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Impact of COVID-19 on the Co-Movement of Cryptocurrencies and Financial Assets: Evidence from Malaysia

Pick-Soon Ling

School of Business and Management, University College of Technology Sarawak,
96000 Sibul, Sarawak, Malaysia, Centre on Technological Readiness and Innovation in
Business Technopreneurship, University College of Technology Sarawak, 96000 Sibul,
Sarawak, Malaysia

Email: ling.pick.soon@ucts.edu.my

Abstract

Due to the significant increase in novel coronavirus disease (COVID-19) cases in Malaysia, this study took the initiative to examine the impact of COVID-19 on the co-movement of five selected cryptocurrencies and two financial assets, namely FTSE Bursa Malaysia Kuala Lumpur Composite Index (FBMVKLI) and Ringgit Malaysia over United States Dollar (MYRUSD). By using the daily frequency data from May 2013 to July 2021, the Dynamic Conditional Correlation of Multivariate GARCH (MGARCH-DCC) was applied to examine the time-varying conditional correlation of these financial assets as it could determine the co-movement of the assets. Then, independent t-test and non-parametric Mann-Whitney U test were utilised to examine the conditional correlation difference from the pre-COVID-19 pandemic and during the COVID-19 pandemic period. The results of the independent t-test and Mann-Whitney U test proved that the co-movements of the cryptocurrencies and FBMVKLI and MYRUSD had significant differences after the COVID-19 pandemic outbreak in Malaysia. This implied that co-movement between the cryptocurrencies and FBMVKLI and MYRUSD was impacted by the COVID-19 pandemic as it was strengthened during the COVID-19 pandemic period, except for Binance and Cardano with FBMVKLI, which showed a weakened co-movement during the COVID-19 pandemic period. These findings provided a crucial implication for all stakeholders as the findings could be used as guidance in reallocating the investment portfolio, especially during the COVID-19 pandemic period.

Keywords: Co-Movement, COVID-19, Cryptocurrencies, Malaysian Stock Market, MGARCH-DCC

Introduction

At the end of 2019, the first novel coronavirus disease (COVID-19) was reported in Wuhan, China and soon after that, the disease spread worldwide. Thailand reported the first confirmed case outside of China on 13 January 2020 (Shah et al. 2020). The disease was expected to have a huge impact on the world's economy, especially in the financial markets.

As mentioned by He et al. (2020), COVID-19 pandemic has a remarkable effect on the economies of affected countries. The economic growth and development of economies were threatened by the COVID-19 pandemic, especially in developing economies that have inadequate healthcare systems, insufficient resources and others (Takyi and Bentum-Ennin, 2021). In the financial market, this COVID-19 pandemic was also assumed as a “*Black Swan*” event, which will lead to a negative shock on the financial markets and the investors will fear the event (Hassan et al., 2021). Moreover, this “*Black Swan*” event could increase the market uncertainty, and investors tend to react negatively by withdrawing their investments from the stock markets. Therefore, the financial markets are expected to react negatively to this kind of event and it is acknowledged in many studies (Chen et al., 2007; Tavor and Teitler-Regev, 2019; Feng and Li, 2021).

Similarly, the Malaysian stock market also responded adversely to the COVID-19 pandemic as the market index dropped significantly (Lee et al., 2020). As one of the emerging markets that relied on international trade, Malaysia was also impacted by this disease after the first confirmed COVID-19 case was reported on 25 January 2020 (Shah et al., 2020). The scenario became worse in March 2020 because some of the new confirmed cases were found to have attended different meetings or gatherings, and thus the new confirmed cases increased significantly. To break the virus transmission within the country, the Malaysian Government implemented several restrictions, including limited or forbade flights and travellers from China, declared the implementation of a movement control order (MCO), and banned foreigners from entering the country. These restrictions had a great influence on the national economics, especially in tourism, airlines, food and beverages, and other related industries. The stock market responded immediately after those restrictions were announced as the prospect revenue and profit of particular stocks in affected industries declined dramatically. Several countries also implemented similar restrictions. Moreover, the “*lockdown*” had impacted the international financial market stability (Melki and Nefzi, 2021).

