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Portfolio Diversification Benefits of Cryptocurrencies and ASEAN-5 Stock Markets*

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Abstract

This paper examines the portfolio diversification benefits in the cryptocurrencies (Bitcoin, Ethereum, Ripple, Litecoin, Stellar and Dash) and ASEAN-5 stock markets (Malaysia, Indonesia, Singapore, Thailand and Philippines). Cointegration and Granger causality tests are used in this study for the period from August 2015 to October 2019. We found evidence of no cointegration among the cryptocurrencies. Thus, the cryptocurrencies market provides an opportunity for the potential benefits from portfolio diversification and hedging strategies. However, cointegration is found between cryptocurrencies and ASEAN-5 stock markets thus indicating limited portfolio diversification benefits in the long-run among these markets. In addition, the results also show that ASEAN-5 stock markets are going towards a greater integration among them which is in congruence with the previous studies. However, in the short-run, Granger causality tests show that Dash, Ethereum, Lite, Ripple and Stellar have no causality relationship with all ASEAN-5 stock markets and no causality is also found between Bitcoin and three of ASEAN-5 stock markets (Malaysia, Singapore and Philippines). Therefore, there still exists an opportunity for portfolio diversification between cryptocurrencies and ASEAN-5 stock markets in the short-run. The findings of this study suggest that crypto-investors, international investors and fund managers can diversify their investments in both cryptocurrencies and the ASEAN-5 stock markets.

Keywords: Cryptocurrencies, Stock Markets, Portfolio Diversification, ASEAN-5

JEL Classification Code: C58, G11, G15

1. Introduction

Cryptocurrencies can be defined as peer-to-peer electronic cash system that enable online payments, have no association with authority, has no physical representation and infinitely divisible (Corbet et al., 2019). Cryptocurrencies are digital assets that based on cryptography technology and have ability to function as a medium of exchange. Since the creation of Bitcoin in 2009, the popularity, development and exponential growth of cryptocurrencies have attracted media attention, academic research and policy makers. However, Bitcoin has been slowly losing its power in the cryptocurrencies market to the new rival cryptocurrencies such as Ethereum, Ripple, Litecoin and Stellar (Bouri et al., 2020). For example, total market capitalization of Ripple, Ethereum, Litecoin, Nem, Dash and Stellar totaled over USD195 billion or 39.11% of the total market capitalization of cryptocurrencies market while for Bitcoin was at 44.8% market share (Bouri et al., 2019). Today, there are about more than 1600 cryptocurrencies with market value of more than USD 450 billion (Bouri et al., 2020).

The cryptocurrencies market has rapidly become a vital component in the global financial market with its value growing from USD17.7 billion in early 2017 to USD700 billion in early 2018 (Ji et al., 2019). The surge growth in trading volume, prices of cryptocurrencies and volatility

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can be linked to their cheaper transaction costs, peer-to-peer-systems and governmental free structure (Corbet et al., 2019). Investors are always looking for alternative assets to reduce the downside risk of their equity investments. The emergence of cryptocurrency has attracted a lot of discussion as they have a potential in hedging and investments (Bouri et al., 2020). Investors and fund managers have seen cryptocurrencies as an investable asset with the ability to generate high return regardless of their extreme volatility (Ji et al., 2019). Nevertheless, the substantial price bubbles of these digital assets have created inherent episode of extreme volatility due to regulatory disorientation and cybercriminality (Corbet et al., 2019).

Although empirical studies on cryptocurrencies are rapidly increasing, studies on co-movements and integration amongst cryptocurrencies and also between cryptocurrencies and stock markets remains very limited (Al-Mansour, 2020). Corbet et al. (2019) have provided a good systematic literature review on major topics of cryptocurrencies such as pricing bubble, regulation, cybercrime, diversification and efficiency. In addition, Fauzi et al. (2020) discussed the challenges and investment opportunities in the cryptocurrency. Dang (2019) argued that governments of many countries required more time, suitable technology and regulatory capabilities to take advantage of these digital currencies. While Al-Mansor (2020) shows that the theories of herding, prospect and heuristic are all significant factors which influence the investment decision of investors in the cryptocurrency market. Besides that, Jalal et al. (2020) also found the presence of herding behavior in cryptocurrencies especially during bullish and extreme volatility periods.

In this paper, we extend the line of research by examining the issue of integration and dynamic linkages among cryptocurrencies and ASEAN-5 stock markets which are still lacking in literature. With a nominal GDP in excess of USD2.5 trillion and a population of over 600 million, ASEAN is fast becoming a major economic force in Asia and an attractive investment destination. According to World Federation of Exchanges, in 2010, total market capitalization of ASEAN-5 countries stood at USD1.8151 trillion with 2948 listed firms and its value increased to USD2.331 trillion in 2018 with 3243 listed firms. This study contributes to the literature in three ways. First, it examines the integration amongst major cryptocurrencies from the perspective of ASEAN-5 investors. Second, it examines the integration of cryptocurrencies and each of ASEAN-5 stock markets. Third, it examines the integration of each of cryptocurrency and ASEAN-5 stock markets. The findings of this study shall help crypto-investors, international investors and fund managers in investment planning and trading strategies.

The rest of the paper is structured as follows. Section 2 provides literature review while Section 3 explains empirical framework and data description. Section 4 reports empirical results and discussion. Lastly, Section 5 presents some concluding remarks.

