Returns on Cryptocurrency, Stock Market, Exchange Rate and Monetary Instruments

Hongzhe Wen[1], Yochanan Shachmurove[2, *

[1]Blue Ridge School

[2]The City College of The City University of New York

*Corresponding author 921680665@qq.com

Abstract: This paper analyzes the dynamic relationships among 15 cryptocurrencies and other financial instruments as well as macroeconomic variables, such as stock market indices, interest rates and exchange rates. Cryptocurrencies, decentralized digital tokens, are based on blockchain technologies. Participants in financial transactions in these markets avoid the use of exchange intermediaries. These markets are highly volatile. Research indicates that volume and market capitalization is closely related to the price of the cryptocurrencies. In addition to that, foreign exchange rates and the stock markets have a large contribution to the volatility of the cryptocurrency market.

1. Introduction

The aim of cryptocurrencies is to build a completely decentralized transaction system based on blockchain technology. This new payment system that can perform peer-to-peer transactions, has the characteristics of anonymity (Yelowitz and Wilson, 2015; Wilson and Yelowitz, 2014). On October 31, 2008, Satoshi Nakamoto created Bitcoin (Nakamoto, 2008). The first commonly acknowledged transaction that showed the value of Bitcoin occurred on May 22, 2010. The preliminary purpose of the invention was to form a trustworthy transaction system, but it slowly has turned into a financial asset similar to gold (Dyhrberg, 2016; Baur et al, 2018; Qin et al, 2021). Since then, market capitalization has increased rapidly to 1.08 trillion USD by May 9, 2021. Its price has once passed 64,779.38 USD on April 4, 2021. Because of its unpredictable behavior and high returns, Bitcoin attracted plenty of speculative investors. Moreover, the use of Bitcoin and other cryptocurrencies has fanned curiosity from researchers. .

As the application of cryptocurrencies spreads, policy makers start to look into their effects on the macroeconomic environment. Generally, governments have a negative attitude towards cryptocurrencies. The U.S. and the Chinese governments are two leading countries openly discussing (Cvetkova, 2018; Perkins, 2018) the disturbance brought by this new asset category. As for the US government, the Congress is debating its macroeconomic and financial effects, including market manipulation, uninformed retail investment, and illegal activities facilitation. As for China, the government has forbidden trade in cryptocurrencies on the mainland (Hong Kong and Macau allowed).

Cryptocurrencies present a potential negative impact on the government's monopoly power, i.e., threat to seigniorage. The widespread use of these cryptocurrencies makes government regulation a necessity in the near future. One possibility is for governments to issue their own cryptocurrencies, backed by the power of the state and the blockchain technology (Allen et al., 2020; Perkins, 2018).

This process is already activated—the Chinese central bank has invented a Digital Currency Electronic Payment system based on the existing blockchain technology (Peters, 2020; Shi and Zhou, 2020). Although still uncertain whether the system will become the dominant payment method, the Chinese government's adoption of the technology, which also supports typical cryptocurrency, has signaled the technologies' possible wide application in digital assets or payment in the future.

Currently, over 8,000 cryptocurrencies have been invented, majority of which have their own unique applications and closed networks. For example, Ethereum aims to establish a trustful framework for message processing (Wood, 2014); Dogecoin has a block production speed of one minute, which is 10 times as faster than Bitcoin so it can be used as tips payment (Chohan, 2017); and Filecoin (Benet, 2017), a decentralized storage system, is a symbol of personal data privatization. Moreover, the network and the blockchain technology can hold decentralized finance (DeFi) and decentralized applications (DApps). This replicated infrastructure can provide financial services without any intermediaries (Schär, 2021).

This paper applies a linear regression model to discover the relationships between the cryptocurrency market and other possible related macroeconomic indices. A strong correlation between financial indices and the cryptocurrency market can help predict the upcoming tendency and behaviors of the cryptocurrencies. Therefore, this work can contribute to the existing literature by analyzing the effects of multiple variables, ascertaining causes of markets' characteristics and enabling market participants to adequately construct an appropriate portfolio.

The remainder of the paper is organized as follows: Section II reviews the literature; Section III describes the methodology. Section IV details the data sources. Section V presents the results. Section VI concludes.