The COVID-19 pandemic also affected the stability of cryptocurrency markets and increased market volatility (Lahmiri and Bekiros 2020). As mentioned by Umar et al. (2021), the cryptocurrency market was significantly impacted by the COVID-19 pandemic as the market experienced a substantial sale of cryptocurrencies. Then, the total market capitalisation of the cryptocurrency market resulted in a dramatic dropped and caused “*Black Monday*” in the stock market (Umar et al., 2021). Several studies were conducted to explore the effect of COVID-19 pandemic on the cryptocurrency market. For instance, Conlon and McGee (2020) and Corbet et al. (2020) revealed that there was no safe-haven benefit provided by bitcoin on the stock markets during the COVID-19 pandemic. However, Corbet et al (2020); Corbet et al., (2021) suggested that cryptocurrencies could be a good safe-haven instrument during the COVID-19 pandemic period. These unconvincing findings had raised interest in the COVID-19 pandemic impact on the co-movement between the cryptocurrencies and traditional financial markets as some studies found that cryptocurrencies were effective safe-haven and/or hedging instruments for traditional financial markets, but some discovered otherwise. This was consistent with the argument, whereas the impact of COVID-19 pandemic on the economy is still under debate (He et al. 2020). Theoretically, if the cryptocurrency is likely to be highly correlated with another traditional financial instrument, it indicates that the cryptocurrency does not provide such diversification benefit or behave as a safe-haven for those traditional financial markets. This is relatively important for the “*Black Swan*” events such as the COVID-19 pandemic as stakeholders have to know if the cryptocurrencies could provide such benefit for them to

reallocate their investment portfolio to mitigate the COVID-19 pandemic impact on traditional financial markets. For that reason, this study is intended to achieve the following objectives:

- To examine the impact of the COVID-19 pandemic on the co-movement between five selected cryptocurrencies and the Malaysian stock market index (FBMKLCI); and
- To examine the impact of the COVID-19 pandemic on the co-movement between five selected cryptocurrencies and the foreign exchange rate (MYRUSD).

This study offers some contributions. Firstly, studies which examined the impact of COVID-19 pandemic on the co-movement between cryptocurrencies and financial markets by comparing the pre-COVID-19 and during COVID-19 are lacking. Most of current studies have investigated the property of hedge and/or the safe-haven of cryptocurrencies on the financial markets during this pandemic period. Moreover, most previous studies investigated the context by using developed market samples. Therefore, this study provides new evidence in literature, especially on the investment and portfolio management by examining the topic from the developing market perspective such as Malaysia. Malaysia is one of the heavily impacted markets by the COVID-19 pandemic. Therefore, it is essential to discover such a shock on the co-movement between the cryptocurrency and financial markets as it could provide a crucial implication to stakeholders.

Literature Review

Many studies empirically examined the impact of several international events on financial markets such as terrorisms, natural disasters, public health pandemics, and others (Ferreira and Karali 2015; Scholtens and Voorhorst 2013; Tavor and Teitler-Regev 2019; Feng and Li 2021; Chen et al., 2007). For instance, Chensney et al (2011) concluded that terrorist events have a significant negative effect on stock markets. Scholtens and Voorhorst (2013) revealed that earthquakes have significantly negative impacts on stock market. Ferreira and Karali (2015) found that financial markets are marginally impacted by the earthquake shocks as most markets had zero returns. Tavor and Teitler-Regev (2019) found that disasters and terrorisms had a bad impact on the stock market, especially on the day of the events. Similarly, the negative impact of SARS on stock markets was also acknowledged in some studies (Chen et al., 2007; Feng and Li, 2021). Therefore, these international events possess a huge influence on the financial markets, including stock markets, commodities markets, cryptocurrencies markets and others.

By focusing on the stock markets, Liew (2020) found that the COVID-19 pandemic had caused a prompt decline in the tourism-related share performance, while the investment risks were increased. Similarly, Takyi and Bentum-Ennin (2021) discovered that the COVID-19 pandemic caused a significant decline in the African stock market performance. Harjoto and Rossi (2021) also found the negative impact of COVID-19 pandemic on the emerging stock markets rather than developed stock markets. Moreover, the negative impact is noticeable in small capitalisation and growth firms. However, a different impact of COVID-19 pandemic was revealed by the authors. The negative impact was stronger for the energy sector and financial sector in both emerging and developed markets, while the healthcare and communication sectors in emerging markets and information technology sector in developed markets had a positive impact. A similar negative significant effect of COVID-19 pandemic was also acknowledged by Elhini and Hamman (2021), but only in a few industries, such as communications, health, technology, consumer discretionary and staples. Meanwhile, the positive significant association of the COVID-19 pandemic and S&P 500 Index was found in

the second period for communications, financial, industrial, utilities, and information technology industries.