2. Literature Review

In terms of co-movement of cryptocurrencies, few studies are worth discussing. Using multivariate BEKK-GARCH methodology and impulse response analysis, Beneki et al. (2019) examined the relationship between Bitcoin and Ethereum. They found significance in the time-varying correlation and a positive response of Bitcoin volatility on a positive volatility shock on Ethereum returns. Ferreira and Pereira (2019) attempted to evaluate the contagion effect amongst Bitcoin and other major cryptocurrencies. Using DCCA approach, they found evidence of a contagion effect and concluded that the cryptocurrencies markets are more integrated. While, Ji et al. (2019) examined the linkages of returns and volatility across six large cryptocurrencies for the period between August 2015 to February 2018. They found that returns shocks from Litecoin and Bitcoin has the most effect on other cryptocurrencies. In addition, negative returns linkages are stronger than the positive returns and Ethereum and Dash show very weak integration.

In addition, Corbet et al. (2018) investigated the dynamic relationships between three cryptocurrencies and several financial assets. They found evidence that cryptocurrencies could provide diversification benefits for investors particularly with short term investment horizons. Employing spanning tests, Briere (2015) provided evidence that the inclusion of a small proportion of Bitcoins improve the risk-return trade-off of diversified portfolios. Thus, this indicate that Bitcoins offer significant diversification benefits. Moreover, Bouri et al. (2017) examined the dynamic conditional correlation between Bitcoin and four major world stock indices, bond, oil, gold, commodity index and the US dollar. They found that Bitcoin is able to provide a good diversification. Besides that, Demir et al. (2018) found that the economic policy uncertainty (EPU) has predictive power on Bitcoin returns in negative association and Bitcoin served a good hedging tool against uncertainty. Moreover, Baur et al. (2018) show that Bitcoin displayed different return, volatility and correlation features compared to other assets and it possessed the same hedging abilities as gold. Relying on ARDL methodology, Ciaian and Rajcaniova (2018) examined the interdependencies between Bitcoin and Atlcoin markets for the period between 2013 to 2016. They conclude that the cryptocurrencies have stronger relationship in the short-run than in the long-run.

In another study, Walther et al. (2019) utilized GARCH-MIDAS framework to forecast the daily, weekly, and monthly volatility of Bitcoin, Etherium, Litecoin, Ripple, Stellar and the Cryptocurrency index CRIX. The results indicate that the

Global Real Economic Activity outperforms all other economic and financial drivers under examination. The Global Real Economic Activity provides superior volatility predictions for both, bull and bear cryptocurrencies markets. Using the VAR-MGARCH-GJR-BEKK techniques, Okorie and Lin (2020) found evidence of unidirectional volatility spillover effect from crude oil market to Bitcoin Cash market and also unidirectional volatility spillover from Ethereum, XRP, and ReddCoin cryptocurrency markets to the crude oil markets.

In the context of stock markets integration, Sharma and Seth (2012) have organized and reviewed 105 articles on stock markets integration covering the period of 1990 to 2010. Their study discusses on methodology/econometric tools, year classification, country distribution, number of years (sample), number of countries and source of the articles. They found that coverage of stock market integration across emerging economies has increased in recent years. Furthermore, Mitra and Bhattacharjee (2015) have identified three main drivers of stock market integration namely financial liberalization policies, economic cooperation and trade and exchange rate regime. In addition, Bekaert and Harvey (1995) argued that the development of stock market integration is a gradual, time-varying process and complex. Arouri and Foulquier (2012) noted that domestic stock markets were inevitably exposed to the information spillover and shocks from the global markets. Consequently, this led to more integrated stock markets amongst domestics and global markets. In addition, investors are able to achieve effective capital allocation and wider portfolio diversification benefits (Chien et al., 2015).

It is well documented in the literature that ASEAN stock markets are integrated. For example, Karim and Karim (2012) revealed that the ASEAN stock markets were going towards a greater integration among themselves particularly in the post-1997 financial crisis. While, Gkillas et al. (2019) showed that the stock markets had a greater degree of integration during the global subprime crisis. Moreover, Chien et al. (2015) provided evidence that regional financial integration between China and ASEAN-5 has gradually increased. Besides that, Vo and Tran (2019) found a significant volatility spillover from the US to ASEAN equity markets. Using Gregory and Hansen cointegration method and Detrended Cross Correlation, Mohti et al. (2019) concluded that all emerging markets in Asian region showed evidence of both global and regional integration. However, Jiang et al. (2017) found that the ASEAN-5 stock markets integration was only temporary and will disappear within two years. Only Malaysia and Indonesia showed strong fundamental integration while Vietnam had the lowest interdependence with other ASEAN countries. In a recent study, Wu (2020) examined the financial integration amongst the ASEAN-5 plus China, Japan and South Korea. Using both graph theory and VAR approach, he found that the level of interdependence amongst the stock markets was high with time varying patterns.

3. Empirical Framework

3.1. Johansen Cointegration Test

Sharma and Seth (2012) have documented that majority of research papers on stock market integration worldwide used unit root test and Johansen's cointegration test. Therefore, in order to examine the integration among the variables of interest, this paper also uses the Johansen (1988) and Johansen and Juselius (1990) cointegration test. Gonzalo (1994) provided empirical evidence to support the Johansen procedure's relatively superior performance compared to other methods for testing the order of cointegration rank.

This method is based on a vector autoregression (VAR) model as follows:

$$\Delta Y_t = \mu + \Gamma_i \Delta Y_{t-1} + \ldots\ldots + \Gamma_k \Delta Y_{t-k} + \Pi Y_{t-k} + \varepsilon_t \qquad (1)$$

Where

Δ = first difference
Y_t = $n \times 1$ vector of variables
μ = is an $n \times 1$ vector of constant
Γ = $n \times n$ matrix (short-run dynamics)
$\Pi = \alpha\beta'$ where α refers to $n \times 1$ column vector (the speed of short-run adjustment to disequilibrium) and β' represents $1 \times n$ cointegrating row vector (the matrix of long-run coefficients such that Y_t converge in their long-run equilibrium path).
ε_t = $n \times 1$ vector of error term
k = the order of autoregression

In addition, Johansen also established two main statistics to test for cointegrating relations which are maximum likelihood and trace. We also note that the results of Johansen test are sensitive to the lag length, thus we specify the lag length using AIC information criterion. Prior to the Johansen test, the standard Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests are conducted to determine the order of integration for each variable.

