



Co-Movement of Digital Currencies and Asian Stock Indexes: A Wavelets Based Multiresolution Analysis

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ABSTRACT

The paper examines the co-movement relationship between Cryptocurrency and Asian major indices through Wavelet Coherence multiresolution technique and the Granger causality for result robustness. The indices data of Singapore and Japan stock market was used from January 2018 to December 2022, the outcome of our study shows great of co-relationship in the movement between Asian two major listed equity market indices and Cryptocurrencies investments. Moreover, the study shows that Japan stock market found to be more positively correlated with existing cryptocurrencies in comparison to Singapore stock market.



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1. Introduction

The Cryptocurrency has approximately more than 80-billion-dollar valuation as of today, Cryptocurrency is the technology of decentralize transaction of ledgers which are highly encrypted. The process of encryption and decryption is also decartelized and completely cloud computing (Liaqut & Siddiqui, 2021). The stock market volatility transmission and Return are the measure of inter-market connection, it gives latest details and understanding of global finance and has substantial ramifications for portfolio and hedging making Decisions. The fluctuating correlations between cryptocurrency price fluctuations and values of Equity Stocks have significant interest from academics and professionals. The increasing market blending of conventional financial assets and cryptocurrencies has made this problem more urgent (Bouri, Gupta, Lau, Roubaud, & Wang, 2018). This research article will focus on examining the co-

movement between Blockchain in crypto and equity of two Asian major indices from developed market, which holds significant importance for investors. They study about the how returns in long term of investment in these two Assets, Government or Policy makers analyze huge investment and their impacts on macro-Economy of their country.

The investigation of relationship of cryptocurrency and traditional Equity has significant impact on indices of stock market. The previous research regards to relationship between cryptocurrency and African Equity Market, Kumah, Odei-Mensah, and Baaba Amanamah (2022), The Economic downturn impact the investments in Equities by Cryptocurrency Asl, Adekoya, and Oliyide (2022), The further research of middle east market that Cryptocurrency and stock market performance and their moments accordingly (Sami & Abdallah, 2021). In regard of studies which show relationship or no connection between trade in stocks of Equity of specific indices and in support of this study shows Briere, Oosterlinck, and Szafarz (2015); Corbet, Meegan, Larkin, Lucey, and Yarovaya (2018); Luu Duc Huynh (2019); Trabelsi (2018); Yaya (2018); Yousaf and Ali (2021), the global indices characteristics in term of efficiency, volatility, fluidity and co-movement with different indices and African equity indices are found to have weaker link with global stock markets indices. Agyei-Ampomah & Sam (2018).

The problem statement of this research finds the discrepancy in literature of interrelation of Cryptocurrency and listed companies Equity Market of Japan and Singapore stock market indices, Cryptocurrencies have secured significant interest from global public companies, Corporates, and small and medium size businessmen and individuals and their impacts on traditional equity market is ambiguous. This Research is about relationship between blockchain cryptocurrencies and significant changes, values and impacts on equity of listed companies of two major developed Asian countries (Japan, Singapore), using wavelet multiresolution analysis.

The significance of the study is that the findings of the study can provide important information about investment in these two different classes of assets and may be find the impact on the economy of Japan and Singapore of the investment in digital assets may be more appropriate which is beneficial for economy. Findings give insights for policy makers and educational institutes for the purpose of further research or education about implication of dynamics of new digital assets.

2. Literature Review

This literature review shows the previous studies of correlation between cryptocurrency, stock market prices, their dependencies and dilution of both class of assets and impacts on economy, some studies have shown positive in co-relation of both class of assets and impacts indices of stock market indices. suggesting that cryptocurrencies may have a hedging role in diversified portfolios (Briere et al., 2015; Corbet, Meegan, et al., 2018). Other research study concludes that there is invalid correlation between Cryptocurrency and Stock market share prices and valuation of market indices. Block chain cryptocurrency has autonomous position in the global investment market which mean that the digital currency has separate class which has no impact on stock market indices and operates independently of traditional financial instrument (Peltomäki, 2022). Some Researches have also concluded that due to investment in cryptocurrencies and equities and impacts in economic deterioration (Goodell & Goutte, 2021). Study found that heavy investment in cryptocurrency has a significantly disrupting impact on Stock market index during economic downturn, furthermore the study shows that investment by different numbers of investors in Bitcoin destabilizes Developed market countries.