2. Literature Review 541

Multiple cryptocurrencies are on the market. Wood (2014) introduces, defines and discusses the protocol of Ethereum. Chohan (2017) presents the historical evolution of Dogecoin. Among economists who investigate the cryptocurrency market is Jinan Liu (2019), who applies GARCH-in models to examine the historical price and the interconnection between the volatility of the cryptocurrency market and other financial markets. He finds spillover effects of the US financial onto the cryptocurrency markets. Yi et al. (2018) investigates the volatility connectedness of the cryptocurrency market, which exhibits the connection between Bitcoin and other 51 currencies, and the unexpected result has shown that some unnoticeable cryptocurrencies can determine the short-term price of the popular types. Dyhrberg (2016) indicates that Bitcoin has a place in the financial market and classifies somewhere between the US dollar and gold for the purpose of pure store of value. Shahzad (2019) performs a study on whether Bitcoin is a better choice as a safe-haven investment. The result exhibits that Bitcoin, general commodity index, and gold are weak safe-haven investments and vary based on the time difference and different markets. Qin (2021) investigates the relationships between Bitcoin and changes in economic policy of various countries. He ascertains a positive reverse impact of the Bitcoin return and the uncertainty of the global economy. According to Szetela et al. (2014), no long-term but a weak short-term relationship exists between the volume of cryptocurrencies and the overall trend of the market, which eliminates the possibility of predicting future behavior of the cryptocurrency market based on the volume.

The blockchain technology that derived originally from Bitcoin can build a closed network and develop various uses. One such use is Decentralized Finance (DeFi) which is a financial infrastructure based on the blockchain technology that is controlled by decentralized applications (DApps). DeFi may be a flourishing translucent financial infrastructure in the future due to its properties in terms of efficiency and accessibility according to Schär (2021). Noda (2021) demonstrates the evolution of efficiency for the majority of the existing cryptocurrency market. Adaptive Market Hypothesis (AMH) of Lo's (2004) has been confirmed based on his examination, which explains to the investors the value of the cryptocurrencies as financial assets.

Yelowitz, Wilson (2015) and Wilson, Yelowitz (2014) seek the tendency of users who searched and needed the information about Bitcoin. The result reveals that computer programming enthusiasts, criminals, investors and libertarians are the people who will most likely look for information about Bitcoin, which means that people such as criminals can also apply it as a tool for their illegal activities. Due to similar concerns, governments' attitudes toward the cryptocurrency application seem negative. Allen (2020) conveys a survey result and points out possible regulations and policies due to the potential of blockchain technology being disruptive to the financial system. Perkins (2018) discusses the policy of cryptocurrencies and potential threats to the US government. Widespread use of cryptocurrencies may lead to serious effects on the financial market of multiple countries if any government forbids it or controls it. Shi and Zhou (2020) introduces the Digital Currency Electronic Payment (DCEP) that was recently designed by the central bank of China. Its current form can still match the demand of the central bank and the market even though the system is incomplete.

3. Methodology 726

This paper aims to discover the relationships between the cryptocurrency market and other financial indices. For the calculation, the paper applies linear regression analysis to the top 15 most popular cryptocurrencies, four stock market indexes, five exchange rates and treasury yields with four different maturity dates. The model assumes daily return on each cryptocurrency (defined as defined as $r_t=[\ln(P_t)-\ln(P_{t-1})]*100$) as dependent variables and all other variables as independent ones. Admittedly, the variables that affect the dependent variable are not certain. In other words, there is a possibility that other related variables are not included in the model.

The model's first run includes all independent variables in the hypothesis and the second run includes only variables with low p-value. Correlation matrix is applied to verify the result.

The paper constructs four hypothesis:
1. Market capitalization and volume:
a. When the market capitalization of a cryptocurrency increases, the rate of return of the cryptocurrency increases.
b. When the volume of a cryptocurrency increases, the rate of return of the cryptocurrency decreases.

Since market capitalization is defined as price times volume, price increases market capitalization, holding volume constant. Trading volume, in the real life market, should be determined by price because when the price drops, more investors are willing to buy or sell cryptocurrencies; when the price increases, more investors are willing to hold the cryptocurrencies and less investors will but them because of its high price. However, trading volume is set as independent variables in the model for consistency. Therefore, due to the correlation effect, trading volume should have a negative impact on the cryptocurrency market, though the inverse relation needs to be kept in mind.
2. Treasury yields:
a. As for 10-year treasury yield, when it changes, there will be no significant influence made to the price of cryptocurrency.
b. As the term of the treasury yields becomes shorter, the influence of it on cryptocurrencies will get stronger.
c. When three-month treasury yield increases, the close price of the cryptocurrencies will decrease.

For treasury yield, the data of ten-year, five-year, one-year and three-month treasury yield are included. Major investor groups for treasury security and emerging alternative investment instruments (including cryptocurrency) are different, with treasury bonds investors more conservative while cryptocurrencies investors more speculative. Therefore, the cryptocurrency return rate is unrelated to treasury yields.
3. Stock Market:
a. When the rate of change of the Shanghai composite index increases, the rate of change of cryptocurrencies increases.

b.   The rate of change of gold will cause the rate of change of cryptocurrency to move up.

c.   Wilshire and NASDAQ's rate of change will have the same action as the cryptocurrency market has.