3.2. Granger Causality Test

In order to test the dynamic linkages among the variables, this study uses Granger causality test. Granger (1988) indicated that, for a cointegrated among time series, there must be causality among them at least in one direction. In addition, for any cointegrated series, error correction term must be in the model. This model is known as a vector error

correction model (VECM). Engle and Granger (1987) noted that ignoring this error correction term in the model leads to model mis-specification. However, if the variables are not cointegrated, it is appropriate to use VAR model in first differences. The VECM model is as follows (assume only two variables X and Y):

$$\begin{bmatrix}\Delta x\\ \Delta y\end{bmatrix}=\begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix}+\sum_{i=1}^{k}\Gamma_i\begin{bmatrix}\Delta x\\ \Delta y\end{bmatrix}_{t-k}+\Pi\begin{bmatrix}x\\ y\end{bmatrix}_{t-1}+\begin{bmatrix}\varepsilon_1\\ \varepsilon_2\end{bmatrix} \quad (2)$$

The Granger causality tests are investigated through restricting all estimated coefficient of lagged difference variables equal to zero using a standard χ^2 test.

3.3. Data Description

This study uses monthly data of the cryptocurrencies and ASEAN-5 stock markets, covering the period from August 2015 to October 2019. Following Ji et al. (2019). we also use six major cryptocurrencies (Bitcoin, Ethereum, Ripple, Litecoin, Stellar and Dash). The cryptocurrencies data was collected from https://coinmarketcap.com while the ASEAN-5 stock markets data was extracted from the Datastream International. All series are transformed into natural logarithm.

4. Empirical Results

4.1. Descriptive Statistics and Correlations

Table 1 reports the descriptive statistics of the variables, including sample mean, maximum, minimum, standard deviations, skewness and kurtosis. All cryptocurrencies and ASEAN-5 stock markets are positive with average monthly returns. The Ethereum has the highest mean monthly returns at 10.2% while the Malaysian stock market is the lowest at 0.1%. In terms of standard deviations, Ripple and Stellar are found to be more volatile than the others markets. In addition, both Ripple and Stellar also have larger excess kurtosis (greater than 3) indicating that they have a thicker tail and a higher peak than a normal distribution.

It seems that all cryptocurrencies provided higher returns than the stock markets. The results are in line with Bouri et al. (2020). where they also found the cryptocurrencies returns were higher than the S&P 500 and sectoral indices returns. In addition, they further concluded that the cryptocurrencies can act as safe-haven assets against downside risk of US equity due to its advantages such as attractiveness, electricity prices and mining difficulty. Thus, equity investors could improve their investment strategies to offset the downside risk of US equities through appropriate cryptocurrencies. Kristoufek (2015) argued that the cryptocurrency such as Bitcoin was independent from the global financial system as its prices were determined by non-economic and financial factors.

The results from standard correlation of coefficient are reported in Table 2. The results show that all correlations among various markets returns are positive. The highest correlation is between Ripple and Stellar at 0.78 while the lowest is between Ripple and Thailand (0.07). Among the ASEAN-5 stock markets, the Philippines and Indonesia stock markets are highly correlated (0.63) while the lowest are between Malaysia and Singapore (0.38). In the context of ASEAN-5 stock markets, since the correlation coefficients are between 0.38 to 0.63, we can conclude that the stock market returns are highly correlated. Thus, this indicate that portfolio diversifications in the ASEAN-5 stock markets are limited. In terms of correlation between cryptocurrencies

Table 1: Descriptive Statistics of Market Returns

	Mean	Max	Min	SD	Skew	Kurtosis	JB	Prob.
BITCOIN	0.075	0.528	−0.453	0.222	−0.053	2.860	0.062	0.970
DASH	0.069	1.036	−0.648	0.354	0.572	3.221	2.715	0.257
ETHEREUM	0.102	1.152	−0.769	0.430	0.540	3.019	2.337	0.311
LITE	0.062	0.966	−0.554	0.318	0.670	3.542	4.180	0.124
STELLAR	0.067	1.957	−0.517	0.505	1.775	6.733	53.086	0.000
RIPPLE	0.073	2.216	−0.684	0.522	2.218	8.722	104.836	0.000
INA	0.007	0.066	−0.065	0.029	−0.529	3.356	2.489	0.288
MAL	0.001	0.053	−0.072	0.024	−0.382	3.825	2.526	0.283
PHIL	0.002	0.085	−0.088	0.037	−0.140	2.951	0.162	0.922
SING	0.004	0.073	−0.092	0.038	−0.428	2.943	1.472	0.479
THAI	0.003	0.073	−0.078	0.033	−0.170	2.897	0.252	0.881

Table 2: Correlation of Market Returns

Corr	1	2	3	4	5	6	7	8	9	10	11
BIT[1]	1.00										
DASH[2]	0.56	1.00									
ETHE[3]	0.44	0.67	1.00								
LITE[4]	0.68	0.64	0.58	1.00							
STEL[5]	0.59	0.45	0.58	0.60	1.00						
RIPP[6]	0.47	0.52	0.61	0.73	0.78	1.00					
INA[7]	0.10	0.15	0.32	0.26	0.27	0.32	1.00				
MAL[8]	0.16	0.26	0.23	0.25	0.32	0.27	0.44	1.00			
PHIL[9]	0.20	0.18	0.27	0.23	0.23	0.15	0.63	0.48	1.00		
SING[10]	0.24	0.25	0.18	0.22	0.26	0.13	0.39	0.38	0.42	1.00	
THAI[11]	0.16	0.19	0.22	0.23	0.19	0.07	0.50	0.49	0.47	0.53	1.00

and ASEAN-5 stock markets, to some extent Bitcoin, Ripple and Ethereum had lesser correlation coefficient value with most of ASEAN-5 stock markets indicating the potential benefits for short-term portfolio diversifications.