Besides, Li et al (2021) found that COVID-19 pandemic increased connectedness on the total volatility of the G20 stock markets and demonstrated dynamic evolution characteristics of connectedness in different periods of the COVID-19 pandemic. Furthermore, Rehman et al. (2021) also found that G7 markets had high coherence with the number of confirmed COVID-19 cases and the number of deaths, but Canadian and Japanese markets demonstrated a marginal relation. By comparing the conventional and Islamic stock markets, Hassan et al (2021) found that COVID-19 pandemic had established identical volatility in both Islamic and conventional markets, whereas both markets were strongly correlated and move in the same manner during the pandemic period. However, unlike previous findings, Insaïdoo et al. (2021) found that COVID-19 pandemic had no significant impact on the Ghana stock returns but it raised in the volatility of the Ghana stock returns. With that, the stock markets are likely to be negatively impacted by the COVID-19 pandemic as most investors will panic and react conservatively during that period.

A similar impact was also observed in the cryptocurrencies markets as most studies revealed that the COVID-19 pandemic had a significant impact on the cryptocurrency market in different research contexts. For example, Corbet et al (2020) found that Bitcoin did not react as an effective hedge or safe-haven benefit for the Chinese stock markets as the dynamic correlation was increased during the COVID-19 pandemic. Conlon and McGee (2020) concluded that the safe-haven characteristic was not offered by Bitcoin on the stock market in the COVID-19 pandemic period because they were moving in the same direction, and thus it could increase the portfolio risk. Conlon et al (2020) also revealed that Bitcoin and Ethereum did not provide the safe-haven property for most of the international stock markets as they would increase the downside risk on the portfolio. However, Tether could be a safe-haven destination for international stock markets.

Nevertheless, Corbet et al (2020) found that the large cryptocurrencies recorded a significant increase in the return and transaction volumes during the COVID-19 pandemic. Therefore, cryptocurrencies could provide an effective diversification benefit and also safe-haven characteristic during the pandemic period. Corbet et al (2021) found that cryptocurrencies were potential safe-haven instruments in the COVID-19 pandemic as liquidity was significantly improved after the declaration of COVID-19 pandemic as a worldwide pandemic. Similarly, Melki and Nefzi (2021) revealed that Ethereum could provide a strong safe-haven property on the commodity market in pre- and during the COVID-19 pandemic period. However, Bitcoin only displayed a strong safe-haven property for the commodity market in the COVID-19 pandemic period, while Ripple only showed a weak safe-haven characteristic for the foreign exchange market. In terms of return, Nguyen (2021) found that during the high uncertainty periods and during the COVID-19 pandemic, the return of Bitcoin was significantly affected by previous stock market returns. Besides, Mnif and Jarboui (2021) found that Bitcoin became less fractal but more efficient after the COVID-19 pandemic.

In Malaysia, different studies were conducted to examine the impact of COVID-19 pandemic on the financial markets. For example, Chia et al (2020) found that the daily new confirmed COVID-19 cases and deaths had an insignificant negative effect on the stock indices' returns, while the MCO had a significantly positive effect on the return of involved indices and foreign financial risks were adversely influenced on these returns. Lee et al. (2020a) found that the numbers of COVID-19 cases in Malaysia were likely to impact badly on the FBMKLCI index performance and all sectoral indices, except for the Real Estate Investment

Fund (REIT) index. The study also revealed that the Brent oil price and the volatility index were inclined to impact the Malaysian stock market performance. Besides, Lee et al. (2020b) also found that the majority of moving average rules could provide positive returns on banking stocks before the MCO and loan moratorium announcement dates. Therefore, the technical rules were an informative signal for an investment decision. Similar findings were also revealed by Lee and Jais (2021), whereas during the COVID-19 pandemic period, the moving average rule could provide a positive return in the Malaysian stock market.

Moreover, Ishak et al (2021) revealed that cyclical sectors, such as tourism, airlines, restaurants and transportation were impacted by the COVID-19 pandemic due to fear of society on the transmission of the virus during transaction with these companies. Meanwhile the non-cyclical industries, such as manufacturing, healthcare, and telecommunications could perform positive abnormal returns, as more transactions were shifted into the online medium. Furthermore, by using cross-countries data, Mubarok and Al-Arif (2021) further found that all Islamic indexes tended to decline because the COVID-19 pandemic inclined to impact current and future economic performances. Therefore, it is expected that the COVID-19 pandemic could significantly affect the financial markets, no matter from the different context of studies, as reviewed in the previous section.

