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Co-Movement between Bitcoin and Stock Indices in ASEAN-5 Markets

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Abstract

Cryptocurrencies are one of the new financial assets that might provide some hedge, safe havens and diversification benefits towards traditional financial assets. However, the impact of COVID-19 towards their properties was also acknowledged in the literature and showed that COVID-19 significantly changed their properties against other financial assets. However, the comparison of the co-movement for the cryptocurrency and financial assets in the three different periods (pre-COVID-19, during COVID-19, and post-COVID-19) is relatively limited. Therefore, this study aimed to study the differences in the co-movement between Bitcoin and stock indices in ASEAN-5 markets in these three periods. The study period spanned from early January 2018 until the end of June 2024, and the conditional correlation was obtained through the MGARCH-DCC approach. These conditional correlation series were then divided into three periods, and statistically compared their statistical differences using an independent t-test. The results found that the co-movement between Bitcoin and market indices was significantly different between pre-COVID-19 and during COVID-19 in all ASEAN-5 markets. Besides, when comparing pre-COVID-19 and post-COVID-19, the result showed that the co-movement between Bitcoin and market indices in Malaysia and Thailand was significantly reduced, while significantly enhanced between Bitcoin and market indices in Indonesia and the Philippines markets. Moreover, the results further revealed the significant differences between the co-movement of Bitcoin and market indices in Malaysia, Singapore and Thailand markets. Some useful implications were obtained from the study's findings, and it is expected to be beneficial to the literature and also to stakeholders.

Keywords: Co-Movement, COVID-19, Bitcoin, Stock Indices, ASEAN-5 Markets

Introduction

Cryptocurrency is a digital currency that was first introduced by Satoshi Nakamoto (2008) and operates based on the cryptographic technique. As remarked by Chan, Chu, Nadarajah, and Osterrieder (2017), greater liquidity and lower costs were some of the advantages of the cryptographic technique. Since its inception, cryptocurrency has not only reacted as a digital currency but it has also been perceived as an investable financial instrument due to its greater volatility and bubbles (Cheah & Fry, 2015). Cryptocurrencies consist of some special features over other financial assets like stocks, foreign exchange rates, commodities, and the like (Troster, Tiwari, Shahbaz, & Macedo, 2019), and this further suggests that cryptocurrencies might offer some hedges, safe havens, and diversification properties against these traditional financial assets. The hedge, safe havens and diversification benefits of cryptocurrencies offered have been widely

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acknowledged in the literature (Abdullah, Abdul Wahab, Ghazali, Yaacob, & Mohammed Masih, 2022; Ali, Khurram, Sensoy, & Vo, 2024; Naeem, Sehrish, & Costa, 2021; Kumah, Odei-Mensah, Amanamah, 2022; Nkrumah-Boadu, Junior, Adam, & Asafo-Adjei, 2022; Tan, Ling, Sim, & Lee, 2023), as this showed that investing in cryptocurrencies could help investors to minimal their investment risks. Therefore, these studies proved that cryptocurrencies might offer some different characteristics than traditional financial assets, and they could be considered as investable instruments for investors in establishing well-diversified investment portfolios.

The studies on cryptocurrencies have received great attention since their inception. These studies mainly discovered the cryptocurrencies properties from different perspective, such as efficiency of the cryptocurrency market (Caporale, Gil-Alana, & Plastun, 2018; Kristoufek, 2018; Nadarajah & Chu, 2017; Urquhart, 2016), market anomalies of the cryptocurrency market (Aharon & Qadan, 2019; Mbanga, 2019), hedge, safe havens and diversification properties of the cryptocurrencies against other financial assets (Dyhrberg, 2016; Gajardo, Kristjanpoller, & Minutolo, 2018; Husain, Yii, & Lee, 2023; Tan et al., 2023; Thampanya, Nasir, & Huynh, 2020), and others. Recently, quite some studies have evaluated how COVID-19 affected the cryptocurrency market (Abdelmalek, 2023; Goodell & Goutte, 2021; Ling, 2021). However, most of these studies mainly investigated the effect of COVID-19 by comparing before-COVID-19 and during-COVID-19. For example, Ling (2021) found significant changes in the co-movement between cryptocurrencies with the market index and foreign exchange rate in Malaysia, by comparing before-COVID-19 and during COVID-19. The diversification capabilities of cryptocurrencies before and during the COVID-19 pandemic were also examined by Abdelmalek (2023). Regrettably, the comparison of the co-movement between the cryptocurrencies and traditional financial assets for the post-COVID-19 period is still underexplored. This signified that relatively scarce studies have been conducted in examining the co-movement of cryptocurrencies and financial assets by comparing pre-COVID-19, during COVID-19, and post-COVID-19. Moreover, the evidence of the connections between cryptocurrencies and traditional financial assets is still inconclusive, as mixed findings are still documented in the literature. Therefore, further study is required to better understand this subject matter, as the financial markets tend to show diverse characteristics and movements during the post-COVID-19 and hence it is important for investors to recover their previous losses by re-adjusting their investment portfolio.