Table 4 shows the additional information on the six cryptocurrencies under study. From the table, it can be clearly seen that the Bitcoin continued to dominate the cryptocurrency market with more than USD172.1 billon market capitalization followed by Ethereum (USD25.6 billion) and Ripple (USD8.3 billion). In terms of price, Bitcoin recorded the highest value at USD9,348 while the lowest is Ripple at USD0.19. Although Dash has the lowest market capitalization, its price was ranked third at USD71. In addition, Bitcoin recorded the highest daily trading volume at USD17.1 billion while Dash was the lowest at USD302 million. The dominance of Bitcoin over other cryptocurrencies has substantially decreased from more than 80% to below 40% from 2010 to 2019. Most cryptocurrencies share much in common with regards to their underlying technology, anti-government features, mining process, popularity to avoid capital control, media function in market creation, trading 24/7, disconnection from the global financial system, user anonymity and use in gambling (Bouri et al., 2019). In addition, Bouri et al. (2019) also argued that price variations in one currency can be transmitted to another cryptocurrency. See Table 4 below.

4.2. Unit Root Tests

Table 3 reports stationarity of the variables employing both the ADF and PP unit root tests based on constant and trend. From the table, both the ADF and PP tests show that that all cryptocurrencies and stock markets are non-stationary at level but stationary in the first-difference. Thus, all variables considered are *I*(1) process. Since all variables are *I*(1) process, next we proceed to cointegration analysis.

Table 3: Unit Root Tests

Variables	Level		First-Difference	
	ADF	PP	ADF	PP
BITCOIN	−1.12	−1.39	−5.95***	−5.99***
ETHEREUM	−1.47	−1.11	−5.69***	−5.69***
LITECOIN	−1.34	−1.27	−5.23***	−5.21***
DASH	−0.24	−0.48	−5.89***	−5.88***
RIPPLE	−1.35	−1.45	−6.36***	−6.35***
STELLAR	−1.18	−1.18	−5.55***	−5.46***
MAL	−1.76	−1.65	−6.22***	−6.37***
INA	−2.29	−1.84	−7.29***	−7.26***
SING	−1.32	−2.05	−3.86***	−10.36***
PHIL	−2.60	−2.45	−6.36***	−6.36***
THAI	−1.90	−1.80	−7.33***	−7.72***

Note: *** Denotes significance at the 1% level. The lag lengths are based on the Akaike Information Criteria (AIC).

4.3. Johansen Cointegration Test

The results of Johansen multivariate cointegration test are reported in Table 5. Both trace and max statistics suggest no cointegration among these six cryptocurrencies portfolio. However, both trace and max statistics suggest cointegration among these six cryptocurrencies and each of ASEAN-5 stock markets portfolios. Similar results of cointegration was also found for the ASEAN-5 and each of cryptocurrency's portfolios.

Table 4: Information on the Six Cryptocurrencies Under Study

#	Name	Market Cap ($)	Price ($)	Circulating Supply	Daily Trading Volume ($)
1	Bitcoin	172,103,124,403	9,348.29	18,410,112 BTC	17,064,476,119
2	Ethereum	25,555,298,490	229.33	111,433,705 ETH	6,230,413,303
3	Ripple	8,330,117,093	0.188218	44,257,803,618 XRP	963,968,936
4	Litecoin	2,818,635,170	43.46	64,856,833 LT	1,494,686,999
5	Stellar	1,422,161,584	0.069912	20,342,065,965 XLM	372,346,345
6	Dash	677,772,414	70.92	9,556,787 DASH	302,231,117

Note: The main source is https://coinmarketcap.com/. Extracted on 21/6/2020.

Table 5: JJ Cointegration Tests

Null Hypotheses	Portfolios											
	Cryptos		Cryptos & Malaysia		Cryptos & Thailand		Cryptos & Philippines		Cryptos & Singapore		Cryptos & Indonesia	
r	Tr.	Mx.	Tr.	Mx.	Tr.	Mx.	Tr.	Mx.	Tr.	Mx.	Tr.	Mx.
=0	83	26	186**	67**	191**	63**	224**	77**	241**	81**	226**	83**
≤1	57	20	119**	39	128**	46**	147**	53**	161**	54**	143**	46**
≤2	37	18	80**	34	82**	29	95**	38**	106**	46**	98**	40**
≤3	19	13	45	23	53	28	57**	30**	60**	26	58**	30**
≤4	7	6	21	11	25	15	26	15	34**	22	28	20
≤5	0.8	0.8	10	9	10	10	12	12	13	12	8	8
≤6			1	1	0	0	0	0	1	1	0.1	0.1
	ASEAN-5 & Bitcoin		ASEAN-5 & Dash		ASEAN-5 & Ethereum		ASEAN-5 & Lite		ASEAN-5 & Ripple		Cryptos & Stellar	
=0	151**	58**	156**	64**	143**	53**	143**	57**	135**	52**	135**	53**
≤1	94**	41**	92**	38**	89**	32	87**	35**	83**	33	81**	30
≤2	52**	29**	53**	28**	57**	28	52**	24	50**	24	52**	23
≤3	23	15	25	13	29	16	27	17	25	14	28	15
≤4	8	8	12	11	13	12	10	10	12	11	14	11
≤5	0	0	0.2	0.2	1	1	0.1	0.1	0.4	0.4	3	3

Note: The computed Ljung-Box Q-statistics indicate that the residuals are white noise. The optimal lag length chosen which is based on AIC. NH: Null Hypothesis; Tr: Trace Statistic; Mx: Max Statistics and ** significance at 5% level.

