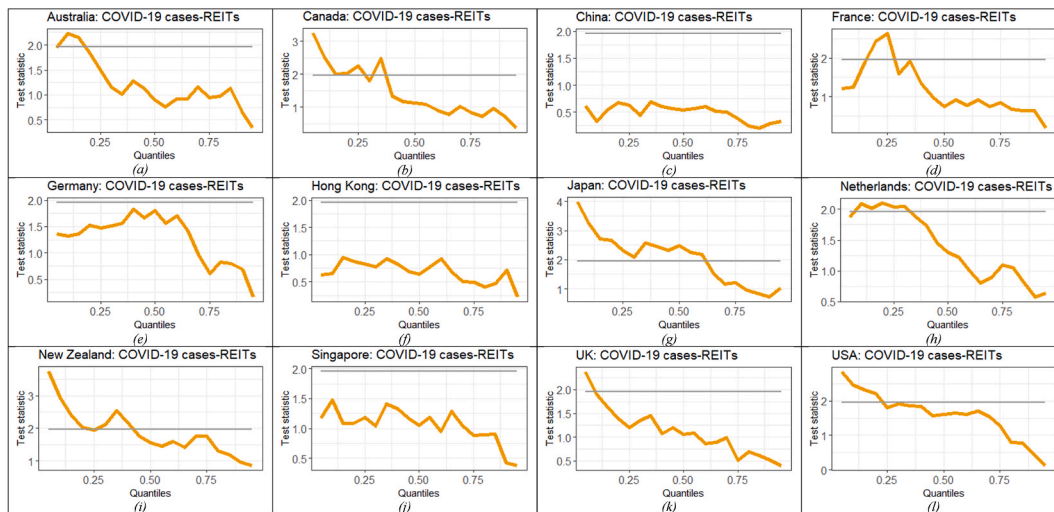


Fig. 1. t-statistics for quantile causality-in-mean tests.

Notes: The causation results from COVID-19 cases to REIT returns are shown in this Figure. According to the null hypothesis, a change in the price of COVID-19 cases does not induce a change in REIT returns as measured by the mean returns. In each plot, test statistics are shown (the vertical axis) against the matching quantiles on the horizontal axis. The horizontal solid line corresponds to a crucial value (CV) of 1.96 at the 5% significance level.

2021).

Generally, we find evidence in support of the alternate hypothesis that the change in COVID-19 cases' returns causes the change in REIT returns at lower quantiles, which denote bearish market conditions. We find a strong predictive power of COVID-19 cases on REIT returns within the lower conditioned quantiles. We ascertain additional insights from the QQR approach.

Table 2
Test statistics from quantile causality test on REITs-COVID-19 cases.

Countries	Australia	Canada	China	France	Germany	Hong Kong	Japan	Netherlands	New Zealand	Singapore	UK	USA
τ												
0.05	1.9545*	3.2576***	0.6129	1.2069	1.3631	0.6217	3.9885***	1.8718**	3.7544***	1.1752	2.3818**	2.8485***
0.10	2.2320**	2.5114**	0.3268	1.2555	1.3225	0.6477	3.2412***	2.0961**	2.9578***	1.4796	1.8997*	2.4521**
0.15	2.1518**	2.0184**	0.5433	1.8978**	1.3551	0.9461	2.7070***	2.0157**	2.4007**	1.0799	1.6315	2.3311**
0.20	1.8583*	2.0197**	0.6725	2.4378**	1.5280	0.8699	2.6738***	2.1047**	2.0340**	1.0834	1.3992	2.2086**
0.25	1.4991	2.2575**	0.6292	2.6399***	1.4740	0.8219	2.3289**	2.0407**	1.9348**	1.1874	1.2050	1.7996**
0.30	1.1539	1.7974*	0.4421	1.6028	1.5083	0.7691	2.0977**	2.0505**	2.1066**	1.0401	1.3566	1.9116*
0.35	1.0093	2.4718**	0.6910	1.9255*	1.5678	0.9223	2.5653**	1.8872*	2.5421**	1.4108	1.4571	1.8513*
0.40	1.2795	1.3268	0.5979	1.3309	1.8332*	0.8232	2.4511**	1.7303*	2.1662**	1.3333	1.0795	1.8300*
0.45	1.1300	1.1721	0.5637	0.9906	1.6705*	0.6856	2.3281**	1.4465	1.7609*	1.1764	1.1982	1.5616
0.50	0.9060	1.1274	0.5380	0.7521	1.8007*	0.6425	2.4761**	1.2971	1.5613	1.0481	1.0597	1.6110
0.55	0.7588	1.0848	0.5631	0.9110	1.5623	0.7758	2.2530**	1.2258	1.4429	1.1843	1.0853	1.6474*
0.60	0.9126	0.9129	0.6052	0.7844	1.7053*	0.9180	2.1782**	0.9913	1.5976	0.9543	0.8623	1.6098*
0.65	0.9171	0.7771	0.5170	0.9219	1.4248	0.6722	1.5421	0.8058	1.4190	1.2876	0.8935	1.7054*
0.70	1.1631	1.0274	0.5025	0.7454	0.9690	0.4997	1.1719	0.8926	1.7584*	1.0512	0.9875	1.5564
0.75	0.9447	0.8511	0.3838	0.8542	0.6033	0.4893	1.2031	1.0970	1.7627*	0.8873	0.5092	1.2705
0.80	0.9779	0.7262	0.2369	0.6764	0.8188	0.4096	0.9534	1.0526	1.3086	0.8915	0.6887	0.7864
0.85	1.1367	0.9720	0.2019	0.6324	0.7999	0.4607	0.8296	0.8082	1.1834	0.9034	0.6058	0.7724
0.90	0.6605	0.7276	0.2949	0.6346	0.6840	0.7115	0.7196	0.5711	0.9639	0.4198	0.5180	0.4489
0.95	0.3407	0.3717	0.3293	0.1861	0.1608	0.2174	1.0293	0.6334	0.8527	0.3771	0.3971	0.1150