Stock market shares similar characteristics with the cryptocurrency market (high return, high risk) though cryptocurrency has higher volatility. Therefore, stock can act as an alternative to cryptocurrency when people hold bullish investor sentiment. From these similar points, the cryptocurrency market may have a similar fluctuation in its price.

4.   Foreign exchange rate:

a.   Any change in the foreign exchange rate will strongly influence the cryptocurrency market. When the foreign exchange rates drop, the rate of change in the cryptocurrency market will increase.

The volatility of foreign exchange rate and the cryptocurrency market may display a negative correlation because of the basic settings of the cryptocurrencies. The maximum number of cryptocurrencies units is set when the cryptocurrency type is created initially, which may cause deflation in the future. Further, less cryptocurrency will be traded in the market as people keep losing these cryptocurrencies (if the property is not saved in an exchange but remains in your hardware wallets; the cryptocurrency will be permanently lost if the password is forgotten). Although the ultimate number of coins did not make a great impact in the past, as each cryptocurrency reaches the maximum amount, the close price of a cryptocurrency will increase exponentially when the foreign exchange rate increases.

4. Data 455

The paper uses data for 15 high-frequency cryptocurrencies (Bitcoin (BTC), Ethereum (ETH), Cardano (ADA), Binance Coin (BNB), Ripple (XRP), Uniswap (UNI), Litecoin (LTC), Chain Link (LINK), Dogecoin (DOGE), Stellar (XLM), AAVE (AAVE), EOS, Cosmos (ATOM), Cryptocom Coin (CRO), and USD Coin (USDT)) from April 29, 2013 to February 27, 2021. The data encompass closing price, market capitalization, and volume of the cryptocurrencies from kaggle.com/sudalairajkumar/cryptocurrencypricehistory. Cryptocurrency with low market capitalizations and without enough trading data for econometric analysis are filtered out.

In addition, the other set part of the data of common financial intermediaries includes exchange rate of five representative foreign currencies (Euro, CHF, CNY, JPY, GBP, and USD), price of stock market benchmark (NASDAQ, SSE, and Wilshire), gold price, and treasury yields (10 year, 5 year, 1 year and 3 month). The starting dates of these data are the same as cryptocurrencies in order to make comparisons. Chosen variables are either commonly used measures in the overall market or essential indices in each country.

Table 1 presents descriptive statistics for each cryptocurrency. Overall, major US macroeconomic indicators are comparatively stable. The range of the exchange rates and those macroeconomic indicators, which have a lower range, have a more stable market and predictable behavior. As for the majority of cryptocurrencies, NASDAQ, and SSE compared to the other indices were relatively high. Additionally, the standard deviation of Bitcoin, Ethereum, and the stock market all have an unexpectedly high value, which means that the price of these two currencies are either far above or far lower than the mean of the currency. In contrast, no other currencies had extreme values like the dominant cryptocurrency types. Large standard deviation values of the two leading cryptocurrencies show that the prices are far away from the mean, indicating the high risk of investment on these two.

