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COVID-19 Pandemic and Bitcoin Returns: Evidence From Time and Frequency Domain Causality Analysis

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This study explores the causal relationship between COVID-19 pandemic and Bitcoin returns by applying the time and frequency domain Granger causality framework. We find that COVID-19 has a causal effect on Bitcoin returns across time. We further find that the causal effect of COVID-19 on Bitcoin returns, varies across different frequencies from short to medium and long term. From a policy perspective, investors need to be alert while investing in Bitcoin.

I. Introduction

The enthusiasm for bitcoin and cryptocurrencies has increased among investors and researchers worldwide (Bouri et al., 2019). Investors have increased their attraction to the short-term profit by investing in such a virtual asset. But during the COVID-19 pandemic, bitcoin and the cryptocurrency markets are also facing many difficulties with high volatility (Corbet et al., 2020). By seeing the economic hitches due to the COVID-19 pandemic, many studies attempted to investigate the impact of COVID-19 on various stock and financial markets. A more recent study by Al-Awadhi et al. (2020) examined the effect of the initial COVID-19 outbreak on the stock price of different countries and found that stock markets have responded negatively to the growth in COVID-19 cases and deaths. Other studies also found the adverse effect of COVID-19 on stock markets and other financial markets (Mishra et al., 2020; Narayan, 2020).

As we know, bitcoin is extremely volatile, similar to various stocks and financial assets (Baig et al., 2020; Chen et al., 2020; Pelster et al., 2019; Sahoo et al., 2019; Sami & Abdallah, 2020). At the same time, it provides more hedging capabilities across a variety of stocks and the US dollar (Dyhrberg, 2016). As a result, during the epidemic, investors attempted to diversify their portfolio by investing in cryptocurrencies to make profits in the short term. However, the “COVID-19 outbreak” situation had adverse effects on Bitcoin markets. As a result, Lahmiri & Bekiros (2020) found that cryptocurrency markets were more volatile and irregular during the worldwide COVID-19 outbreak situation. Similarly, Usman & Nduka (2022) examined the efficiency of the cryptocurrency market during the

COVID-19 situation, and the study by Corbet et al. (2020) detected the uncertainty of cryptocurrency markets during the COVID-19 pandemic. There is also another strand of studies that predict the future price movement of the assets through the cause-and-effect relationship (Li et al., 2016; Sahoo, 2021).

The present study contributes to the existing literature on the following grounds. The existing study examines the causal relationship between the COVID-19 pandemic and bitcoin price returns (*BTCR*), particularly in terms of time domain approach, but no research has looked at the relationship particularly in terms of time and frequency domains. First, the present study examines the direction, strength and extent of causality between the COVID-19 pandemic and *BTCR* by using both time and frequency domain approaches. More specifically, this paper differs from others by examining the empirical link between “COVID-19 confirmed cases and bitcoin returns” by applying both Toda and Yamamoto’s (1995) time-domain Granger causality (hereafter TYM) and Breitung & Candelon’s (2006) “spectral Granger causality” (hereafter BCG) of frequency-domain approach. Second, the study looks into the link between Bitcoin returns and the rise of COVID-19 mortality cases (*CD*) of different time frequencies. By examining the COVID-19 situation and the increasing daily trend of COVID-19 verified occurrences, the objective is to assess the volatility of bitcoin prices and any potential for market forecasting.

The reminder of the paper is organized as follows. Section II describes the data and methodology. The main findings are discussed in Section III followed by the discussion on concluding remarks in Section IV.

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II. Data and Methodology

A. Data

We use two proxies for the COVID-19 pandemic, namely total number of confirmed cases (CC) and total number of deaths caused by the COVID-19 (CD). We source data from CEIC Global premium database at a daily frequency. The daily data of bitcoin (BTC) is sourced from coinmarketcap.com. Our data spans the period 15 March 2020 to 15 December 2021. The return series of bitcoin is calculated as $BTCCR_t = (\ln PC_t - \ln PC_{t-1})$, where $BTCCR$ is the price returns of the bitcoin and PC represents the bitcoin price.