Notes: τ represent quantiles; test statistic is tested at the 5%, where critical value = 1.96; [***], [**], [*], are [1%], [5%], and [10%] respective significance levels for critical values of 2.567, 1.96, and 1.645.

Table 3
QRM estimates from COVID-19 cases to REIT returns.

Countries	Australia	Canada	China	France	Germany	Hong Kong	Japan	Netherlands	New Zealand	Singapore	UK	USA
τ (QR)												
0.05	-0.64215 ^a	-0.59909 ^a	-0.42931	-0.24831 ^a	-0.30949 ^a	-0.31687 ^a	-0.54283 ^b	0.065889	-0.01606	-0.58297 ^a	-0.26471 ^a	-0.47588 ^a
0.10	-0.45408 ^a	-0.43963 ^a	-0.46128	-0.21123 ^a	-0.19951 ^b	-0.19714	-0.32561 ^b	0.01298	-0.03094	-0.21683	-0.18052 ^a	-0.27002 ^b
0.15	-0.36995 ^a	-0.33951 ^a	0.098937	-0.2103 ^a	-0.09409	-0.13122	-0.17351 ^b	-0.00954	-0.03806	-0.15868 ^c	-0.15834 ^a	-0.24531 ^b
0.20	-0.20459 ^c	-0.29117 ^a	0.07038	-0.15853 ^a	-0.0702	-0.09056	-0.15489 ^a	0.001509	0.004892	-0.11972 ^b	-0.14298 ^a	-0.17833 ^c
0.25	-0.13351	-0.13246	0.100279	-0.09507 ^c	-0.0595	-0.05317	-0.11236 ^b	0.016472	-0.00014	-0.10297 ^c	-0.13474 ^a	-0.15083 ^b
0.30	-0.03276	-0.10253	0.093996	-0.09964 ^b	-0.04284	-0.04068	-0.09276 ^c	0.009622	0.003429	-0.03837	-0.10667 ^c	-0.11674 ^c
0.35	-0.04174	-0.06063	0.086779	-0.08098 ^b	-0.04357 ^c	0.013872	-0.02785	0.003922	0.00154	0.003539	-0.10293 ^c	-0.07452
0.40	-0.0313	-0.05727	0.08085	-0.07004 ^b	-0.03676 ^b	0.007536	-0.02495	0.003829	-0.00279	0.004411	-0.02917	-0.04145
0.45	-0.03131	-0.0334	0.072535	-0.05499 ^b	-0.03279	0.011699	-0.01232	0.00035	0.000364	0.003229	-0.01989	-0.00831
0.50	-0.01407	-0.0115	0.06577	-0.05503 ^b	-0.03404 ^c	0.015945	-0.00558	-0.00335	0.000258	-0.00029	-0.00311	-0.00444
0.55	-0.00983	0.006656	0.06348	-0.05607 ^a	-0.01423	0.039115	-0.00866	-0.00679	-6.78E-06	0.002928	-0.00246	-0.0019
0.60	-0.00536	0.011387	0.070608	-0.04024 ^b	-0.00843	0.062894	-0.01219	-0.00987	-0.00414	0.027128	-0.0026	0.005006
0.65	-0.00813	0.010247	0.055023	-0.043 ^c	-0.00388	0.057468	-0.00881	-0.0114	-0.00337	0.024093	-0.0037	0.040984
0.70	-0.00059	0.046849	0.046177	-0.04178	-0.00553	0.072805 ^c	-0.01391	-0.01681	-0.00483	0.022602	-0.0049	0.070937
0.75	0.046223	0.044706	0.037754	-0.04404	0.014919	0.058177	-0.02438	-0.00256	-0.00661	0.079242 ^c	-0.00601	0.084943
0.80	0.079651	0.078628 ^a	0.026228	-0.01513	0.041814	0.089021	-0.02637	-0.01306	-0.00877	0.079637	-0.00708	0.125156 ^b
0.85	0.218225 ^c	0.090157	0.015917	-0.00225	0.079513	0.089091	-0.02286	-0.01644	-0.01172	0.122439	0.050277	0.194838 ^a
0.90	0.23159 ^a	0.144765	0.106564	-0.00777	0.147251 ^a	0.064441	0.018922	-0.03128 ^b	-0.01152	0.249544 ^b	0.12902	0.206241 ^a
0.95	0.281055 ^a	0.411326 ^a	-0.0097	0.079121	0.137505 ^c	0.145957	0.081374	-0.06373 ^b	-0.01286	0.520653 ^a	0.223893 ^b	0.325756 ^a
OLS												
Cases	-0.07346 ^a	-0.08779 ^a	-0.00831	-0.0638 ^a	-0.02520 ^a	0.01161	-0.05526 ^b	-0.01753	-0.00627	-0.00364	-0.02357 ^a	-0.03656 ^a
R ²⁺	0.02266	0.06168	-0.00186	0.04497	0.01439	-0.00152	0.00754	-0.00124	-0.00134	-0.00186	0.01255	0.01353