Due to the research problems above, the main objective of the study is to examine the co-movement between Bitcoin and stock indices in ASEAN-5 markets by statistically comparing the differences within three periods, namely pre-, during, and post-COVID-19. ASEAN-5 markets are chosen as Bitcoin is one of the most commonly used hedging instruments for the ASEAN-5 markets (Adjani & Husodo, 2023). Through the study, the findings are expected to make some contributions to the existing knowledge and also offer some important practical implications for stakeholders, such as market regulators, fund management companies, professional fund managers, and retail investors. Firstly, this study provided evidence regarding the influence of COVID-19 on the co-movement between cryptocurrencies and financial assets in three different periods, and this would further enrich the literature, as very limited evidence was discovered in this area. Besides, the study also extends the literature by offering empirical evidence on changes in the linkages between cryptocurrencies and financial assets from the ASEAN-5 markets, due to COVID-19. Moreover, the relevant stakeholders would benefit from the study's findings as well

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as the study's findings might be useful for them in reallocating their investment portfolio to obtain optimal returns, especially during market downturn.

Literature Review

The study on the co-movement between financial assets has been extensively examined in different studies. The co-movement between financial assets could be used to understand the relationships between the time-series pairwise correlation, and it was superior to the conventional correlation analysis, which only produces a correlation coefficient for a certain period. Therefore, the time-varying co-movement between the financial assets is widely used to determine the hedging, safe-haven and diversification properties between the financial assets. As defined by Baur and Lucey (2010), the financial assets could offer hedging (diversification) properties toward another asset if they are positively (negatively) related in the normal period. However, if the financial assets are negatively correlated during the period of crisis, this signifies that they provided a safe haven benefit to each other. Based on these definitions, cryptocurrencies are expected to offer a hedging (or diversification) effect when they have positive (negative) co-movement with the stock markets in the pre- and post-COVID-19 periods, while providing a safe haven property when correlated negatively during the COVID-19 period.

To date, abundant studies have been carried out regarding cryptocurrencies. These studies range from the efficiency of cryptocurrencies to the hedge, safe-haven and diversification benefits of cryptocurrencies towards traditional financial assets. For instance, the efficiency of Bitcoin was first investigated by Urquhart (2016), who found the inefficiency of Bitcoin. However, the efficient property of Bitcoin was then revealed by Nadarajah and Chu (2017). Kristoufek (2018) further remarked on the inefficiency of Bitcoin in both USD and CNY currencies. Caporale, Gil-Alana and Plastun (2018) confirmed the inefficiency of the cryptocurrency market. The market anomalies effect was also investigated by Aharon and Qadan (2019) and Mbanga (2019), but documented inconclusive results. Aharon and Qadan (2019) found a day-of-the-week effect on Bitcoin returns and volatility, while Mbanga (2019) found no weekend effect in Bitcoin price clustering.

Besides, the relationships between these cryptocurrencies with traditional financial assets have also been studied in the literature. For example, Dyhrberg (2016) has studied the volatility of Bitcoin with gold and the dollar. Their study found that Bitcoin is similar to gold and the dollar, and further indicated that the hedging capabilities of both Bitcoin and gold are alike and react correspondingly to positive and negative shocks. Ji, Bouri, Gupta, and Roubaud (2018) also reported the isolation of Bitcoin from the contemporaneous analysis. Moreover, Gajardo et al. (2018) further found that Bitcoin is more influenced by gold than stock indices, and this suggests that Bitcoin is different from commodities and stock indices.

The hedge, safe-haven and diversification abilities of cryptocurrencies over other financial assets continue to receive great attention in academia. Thampanya et al. (2020) found that Bitcoin does not provide hedge and safe haven benefits for the Thailand stock market, but the low correlation coefficient between them may signify that Bitcoin could offer some diversification benefits. Likewise, Husain et al. (2023) also revealed the findings of the absence of hedge and safe haven capability of green cryptocurrencies compared to conventional assets. However, the hedging effect of Bitcoin against the conventional and Islamic stock indices was further remarked by Naeem et al. (2021). Similarly, Kumah et al. (2022) also remarked on the hedging ability of Bitcoin

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toward the stock price in Ghana, Morocco, and Egypt, but in different investment periods. Tan et al. (2023) also concluded that Bitcoin, Litecoin and Ethereum possess strong hedge benefits on most of the East Asia-5 markets. Contrastively, the weak hedge capabilities of Bitcoin over the MSCI Emerging Market Index are also documented by Chopra and Mehta (2022). The similar weak hedge ability of cryptocurrency was also revealed in the Indian stock market by Majumder (2022), and also in the world conventional stock market by Bahloul, Mroua, and Naifar (2022). Additionally, Naeem et al. (2021) also found that Bitcoin is not a good safe haven for stock markets during the economic crisis. However, Nkrumah-Boadu et al. (2022) remarked on the safe haven benefits of Bitcoin in the Ghana market, especially during 2019 and 2020. Regarding the diversification property, the diversification benefits of Bitcoin against the Australian stock indices are revealed by Abdullah et al. (2022). Ali et al. (2024) also found the diversification property of green cryptocurrencies, especially for Cardano and Tezos.