The number of cointegrating vectors for Trace and Max statistics ranging from one to five. Trace statistics recorded the highest number of cointegrating vectors at five (Cryptos and Singapore portfolio) while the highest number of cointegrating vectors for max statistics is four (Cryptos and Philippines; Cryptos and Indonesia portfolios). In addition, we also run cointegration tests for the ASEAN-5 stock markets and the combination of ASEAN-5 stock markets and all cryptocurrencies. The results also show that both trace and max suggesting the presence of cointegration amongst them. To conserve space the results are not reported here but is available upon request.

Thus, the cryptocurrencies markets are not tied together in the long-run which indicates that the cryptocurrencies markets are efficient following the Efficient Market Hypothesis (EMH). The evidence of no cointegration among these markets, indicate that the cryptocurrencies offer potential benefits of portfolio diversification. The results are in line with Baur et al. (2018), Corbet et al. (2018), Ciaian and Rajcaniova (2018) and Bouri et al. (2017) but not consistent with Ji et al. (2019), Beneki et al. (2019) and Ferreira and Pereira (2019). For example, Baur et al. (2018) provided evidence that cryptocurrency such as Bitcoin

displayed different returns, volatility and correlation features compared to other assets and it possessed the same hedging abilities as gold.

In addition, using the cross-quantilogram, Bouri et al. (2020) found evidence that many cryptocurrencies were potentially valuable asset class and safe-havens. In addition, using three most popular cryptocurrencies and a variety of other financial assets, Corbet et al. (2018) found evidence of the relative isolations of cryptocurrencies form other financial and economic assets. Besides that, Ciaian and Rajcaniova (2018) examined the interdependencies amongst Bitcoin and Altcoin markets for the period between 2013 and 2016. They found that both markets are interdependent. Another study by Bouri et al. (2017) revealed that Bitcoin does act as a hedge against uncertainty using principal component analysis of the VIX and fourteen developed and developing stock markets. However, Caporale et al. (2018) found persistence which implied predictability and market inefficiency amongst Bitcoin, Litecoin, Ripple and Dash suggesting that trading strategies using trend approach was able to produce abnormal returns in the cryptocurrency market. Moreover, using both parametric and semiparametric approach, Bouri et al. (2016) also detected long memory in the cryptocurrency market.

The findings of cointegration amongst the crypto-currencies and each of ASEAN-5 stock markets and also amongst a cryptocurrency and ASEAN-5 stock markets shall reduce the benefits of portfolio diversification amongst them in the long-run. The results are not consistent with Bouri et al. (2020) and Corbet et al. (2018). We found evidence of the cryptocurrencies and ASEAN-5 stock markets are moving together and are not isolated as argued by Corbet et al. (2018). It is well known that the global financial markets are integrated due to liberalization, financial globalization, financial innovation and technological advancement. The results also show that ASEAN-5 stock markets are moving towards greater integration. Karim and Karim (2012) revealed that the ASEAN stock markets are going towards a greater integration among themselves particularly in the post-1997 financial crisis.

In addition, Chien et al. (2015) also provided evidence that regional financial integration between ASEAN-5 countries and China has gradually increased. In a recent study, using Gregory and Hansen's cointegration tests and Detrended Cross Correlation, Mohti, Dionisio, Vieira and Ferreira (2019) found that all emerging markets in Asian countries display some evidence of both global and regional integration. While Wu (2020), found evidence that ASEAN-5, China, Japan and South Korea are strongly integrated with time varying patterns. ASEAN-5 countries have shown a rapid and tremendous economic growth over the last two decades. Moreover, ASEAN-5 countries received very high inflow of foreign investment and also witnessed incredible growth in the size of their stock markets due to its financial liberalization and deregulation undertaken (Chien et al., 2015). Narayan and Smyth (2004) claimed that stock markets are highly interdependence due to strong economic integration in the form of trade linkages and investment flows. In addition, Kearney and Lucey (2004) also noted that the world's economic and financial systems are increasingly integrated due to the rapid development of international trade in commodities, services and financial assets. While Chowdhury (2005) argued that the intra-regional trade expansion is one of the efficient ways of integrating to the much larger international economy as the countries become more competitive.

Nevertheless, Jiang et al. (2017) argued that the ASEN-5 stock markets integration was only temporary and shall disappear within two years indicating the potential benefit of diversification in the third year onwards. In addition, Click and Plummer (2005) also argued that although ASEAN-5 stock markets were integrated in the economic sense, but that integration was far from complete thus from the international portfolio investors, international portfolio diversification across these markets were reduced but not eliminated. Thus, with the right investment strategy and planning, there still exists an opportunity for potential benefits of portfolio diversification in this region.