Methodology

In this study, five largest cryptocurrencies, except Tether, were selected to examine the co-movement with FBMKLCI and MYRUSD. These five cryptocurrencies are Bitcoin, Ethereum, Binance, Cardano, and Ripple. The daily frequency dataset was spanned from May 2013 to July 2021 for Bitcoin, FBMKLCI, and MYRUSD, while other cryptocurrencies were assessed from their inception date until July 2021. The full dataset was divided into two sub-periods to separate the before and during COVID-19 pandemic. As the first positive COVID-19 case in Malaysia was declared on 25 January 2020 (Shah et al. 2020), therefore, the period before 28 January 2020 was categorised as before the COVID-19 period while starting on 28 January 2020 until July 2021 was categorised as the during COVID-19 period. The dataset of the study including the price of cryptocurrencies, FBMKLCI and MYRUSD, were downloaded from the websites of coinmarketcap.com and investing.com, respectively. However, due to the incomplete dataset on the website, Tether was excluded from this study and was replaced with Ripple, which is ranked as the sixth-largest cryptocurrency. According to coinmarketcap.com, the total market capitalisation of the cryptocurrencies was \$1,931.2 billion as of 18 August 2021. These five selected cryptocurrencies were accounted for approximately 73% of the overall cryptocurrencies market. The collected dataset for cryptocurrencies was then harmonised with the datasets of FBMKLCI and MYRUSD as the trading period of these two assets was only limited to weekdays. Therefore, the cryptocurrencies data for weekends were excluded to ensure the consistency of the datasets between cryptocurrencies and FBMKLCI and MYRUSD, and this was followed by the works of Klein et al. (2018) and Smales (2019). The daily returns of the dataset were calculated by using the capital gain yield formula $(R_t = \frac{(P_t - P_{t-1})}{P_{t-1}})$, where R_t is the daily returns of cryptocurrencies, FBMKLCI, and MYRUSD series at time t ; and P_t and P_{t-1} are the closing prices/rates of the series at time t and $t-1$, respectively.

The dynamic conditional correlation of multivariate GARCH estimation (MGARCH-DCC) was utilised to examine the time-varying pairwise conditional correlation or co-movement between the return series of the selected cryptocurrencies together with FBMKLCI

and MYRUSD. MGARCH-DCC could provide a robust correlation series on the changes of the conditional correlation between two return series throughout the study period, as compared to conventional correlation, which only provided a correlation value for the entire study period. Moreover, MGARCH-DCC also provided the positive or negative direction together with the degree of correlation between two return series (Saiti and Noordin 2018). The complementation or substitution of correlation for the two return series could also be determined by using this method (Abdullah et al. 2016). In the estimation of MGARCH-DCC, the standard residuals of the return series were first estimated by using the univariate GARCH method, and this standard residual was used to calculate the time-varying conditional correlation by using the equation of $H_t = D_t R_t D_t$, where H_t is the multivariate conditional covariance, D_t is the conditional time-varying standardised residuals (ε_t), and R_t is the time-varying correlation matrix. Additionally, the MGARCH-DCC model can be characterised as $Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha \varepsilon_{t-1}\varepsilon_{t-1}' + \beta Q_{t-1}$, where Q_t represents the time-varying conditional correlation of standardised residuals, \bar{Q} represents the unconditional correlation of $\varepsilon_{t-1}\varepsilon_{t-1}'$, and α and β represent the non-negative parameters of $\alpha + \beta < 1$. Lastly, the DCC linking the selected cryptocurrencies (i^{th}) and FBMKLCI and MYRUSD (j^{th}) is estimated using the equation of $p_{ij,t} = \frac{q_{ij,t}}{(\sqrt{q_{ii,t}}\sqrt{q_{jj,t}})}$, where q_{ij} represents the elements of the i^{th} and j^{th} columns on the matrix Q_t . After the conditional correlation or co-movement of the assets were obtained from MGARCH-DCC, the independence t-test and non-parametric Mann-Whitney U test were adopted to examine the differences between pre-COVID-19 and during the COVID-19 period.

Results and Discussions

The descriptive statistics of the involved return series is presented in Table 1 and it is divided into three panels. Panel A showed the mean and standard deviation of the return series for the full study period, while Panel B and Panel C provided the mean and standard deviation for the period before COVID-19 pandemic and during the COVID-19 pandemic. As shown in Panel A, all five selected cryptocurrencies can provide a positive daily return, whereby Binance was found to be the most profitable cryptocurrency with an average daily return of 0.96% and Bitcoin recorded the lowest average daily return (0.35%) during the study period. However, negative daily return was reported for FBMKLCI and MYRUSD with -0.0045% and -0.0156%, respectively. By comparing the average daily return between the period before COVID-19 pandemic and during COVID-19, it showed that Bitcoin, Ethereum, and Cardano generated higher average daily returns during the COVID-19 period, while the average daily returns of Binance and Ripple were reduced during the COVID-19 pandemic. As affected by the COVID-19 pandemic, the average daily returns for FBMKLCI also decreased, while the negative average daily returns of the MYRUSD was improved. In terms of the standard deviation, Cardano, Binance, and Ripple were the three risky cryptocurrencies for the full study period and before and during COVID-19 pandemic period.