Inset Table I here

	Mean	Median	Standard Deviation	Coefficient of variation	Range	Skewness	Kurtosis
Bitcoin (BTC)	4,852.09	1,182.81	6,975.11	5.90	57,471.51	3.26	219.09
BTC Volume	8,978,474,976.98	330,195,008.00	16,581,352,325.07	50.22	350,968,000,000.00	4.99	861.44
BTC MarketCap	85,916,224,267.47	19,242,382,456.50	128,741,447,758.55	6.69	1,071,481,588,821.10	3.40	232.13
Ethereum (ETH)	258.14	185.03	309.32	1.67	1,959.73	2.36	-358.82
ETH Volume	5,429,598,554.69	1,844,269,952.00	8,100,359,387.23	4.39	60,733,528,172.00	2.57	-409.07
ETH MarketCap	26,986,559,256.69	19,729,633,078.00	33,473,360,395.85	1.70	224,877,786,373.83	2.67	-440.71
Cardano (ADA)	0.14	0.08	0.17	2.16	1.22	3.22	11.79
ADA Volume	472,962,192.74	101,190,601.60	1,427,984,552.93	14.11	19,140,240,828.00	6.55	53.82
ADA MarketCap	3,788,101,187.84	2,102,087,914.00	5,099,696,125.60	2.43	40,739,030,873.60	3.53	14.88
BinanceCoin(BNB)	19.09	15.34	24.98	1.63	332.52	7.32	-80.25
BNB Volume	287,739,423.42	173,683,856.90	821,359,931.60	4.73	17,982,935,904.81	12.53	-234.62
BNB MarketCap	2,714,482,635.36	2,256,062,410.00	3,886,386,094.25	1.72	51,390,095,168.00	7.32	-80.38
Ripple (XRP)	0.20	0.16	0.30	1.90	3.37	3.95	-1,550.94
XRP Volume	943,294,613.32	51,265,500.00	2,436,646,811.30	47.53	34,974,233,953.00	6.17	-2,855.68
XRP MarketCap	8,208,209,356.39	6,229,239,733.50	11,826,889,914.53	1.90	130,831,030,087.93	3.63	-1,390.00
Uniswap (UNI)	7.61	3.84	7.10	1.85	27.21	1.52	0.86
UNI Volume	1,242,620,880.93	767,599,935.80	1,183,725,639.67	1.54	6,183,502,322.00	2.16	4.97
UNI MarketCap	2,007,867,885.42	877,520,702.10	2,268,495,553.40	2.59	8,513,871,610.80	1.49	0.81
Litecoin (LTC)	41.96	23.93	52.65	2.20	357.18	2.05	96.70
LTC Volume	1,119,235,562.82	44,923,600.00	2,063,368,280.24	45.93	17,994,263,494.00	2.88	170.06
LTC MarketCap	2,429,446,536.92	631,118,987.60	3,128,372,140.67	4.96	19,444,731,318.01	1.83	79.89
ChainLink (LINK)	3.84	1.34	5.96	4.45	34.58	2.47	6.59
LINK Volume	567,674,271.18	47,769,558.58	4,877,196,347.14	102.10	170,548,601,227.00	33.80	1,178.29
LINK MarketCap	1,435,046,953.68	469,341,345.10	2,353,841,736.34	5.02	14,083,527,176.00	2.69	7.99
Stellar (XLM)	0.09	0.04	0.13	2.90	0.94	2.25	142.25
XLM Volume	178,783,019.19	33,585,150.00	483,422,157.19	14.39	10,408,577,935.91	8.80	1,972.30
XLM MarketCap	1,590,467,379.95	658,005,351.80	2,278,837,403.18	3.46	16,021,076,758.48	2.06	120.46
Dogecoin (DOGE)	0.00	0.00	0.01	4.02	0.08	8.43	1,518.36
DOGE Volume	106,310,410.77	4,485,170.00	845,863,838.51	188.59	25,403,310,432.00	17.53	7,370.33
DOGE MarketCap	287,462,535.73	155,284,725.00	782,292,741.41	5.04	10,110,947,017.84	8.59	1,558.83
Aave (AAVE)	153.84	82.11	146.57	1.78	502.18	1.32	0.34
AAVE Volume	439,472,804.82	299,014,897.40	437,769,267.33	1.46	2,838,572,596.00	2.07	6.37
AAVE Market Cap	1,853,664,905.80	991,770,343.15	1,856,006,783.68	1.87	6,491,552,767.10	1.28	0.25

EOS	4.52	3.36	3.21	0.95	21.05	1.88	-11.76
EOS Volume	1,724,971,318.07	1,501,128,756.00	1,457,236,653.45	0.97	10,010,146,898.00	1.44	-10.74
EOS MarketCap	3,795,451,403.60	3,083,125,737.00	2,591,709,526.84	0.84	17,769,451,250.00	1.71	-12.21
COSMOS (ATOM)	4.71	4.22	3.06	0.73	23.54	3.93	18.70
ATOM Volume	243,263,570.99	159,379,489.55	324,041,417.19	2.03	3,363,380,367.47	4.87	31.56
ATOM MarketCap	4.71	4.22	3.06	0.73	23.54	3.93	18.70
CryptocomCoin(CRO)	0.07	0.06	0.04	0.71	0.21	1.05	0.30
CRO Volume	35,215,333.84	11,371,323.42	87,171,699.53	7.67	1,993,612,398.49	15.50	325.74
CRO Marke=tCap	1,067,881,875.87	591,943,693.25	998,814,927.58	1.69	5,317,939,793.00	1.14	0.27
USDCoin (USDT)	1.00	1.00	0.01	0.01	0.07	1.29	4.35
USDT Volume	415,813,381.47	270,605,260.90	522,982,315.67	1.93	4,522,276,766.00	2.72	10.06
USDT MarketCap	1,161,064,480.31	454,869,720.50	1,569,059,944.85	3.45	8,658,975,906.00	2.42	5.83
Exchange Rate USA	1.00	1.00	0.00	0.00	0.00	-	-
EX Euro	0.83	0.84	0.07	0.09	0.29	-0.19	55.12
EX CNY	6.53	6.49	0.30	0.05	1.14	0.29	61.81
EX CHF	0.95	0.96	0.04	0.05	0.33	-0.88	142.89
EX JPY	102.38	106.44	13.52	0.13	49.51	-0.63	73.54
EX GBP	0.70	0.67	0.07	0.11	0.28	0.22	48.72
NASDAQ	5,134.52	4,677.32	2,759.35	0.59	12,826.83	1.01	-201.53
Gold	1,360.18	1,296.10	242.16	0.19	1,244.80	0.76	-155.67
Wilshire	91.21	88.61	39.87	0.45	174.58	0.54	-140.47
SSE	2,183.66	2,439.18	1,204.04	0.49	5,061.45	-0.53	-137.39
10 Year	2.37	2.33	2.67	1.14	173.49	57.51	-211,679.32
5 Year	1.62	1.61	2.66	1.65	173.82	57.32	-216,995.70
1 Year	0.72	0.30	2.70	8.99	173.95	55.22	-210,077.98
3 month	0.52	0.13	0.74	5.72	2.48	1.22	-198.24