4.4. Granger Causality Results

In order to examine dynamic linkages amongst the cryptocurrencies and ASEAN-5 stock markets, we run the VECM Granger causality. The results of multivariate VECM causality analysis are reported in Table 6. There seems to be short-run unidirectional causalities relationship running from Dash, Lite and Indonesia stock markets to Bitcoin, from Bitcoin to stellar, from Dash to Ripple, and from Ripple to Stellar. The results show that Dash, Ethereum, Lite, Ripple and Stellar have no causality relationship with all ASEAN-5 stock markets. The findings also show that there is no causality found between Bitcoin and three of ASEAN-5 stock markets (Malaysia, Singapore and Philippines). For cryptocurrencies, there is evidence of no causality running amongst Ethereum and other cryptocurrencies. No causality was also found between Bitcoin-Ripple, Dash-Lite, Dash-stellar, Lite-Ripple and Lite-Stellar. Ethereum is the most uncorrelated with other cryptocurrencies. From these causality results, we can conclude that ample opportunity exists in both cryptocurrencies and ASEAN-5 stock markets in the short-run. Malaysia, Singapore and Philippines are consistently found to have no short-run causality with all cryptocurrencies under study. The results are consistent with Corbet et al. (2018) where they also provide evidence that cryptocurrencies provide diversification benefits for investors mostly with short term investment horizons. This is also in tandem with Ciaian and Rajcaniova (2018) that conclude the cryptocurrencies have stronger relationship in the short-run than in the long-run.

Table 6: Granger Causality Test Results

Cryptocurrency v/s ASEAN-5 Stock Markets			**Cryptocurrency v/s Cryptocurrency**		
Crypto	**ASEAN-5**	**Findings**	**Crypto**	**Crypto**	**Findings**
Bit	Mal	Bit ≠ Mal	Bit	Dash	Bit ⇐ Dash
	Ina	Bit ⇐ Ina		Ethe	Bit ≠ Ethe
	Sing	Bit ≠ Sing		Lite	Bit ⇐ Lite
	Phil	Bit ≠ Phil		Ripple	Bit ≠ Ripple
	Thai	Bit ⇐ Thai		Stellar	Bit ⇒ Stel
Dash	Mal	Dash ≠ Mal	Dash	Etherum	Dash ≠ Ethe
	Ina	Dash ≠ Ina		Lite	Dash ≠ Lite
	Sing	Dash ≠ Sing		Ripple	Dash ⇒ Ripp
	Phil	Dash ≠ Thai		Stellar	Dash ≠ Stel
	Thai	Dash ≠ Phil	Ethe	Lite	Ethe ≠ Lite
Ethereum	Mal	Ethe ≠ Mal		Ripple	Ethe ≠ Ripp
	Ina	Ethe ≠ Ina		Stellar	Ethe ≠ Stel
	Sing	Ethe ≠ Sing	Lite	Ripple	Lite ≠ Ripp
	Phil	Ethe ≠ Phil		Stellar	Lite ≠ Stel
	Thai	Ethe ≠ Thai	Ripple	Stellar	Ripp ⇒ Stel
Lite	Mal	Lite ≠ Mal			
	Ina	Lite ≠ Ina			
	Sing	Lite ≠ Sing			
	Phil	Lite ≠ Phil			
	Thai	Lite ≠ Thai			
Ripple	Mal	Ripp ≠ Mal			
	Ina	Ripp ≠ Ina			
	Sing	Ripp ≠ Sing			
	Phil	Ripp ≠ Phil			
	Thai	Ripp ≠ Thai			
Stellar	Mal	Stel ≠ Mal			
	Ina	Stel ≠ Ina			
	Sing	Stel ≠ Sing			
	Phil	Stel ≠ Phil			
	Thai	Stel ≠ Thai			

Note: ≠ indicates does not Granger cause.

Unlike Ji et al. (2019), who found that Litecoin and Bitcoin have the most effect on other cryptocurrencies, we found evidence that Bitcoin is no longer influential on others. It seems that the Bitcoin price is affected by both Dash and Litecoin while Bitcoin only influences the value of Stellar in the market. To some extent, Dash is considered as the most dominant in the market. This might be due to the fact that other cryptocurrencies are gradually cutting into Bitcoin's leading market value share. For example, the Bitcoin's market share has dropped from more than 85% in 2015 to 39% in 2017 as investors are looking at alternative cryptocurrencies Ji et al. (2019). On top of that, consistent with Luu Duc Huynh (2019), we also found that the Ethereum is the independent coin in cryptocurrencies market.

Therefore, cryptocurrency investors, equity investors and fund managers can restructure their investment strategies to maximize the risk-returns trade-off using right combination

of cryptocurrencies and ASEAN-5 stock markets. Moreover, Ji et al. (2019) noted that cryptocurrencies are investable asset class which is capable of producing high returns notwithstanding their extreme volatility.

5. Conclusion

In this paper we have investigated market integration amongst cryptocurrencies (Bitcoin, Ethereum, Ripple, Litecoin, Dash and Stellar) and the ASEAN-5 stock markets (Malaysia, Indonesia, Singapore, Thailand and Philippines) relying on cointegration and Granger causality tests over the period from August 2015 to October 2019. The results show that there is no cointegration found amongst the cryptocurrencies thus indicating that potential benefits of portfolio diversification and hedging strategies in long-run. In addition, we also found evidence of huge portfolio diversification opportunity which is also present in the short-run. The influential role of Bitcoin on other cryptocurrencies was reduced significantly. This might be due to the fact that other cryptocurrencies are steadily competing the Bitcoin's market value and also popular in the cryptocurrency market. Furthermore, Ethereum is the most uncorrelated with other cryptocurrencies thus signifying the fact that it can be the best cryptocurrency for hedging asset class and safe-haven instrument. In contrast, we found evidence of cointegration amongst cryptocurrencies and ASEAN-5 stock markets. Although the markets are cointegrated in the long-run, from the Granger causality results, we can conclude that there still exists ample opportunity for portfolio diversification between cryptocurrencies and ASEAN-5 stock markets in the short-run. With the right investment strategies and structure, investors and fund managers can still benefit from portfolio diversification to maximize the risk-return trade-off. Cryptocurrencies extended the variety of investment and risk management strategies available for investors.