Table 1. Descriptive Statistics

	Full Period		Before COVID-19		During COVID-19	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Bitcoin	0.3455	4.6059	0.3141	4.5988	0.4852	4.6410
Ethereum	0.5478	6.6456	0.5314	6.8724	0.5959	5.9396
Binance	0.9559	8.1171	1.0505	8.3193	0.8008	7.7828
Cardano	0.4634	8.7822	0.3294	9.7731	0.6675	7.0189
Ripple	0.5858	7.9629	0.6048	8.0170	0.5043	7.7375
FBMKLCI	-0.0045	0.6852	-0.0037	0.5632	-0.0080	1.0722
MYRUSD	-0.0156	0.4142	-0.0169	0.4365	-0.0094	0.2959

Table 2 presents the unconditional volatilities of each return series and unconditional correlation between the selected cryptocurrencies and FBMKLCI or MYRUSD. Amongst all return series, Cardano had the highest volatilities (8.7530), followed by Ripple (7.9753) and Binance (7.5399), while FBMKLCI and MYRUSD reported the lowest unconditional volatilities (0.6818 and 0.4119, respectively). Panel A in Table 2 also demonstrated the unconditional correlation between cryptocurrencies and FBMKLCI and it showed that Bitcoin, Ethereum, and Ripple had a negative unconditional correlation with FBMKLCI, which indicated that these three cryptocurrencies could be an effective hedge instrument for FBMKLCI. Meanwhile, Cardano and Binance had a positive unconditional correlation with FBMKLCI. Besides, the unconditional correlation of the cryptocurrencies and MYRUSD in Panel B showed that only Ethereum possessed the hedging characteristic over MYRUSD, as it was the only cryptocurrency that had a negative unconditional correlation with MYRUSD while the other four cryptocurrencies had a positive unconditional correlation with MYRUSD.

Table 2. Unconditional Correlation and Volatilities

	FBMKLCI	MYRUSD	Unconditional Volatility
Bitcoin	-0.0098	0.0026	4.6256
Ethereum	-0.0085	-0.0069	6.3595
Binance	0.0206	0.0389	7.5399
Cardano	0.0308	0.0447	8.7530
Ripple	-0.0088	0.0286	7.9753
Unconditional Volatility	0.6818	0.4119	

Figure 1 and Figure 2 illustrate the time-varying conditional correlation or co-movement between the five selected cryptocurrencies with FBMKLCI and MYRUSD, respectively. In Figure 1, the conditional correlation or co-movement of the cryptocurrencies and FBMKLCI showed that the cryptocurrencies tended to have a negative co-movement with FBMKLCI during early period, especially for Bitcoin, Ripple, and Ethereum, while Cardano and Binance showed a positive co-movement with FBMKLCI since their inception. All five cryptocurrencies possessed a greater correlation with FBMKLCI in 2018, especially after the 14th general election in May 2018, whereby the Bitcoin start turned to positively correlated with FBMKLCI. However, the correlation of the five cryptocurrencies reached its peak in November 2018 and fell after that, whereas Bitcoin, Ripple, and Ethereum turned negative in January 2019. The co-movement of all five cryptocurrencies and FBMKLCI was enhanced after the COVID-19 pandemic outbreak, which started in January 2020, whereas, the first

confirmed cases were declared on 25 January 2020. The co-movement of these cryptocurrencies and FBMKLCI continued to increase after that but began to fall in November 2020; Ripple and Ethereum turned negative in April 2021 but reversed to positive again in May 2021. Therefore, Figure 1 shows that the co-movement of the five selected cryptocurrencies and FBMKLCI was greatly improved during the early COVID-19 pandemic period, especially for Bitcoin and Ripple, which had a negative correlation before the pandemic, but the movement was reduced after November 2020. This provided an intuition that the cryptocurrencies might not be a better investment choice to hedge the stock market investment in the pandemic period as the co-movement between them was greatly improved in the pandemic period.