B. Frequency-Domain Granger Causality Test

The time-domain causality explains a single statistical measure that considers the whole frequency analysis by seeing the “infinite time horizon”. However, studies by Geweke (1982) proposes the causal effect not only covers the whole frequency. Rather it varies across different frequencies. As such they point towards the problem of non-linear frequency domain causality. Seeing the difficulties, Breitung & Candelon (2006) suggested the parameter Autoregressive process to the VAR model and allowed different frequency domain approaches (of various frequency intervals) to causality. The BCG approach has been tested in the literature (see, for instance, Bouri et al., 2017; Tiwari et al., 2014; Bekiros et al., 2017). By following earlier studies, the present study also uses the BCG test to examine the causal effect between COVID-19 and $BTCCR$. The test has been clearly explained using following equations:

$$H_0 = R(\omega)\beta = 0, \quad (2)$$

where $\beta = [\beta_1, \dots, \beta_p]'$ and the $R(\omega)$ restriction matrix is expressed as:

$$R(\omega) = \begin{pmatrix} \cos(\omega) & \cos(2\omega) & \dots & \cos(p\omega) \\ \sin(\omega) & \sin(2\omega) & \dots & \sin(p\omega) \end{pmatrix}$$

here BCG uses the null for the frequency interval $\omega \in (0, \pi)$ with the presence of F-statistic which is distributed approximately at $F(2, T - 2p)$ and $T = 2\pi/\omega$, where T is the period and ω is considered as time frequency.

III. Main Findings

First, we examine the integrational order of the series $BTCCR$, CC , and CD using three unit root tests, namely Augmented Dickey-Fuller, Phillips and Perron, and Kwiatkowski, Phillips, Schmidt & Shin's. These results are reported in [Table 1](#). Overall, we conclude that $BTCCR$, CC and CD follow a stationary process and do not contain a unit root.

After identifying all variables are stationary at level, in the second step, we employ TYM linear causality test. These results are presented in [Table 2](#). We reject the null hypothesis that CC do not granger cause $BTCCR$ at the five percent significance level. It implies that the confirmed total number of cases granger causes the $BTCCR$, but the reverse causality is statistically insignificant. When we consider the CD as a proxy for the pandemic, we do not find granger causality between CD and $BTCCR$. This is due to the

low death rate compared to total confirmed cases in the world (2.1%). It is thus verified that the findings yield some insightful knowledge for the investors to diversify some portion of their investment portfolio in bitcoin market during the COVID-19 pandemic.

In the third step, in case of the frequency domain, this study examines the behavior of the variables, that is, $BTCCR$ to “transitory high-frequency shock” in another variable, say CC , is not equivalent and “permanent to low-frequency shocks.”

We note that from 0.28 to 1.49 frequency (means from low to middle frequency), CC cases granger cause $BTCCR$ at the 10% significance level, but do not find the causal effect for the high-frequency domain after 1.5 frequencies region (see Panel A of [Figure 1](#)). It shows that CC have a predictive capacity for $BTCCR$ only in the medium frequencies starting with day 4 to 24, as $T = 4$, with 1.49 frequency and $T = 24$ with 0.26 frequency. But the initial 3 days and the long period does not have any causal relation between them. This shows that the lower the frequency, the higher the time-period and vice-versa. Similarly, we note from Panel B that there is no causal effect from $BTCCR$ to CC from medium to long frequency except in the case of short frequency zone (with $\omega = 0.7$ to 0.001).

Additionally, Panels C and D plots the causality from CD to $BTCCR$ and vice-versa, respectively. Our findings show that there is no causal relationship between them irrespective of the short, medium, and long frequency periods considered for analysis. As a consequence of the findings, investors who want to invest in the bitcoin and cryptocurrency markets should review the past behavior of the bitcoin market during the COVID-19 situation before parking their portfolio in the bitcoin market. Our findings also suggest that Bitcoin investors and traders should keep an eye on the medium- and long-term trend line of the COVID-19 cases as we see COVID-19 cases have more predictive capacity of $BTCCR$ during the medium-term time horizon.

IV. Conclusion

This paper examined the causal relationship between the COVID-19 pandemic and bitcoin returns. Our data spans the period 15 March 2020 to 15 December 2021. By using the Toda-Yamamoto granger causality test, this study found that there is causal relation from total number of confirmed COVID-19 cases to bitcoin returns. However, when the study used the spectral granger causality test, the result varies depending on the time zone. We noticed that the causal effect of total number of confirmed COVID-19 cases to bitcoin returns only during short and medium frequencies. This showed that in the medium-term frequency, total number of confirmed COVID-19 cases enables us to predict the bitcoin returns. From a policy perspective, the investors must pay attention to the growth of total number of confirmed COVID-19 cases across the world, particularly in the major economies, before investing their funds in the bitcoin market.