Recently, due to the outbreak of COVID-19, some studies have also examined the impact of COVID-19 on cryptocurrencies and traditional asset instruments. For example, Ling (2021) found that COVID-19 significantly changed the co-movement of cryptocurrencies and financial assets in Malaysia. Goodell and Goutte (2021) revealed that the co-movements between cryptocurrencies and selected equity indices gradually increased as COVID-19 progressed. However, the finding also found that selected cryptocurrencies don't offer diversification property during normal periods and market turmoil. Similarly, Maitra, Rehman, Dash, and Kang (2022) remarked on the negative effect of the optimal investment portfolio by including cryptocurrencies during the COVID-19 period, although these cryptocurrencies offer diversification effects in portfolios during the normal period. A contrasting finding was reported by Abdelmalek (2023), whereas cryptocurrencies offer diversification property during COVID-19 and suggesting including cryptocurrencies in well-diversified investment portfolios would generate better performance. Furthermore, the diverse findings were found by Jana and Sahu (2024) as Bitcoin, Ethereum, and Cardano don't play as good safe havens or diversifiers in the Indian market during economic downturn.

Thus, these empirical studies provided some inconclusive findings about cryptocurrencies relative to traditional financial assets, especially in terms of their hedge, safe havens and diversification properties. Also, the influence of COVID-19 towards the co-movement between cryptocurrencies such as Bitcoin and traditional assets like stock indices is relatively limited, specifically focusing on the three periods (pre-COVID-19, during COVID-19, and post-COVID-19).

Methodology

The study employed quantitative secondary time series data to examine the study's objective. Bitcoin was selected as the representative for the cryptocurrencies as it has the highest market capitalisation ($1.26 trillion) as of 19 July 2024, which is approximately 53.62% of the global cryptocurrency market. Besides, the stock indices from the ASEAN-5 markets, consisting of Malaysia (KLCI), Singapore (STI), Thailand (SET), Indonesia (JKSE), and the Philippines (PSEi) also selected to achieve the study's objective. As remarked by Adjani and Husodo (2022), Bitcoin is widely used as the hedging asset for the ASEAN-5 markets in both short- and long-term. This further justified the selection of Bitcoin and also the stock indices from the ASEAN-5 markets for the study, as it is crucial to advance the knowledge in this subject area. The daily frequency data

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for all data series spanned from 1 January 2018 until 30 June 2024 were retrieved from https://finance.yahoo.com/. By referring to the World Health Organization (WHO), the proclamation of COVID-19 was on 11 March 2020, and the end is on 5 May 2023. The study period was further divided into three periods, namely pre-COVID-19 (1/1/2018 – 10/3/2020), during COVID-19 (11/3/2020 – 4/5/2023), and post-COVID-19 (5/5/2023 – 30/6/2024).

Table 1: Summary of the Data Series

	Pre-COVID-19	During COVID-19	Post-COVID-19	Overall Period
Study Period	1/1/2018 – 10/3/2020	11/3/2020 – 4/5/2023	5/5/2023 – 30/6/2024	1/1/2018 – 30/6/2024
	Observation	Observation	Observation	Observation
Malaysia	533 (514)	767	283	1564
Singapore	548 (529)	789	288	1606
Thailand	535 (516)	757	279	1552
Indonesia	533 (514)	765	270	1549
Philippines	532 (513)	771	282	1566

*Note: the number of observations in parentheses is the number of observations for calculated conditional volatility.
Source: Authors (2024)

The data series of Bitcoin was further harmonised with the stock indices series for the five involved market indices to ensure the consistency of the data series, by excluding the data for weekends and public holidays. Due to the different holidays celebrated in each market, therefore, the number of observations was different for all markets. Besides, due to the calculation requirement for the dynamic conditional correlation of multivariate GARCH estimation (MGARCH-DCC), the first 20 observations for each series were used to calculate the conditional volatility and correlation for the 20th observation. Hence, the number of observations will be less than its initial observations. The summary of the data series was provided in Table 1 above and showed that Singapore has to highest number of observations (1606) compared to other markets, while Indonesia has the lowest number of observations (1549). The daily returns of the data series were determined through the capital gain yield method.

To calculate the co-movement of the data series, the MGARCH-DCC was employed to measure the time-varying pairwise conditional correlation between the data series, especially for Bitcoin and also the stock indices. The equation below represents the MGARCH-DCC model that was used in the study.

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha\, \varepsilon_{t\_1}\acute{\varepsilon}_{t-1} + \beta Q_{t-1}$$

Q_t represents the time-varying conditional correlation, $\bar{Q}$ represents the unconditional correlation of $\varepsilon_{t\_1}\acute{\varepsilon}_{t-1}$, and α and β are the non-negative parameters of $\alpha + \beta < 1$.

As proved in previous studies (Ling, 2021), the robust correlation time-varying series could be generated through MGARCH-DCC for the entire study period. This provided a greater advantage compared to the conventional correlation, as only one correlation coefficient value will be provided for the entire study period. In addition, the direction (positive or negative) and the magnitude of the correlation between the pairwise series could be obtained through the MGARCH-DCC (Saiti & Noordin, 2018). In this study, the conditional volatility and correlation between

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Bitcoin and five market indices will be determined through the MGARCH-DCC method by using the Microfit software version 5.5. After the conditional correlation was obtained from MGARCH-DCC, it will be divided into three periods and labelled as pre-COVID-19, during COVID-19, and post-COVID-19. The conditional correlation of the data series was then tested using an independent t-test to investigate whether these conditional correlations were significantly different between the three periods.