2.1. Empirical Review

Previous studies have investigated the relationship between cryptocurrency and equity markets, but there is still limited research on the co-movement between blockchain in crypto

and equity of primary global indices. Briere et al. (2015) examined the impact of cryptocurrencies on equity market returns and found that there is a significant impact of cryptocurrency returns on equity market returns. Corbet, Larkin, Lucey, Meegan, and Yarovaya (2018) explored the interdependence of Bitcoin returns and equity market returns, finding that Bitcoin returns were negatively related to equity market returns during the financial crisis of 2008. Huynh and Burggraf (2019) did an analysis of the relationship between Bitcoin and stock markets in different regions, concluding that there is a positive correlation between the two in emerging countries. Trabelsi (2018) investigated the link between Bitcoin and stock market volatility, showing that Bitcoin has a positive impact on stock market volatility. Analyzed the interdependence of Bitcoin and stock markets in Asia, showing that Bitcoin has a significant influence on stock markets in Asia (Yaya, 2018). Analyzed the co-movement between stock markets and Bitcoin, results suggested a significant relationship between Bitcoin and stock markets. Yousaf and Ali (2021) investigated the influence of Bitcoin on the performance of stock markets, results suggested significant influence of Bitcoin on the performance of stock markets.

Based on the previous empirical reviews, the following hypotheses are proposed:

H1: There is a significant correlation between cryptocurrency and stock market of Singapore and Japan.

3. Research Methodology

The study considers five major cryptocurrencies that fluctuate in line with supply and demand for equity instruments, are connected. The primary focus is on the stocks of significant publicly traded corporations in developed regions. This study will use a quantitative approach, gathering secondary data from a variety of sources, such as Investing.com and Yahoo Finance. Additionally, the wavelet approach, a method used to analyze non-stationary time series data in various time-frequency domains utilized to analyze the data and further employ Granger causality test and Wavelet Coherence.

4. Research Approach

The study method is quantitative since it employs the Continuous Morlet Wavelet Transform (CMWT) to analyze data on the co-movement of blockchain cryptocurrency asset markets. To study the intermarket relationships between cryptocurrency and stock markets, the research will employ time-series data from both asset markets. The information will be gathered from publicly accessible sources, including internet platforms and financial databases. The data is analyzed statistically to find trends and correlation between the two markets using the CMWT. The conclusions concerning the co-movement of asset markets will be made using the findings, which will also be utilized to assess the study's assumptions.

4.1. Data Collection Procedure

The procedure of Data collection used to gather data for the study of " Co-movement of Cryptocurrency, Singapore, and Japan Stock Market indices using Wavelet Analysis ". The following information is discussed:

Study Population: The data for this study was collected for the following groups

- 1) Cryptocurrencies
- 2) Japan Stock Market Indices
- 3) Singapore Stock Market Indices.

Table 1: Source of Variables

Variable	Measurement Dependent Variable	Variable Adoption
Japan Stock Market	Nikkei 225	"Umar, Hung, Chen, Iqbal, and Jebran (2020) cryptocurrencies connected?. <i>The Singapore Economic Review</i> , 1-16".
Singapore Stock Market	FTSE ST Singapore	"Umar et al. (2020) Are stock markets and cryptocurrencies connected?. <i>The Singapore Economic Review</i> , 1-16".
	INDEPENDENT VARIABLE	
Crypto-Currency	Bitcoin, Ethereum, Binance Coin, Repple, Tether	(Kumah et al., 2022). Co-movement of cryptocurrencies and African stock returns: A multiresolution analysis. <i>Cogent Business & Management</i> , 9(1), 2124595.

Data for statistics was collected from various purpose for this study:

- a) Existing in official data: investing.com and finance.yahoo.com has data base of many countries, it was used to collect data of Japan stock market indices and Singapore stock market indices.
- b) Data on Cryptocurrencies is collected from coinmarketcap.com and coindocdex.com the data is accessible for everyone and has extensive APIs.
- c) For the categories of countries <https://www.msci.com/our-solutions/indexes/market-classification>.