However, not all of the measures are the same for the stock market and cryptocurrency market. Every cryptocurrencies is right-skew and all of the other measures are displayed as left-skew. At this point, the exchange rate, stock market and treasury yields have a surprisingly similar performance. SSE and exchange rates presented a left-leaning curve, which demonstrates longer tails. Right skewed for cryptocurrencies means that for most of the time, the price is under the median value of the price, and the price rarely goes high.

5. Result and Discussion

Table II presents the summarized result after running the regressions. The coefficients in the graph were labeled with asterisks (* means the p-value of the variable is below 0.1 but larger than 0.05; ** means the p-value is higher than 0.01 but less than 0.05; *** means the p-value is below 0.01). The coefficients can be used to estimate the rough line that represents the relationship between different variables. The return on cryptocurrency may be affected or affects other variables as well.

	Volume	Market Capitalization	Exchange CNY	Exchange CHF	Exchange JPY	Exchange GBP	Exchange Euro	Treasury 10 yr	Treasury 5yr	Treasury 1yr	Treasury 3 mon	Willshire	Gold	NASDAQ	SSE	Adjusted r squared
BTC	-0.153***	100.712***		1.352*	0.369*				-0.023*	0.023*	-0.019*					0.994
ETH	-_	98.123***	-47.210***									7.903***				0.9903
ADA		-8.996**				-178.30**										0.02009
BNB	-0.211***	101.070***					-5.138**					4.170***				0.993
XPR	0.353***	60.064**														0.6717
LTC	-0.445***	98.919**											3.972***			0.9913
DOGE	-0.312***	71.449**		-24.033*				-1.952***	2.282**	-0.334*	-0.195*					0.8795
LINK	-0.023**	96.705**				-20.813***			-0.387**	0.388**			7.768*			0.9869
XLM	0.836***	51.432**	21.632	-81.666***	16.528	5.485	23.480	-2.485*	1.904	0.576	-0.543*	69.938	13.957	-62.302	0.062	0.4751
EOS	-1.028***	100.442***						-0.472*	-0.624**	1.094**	-0.148**					0.991

Bitcoin (BTC) has an adjusted r-squared value of 0.994. Most of the variables such as market capitalization, the exchange rate of CHF and JPY showed a positive correlation with BTC. Specifically, market capitalization has a coefficient of over 100, which verifies the previous hypothesis that the price of Bitcoin increases when market capitalization increases. In contrast, the volume has a low negative coefficient, which indicates that when volume increases, the price decreases slightly. These results completely matched with the hypothesis that was mentioned in Section III. For treasury yields, the relationship between them and BTC is weak, so any change to treasury yield will not seriously influence the price of BTC.

For Ethereum (ETH), volume and market capitalization has a similar coefficient as BTC, the CNY exchange rate and Wilshire can influence ETH in an unexpectedly large way. ETH has an adjusted r-squared value of 0.990. Although the volume cannot affect ETH as much, CNY exchange rate, which has a large negative coefficient value, shows that a slight change may cause a drastic decline in the price of ETH. Therefore, investors need to pay attention to the change in the exchange rate of CNY. This result did not match with our expectation on foreign exchange rate.

ADA is a special case. The coefficient of ADA's market capitalization is the only negative one. In addition to this, the result indicates a strong negative relationship between ADA and the exchange rate of GBP. ADA has a low adjusted r-squared value of 0.020, suggesting that the data of ADA does not fit with the curves well.

BNB has an adjusted r-squared value of 0.993. Wilshire and the exchange rate of Euro affect the price of BNB. The exchange rate of Euro makes a negative impact, which disagrees with the previous hypothesis. The coefficient of Wilshire for BNB is less than ETH's, which infers that the volatility of BNB may be similar to ETH and Wilshire but in a narrower range.