Results and Discussions

Appendix A provides the result of the unit root test through the Augmented Dickey-Fuller (ADF) test for all data series for Bitcoin and stock indices in ASEAN-5 markets. As the results showed that, in the level data, all data series have a unit root as the p-value is greater than 0.05 significance level, except for PSEi at the intercept, but insignificant at the trend and intercept. Moreover, the findings show all the variables are significant at the 5% level, which means there is stationarity in first differences for all the variables. Therefore, it concluded that the data series is not stationary and it is adequate for subsequent analysis.

Table 2: Descriptive Statistics of the Data Series

	Pre-COVID-19		During COVID-19		Post-COVID-19	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Panel A: Malaysia						
Bitcoin	-0.000128	0.046192	0.002766	0.045623	0.003037	0.030127
KLCI	-0.000393	0.006333	0.000036	0.008955	0.000395	0.004418
Panel B: Singapore						
Bitcoin	-0.000129	0.045461	0.002678	0.044883	0.003013	0.030180
STI	-0.000317	0.008040	0.000233	0.010126	0.000085	0.005991
Panel C: Thailand						
Bitcoin	-0.000162	0.045914	0.002806	0.046026	0.003099	0.030958
SET	-0.000590	0.008583	0.000313	0.011369	-0.000564	0.007046
Panel D: Indonesia						
Bitcoin	-0.000160	0.045475	0.002813	0.046503	0.003218	0.031362
JKSE	-0.000320	0.009408	0.000417	0.011291	0.000139	0.006654
Panel E: Philippines						
Bitcoin	-0.000149	0.046381	0.002767	0.046063	0.003074	0.030426
PSEi	-0.000547	0.010888	0.000190	0.015218	-0.000110	0.008671

Source: Authors (2024)

Table 2 provides the descriptive statistics of the data series involved in the study, including the daily returns of Bitcoin and also the daily returns of the stock indices for the ASEAN-5 markets (KLCI, STI, SET, JKSE, and PSEi), in three periods. Generally, all data series have an average of negative daily returns in the pre-COVID-19 period, and the stock indices series have suffered larger losses compared to the Bitcoin series. Consistently, all data series, including Bitcoin and stock indices, have a relatively higher daily return during COVID-19, and the daily return of Bitcoin is higher compared to the stock indices. In post-COVID-19, the daily return of the Bitcoin series exceeded its return in the previous two periods, and this signified that Bitcoin was able to generate the highest daily return in post-COVID-19. However, among the ASEAN-5 markets, only KLCI produced higher daily returns compared to the previous two periods, while the remaining

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four market indices (STI, SET, JKSE, and PSEi) generated lower daily returns compared to during COVID-19, but the daily returns in post-COVID-19 are still higher than pre-COVID-19.

In terms of standard deviation, the result in Table 2 consistently showed that Bitcoin return series generally have higher standard deviation values compared to all ASEAN-5 market indices, no matter of which period. This showed that Bitcoin's daily return series is riskier than the market indices. The standard deviation during COVID-19 is the highest compared to pre-COVID-19 and post-COVID-19 in all data series. Interestingly, the standard deviation for post-COVID-19 is slightly lower than the pre-COVID-19, and this shows that the daily return of all data series is relatively riskier in pre-COVID-19, compared to post-COVID-19. This is against the concept of "risk-return trade-off", where the higher risk should be associated with the higher returns. These findings provided some vital implications for fund managers and retail investors as they could use this information in managing their investment risk to maximise their investment returns.

Table 3 presents the unconditional correlation and volatility of Bitcoin and the five stock indices. Among the five market indices, SET (0.120790) has the highest unconditional correlation with Bitcoin, followed by JKSE (0.065775) and STI (0.037512), while KLCI (0.030364) and PSEi (0.027191) have the least unconditional correlation with Bitcoin. Regarding the unconditional volatility, parallel with the standard deviation above, Bitcoin have the highest unconditional volatility compared to the five market indices. Besides, PSEi (0.012916) reported the highest unconditional volatility among the five market indices, followed by JKSE (0.010019), SET (0.009860), STI (0.008855), and KLCI (0.007504) have the lowest unconditional volatility.

Table 3: Unconditional Correlation and Volatilities

	KLCI	STI	SET	JKSE	PSEi
Bitcoin	0.030364	0.037512	0.120790	0.065775	0.027191
Unconditional Volatility	0.007504	0.008855	0.009860	0.010019	0.012916
Unconditional Volatility of Bitcoin	0.043080	0.042466	0.043309	0.043525	0.043429

Source: Authors (2024)

Figure 1 illustrates the co-movement of Bitcoin and the five market indices using the time-varying pairwise conditional correlation obtained from MGARCH-DCC.