5. Data Analysis & Results

The information and data that has already existed in external database is known as secondary data. The data sources utilized were Investing.com and finance.yahoo.com, coinmarketcap.com and coindocdex.com which gave us existing information over a five-year period on cryptocurrencies, Stock market indices. Having access to these appropriate sources is essential for data collection and secondary data analysis. Using wavelet analysis, it was probable to distinct the co-movement of cryptocurrencies, Stock Market indices after the data had been gathered. By breaking down a time series into its component frequency bands using wavelet analysis, so able to identify patterns and connections between several variables.

5.1. Granger Causality

The Granger Causality Test shows Mathematically The relation of Series X is indicating prediction another series Y, The Causality from X to Y in financial economics this approach is very well defined and detailed approach Granger (1969).

The rigorous analysis of causality created by Dhamala, Liang, Bressler, and Ding (2018) in which causality is quantified with data information details flow (or information transfer as called), is entirely distinct from the Granger causality test. The latter being Thus, causality analysis may be established on a firm foundation because it is a true physical notion.

According Xunfa, LIU, San LIANG, Zhang, and Hairong (2020), an n-dimensional dynamical system with the following form

$$dX = F(X, t)dt + B(X, t) dW \tag{1}$$

W is indicating the Vector of standard Processes of Wiener, Vector F coefficients (operator of Nonlinear) and B a matrix coefficients of perturbation, The flow from component information X_j to X_i (units per time) prove to be:

$$T_{j \rightarrow i} = - E \left[\frac{1}{\rho_i} \int_{\mathbb{R}^{n-2}} \frac{\partial(F_i \rho_i)}{\partial x_i} dx_{ij} \right] + \frac{1}{2} E \left[\frac{1}{\rho_i} \int_{\mathbb{R}^{n-2}} \frac{\partial^2(F_i \rho_i)}{\partial x_i^2} dx_{ij} \right] \quad (2)$$

Where dx_{ij} stands for dx but with dx_i and dx_j excluded, E for mathematical expectation,

$$g_{ij} = \sum_{k=1}^n b_{ik} b_{jk}, \rho_i = \rho_i(x_i), \text{ and } \rho_j = \int_{\mathbb{R}} \rho(x) dx_j. \quad (3)$$

If $T_{j \rightarrow i} = 0$, then X_j is unusual to X_i ; casual; and $T_{j \rightarrow i}$ magnitude, causality size X_j to X_i .

$$T_{2 \rightarrow 1} = \frac{C_{11}C_{12}C_{2,d1} - C_{12}^2C_{1,d1}}{C_{11}^2C_{11} - C_{11}C_{12}^2} \quad (4)$$

The Cryptocurrency and Emerging Stock Markets' Break Point-Dependent Causality $C = (C_{ij})$ is matrix of covariance connecting with from X_i to X_j , and from $C_{i,dj}$ covariance sample between X_i and using Euler Forward mathematically derived series X_j

$$X_{j,n} = (X_{j,n+1} - X_{j,n})/\Delta t \quad (5)$$

Δt is step size of period. For preference when $|T_{2 \rightarrow 1}| > 0$, X_2 is causal to X_1 ; if $T_{2 \rightarrow 1} = 0$, X_2 is un-causal to X_1 ; but in Applied applications, tested significance of statistical. This equation of formula has been applied in many fields.

First apply unit root test for stationary and non stationary data.

Table 2
Unit Root Test

Method	Statistic	Prob.**		
ADF - Fisher Chi-square	47.4280	0.0000		
ADF - Choi Z-stat	-3.03327	0.0012		
Intermediate ADF test results UNTITLED				
Series	Prob.	Lag	Max Lag	Obs
BITCOIN	0.6321	0	24	1825
BNB	0.5892	6	24	1789
JAPAN	0.5654	0	24	1795
ETH	0.6221	1	24	1794
REPPLE	0.0002	0	24	1795
SINGAPORE	0.0684	12	24	1783
TH	0.0000	0	24	1795

The probability is less then 0.05 which mean our data is stationary and then apply Granger Causality.

Cryptocurrency and stock market indices in Japan and Singapore demonstrate the Granger Cause.

Table 3 demonstrates that at the 5% and even 10% levels of significance, there is no statistically significant Granger causation between bitcoin and Japan stock market indices. Thus, neither the null hypothesis that cryptocurrency causes the stock market to rise nor the converse is refuted.