XPR is the only cryptocurrency which exhibits no correlation with independent variables other than volume and market capitalization, and it has an adjusted r-squared value of 0.672. In addition, XPR is the only cryptocurrency that obtains a positive correlation with its volume. As for the other

cryptocurrencies with a negative correlation with their volume, investors may sell it when the price drops. But for XPR, people tend to buy more when price drops, which means that there are valuable aspects about XPR and attract more investors to   expect an increasing price.

LTC has an adjusted r-squared value of 0.991, and it shows a similar performance as ETH. The difference between them is that LTC is strongly connected to the changes in gold price. A positive coefficient demonstrates that when the gold price moves up, the price of LTC will move up at a faster speed.

DOGE has an adjusted r-squared value of 0.800. Except for volume and market capitalization, which shows no difference with the previous cryptocurrencies, treasury yields seem related to the volatility of DOGE. It is interesting that ten-year, one-year and three-month treasury yields have negative coefficients, but five-year treasury yield has a positive coefficient. The reason for this result remains unclear.

LINK has an adjusted r-squared value of 0.987, and its volatility is related to market capitalization, exchange rate of GBP, five-year, one-year treasury yield and gold price. The coefficient of volume is comparatively small. With a coefficient value of -20.813, the GBP exchange rate will make a strong impact on LINK, which is similar to ADA but not as distinct. The coefficient of the five-year treasury yield for DOGE is the only one that is adverse to other treasury yields. Yet for LINK, the coefficient of five-year treasury yield turns out to be negative, and the one-year treasury yield is positive. Unfortunately, the reason stays obscure because of insufficient information.

A wide range of connections with different variables indicates that XLM's price is extremely complicated to predict. Market capitalization for XLM is only half as much as for other cryptocurrencies. CHF exchange rate and NASDAQ are the two variables that have a negative coefficient among other foreign exchange rates and stock markets respectively. Ten-year and three-month treasury yields have negative coefficients at this point. XML has a comparatively low adjusted r-squared value of 0.475, which represents that these variables cannot be explained by the total equation well.

Last, EOS has the smallest coefficient for volume, and treasury yield displayed a connection with its price as well. EOS has an adjusted r-squared value of 0.991. In this case, the volume of EOS has a negative coefficient that is over one, which signifies that the volume will seriously impact the price of EOS because the coefficient was calculated based on the rate of return instead of on the price. One-year treasury yield, for EOS, became the sole one with a negative value, but the other treasury yields are all positive.