Notes: The Table displays the asymmetric relationship between COVID-19 cases' returns and REIT returns. To compare the linear model with the asymmetric model, results are also presented for OLS. τ represent quantiles; [^a], [^b], [^c] are [1%],[5%],[10%] respective significance levels; R²⁺ is adjusted R².

4.2. Analysis of quantile regression results

The quantile regression (QR) results are detailed in Table 3. It is important that we classify quantiles into market conditions for easy analysis. We designate the quantile range 0.05–0.35 as the bearish market state, 0.40–0.60 as the normal market state, and 0.65–0.95 as the bullish market state. All REIT regimes are negatively affected by marginal cases of the COVID-19 pandemic within the quantile range 0.05–0.10. Across other quantile ranges, we find the distinct direction of effect among the REIT regimes. With the aforementioned delineations, we note that Australia, Canada, France, Japan, the UK, and the USA are the REIT regimes whose returns are significantly negatively affected by marginal increases in COVID-19 cases in bearish market conditions (within the quantile range 0.05–0.35).

In normal states (i.e., within the quantile range 0.40–0.60) of trade, France and Germany witness a negative impact of COVID-19 marginal cases on REIT returns with varying degrees of significance, as indicated in Table 2. In the bullish market state (0.65–0.95), the impact of COVID-19 cases' returns on the REIT returns for Australia, Canada, Germany, Singapore, the UK, and the USA is significantly positive. Meanwhile, in the same market state, REIT returns from the Netherlands are negatively affected by marginal increases in