Table 3
Granger Causality Test

Hypothesis	Obs	F-Statistic	Prob.
JAPAN does not Granger Cause BITCOIN	1826	2.00051	0.1574
BITCOIN does not Granger Cause JAPAN		6.16347	0.0131
SINGAPORE does not Granger Cause BITCOIN	1826	5.67707	0.0173
BITCOIN does not Granger Cause SINGAPORE		0.59309	0.4413
JAPAN does not Granger Cause BNB	1826	12.9104	0.0003
BNB does not Granger Cause JAPAN		1.14487	0.2848
ETH does not Granger Cause JAPAN	1826	2.61933	0.1057
JAPAN does not Granger Cause ETH		4.74417	0.0295
REPPLE does not Granger Cause JAPAN	1826	0.13610	0.7122
JAPAN does not Granger Cause REPPLE		8.25904	0.0041
REPPLE does not Granger Cause SINGAPORE		6.33118	0.0120

The Bitcoin cause Singapore and Japan cause Bitcoin the results show there are significant relation between both variables, The Japan indices has granger cause Binance Coin and Japan indices has Relationship with Repple and Singapore does granger cause with Repple mean strong relationship with Repple.

5.2. The Continuous Morlet Wavelet Transform (CMWT)

The research uses the technique of Continuous Morlet Wavelet Transform analysis. Furthermore, co-movement of listed Equity Stock markets. CMWT determines the wavelet depict coherence and decomposing two variables and its signals and can identify scale of time signals with Principles of time frame and frequency. The analysis includes wavelet coherence, cross-correlation, and variance to determine co-movement in the different time frame and In and Kim (2013), define CMWT as the constitutive over time of the product of signal and scaled, transpose genre function of wavelet φ :

$$C(\text{scale, position}) = \int_{-\infty}^{\infty} X_t(\text{scale, position, } t) dt \tag{6}$$

The CMWT generates multiple coefficients C, of wavelet, which are functions of scale and position and may contain various values data of a time series xt. The CMWT for two different continuous variables as defined by Grossmann and Morlet (1984), and Wei, Tian, Wells, and Burrus (1998).

$$F(a,b) = \int X_t \varphi\left(\frac{t-a}{b}\right) dt \tag{7}$$

The simplification of Morlet wavelet

$$\varphi(\omega) = \pi^{-\frac{1}{4}} e^{i\omega\psi} e^{-\frac{\omega^2}{2}} \tag{8}$$

where, ω is a non-dimensional "time" parameter.

5.3. Discussion and Findings

The estimated wavelet coherence, which examines the connection between stock market indices and cryptocurrencies. Using Wavelet coherence, it illustrates the interconnectedness between these two variables. High correlations and considerable interconnection are represented by the warm regions within the of Cone of Significance. Umar et al. (2020) Moreover, low correlation and reduced reliance between the variables are exhibit by the blue regions within the cone of significance. The time and frequency where there is no dependence between the variables are depicted by the blue regions outside the cone of significance zone so LEAD/LAG phase links between the chosen variables are shown by the presence of an arrow in the wavelet coherence plots (Juhro, Iyke, & Narayan, 2021). The two studies series are thought to move in scale on a

certain scale if there is zero phase difference. Positive correlation is shown by vector arrows heading to the right, whereas negative or no correlation is indicated by vector arrows pointing to the left (when the time series are out of phase (Shakri, Yong, & Xiang, 2021)). The stock market indices data lead cryptocurrency by arrows indication or vice versa. The Following results are the stock market indices of two major Asian countries which are Singapore and Japan, these countries are from Developed Asian Stock Market, The Following wavelet graph shows wavelet coherence analysis indicating the correlation between BITCOIN, BNB, ETH, Repple, TH and Singapore and Japan stock market.