The cryptocurrency market, compared to the stock market, shares some similarities in that the market may be influenced by exogenous shocks or unstable economic conditions. The BTC market collapse on March 13, 2020 is one example that was caused by economic regulation and the pandemic. Figures 1, 2 and 3 display the close price change of BTC, ETH, and DOGE respectively with the rate of return on the right side of the graph. A sudden slump, almost half of the normal price, shows on each graph on Mar 13, 2020. Another example from https://fortune.com/2021/07/09/elon-musk-dogecoin-price-crypto/ is on July 9, 2021, Elon Musk sent a tweet about DOGE, and in the following days, the volume of DOGE coin increased but the price dropped. This   aligns with our findings, but the initial reason was simply because of a tweet. Consequently, while observations of the financial indices are indicated, attention to other possible exogenous factors that may cause a turmoil in the market can affect cryptocurrency volatility.
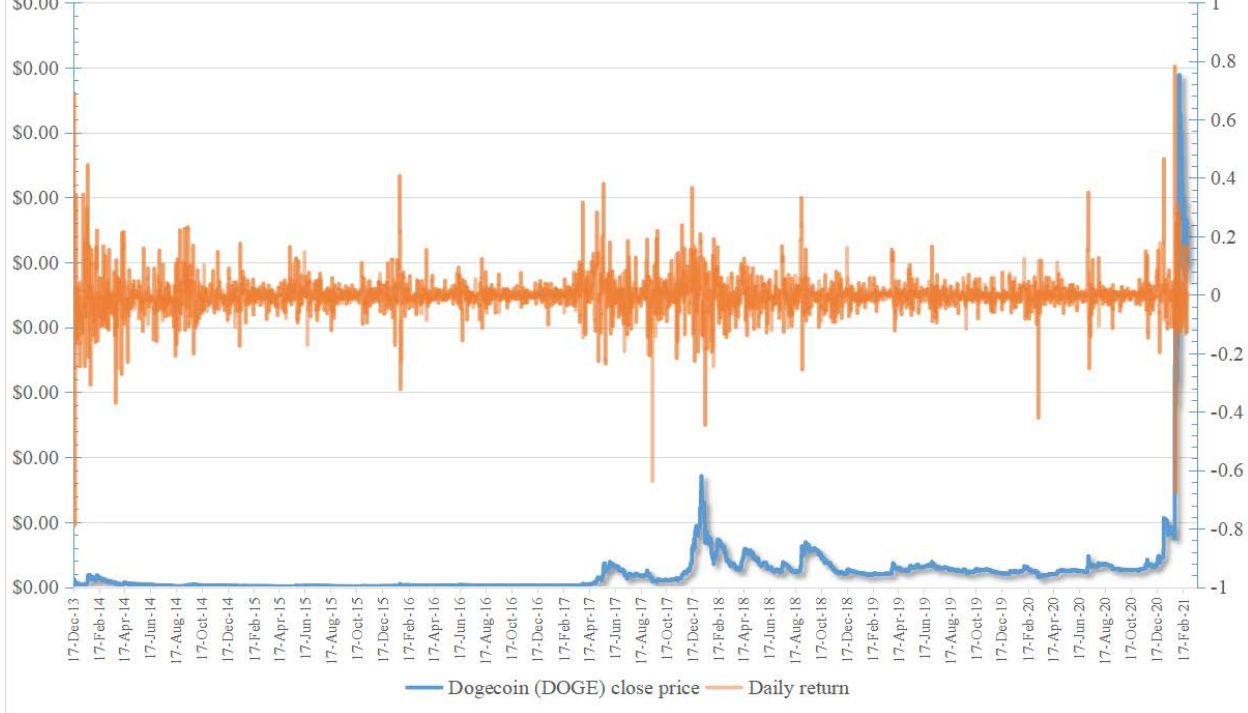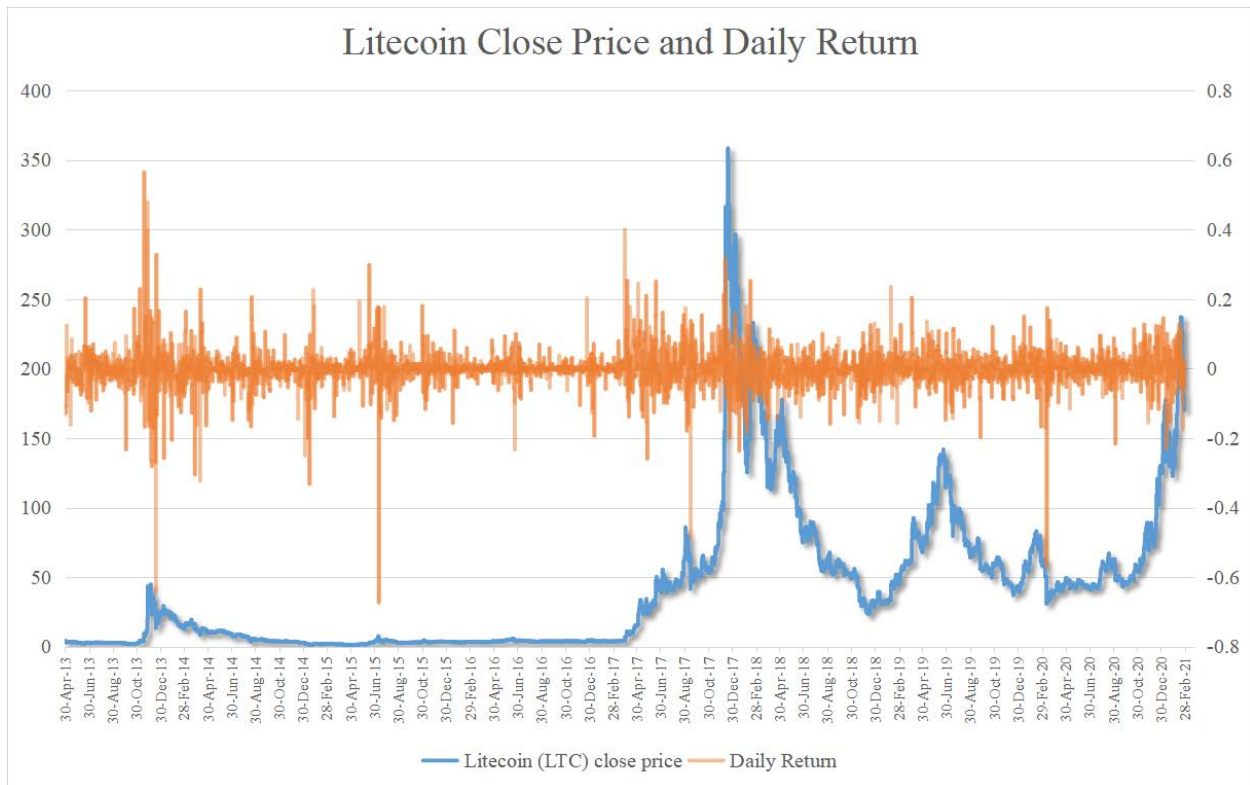
Insert Figures 1, 2, and 3 here.