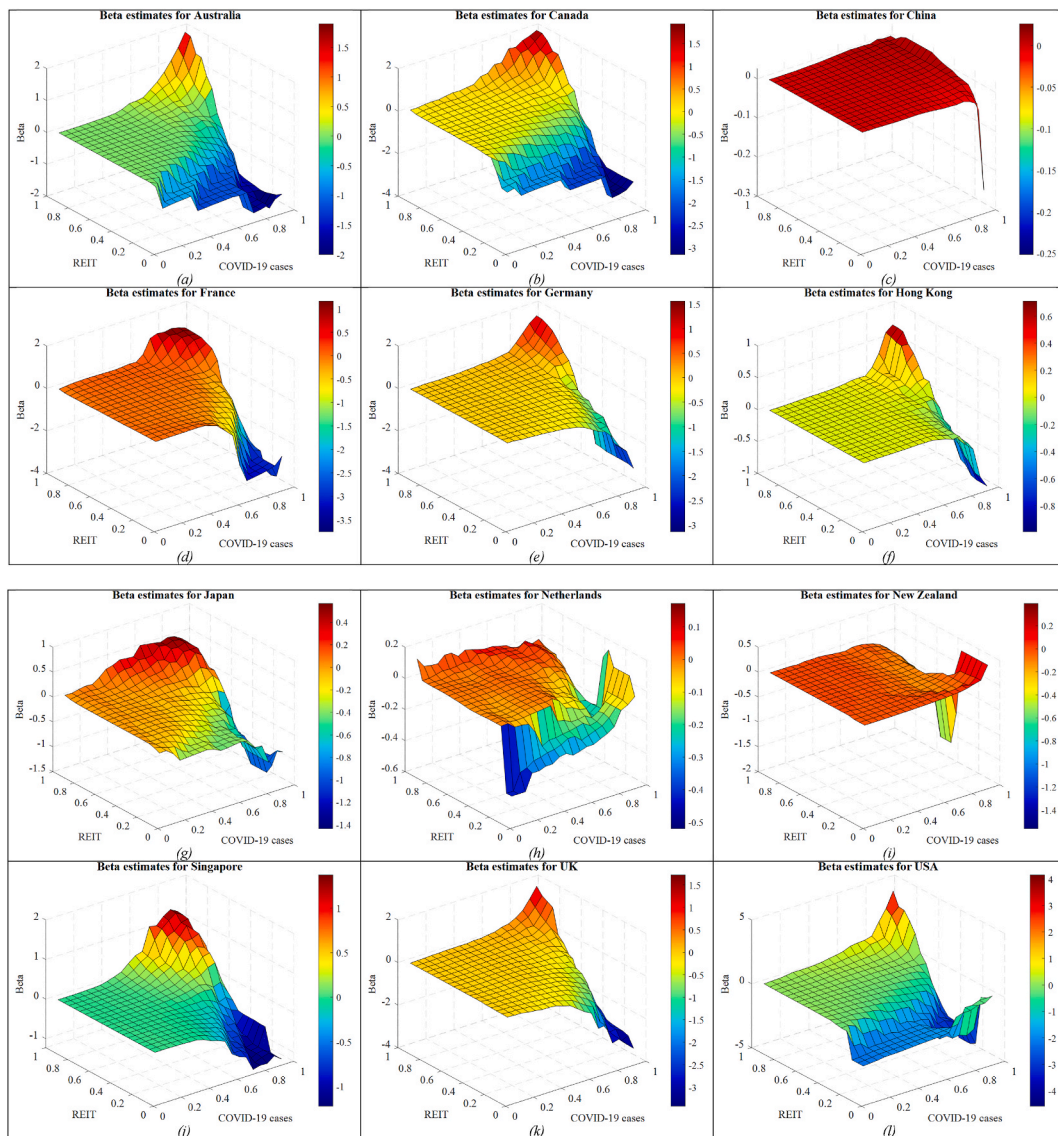


Fig. 2. 3D plots of QQR estimates.

Notes: This Figure exhibits the QQR in three-dimensional plots. For both the regressand (REIT returns) and the regressor (COVID-19 cases' returns), the plots represent quantile-on-quantile slope coefficients as a function of the quantile parameters. Specifically, the graphs present the estimates of the slope coefficient, $\beta_1(\theta, \tau)$, in the z – axis against the quantile of COVID-19 cases' returns (θ) in the x – axis and the quantile of REIT returns (τ) in the y – axis.

Table 4

QQR estimates from COVID-19 cases to REIT returns.

Countries	Australia	Canada	China	France	Germany	Hong Kong	Japan	Netherlands	New Zealand	Singapore	UK	USA
τ (QQR)												
0.05	-1.13655	-2.01914	-0.01892	-1.16171	-0.72640	-0.13841	-0.43289	-0.26179	0.03057	-0.46927	-1.10733	-1.50381
0.10	-1.09299	-1.99081	-0.00668	-1.10713	-0.65884	-0.13215	-0.42402	-0.21988	0.02509	-0.41744	-0.94669	-1.65900
0.15	-1.02211	-1.81314	-0.00407	-0.98704	-0.59037	-0.12352	-0.42356	-0.11485	0.00660	-0.38535	-0.79558	-2.14311
0.20	-0.87338	-1.50611	-0.00189	-0.84197	-0.50411	-0.11560	-0.40037	-0.06721	-0.00499	-0.31585	-0.70061	-2.26474
0.25	-0.72621	-1.22605	-0.00101	-0.64235	-0.46650	-0.09925	-0.36765	-0.05133	-0.01237	-0.27929	-0.60336	-1.99494
0.30	-0.54843	-0.88446	-0.00018	-0.53707	-0.41753	-0.08889	-0.34039	-0.05085	-0.02277	-0.23781	-0.55250	-1.62656
0.35	-0.43011	-0.65465	0.00052	-0.41129	-0.37470	-0.06685	-0.30100	-0.04999	-0.10788	-0.19422	-0.43224	-1.28029
0.40	-0.34009	-0.47661	0.00112	-0.33789	-0.32952	-0.04436	-0.24185	-0.06259	-0.15391	-0.15402	-0.37350	-0.94425
0.45	-0.25823	-0.30789	0.00184	-0.23842	-0.24942	-0.03631	-0.20022	-0.05726	-0.15395	-0.09268	-0.31679	-0.66551
0.50	-0.17806	-0.21170	0.00247	-0.19404	-0.20094	-0.01023	-0.17519	-0.05270	-0.16041	-0.03239	-0.25693	-0.45115
0.55	-0.11427	-0.13953	0.00312	-0.14053	-0.14271	-0.00264	-0.12557	-0.04129	-0.12481	0.02597	-0.18913	-0.30948
0.60	-0.05119	-0.03538	0.00341	-0.07974	-0.06381	0.01627	-0.07268	-0.02826	-0.12278	0.09854	-0.12015	-0.16711
0.65	-0.00507	0.02639	0.00371	0.00253	0.01853	0.02299	-0.01584	-0.00810	-0.09129	0.14936	-0.06158	-0.04103
0.70	0.07694	0.12264	0.00396	0.06686	0.06535	0.04214	0.03967	0.00182	-0.08119	0.19877	0.00141	0.04274
0.75	0.12051	0.21549	0.00419	0.13331	0.11184	0.06086	0.09897	0.00607	-0.07062	0.27961	0.05294	0.18160
0.80	0.18664	0.29805	0.00458	0.19196	0.16304	0.07992	0.14867	0.01717	-0.06275	0.31447	0.14633	0.30261
0.85	0.24063	0.40970	0.00441	0.26811	0.20192	0.08979	0.21402	0.02588	-0.06096	0.36296	0.19307	0.47431
0.90	0.32693	0.55091	0.00377	0.33448	0.23717	0.09968	0.27429	0.03218	-0.05543	0.43129	0.25146	0.62522
0.95	0.39028	0.70711	0.00351	0.40851	0.28860	0.10797	0.33518	0.04243	-0.05272	0.46902	0.31499	0.87446