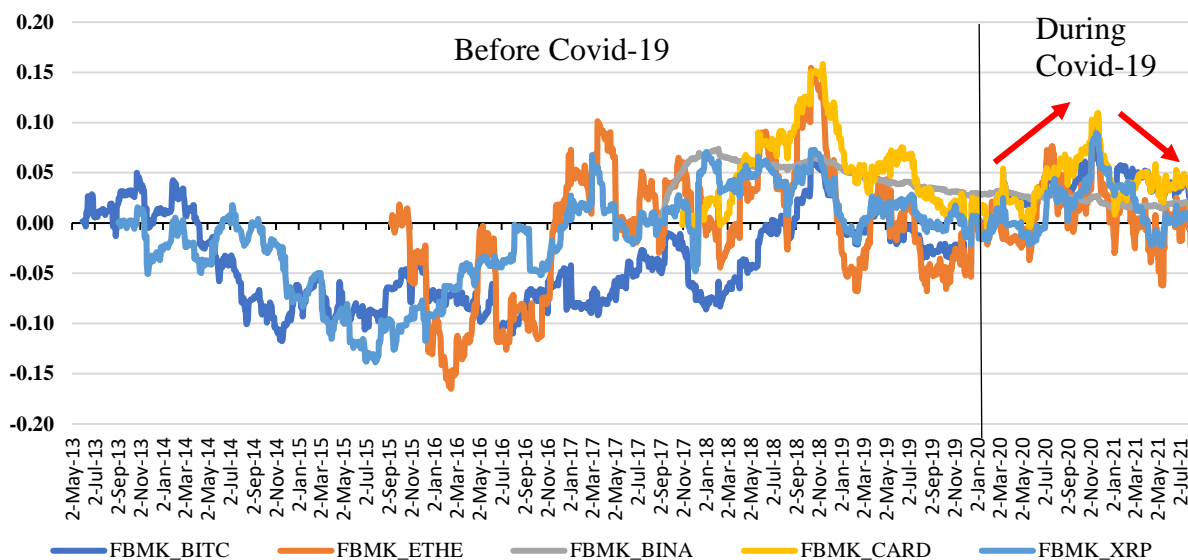


Figure 1. Conditional Correlation between Cryptocurrencies and FBMKLCI

Figure 2 shows the time-varying conditional correlation of the five selected cryptocurrencies and MYRUSD. Unlike Figure 1, Ripple showed a positive co-movement with MYRUSD since its inception. However, Ethereum had the most volatile conditional correlation with MYRUSD as it had a negative co-movement at the beginning period and turned to positive after March 2017. But, again changed to negative in March 2018 and turned to positive in August 2018 before it reversed to negative co-movement together with the other four cryptocurrencies in May 2019. Bitcoin also showed a negative co-movement with MYRUSD for most of the period, except for a short period from September 2018 until March 2019. Same as Cardano, whereby it also had a positive co-movement with MYRUSD since its inception except for May 2019 until November 2019. Interestingly, Binance did not show a similar trend with other cryptocurrencies as it had a stable and consistent positive co-movement with MYRUSD throughout the period. In general, Figure 2 shows that all cryptocurrencies moved in a similar co-movement except for Binance, especially those which started from November 2018 to July 2021. The co-movement between the selected cryptocurrencies and MYRUSD was greatly improved after the COVID-19 pandemic outbreak, except for Binance, which remained a stable trend. Therefore, the cryptocurrencies might not react as an ideal instrument that could be used to hedge foreign exchange investment.