Furthermore, the evidence of cointegration amongst cryptocurrencies and ASEAN-5 stock markets implies that each variable contains information on the common stochastic trends thus investors can also explore the arbitrage profits utilizing information on other variable prices. Moreover, the findings of this study may have implications for crypto-investors, international investors and fund managers who want to diversify their investments in cryptocurrencies and in this region. In the context of ASEAN-5 stock markets, the evidence of cointegration amongst the stock markets also have important implications on financial policies formulation of multinational corporations and macroeconomic policies of ASEAN stock markets.

In addition, growth in cybercrime has also generated an immediate need for improved international regulatory approach and alignment. The significant growing of cybercrimes episodes such as market hacking and theft continued to undermine confidence and stability in the cryptocurrency market Cryptocurrencies have their own structure and not originated in any single country's boarders, which inherently a main problem in defining regulatory alignment (Corbet et al., 2019). However, cooperation among finance regulators across countries can still play a significant role to mitigate the impact of cryptocurrencies pricing bubbles and cybercrimes.

This study only focuses on the six cryptocurrencies (Bitcoin, Ethereum, Ripple, Litecoin, Stellar and Dash) and ASEAN-5 stock markets. In addition, this study relies on cointegration and Granger causality tests. Future study could compare other cryptocurrencies, other financial assets and commodities. In addition, study on the factors leading to co-movement, more sample countries with different region and trading blocs will also enrich the literature on the subject matter. Furthermore, we also recommend future studies to look into the possibility of threshold-effect of macroeconomic variables and global factors such as TED spread, VIX and US Economic Policy Uncertainty (EPU) on this market integration.

References

Al-Mansour, B. Y. (2020). Cryptocurrency Market: Behavioral Finance Perspective. *The Journal of Asian Finance, Economics, and Business*, *7*(12), 159–168. https://doi.org/10.13106/jafeb.2020.vol7.no12.159

Arouri, M. E. H. & Foulquier, P. (2012). Financial market integration: Theory and empirical results. *Economic Modelling*, *29*, 382–394. https://doi.org/10.1016/j.econmod.2011.11.009

Baur, D. G., Dimpfl, T., & Kuck, K. (2018). Bitcoin, gold and the US dollar–A replication and extension. *Finance Research Letters*, *25*, 103–110. https://doi.org/10.1016/j.frl.2017.10.012

Bekaert, G. & Harvey, C. R. (1995). Time-varying world market integration. *The Journal of Finance*, *50*, 403–444. https://doi.org/10.1111/j.1540-6261.1995.tb04790.x

Beneki, C., Koulis, A., Kyriazis, N. A., & Papadamou, S. (2019). Investigating volatility transmission and hedging properties between Bitcoin and Ethereum. *Research in International Business and Finance*, *48*, 219–227. https://doi.org/10.1016/j.ribaf.2019.01.001

Bouri, E., Azzi, G., & Dyhrberg, A. H. (2016). On the return-volatility relationship in the Bitcoin market around the price crash of 2013. Available at SSRN 2869855.

Bouri, E., Molnár, P., Azzi, G., Roubaud, D., & Hagfors, L. I. (2017). On the hedge and safe haven properties of Bitcoin: Is it really more than a diversifier?. *Finance Research Letters*, *20*, 192–198. https://doi.org/10.1016/j.frl.2016.09.025

Bouri, E., Shahzad, S. J. H., & Roubaud, D. (2020). Cryptocurrencies as hedges and safe-havens for US equity sectors. *The Quarterly Review of Economics and Finance*, *75*, 294–307. https://doi.org/10.1016/j.qref.2019.05.001

Bouri, E., Shahzad, S. J. H., & Roubaud, D. (2019). Co-explosivity in the cryptocurrency market. *Finance Research Letters*, *29*, 178–183. https://doi.org/10.1016/j.frl.2018.07.005

Briere, M., Oosterlinck, K., & Szafarz, A. (2015). Virtual currency, tangible return: Portfolio diversification with bitcoin. *Journal of Asset Management*, *16*(6), 365–373. https://doi.org/10.1057/jam.2015.5

Caporale, G. M., Gil-Alana, L., & Plastun, A. (2018). Persistence in the cryptocurrency market. *Research in International Business and Finance*, *46*, 141–148. https://doi.org/10.1016/j.ribaf.2018.01.002

Chien, M. S., Lee, C. C., Hu, T. C., & Hu, H. T. (2015). Dynamic Asian stock market convergence: Evidence from dynamic cointegration analysis among China and ASEAN-5. *Economic Modelling*, *51*, 84–98. https://doi.org/10.1016/j.econmod.2015.06.024

Chowdhury, M. B. (2005). Trade reforms and economic integration in South Asia: SAARC to SAPTA. *Applied Econometrics and International Development*, *5*(4), 23–40.

Ciaian, P., & Rajcaniova, M. (2018). Virtual relationships: Short-and long-run evidence from BitCoin and altcoin markets. *Journal of International Financial Markets, Institutions and Money*, *52*, 173–195. https://doi.org/10.1016/j.intfin.2017.11.001

Click, R. W., & Plummer, M. G. (2005). Stock market integration in ASEAN after the Asian financial crisis. *Journal of Asian Economics*, *16*(1), 5–28. https://doi.org/10.1016/j.asieco.2004.11.018

Corbet, S., Meegan, A., Larkin, C., Lucey, B., & Yarovaya, L. (2018). Exploring the dynamic relationships between cryptocurrencies and other financial assets. *Economics Letters*, *165*, 28–34. https://doi.org/10.1016/j.econlet.2018.01.004

Corbet, S., Lucey, B., Urquhart, A., & Yarovaya, L. (2019). Cryptocurrencies as a financial asset: A systematic analysis. *International Review of Financial Analysis*, *62*, 182–199. https://doi.org/10.1016/j.irfa.2018.09.003