Table 1. Unit Root Test Results

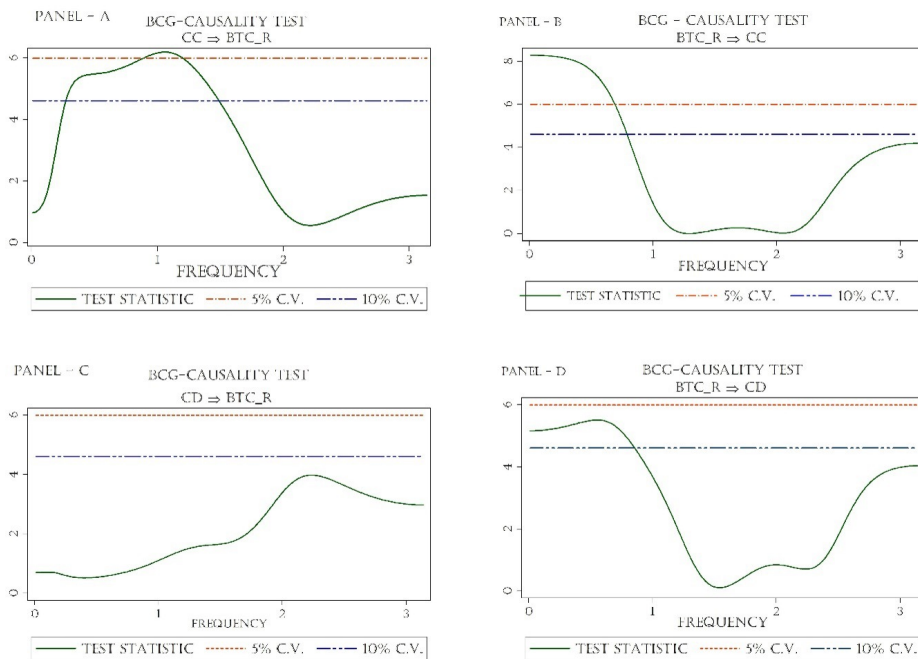
Unit root test	Intercept and Trend		
	ADF	PP	KPSS
<i>BTCR</i>	-26.681*** (0.000)	-26.646*** (0.000)	0.086
<i>CC</i>	-4.065*** (0.007)	-3.359* (0.061)	0.314
<i>CD</i>	-21.842*** (0.000)	-4.965*** (0.000)	0.287

Note: This table reports results obtained from Augmented Dickey and Fuller (ADF), Phillips and Perron (PP), and Kwiatkowski, Phillips, Schmidt & Shin's (KPSS) unit root test. *p*-values are reported in the parenthesis. ***, * denotes statistical significance at 1% and 10% levels, respectively.

Table 2. Toda-Yamamoto Granger Causality Test Results

TYM	Causality direction	BTC
"Growth of COVID-19 confirmed cases does not Granger cause Bitcoin return"	<i>CC</i> → <i>BTCR</i>	11.003** (0.051)
"Bitcoin return does not Granger cause growth of COVID-19 Confirmed cases"	<i>BTCR</i> → <i>CC</i>	6.860 (0.231)
"Growth of COVID-19 death does not Granger cause Bitcoin return"	<i>CD</i> → <i>BTCR</i>	9.235 (0.101)
"Bitcoin Return does not Granger cause growth of COVID-19 death"	<i>BTCR</i> → <i>CD</i>	5.278 (0.382)

This table reports the causality direction between COVID-19 pandemic and bitcoin returns. ** denotes statistically significant at 5% level. *BTCR*, *CC*, and *CD* denote bitcoin returns, COVID-19 is proxied using total number of confirmed cases and death, respectively. *p*-values are in the parenthesis.


Figure 1. Frequency domain causality

Notes: Figure 1 shows the frequency domain causality. Panel A = Causality from *CC* to *BTCR*, Panel B = Causality from *BTCR* to *CC*, Panel C = Causality from *CD* to *BTCR*, and Panel D = Causality from *BTCR* to *CD*.

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