Notes: The Table displays the average conditional (QQR) relationship between COVID-19 cases' returns and REIT returns. The significance of the QQR coefficients is not integrated with the non-parametric model. Hence, verification of the QQR results is made by the QR estimates. τ represent quantiles.

For brevity, all estimates for the entire distributions of COVID-19 and REIT returns are not reported. They are available upon request.

COVID-19 cases. The Chinese REIT returns are positively affected by the COVID-19 cases' returns except for quantiles 0.05–0.10 and 0.95. However, these relationships are statistically insignificant. The findings substantiate the need for the methodological framework used in this study, as we uncover heterogeneous effects of the COVID-19 pandemic on REIT returns across diverse economic states. We provide findings that corroborate the work of Hashmi et al. (2021) in which diverse impacts of COVID-19 cases were revealed on emerging markets' stock prices. Our findings support those from studies that reveal the significant impact of the COVID-19 pandemic on REITs (Adekoya & Oliyide, 2021; Akinsomi, 2021; D'Lima, Lopez, & Pradhan, 2022). Theoretically, the heterogeneous impact of the COVID-19 pandemic on financial markets is explained by the heterogeneous market hypothesis (Bossman, Agyei, et al., 2022; Owusu Junior et al., 2021).

Supplementary to the QR estimates, we present the OLS results for the impact of COVID-19 marginal cases on REIT returns. We report a negative impact of COVID-19 cases on REIT returns for all countries save Hong Kong (which is positively insignificant). This negative relationship is insignificant for REIT returns from China, Netherlands, Singapore, and New Zealand while it is significant for Australia, Canada, France, Germany, Japan, the UK, and the USA. It is worth noting that OLS only provides an average relationship between COVID-19 cases and REITs and therefore, some important information across the tailed conditions of the distribution is hidden. Moreover, we find low explanatory power for several of the OLS estimates. The adjusted R-squared (R^{2+}), as reported in Table 3, for all REIT regimes are all below 1% such that we find a negative explanatory power of COVID-19 on the returns on REITs from the Netherlands. With the inconsistent explanatory power revealed across the various market conditions of the top-advanced REIT regimes, the results expose the inability of the OLS estimator – despite its popularity – to effectively model the heterogeneous links between COVID-19 and REIT returns as the quantile-based estimators (QR and QQR) provide (Ijasan et al., 2021; Owusu Junior, Tiwari, et al., 2020).

4.3. Analysis of QQR results

The QR results so far confirm asymmetries in the effect of the COVID-19 pandemic on various REIT regimes in diverse market conditions. However, we need to further probe into the varied conditions of the dependent and independent variables to assess the conditional impact of COVID-19 cases' returns on the various conditions of REIT returns in the various regimes. This is achieved by extending our analysis to the QQR framework. The estimates from the QQR method are presented in this section. The link between COVID-19 cases' returns and the returns of top-advanced REIT markets is investigated using this method. The slope coefficients $\beta_1(\theta, \tau)$, which represents the effect of the π_{th} quantile of COVID-19 cases on the θ_{th} quantile of REIT returns, are shown with three-dimensional (3D) plots in Fig. 2 and are backed up by the numerical estimates in Table 4. The findings show that the impact of every quantile of COVID-19 marginal cases on REIT returns differs across quantiles of REIT returns with a few similarities in certain REIT regimes and market conditions of REIT returns. Note that owing to the non-parametric process involved in QQR estimations, it is not practical for the significance levels of the coefficients to be determined. Notwithstanding, these estimates are confirmed by our QR results, as we offer details in our robustness analysis. Note that in our analysis of the 3D plots in Fig. 2, we use high and low quantiles as a resemblance of bullish and bearish markets, respectively.

From Fig. 2, we report that the magnitude of the effect of the marginal cases of COVID-19 in Australia fluctuates around zero and is almost negligible at quantiles 0.20–0.95 for REITs but 0.05–0.60 for COVID-19 (see Fig. 2a). Taking the quantiles of COVID-19 into perspective, COVID-19's effect on REIT returns is substantially negative between quantiles 0.40–0.95 of COVID-19 and 0.05–0.40 of REITs. At high quantiles (0.80–0.95) of both COVID-19 and REITs, the impact is strongly positive, approachable to 1.50. These findings show that marginal COVID-19 cases have a slight positive linkage with Australian REIT returns in the upper quantiles, but that this effect becomes considerably negative in the lower quantiles of REIT returns.