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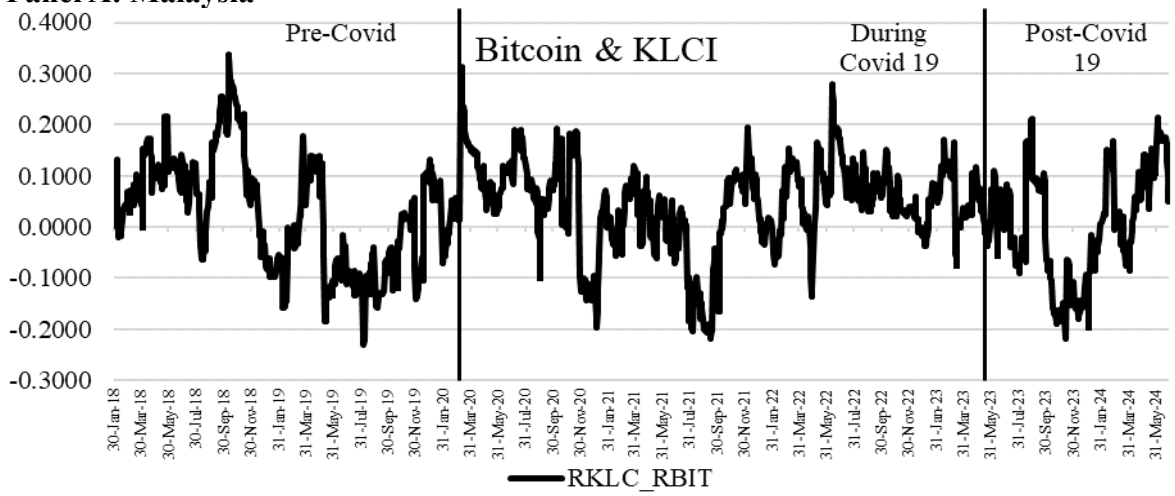
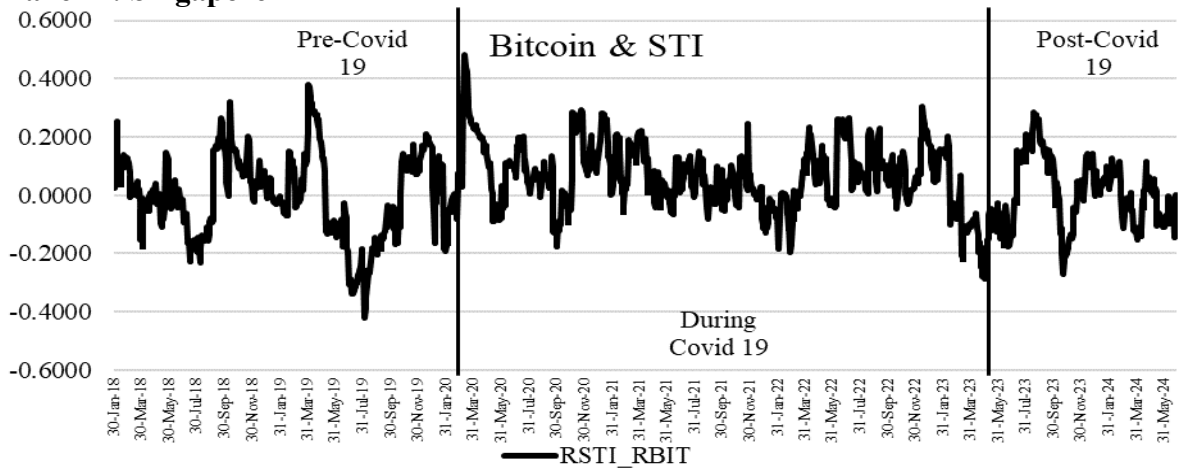
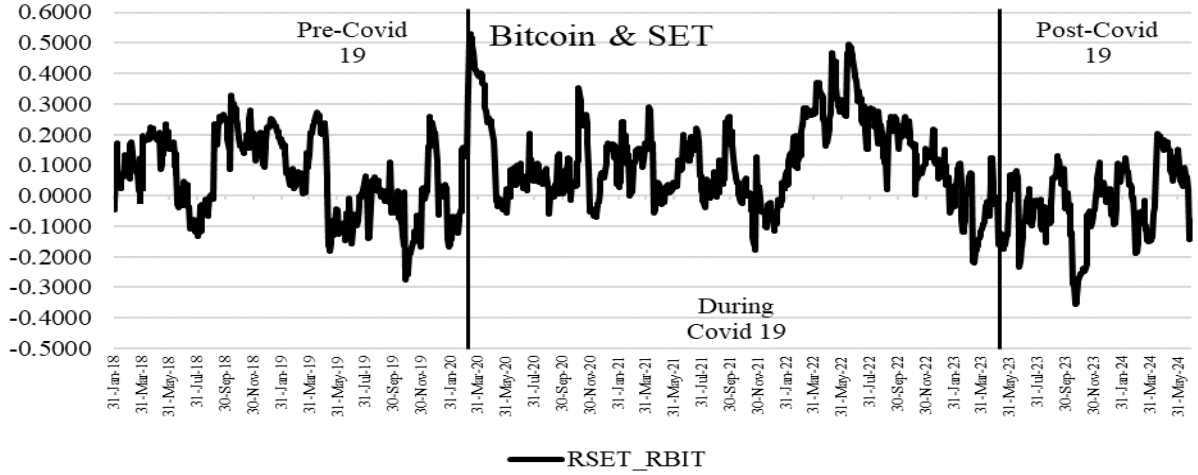
Panel A: Malaysia