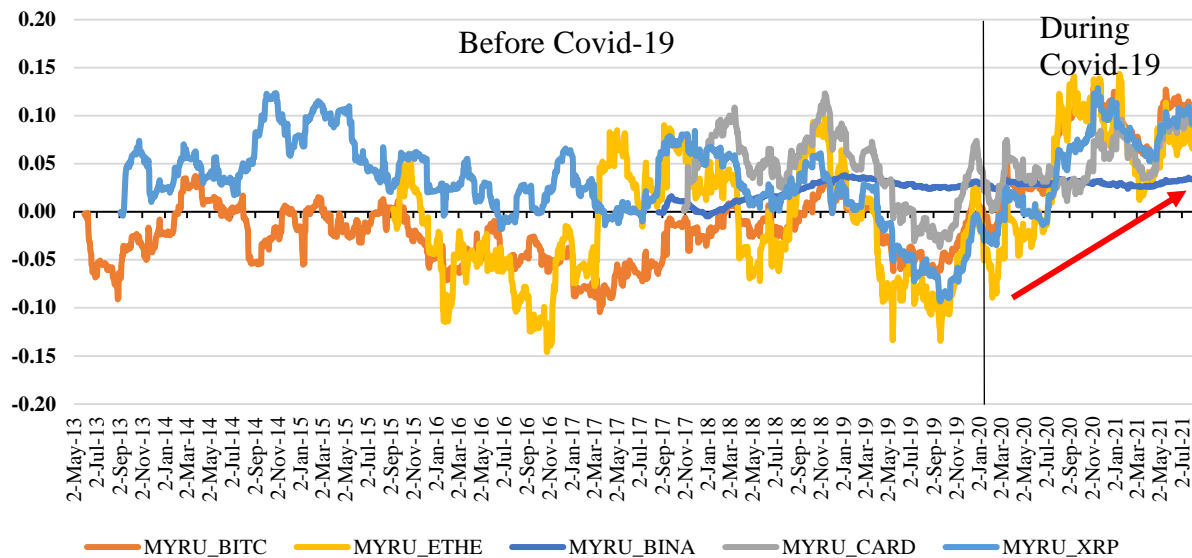


Figure 2. Conditional Correlation between Cryptocurrencies and MYRUSD

Table 3 presents the descriptive statistics of the conditional correlation of these return series, to provide a clear picture of the movement on the conditional correlation between the five selected cryptocurrencies and FBMKLCI and MYRUSD, especially before the COVID-19 pandemic and during the COVID-19 pandemic period. The table showed that Bitcoin, Ethereum, and Ripple had a negative average daily conditional correlation with FBMKLCI and the average daily conditional correlation turned to positive in the COVID-19 pandemic period. However, the average daily conditional correlation of Binance and Cardano was reduced in the COVID-19 pandemic period, which was from 0.0484 and 0.0521 to 0.0226 and 0.0407, respectively. This indicated that the conditional correlation of Binance and Cardano was weak in the COVID-19 pandemic period, but the correlation was strengthened for Bitcoin, Ethereum, and Ripple in the same COVID-19 pandemic period.

A similar scenario was also observed from the conditional correlation between the cryptocurrencies and MYRUSD, whereby the average daily conditional correlation of the cryptocurrencies and MYRUSD was strengthened in the COVID-19 pandemic period. Unlike FBMKLCI, only Bitcoin (-0.0260) and Ethereum (-0.0185) had a negative average daily conditional correlation with MYRUSD in the period before COVID-19, while the other three cryptocurrencies had a positive average daily conditional correlation before COVID-19. However, the average daily conditional correlation of all five cryptocurrencies and MYRUSD was stronger in the COVID-19 pandemic period. Therefore, this implied that the conditional correlation of the cryptocurrencies and MYRUSD was improved during the COVID-19 pandemic period.

Table 3. Conditional Correlation before and during COVID-19 pandemic

	Before COVID-19			During COVID-19		
	Mean	Min.	Max.	Mean	Min.	Max.
Cryptocurrencies and FBMKLCI						
Bitcoin	-0.0400	-0.1177	0.0621	0.0350	-0.0137	0.0757
Ethereum	-0.0076	-0.1651	0.1544	0.0115	-0.0622	0.1030
Binance	0.0484	0.0012	0.0740	0.0226	0.0144	0.0347
Cardano	0.0521	-0.0306	0.1584	0.0407	-0.0055	0.1097
Ripple	-0.0163	-0.1387	0.0727	0.0155	-0.0226	0.0894
Cryptocurrencies and MYRUSD						
Bitcoin	-0.0260	-0.1044	0.0398	0.0708	-0.0275	0.1322
Ethereum	-0.0185	-0.1458	0.0973	0.0477	-0.0893	0.1436
Binance	0.0212	-0.0049	0.0381	0.0296	0.0236	0.0355
Cardano	0.0431	-0.0367	0.1231	0.0518	0.0007	0.1072
Ripple	0.0296	-0.0933	0.1234	0.0550	-0.0347	0.1290

Notes: Max. represents the maximum value and Min. represents the minimum value.

Figure 1 and Figure 2 together with Table 3 demonstrated that the co-movement of the cryptocurrencies with FBMKLCI and MYRUSD was likely strengthened during the COVID-19 pandemic period. The independence t-test and non-parametric Mann-Whitney U test were further utilised to examine the significant differences of the co-movement of cryptocurrencies with FBMKLCI and MYRUSD before and during the COVID-19 pandemic period and results are shown in Table 4. Panel A showed that the co-movement of all five cryptocurrencies with FBMKLCI before the COVID-19 pandemic period had a significant difference during the COVID-19 pandemic period. This proved that COVID-19 pandemic had significantly impacted the co-movement of cryptocurrencies and FBMKLCI, but in a different direction. Specifically, the COVID-19 pandemic strengthened the co-movement of Bitcoin, Ethereum, and Ripple with FBMKLCI, while the COVID-19 pandemic significantly weakened the co-movement between Binance and Cardano with FBMKLCI. Therefore, this result suggested that the stock market investment can only be hedged by investing in Binance and Cardano in the pandemic period as the co-movement was reduced during the period. The findings of Bitcoin, Ethereum, and Ripple were consistent with Corbet et al (2020), Conlon et al (2020), and Conlon and McGee (2020) who also found a similar property on cryptocurrencies.