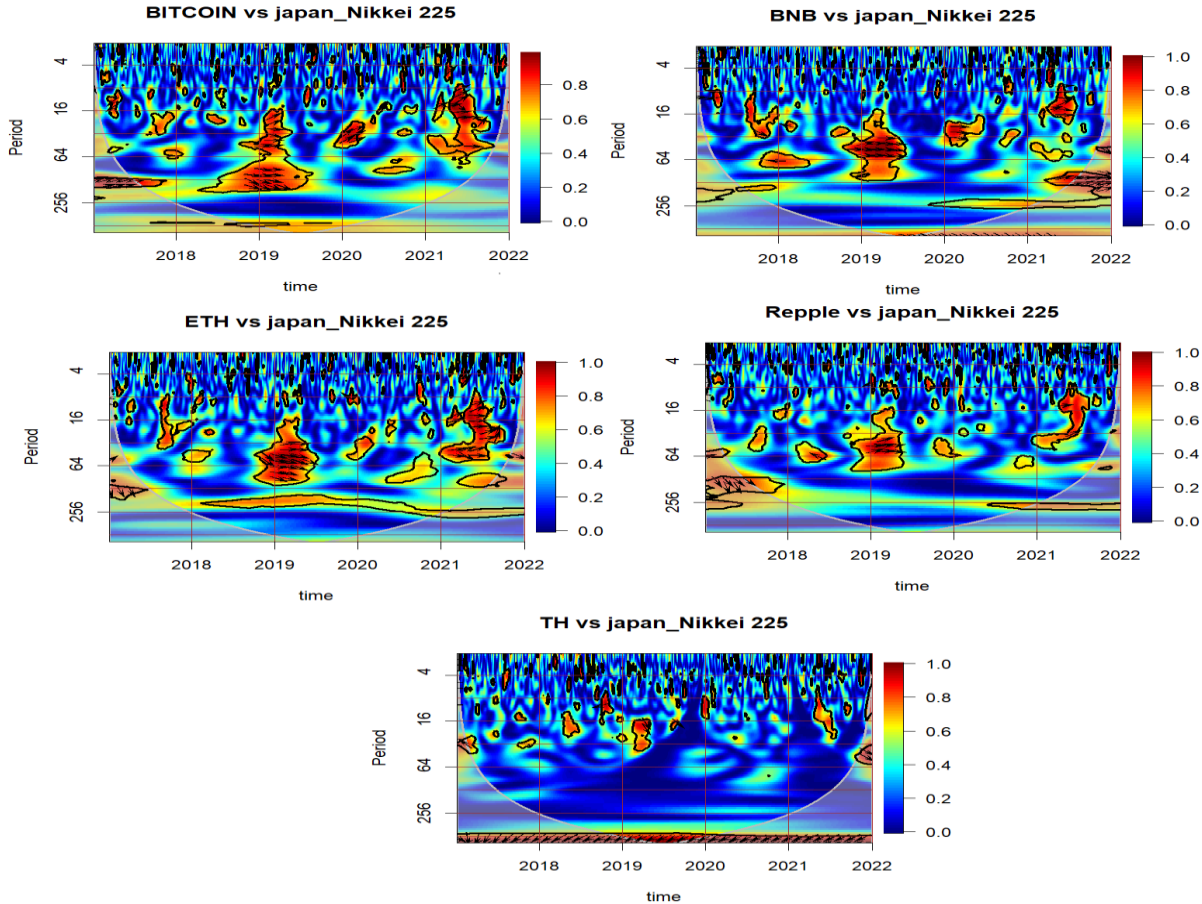


Figure 1: Depicts The Results Of Wavelet Coherence Of Cryptocurrency Vs Japan Stock Market.

Note: BTC=BITCOIN, BNB=BINANCE COIN, REPPLE COIN, TH=TETHER COIN

In Figure 1, (BITCOIN, BINANCE COIN, REPPLE COIN, TETHERCOIN) The wavelet graph shows analysis about the correlation between BITCOIN, BNB, ETH, Repple, TH and JAPAN stock exchange. The dynamic graphs of Bitcoin and BNB during 2018 and 2019 showed interesting patterns as they primarily displayed colder colors (Blue), with irregular tiny patches exhibiting warmer colors (Red) within the cone of importance. The Japan Stock Market had a notable degree of connection throughout this time, which was most striking where the warm (Red) and yellow sectors coincided. With the exception of TH vs the Japan stock market, which unexpectedly showed no meaningful connection beyond the 64th point, the graphs of ETH and Ripple also showed an impressive degree of correlation during this two-year period. This discovery shows that during those particular times, the two variables were less reliant on one another.

The graphs of Bitcoin, BNB, ETH, Ripple, and TH versus the Japan Stock market showed remarkable patterns when we look ahead to the time period from 2019 to 2020. The graphs had

a wider area of redder, warmer colors (Red), showing a much higher connection for periods 16 to 258. Interesting insights were revealed by the Wavelet coherence Plot, which showed that vector arrows in Japan were pointing right in a positive correlation. While Singapore and the Japan Stock Market trailed TH, exhibiting a decreasing trend during those exact intervals, TH/Japan showed downward arrows during the periods from 16 to 256.