It is worth noting that save for some peculiarities, which we detail shortly, the results for Australia are comparable to all REIT regimes except for the Chinese REITs which the marginal cases of COVID-19 in China have almost a nil impact (Fig. 2c). To some extent, the results for New Zealand (Fig. 2i) are comparable to China, but within the quantile range 0.35–0.45 of REIT returns and 0.80–0.95 of COVID-19, mild negative effects are envisaged rather than a nil effect in the Chinese case. Turning to the peculiarities, relative to the Australian case, we note that across the quantiles of COVID-19 cases' returns in Canada (Fig. 2b) and Japan (Fig. 2g), a higher magnitude of effects is envisaged at wider quantiles (i.e., 0.75–0.95 of both COVID-19 and REITs).

In respect of France (Fig. 2d), we document a substantially negative effect of COVID-19 marginal cases on REITs between the quantile ranges 0.65–0.95 of COVID-19 and 0.05–0.40 of REITs, with a high magnitude (almost -4). At high quantiles (0.70–0.95) of both COVID-19 and REITs, the impact is strongly positive, exceeding one. This is no different for Singapore (Fig. 2j) despite the relatively low QQR estimates. For Germany (Fig. 2e) and the UK (Fig. 2k), and Hong Kong (Fig. 2f), we report that the negative impact of high distributions of COVID-19 occurs within the quantile range 0.80–0.95 but within 0.05–0.35 for REITs as well as in high magnitudes up to -3 (-1), for Germany and the UK (Hong Kong). In the case of the Netherlands, in all aspects but along the quantiles of COVID-19, a negative impact is revealed for the 0.05–0.10 quantiles of REITs, although they are somewhat negligible as they may only go as high as negative 0.5 for the comparable distributions of COVID-19 cases' returns and diminish across increasing quantiles of COVID-19 cases (Fig. 2h). In respect of the USA (Fig. 2l), the results are similar in all aspects to those of Australia, but in high magnitudes for the USA across all distributions. The impact of the COVID-19 pandemic on REITs market returns cannot be overemphasized.

4.4. Robustness test for QQR

Verification of the QQR results is made by the QR to facilitate inference of the connections given by the QQR from those shown by the QR. It is impracticable to determine the significance of the coefficients revealed by the QQR because it is a non-parametric model.

The QQR estimates are the decomposed estimates of QR into particular quantiles of the regressors and, hence, the QQR estimations may be validated by comparing their coefficients to those of QR (Adebayo & Acheampong, 2021; Ijasan et al., 2021). The line graphs of QR and QQR coefficients in Fig. 3 demonstrate this. These graphs are useful for two reasons viz. first, they visually represent the QR estimations to portray the trend of increases and/or decreases in COVID-19 cases' returns and the accompanying movements in REIT returns; second, the plots validate the QQR by comparing it to the QR estimates (Adebayo & Acheampong, 2021; Owusu Junior & Tweneboah, 2020). From the graphs, the horizontal (vertical) axis presents the quantiles (QR/QQR estimates); Green and blue lines or spots are correspondingly for QQR and QR estimates across quantiles.

From the plots in Fig. 3, we find that the QR and QQR estimates for all REIT regimes confirm each other. Movements are in the same