Panel B: Singapore



Panel C: Thailand



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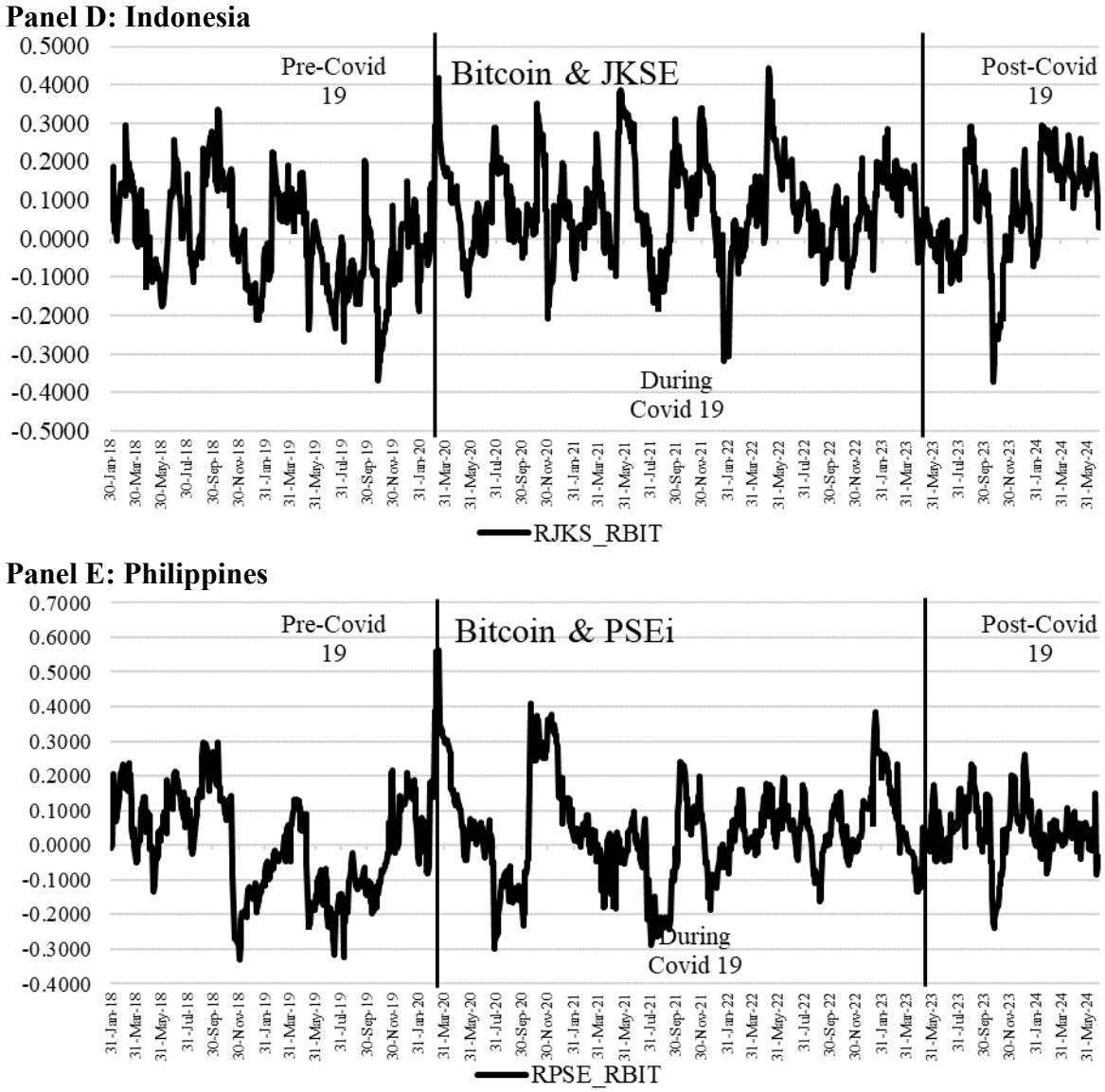

Figure 1: Conditional Correlations between Bitcoin and Stock Indices
Source: Authors (2024)

Generally, all five conditional correlations between Bitcoin and market indices tend to move in similar paths. For example, in pre-COVID-19, the co-movement of Bitcoin and five market indices tended to go high and then become low once it reached its peak. After that, the co-movement was reserved to increase before the proclamation of the COVID-19 pandemic on 10 March 2020, and it continued to go higher after 10 March 2020. However, the time-varying conditional correlation between Bitcoin and five market indices tends to fluctuate more during COVID-19 as it moves up and down more frequently. A few months before 5 May 2023, the co-movement of the five conditional correlation series started to decrease. However, as observed in Figure 2, the co-movement between Bitcoin and market indices went higher at the beginning of

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the post-COVID-19 period, and then it turned down again a few months later. Although all five conditional correlation series showed quite similar paths, however, dissimilar paths were observed in 2024, especially for Malaysia (KLCI), as the co-movement between Bitcoin and KLCI continued to increase at a higher level, while the other four co-movement series showed decreasing trends. Generally, the conditional correlation series in Figure 1 could provide some understanding regarding the co-movement between the Bitcoin return series and the return series for the five market indices, in the three periods.