The subsequent period, from 2021 to 2022, saw an even greater degree of interconnection between Bitcoin, BNB, ETH, Ripple, and the Japan Stock market. From periods 16 to 256, the graph showed a broad, intensely heated (Red) area that persisted. Unusually, vector arrows heading upward showed a strong and positive association between Ethereum and Bitcoin and the Japan Stock Market. TH also showed positive correlation at the same time during this period.

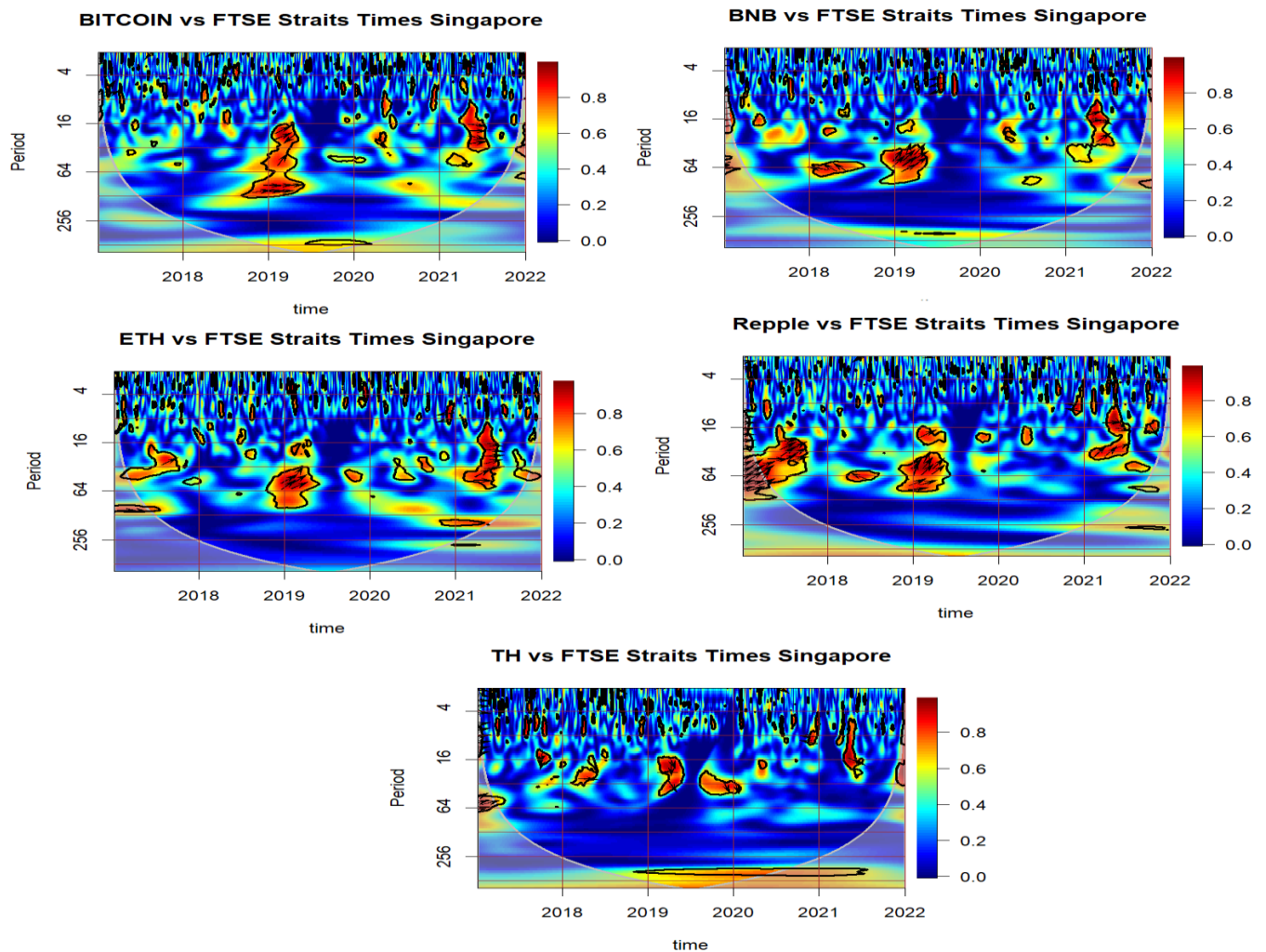


Figure 2: Depicts the Results Of Wavelet Coherence Of Cryptocurrency Vs Singapore Stock Market.