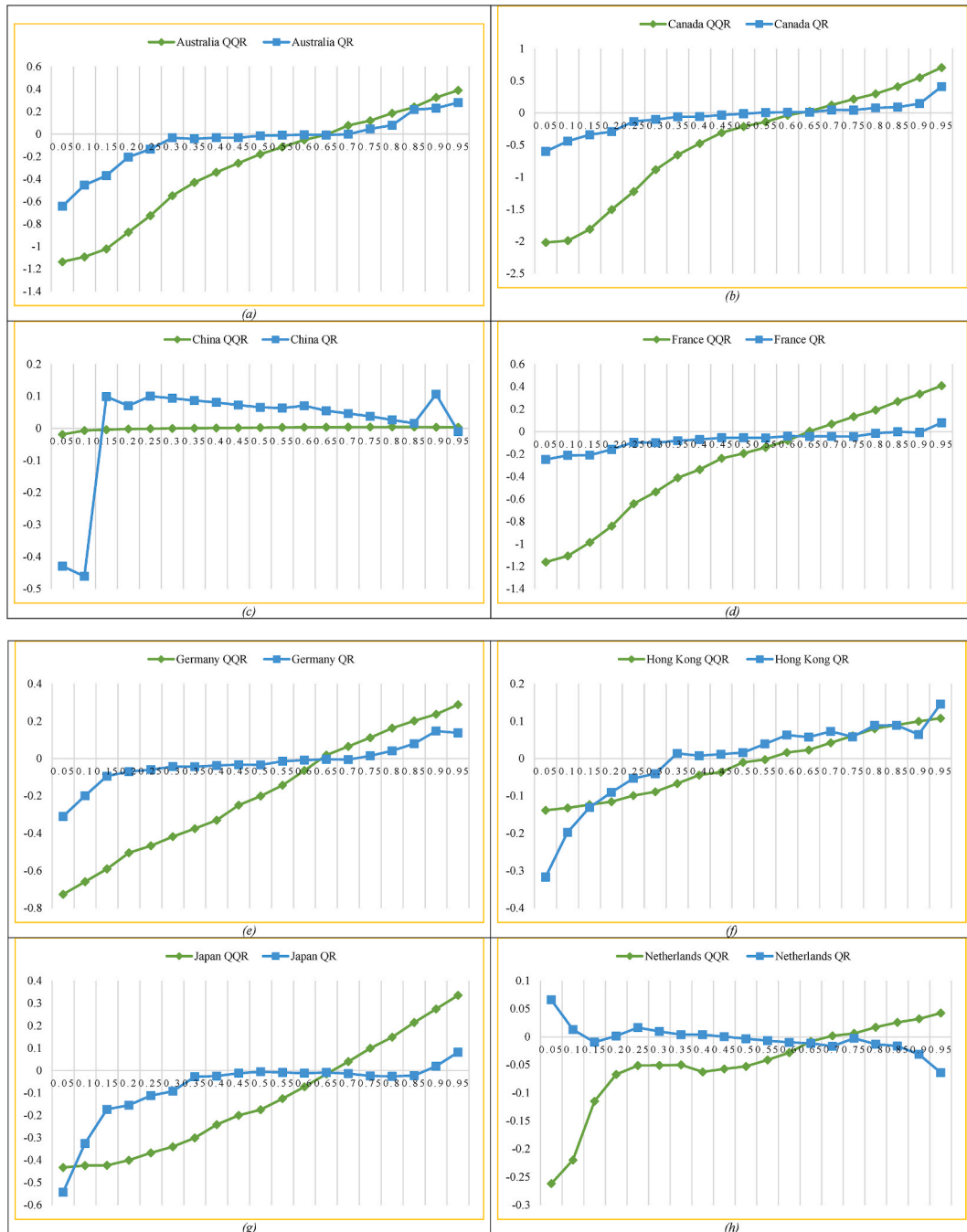


Fig. 3. Line graphs of QR and QQR estimates.

Notes: horizontal (vertical) axis presents the quantiles (QR/QQR estimates); Green (blue) lines and spots are for QQR (QR) estimates.

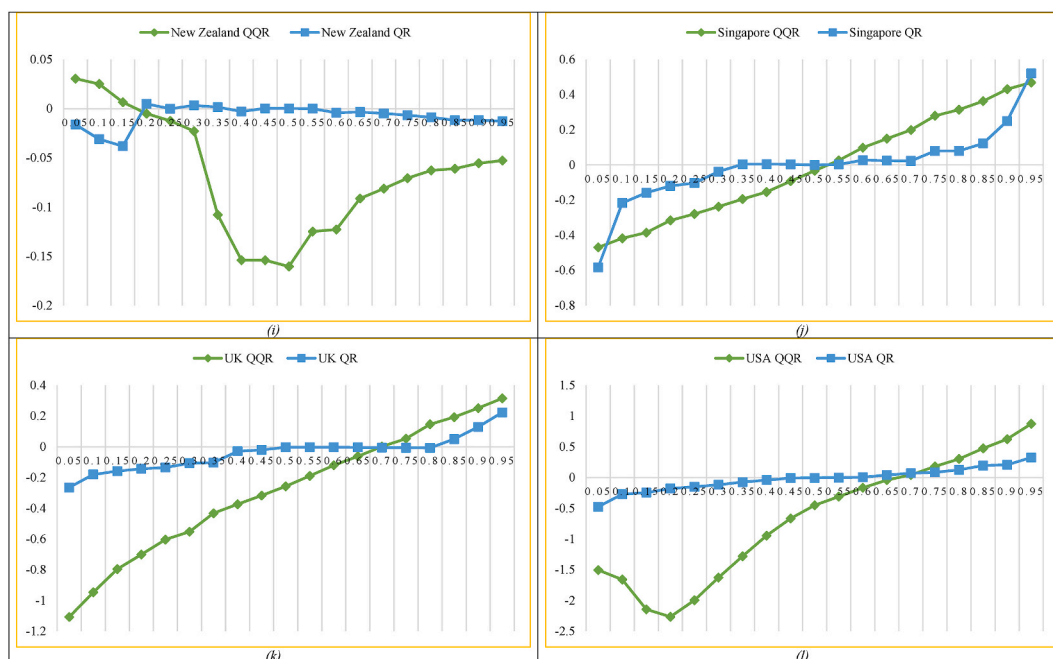


Fig. 3. (continued).

direction as trended by the quantile estimates, with the only difference being the size of effect at some quantiles. Notwithstanding, the QRR estimates are validated by those of the QR approach.⁶

5. Practical implications

To begin with, our findings underscore the causal relationship between COVID-19 cases' returns and REIT returns. The predictive power of COVID-19 cases in this causal relationship is found at the upper tails, which reflect the boom or bullish trading period. Note that the pandemic has stayed with us for over two years, in which markets have undergone different forms of conditions amid the systemic risk. Following our findings of the causal effect at upper tails, the implication to be drawn is that policy decisions need not come as surprises to market participants just as portfolio decisions should be premeditated despite market conditions. At any point in time when the market signifies a bullish period, market participants should observe the conditional state of the COVID-19 and its associated policies before concluding on their aims and objectives, which might influence their decision toward real estate investments.