The co-movement between Bitcoin and the stock indices of the ASEAN-5 markets is illustrated in Figure 1. However, it doesn't provide any statistical evidence regarding the comparison of the co-movement between the three periods. With this, the independent t-test was performed to statistically test the differences in the conditional correlation series for Bitcoin and market indices between the three periods. Table 4 presents the summary results of the independent t-test. Firstly, the result showed that the mean of the conditional correlation between Bitcoin and KLCI was highest during COVID-19 (0.045784), and this co-movement was lowest in post-COVID-19 (0.002203). A similar finding was also observed in the Thailand market, whereas the mean of the conditional correlation between Bitcoin and SET was highest during COVID-19 (0.063106), and lowest (-0.029510) in the post-COVID-19 period. However, for the Singapore market, the mean of the co-movement in the pre-COVID-19 is negative (-0.002986), and highest during COVID-19 (0.063106), and reported a lower mean of conditional correlation in the post-COVID-19 (0.003446). The highest mean of conditional correlation between Bitcoin and stock indices was also reported for both Indonesia (JKSE) and the Philippines (PSEi). In the Indonesian market, the pre-COVID-19 period had the lowest mean of co-movement (0.000501), and this co-movement increased during COVID-19, but further reduced in the post-COVID-19 period. Interestingly, it is worth noting that, although in the pre-COVID-19 period, the Philippines had the lowest mean of co-movement (0.003596), the mean of the conditional correlation for Bitcoin and PSEi increased further in the post-COVID-19 period (0.042536).

Table 4: Summary results of the independent t-test

	Mean of Conditional Correlation			Independent t-test		
Stock Indices	Pre-COVID-19	During COVID-19	Post-COVID-19	Pre vs During	Pre vs Post	During vs Post
KLCI & Bitcoin	0.027910	0.045784	0.002203	-3.054*	3.264*	6.287*
STI & Bitcoin	-0.002986	0.063106	0.003446	-8.866*	-0.688	7.659*
SET & Bitcoin	0.059860	0.116377	-0.029510	-7.289*	9.797*	16.819*
JKSE & Bitcoin	0.000501	0.079761	0.067184	-10.877*	-6.687*	1.336
PSEi & Bitcoin	0.003596	0.039654	0.042536	-4.396*	-4.814*	-0.403

Note: *signified significance at 1% level.
Source: Authors (2024)

The result of the independent t-test revealed the significant differences between the conditional correlation series between the Bitcoin and market indices in ASEAN-5 markets between pre-COVID-19 and during COVID-19. This finding indicated that the co-movement has generally strengthened after the COVID-19 pandemic began in all ASEAN-5 markets. This finding suggests that Bitcoin might be a weak diversifier in diversifying investment portfolios, during COVID-19 as the co-movement became higher during COVID-19. However, when comparing

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pre- and post-COVID-19, the findings showed divergent results among the ASEAN-5 markets. For instance, the co-movement in Malaysia and Thailand was significantly reduced in the post-COVID-19 period, compared to the pre-COVID-19 period. This would imply that Bitcoin might provide some good diversification property for the stock market in Malaysia and Thailand. However, the conditional correlation between Bitcoin and market indices was significantly enhanced in post-COVID-19, compared to pre-COVID-19 in Indonesia and the Philippines market, but insignificant increase in the Singapore market. The significant differences between pre- and post-COVID-19 on the co-movement between Bitcoin and stock indices in Malaysia, Thailand, Indonesia and the Philippines might be due to the inefficiency in their stock market. As remarked by Shaik and Maheswaran (2017), the stock markets in Malaysia, Thailand, Indonesia and the Philippines are not efficient, while the stock market in Singapore is weak-form efficient. With that, the stock market efficiency in Singapore might imply that co-movement between Bitcoin and STI is similar in the post-COVID-19 period compared to pre-COVID-19. The increase in the conditional correlation between Bitcoin and market indices might further show the ineffective diversification property of the cryptocurrency against the stock market in Indonesia, the Philippines and Singapore.

Lastly, the independent t-test showed that the co-movement was significantly lower in post-COVID-19, compared to during COVID-19 in Malaysia, Singapore, and Thailand. The reduction in the co-movement may indicate the hedging capability of Bitcoin on the stock market. This showed that the interest of investors in these three markets in utilising Bitcoin as an alternative investment over the stock market is weak after the COVID-19 pandemic, as their co-movement is lower than pre-COVID-19. Besides, the insignificant differences between during COVID-19 and post-COVID-19 were also reported in the Indonesian and the Philippines markets. This proves that the co-movement between Bitcoin and stock indices in Indonesia and the Philippines in the post-COVID-19 period is similar to the pre-COVID-19 period, and further shows that the investment interest in Bitcoin as an alternative investment instrument of the investors in these two markets is not affected by COVID-19. Therefore, the results of the independent t-test successfully provided evidence regarding the changes in the co-movement between Bitcoin and market indices in ASEAN-5 markets, by comparing pre-COVID-19, during COVID-19, and post-COVID-19.

The result of the significant increase in co-movement series between Bitcoin and market indices was parallelled with Abdullah et al. (2022), Ali et al. (2024), and Thampanya et al. (2020), where Bitcoin or cryptocurrencies might offer limited diversification benefit towards the traditional assets. Specifically, the findings of the study are inconsistent with Abdelmalek (2023) as cryptocurrencies provided a diversification effect during COVID-19. As revealed by Jana and Sahu (2024), cryptocurrency (Dogecoin) has potentially reacted as a good diversifier during COVID-19. Besides, the increase in the co-movements during COVID-19 is parallel with Goodell and Goutte (2021) and Ling (2021). However, the significant difference between the co-movement during COVID-19 and post-COVID-19 is a fresh finding as very limited studies have examined this area. The post-COVID-19 era is crucial as investors tend to look for some financial assets that might offer greater diversification property towards traditional financial assets to better construct their investment portfolio that might offer optimal return, to recover their losses during the COVID-19 period.