In the foreign exchange market, the co-movement between all five cryptocurrencies with MYRUSD was strengthened after the COVID-19 pandemic period, as the independent t-test and Mann-Whitney U test showed significant results. This indicated that the hedging and/or safe-haven characteristics on foreign exchange investment were not provided by all five cryptocurrencies in the pandemic period and this supported earlier studies that also found similar findings in another context, such as Corbet et al (2020); Conlon et al (2020); and Conlon and McGee (2020). However, the findings were not consistent with Corbet et al. (2020); Corbet et al (2021), who concluded that cryptocurrencies could be a safe-haven destination for the other financial instruments in the pandemic period. Overall, the results provided robust evidence on the impact of COVID-19 pandemic on the co-movement between the five selected cryptocurrencies with FBMKLCI and MYRUSD as the co-movement of these series was significantly different as between the period before and during the COVID-

19 pandemic, although a different direction was observed for Binance and Cardano with FBMKLCI.

Table 4. Comparison before and during COVID-19 by using independence t-test

	Before COVID-19	During COVID-19	Independence t-test		Mann-Whitney U Test	
	Mean	Mean	Mean Diff.	Sig.	Sig.	Note
Cryptocurrencies and FBMKLCI						
Bitcoin	-0.0400	0.0350	-0.0750	0.0000	0.0000	Sig. Diff
Ethereum	-0.0076	0.0115	-0.0191	0.0000	0.0000	Sig. Diff
Binance	0.0484	0.0226	0.0258	0.0000	0.0000	Sig. Diff
Cardano	0.0521	0.0407	0.0114	0.0000	0.0190	Sig. Diff
Ripple	-0.0163	0.0155	-0.0318	0.0000	0.0000	Sig. Diff
Cryptocurrencies and MYRUSD						
Bitcoin	-0.0260	0.0708	-0.0968	0.0000	0.0000	Sig. Diff
Ethereum	-0.0185	0.0477	-0.0662	0.0000	0.0000	Sig. Diff
Binance	0.0212	0.0296	-0.0083	0.0000	0.0000	Sig. Diff
Cardano	0.0431	0.0518	-0.0087	0.0000	0.0000	Sig. Diff
Ripple	0.0296	0.0550	-0.0254	0.0000	0.0000	Sig. Diff

Notes: Mean Diff. represents the mean differences, Sig. represents the p-value and Sig. Diff represents a significant difference.

Conclusions and Implications

This study was conducted to examine the impact of COVID-19 pandemic on the co-movement between five selected cryptocurrencies with the Malaysian stock index, FBMKLCI and currency rate of MYRUSD. The findings of the study showed that COVID-19 had a significant impact on the co-movement of the return series between cryptocurrencies with FBMKLCI and also MYRUSD as the co-movement of these return series during the COVID-19 pandemic period was significantly different from the co-movement before the pandemic. The COVID-19 pandemic strengthened the co-movement of these series as the conditional correlation was improved in the pandemic period, except for Binance and Cardano with FBMKLCI, whereby the conditional correlation was reduced during the pandemic period. These findings suggested that the cryptocurrencies were not an effective hedging instrument during the COVID-19 pandemic period because the conditional correlation was increased during this period. However, both Binance and Cardano showed opposite findings, whereby both cryptocurrencies may provide marginal hedging or safe-haven features for the Malaysian stock market.

The findings provided important implications to relevant parties, such as investors and fund managers as the cryptocurrencies were not an effective instrument for them to hedge the stock market risk and foreign exchange investment in the COVID-19 pandemic period. Therefore, they should find other financial instruments that provide a better hedging characteristic over the stock market and foreign exchange investment during the pandemic period. However, investors and fund managers could invest in Binance and Cardano to hedge their stock market investment during the COVID-19 pandemic period as the co-movement of these two cryptocurrencies significantly reduced during this pandemic period. Lastly, market

regulators and authorities should be alert with these findings as the relevant policy and rules should be introduced to establish a more sustainable investment environment for all parties.

Some limitations existed in this study. This study only employed MGARCH-DCC to examine the time-varying conditional correlation between the cryptocurrencies with stock market index and foreign exchange rate in Malaysia. Therefore, future studies are suggested to adopt other time-series econometric methods to better examine the property of hedge and/or safe-haven of the cryptocurrency. Besides, the author(s) could also include other financial instruments like commodity prices to provide more comprehensive results on the co-movement between the cryptocurrencies on other financial instruments during the COVID-19 pandemic period. Moreover, the inclusion of more developing markets or comparing developed and developing markets in the study could also provide more robust results as COVID-19 pandemic may impact the co-movement differently.

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