From the tenets of the heterogeneous market hypothesis, it is expedient that market participants analyse their risk/reward preferences after incorporating all available information on the market including the COVID-19 pandemic across diverse market conditions and states of nature (Müller et al., 1993, p. 130). This hypothesis gains practicality across divergent market conditions of bearish (lower quantiles), normal (median quantiles), and bullish (upper quantiles) and, hence, its operability in the context of this study cannot be compromised. The condition of the COVID-19 pandemic may be different from the prevailing conditions surrounding earnings from REITs, as portrayed by our findings. Consequently, a strategic assessment of market conditions is key to optimising portfolio and policy decisions in the era of a systemic risk like the COVID-19 pandemic. Our commendations corroborate the extant finance literature that emphasises the practicality of the heterogeneous market hypothesis (Agyei, Owusu Junior, Bossman, & Arhin, 2022; Bossman et al., 2022; Asafo-Adjei, Owusu Junior, & Adam, 2021).

Policymaking in REIT regimes cannot overlook the impact of the COVID-19 pandemic on the earnings they record. Once new strands of the virus are announced, short-lived dynamics are expected to impact the steps taken by governments. Therefore, incorporating market conditions in a forward-looking approach to regulating REIT markets is a sure way to mitigate losses from the systemic risk associated with the novel coronavirus. In bearish trading periods, survival and performance tracking may sustain earnings on REITs. Future research can analyse this issue in a multivariate setting by employing different proxies of uncertainty such as VIX, EPU, as well as alternative measures of COVID-19 effect.⁷

⁶ We have also conducted subsample analysis for the year 2020 and our results are qualitatively similar. However, to conserve space we do not report those results here and they are available upon request. We acknowledge useful comments of an anonymous referee here.

⁷ We acknowledge useful comments of anonymous referees for this suggestion.

6. Conclusions

This study investigated the impact of COVID-19 marginal cases on REIT returns of 12 top-advanced REIT regimes (Australia, Canada, China, France, Germany, Hong Kong, Japan, the Netherlands, New Zealand, Singapore, the UK, and the USA) across various quantiles of REIT returns and COVID-19 cases' returns. The predictive power of COVID-19 marginal cases on REIT returns was investigated using the causality-in-quantile test. Additionally, Sim and Zhou's (2015) QQR approach was employed to estimate conditionalized effects of COVID-19 marginal cases on REIT returns across bearish, normal, and bullish market states.

Our findings from the causality-in-quantiles explicate that changes in COVID-19 cases' returns cause the changes in REIT returns at lower quantiles, which denote bearish market conditions. China, Germany, Hong Kong, and Singapore are exceptional in this conclusion. The findings from the quantile and quantile-on-quantile regressions varied between quantiles of COVID-19 marginal cases and REIT returns, according to the QQR estimations. Notably, we underscore market- and quantile-based significant causal effects between COVID-19 and REIT returns. Generally, upper (lower) quantiles of REIT returns, receive a considerable positive (negative) effect from COVID-19 cases' returns. Exceptional REIT regimes from our sample are China and New Zealand. With notable practical implications, our varied results corroborate the heterogeneous market hypothesis (Müller et al., 1993, p. 130) as well as the strands of works in the empirical literature that underscore the heterogeneous impacts of COVID-19 on financial markets (Asafo-Adjei et al., 2021; Bossman et al., 2022; Hashmi et al., 2021; Owusu Junior et al., 2021; Umar, Gubareva, & Teplova, 2021; Umar, Gubareva, et al., 2021).

Inferring from the negative findings for lower quantiles, we explicate that amid unfavourable REIT conditions, investors and other relevant market players lose confidence. This explains why the effect of the COVID-19 pandemic is more pronounced in such (bearish) conditions. We recommend that policymakers take appropriate measures to regulate the spread of information surrounding COVID-19 whilst broadening relief packages to businesses across the real estate industry considering the severe impact they might endure should there be lockdowns, bans on travel and tourism, among others. More importantly, during pandemics, it would be prudent to streamline policy measures across REIT regimes to increase the confidence of market participants, particularly in bullish times when they are needed to reduce losses. Future studies could assess the relationship between policy measures and the performance of REIT regimes using advanced techniques that offer insights into short-, medium-, and long-term market dynamics.

CRedit authorship contribution statement

Ahmed Bossman: Conceptualization, Methodology, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Zaghum Umar:** Conceptualization, Methodology, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Supervision. **Tamara Teplova:** Conceptualization, Validation, Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of competing interest

No competing interest to declare.

Data availability

Data will be made available on request.

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