Dang, T. T. (2019). Current situation of cryptocurrency in Vietnam. *The Journal of Business Economics and Environmental Studies*, *9*(4), 29–34. https://doi.org/10.13106/jbees.2019.vol9.no4.29

Demir, E., Gozgor, G., Lau, C. K. M., & Vigne, S. A. (2018). Does economic policy uncertainty predict the Bitcoin returns? An empirical investigation. *Finance Research Letters*, *26*, 145–149. https://doi.org/10.1016/j.frl.2018.01.005

Engle, R. F., & Granger, C. W. J. (1987). Cointegration and error correction: representation, estimation, and testing. *Econometrica*, *55*, 251–276. https://doi.org/10.2307/1913236

Fauzi, M. A., Paiman, N., & Othman, Z. (2020). Bitcoin and Cryptocurrency: Challenges, Opportunities and Future Works. *The Journal of Asian Finance, Economics and Business* (JAFEB), *7*(8), 695–704. https://doi.org/10.13106/jafeb.2020.vol7.no8.695

Ferreira, P., & Pereira, É. (2019). Contagion effect in cryptocurrency market. *Journal of Risk and Financial Management*, *12*(3), 115. https://doi.org/10.3390/jrfm12030115

Gkillas, K., Bekiros, S., & Siriopoulos, C. (2018). Extreme Correlation in Cryptocurrency Markets. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3180934

Gonzalo, J. (1994). Five alternative methods of estimating long run equilibrium relationships. *Journal of Econometrics, 60,* 203–233. https://doi.org/10.1016/0304-4076(94)90044-2

Granger, C. W. (1988). Some recent development in a concept of causality. *Journal of Econometrics*, *39*(1–2), 199–211. https://doi.org/10.1016/0304-4076(88)90045-0

Jalal, R. N. U. D., Sargiacomo, M., Sahar, N. U., & Fayyaz, U. E. (2020). Herding behavior and cryptocurrency: Market asymmetries, inter-dependency and intra-dependency. *The Journal of Asian Finance, Economics, and Business, 7*(7), 27–34. https://doi.org/10.13106/jafeb.2020.vol7.no7.027

Ji, Q., Bouri, E., Lau, C.K.M., & Roubaud, D. (2019). Dynamic connectedness and integration in cryptocurrency markets. *International Review of Financial Analysis*, *63*, 257–272. https://doi.org/10.1016/j.irfa.2018.12.002

Jiang, Y., Nie, H., & Monginsidi, J. Y. (2017). Co-movement of ASEAN stock markets: New evidence from wavelet and VMD-based copula tests. *Economic Modelling*, *64*, 384–398. https://doi.org/10.1016/j.econmod.2017.04.012

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economics Dynamic and Control*, 12, 231–254. https://doi.org/10.1016/0165-1889(88)90041-3

Johansen, S. & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, *52*, 169–210.

Karim, B. A. & Karim, Z. A (2012). Integration of ASEAN-5 stock markets: A revisit. *Asian Academy of Management Journal of Accounting and Finance*, *8*(2), 21–41.

Kearney, C., and Lucey, B. M. (2004). International equity market integration: Theory, evidence and implications. *International Review of Financial Analysis*, *13*, 571–583. https://doi.org/10.1016/j.irfa.2004.02.013

Kristoufek, L. (2015). What are the main drivers of the Bitcoin price? Evidence from wavelet coherence analysis. *PloS One*, *10*(4), e0123923. https://doi.org/10.1371/journal.pone.0123923

Luu Duc Huynh, T. (2019). Spillover risks on cryptocurrency markets: A look from VAR-SVAR granger causality and student'st copulas. *Journal of Risk and Financial Management*, *12*(2), 52. https://doi.org/10.3390/jrfm12020052

Mitra, A., & Bhattachargee, K. (2015). Financial Interdependence of International Stock Markets: A Literature Review. *New Delhi, Indian Journal of Finance*, *9*(5), 20–33. https://doi.org/10.17010/ijf/2015/v9i5/71447

Mohti, W., Dionísio, A., Vieira, I., & Ferreira, P. (2019). Regional and global integration of Asian stock markets. *Research in International Business and Finance*, *50*, 357–368. https://doi.org/10.1016/j.ribaf.2019.06.003

Narayan, P. K. & Smyth, R. (2004). Modelling the linkages between the Australian and G7 stock markets: common stochastic trends and regime shifts. *Applied Financial Economics*, *14*(14), 991–1004. https://doi.org/10.1080/0960310042000261871

Okorie, D., & Lin, B. (2020). Crude oil price and cryptocurrencies: Evidence of volatility connectedness and hedging strategy. *Energy Economics*, *87*, 104703. https://doi.org/10.1016/j.eneco.2020.104703

Sharma, A., & Seth, N. (2012). Literature review of stock market integration: a global perspective. *Qualitative Research in Financial Markets*, *4*(1), 84–122. https://doi.org/10.1108/17554171211213568

Vo, X. V., & Tran, T. T. A. (2020). Modelling volatility spillovers from the US equity market to ASEAN stock markets. *Pacific-Basin Finance Journal*, 59, 101246. https://doi.org/10.1016/j.pacfin.2019.101246

Walther, T., Klein, T., & Bouri, E. (2019). Exogenous drivers of bitcoin and cryptocurrency volatility–a mixed data sampling approach to forecasting. *Journal of International Financial Markets, Institutions and Money*, *63*, 101133. https://doi.org/10.1016/j.intfin.2019.101133

Wu, F. (2020). Stock market integration in East and Southeast Asia: The role of global factors. *International Review of Financial Analysis*, *67*, 101416. https://doi.org/10.1016/j.irfa.2019.101416