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Conclusions and Implications

This study intended to investigate the comparison of the co-movement between Bitcoin and the stock indices in ASEAN-5 markets for three periods, namely pre-COVID-19, during COVID-19, and post-COVID-19. The daily frequency data from early January 2018 until the end of June 2024 were used in this study. The return series of the data series (Bitcoin, KLCI, STI, SET, JKSE, and PSEi) was further analysed using the MGARCH-DCC to obtain the time-varying conditional correlation between the pairwise data series. These time-varying conditional correlation was then further divided into three periods and further analysed the significant differences using an independent t-test. The results showed that all co-movement series between Bitcoin and ASEAN-5 market indices significantly enhanced during COVID-19 rather than pre-COVID-19. Besides, when comparing the pre-COVID-19 and the post-COVID-19, the result showed significant differences in four markets, except for Singapore. However, the co-movement was further strengthened in Malaysia and Thailand, but the co-movement was further weakened in Indonesia and the Philippines markets. Lastly, the result also showed that the co-movement was significantly reduced in Malaysia, Singapore and Thailand only, while insignificant differences were found in Indonesia and the Philippines.

The study's findings offer crucial implications towards both theoretical and practical insights. For instance, this study provided evidence on the comparison of the co-movement between cryptocurrency and stock indices in ASEAN-5 markets, which will further enrich the literature in this area. Besides, the study also proved that COVID-19 significantly enhanced the co-movement between Bitcoin and stock indices, and this might show the diversification benefit offered by Bitcoin. Furthermore, the evidence of the comparison between the co-movement of Bitcoin and stock indices for the period of pre-COVID-19 and during COVID-19, compared with post-COVID-19 also provided in this study.

As revealed in the study, different findings were found regarding the comparison between the co-movement of Bitcoin and stock indices for the period of pre-COVID-19 and post-COVID-19, together with during COVID-19 and post-COVID-19. These findings also provide some practical implications for the stakeholders, such as fund management companies, fund managers and retailer investors, as the hedge and diversifier property of Bitcoin against the stock indices in ASEAN-5 markets was provided in this study. The stakeholders might use the study's findings to formulate their investment strategies and reallocate their investment portfolios to generate optimal returns for their investments. For example, during the pandemic period, the fund management companies, fund managers or investors might not consider investing in Bitcoin to diversify their stock investment as the co-movement between Bitcoin and stock indices was significantly strengthened when the pandemic began. However, compared to the pre-COVID-19 period, Bitcoin is an effective diversification investment for stock investment in Malaysia and Thailand in the post-COVID-19 period, while Bitcoin might offer certain hedging properties in Indonesia and the Philippines market during the same period as well. Lastly, compared to during COVID-19, the stock market investment in Malaysia, Singapore and Thailand might be considered to invest in Bitcoin as it offered certain hedging properties for the stock indices in these three markets. With that, the stakeholders, especially the fund management companies, professional fund managers and retail investors, could benefit from the study as the study's findings offered a clear direction regarding the co-movement between Bitcoin and stock indices in ASEAN-5 markets.

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Limitations and Suggestions for Future Research

This study consisted of some limitations that need to be addressed in future studies. Firstly, only Bitcoin was selected in this study to represent the cryptocurrency. It is suggested to include more cryptocurrencies in future studies, as different cryptocurrencies may have different properties, and this may offer more comprehensive findings. Besides, only stock indices of ASEAN-5 markets were included in the study. Future study is advised to include some other traditional financial assets in ASEAN-5 markets, such as exchange rate, bond index, and commodities index, as it might provide some interesting findings about the co-movement between cryptocurrencies and financial assets in comparison to pre-COVID-19, during COVID-19, and post-COVID-19. Additionally, to provide more robust and solid findings, future studies may consider employing the wavelet coherence analysis and neural network analysis as a supplement to the MGARCH-DCC. If the results from different analyses revealed similar findings, it could further increase the reliability of the findings.

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Appendix A
Unit Root Test of the Data Series through ADF

	Intercept		Trend & Intercept		Intercept		Trend & Intercept	
	Level				First Difference			
KLCI	-2.2914	0.1749	-2.4099	0.3741	-40.1409	0.0000	-40.1500	0.0000
Bitcoin	-0.7327	0.8365	-1.9165	0.6453	-41.7072	0.0000	-41.7165	0.0000
STI	-2.6117	0.0907	-2.6154	0.2734	-25.7245	0.0000	-25.7352	0.0000
Bitcoin	-0.6222	0.8632	-1.7996	0.7048	-19.1617	0.0000	-19.1833	0.0000
SET	-1.7696	0.3960	-1.9885	0.6067	-40.3279	0.0000	-40.3152	0.0000
Bitcoin	-0.7187	0.8401	-1.9269	0.6398	-41.6462	0.0000	-41.6571	0.0000
JKSE	-1.5827	0.4912	-2.3529	0.4044	-39.7955	0.0000	-39.7886	0.0000
Bitcoin	-0.7702	0.8266	-1.9272	0.6397	-41.4500	0.0000	-41.4592	0.0000
PSEi	-2.8920	0.0465	-3.2105	0.0827	-40.4059	0.0000	-40.4029	0.0000
Bitcoin	-0.7334	0.8363	-1.9154	0.6459	-41.4187	0.0000	-41.4283	0.0000

Source: Authors (2024)