In Figure 2 The graphs of BTC and BNB during 2018 and 2019 showed a cooler (Blue) zone with sporadic little warm (Red) patches inside the cone of importance. But once 2019 got underway, the main region for both BTC and BNB turned heated (Red). The graphs of ETH and Repple, on the other hand, showed a clear connection within the same time period, with arrows going upward, indicating a favorable association between the two variables. The exception was

the TH/Singapore stock market, which showed weak dependencies and low correlations between the variables both before and after the 64th period.

The graphs of BTC vs the Singapore stock market from the 64th to the 96th period revealed a significant rightward connection, demonstrating that cryptocurrencies were leading the stock markets throughout this time. Now let's move on to the period from 2019 to 2020. The upward-pointing arrows from the 16th to 64th periods further supported the idea that cryptocurrencies are outpacing stock markets. With the exception of TH, which exhibited no discernible association, similar patterns were shown in the graphs of BNB, ETH, and Repple from the 24th to the 64th period, indicating that cryptocurrencies were actually outpacing the stock markets.

The graphs of BTC, BNB, ETH, Repple, and TH vs Singapore, when looking ahead to the period of 2021 to 2022, showed sizable warm (Red) regions, showing substantial high correlation over the 4th to 64th periods. The vector arrows on the Wavelet coherence figure, which indicate a high correlation between the variables, supported this positive association same results depict in the literature Najeeb, Kaiser, Siddiqui, and Laraib (2023). The rising movement of the stock market graphs suggested that the second series (stock market indices) was being led by cryptocurrencies. The downward arrows between TH/Singapore, on the other hand, showed that the Singapore stock market was lagging behind TH from periods 16 to 64, supporting the idea of a lead-lag connection.

6. Conclusion

This research studies the co-movement between cryptocurrencies and Developed Asian Market two countries which are Singapore and Japan Stock returns, in order to reveal their consortium and portfolio diversification, The paper is focused on 5 massive cryptocurrencies (Bitcoin, Ethereum, Binance Coin, Repple, Tether) and Two developed Asian countries (Singapore, Japan) Stock market major indices to set objective attain, Apply Wavelet Coherence with the data span of 1 January 2018 to 31 December 2022 at daily frequency. Examine the co-movement. The Results suggest general affinity between stock markets indices data and cryptocurrencies. Great correlations with arrows upward directions in almost all the sets of cryptocurrencies versus Stock market indices between most of the selected sets of cryptocurrencies and stock market indices are time-varying. The empirical findings of our investigation both concur with and deviate from relevant literature. The findings confirm the intermarket relationships between cryptocurrencies and worldwide stock performance shown by (Kumah et al., 2022). Liu, Tsyvinski, and Wu (2022) and Bouri et al. (2018) and contradict Corbet, Meegan, et al. (2018) and Gil-Alana, Abakah, and Rojo (2020) found zero connection between the markets.

The phase difference right upward arrow vectors indicated the direction of correlation and the lead (lag) causal link among the pairings of equity asset markets, and the wavelet coherency was used to evaluate the correlation between the pairs of assets. The Graphs of this analysis suggest that there happens to be a strong relationship between crypto currencies and Japan and Singapore stock Market indices data over the medium to long term, which reflects the continent's aggressive pursuit of long-term integration with the Asian economy. This study suggests that there may be short-term benefits to hedging the risk between cryptocurrencies. Advise to investors to make consider the short-term decisions while employing cryptocurrencies to manage their valuation risk in Japan and Singapore stock markets. More particular, for key investors in the short span of time market, currencies provide greater options for portfolio diversification.

Authors Contribution

Muhammad Laraib: The idea of the research has been established and analysis

Ammar Ahmed Siddiqui: Help in the data analysis and discussion.

Syed Najeeb Ullah Kaiser: Provided guidance for data analysis, reviewed the citations and references.

Conflict of Interests/Disclosures

The authors declared no potential conflicts of interest w.r.t the research, authorship and/or publication of this article.

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