Ethereum Close Price and Daily Return

Dogecoin Close Price and Daily Return

Litecoin Close Price and Daily Return
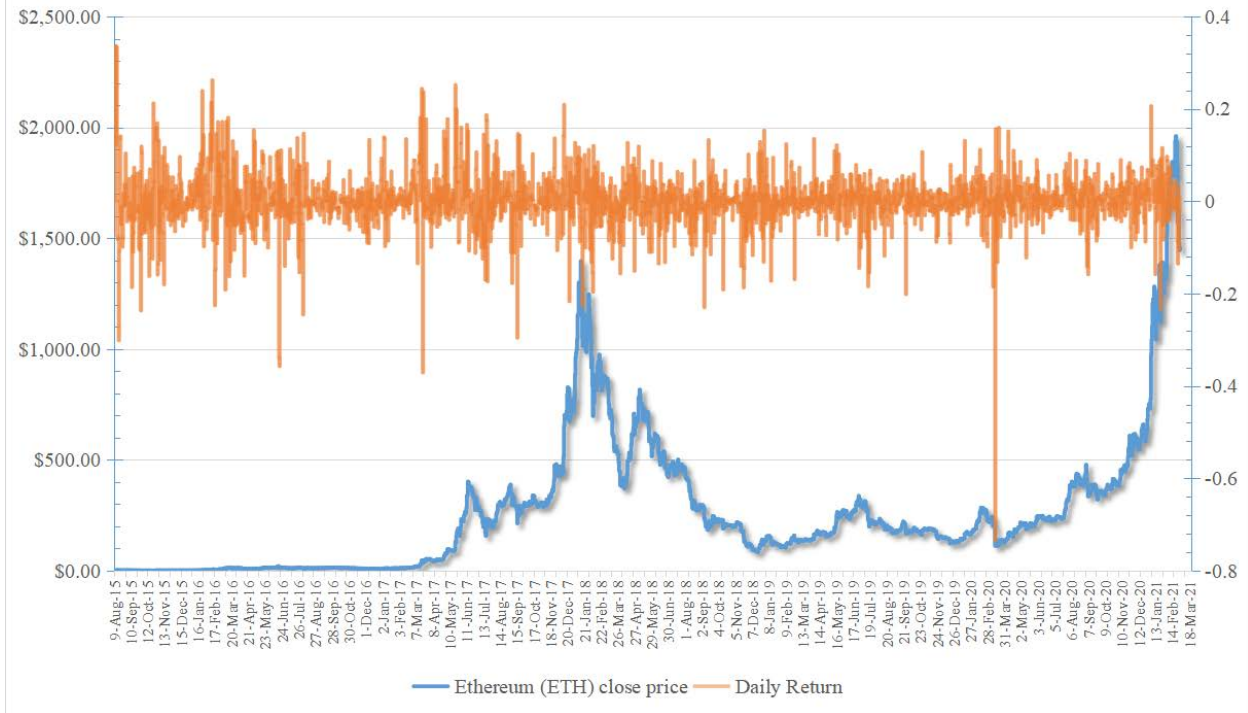
Litecoin (LTC) close price ——— Daily Return

Overall, this work produces some unusual phenomena. The coefficient of treasury yields changed for the same cryptocurrency. For instance, DOGE, LINK, XLM, EOS all showed a correlation with different terms of treasury yields. However, for the same cryptocurrency, treasury yield should share similar properties and characteristics, but the coefficients exhibit large differences. Also, the foreign exchange rates produce a result with abnormally high coefficient values, especially for certain currencies such as GPB, CNY, etc. One example is the coefficient of GBP: when compared with ETH, it has a value of -178.31. The reasons behind these phenomena are unclear, and further studies are needed to disclose it.

6. Conclusion

To summarize, relationships exist between the cryptocurrency market and macroeconomic indices based on linear regression analysis on the 15 most popular cryptocurrencies, foreign exchange rates, stock markets, and treasury yields. The calculation shows that the volume and market capitalization can influence the cryptocurrency market to the maximum extent because they are directly related to the price. The result shows that a cryptocurrency's volume usually has a negative correlation with its price. In contrast, market capitalization exhibited an opposite trend. Other than these, non-directly related variables all demonstrated different situations. In general, the foreign exchange rate and treasury yield obtained negative coefficients, and the stock markets, as expected, displayed a positive correlation. Consequently, in order to see the future pattern of the cryptocurrency market, making observations on the changes of foreign exchange rates and the stock market is indispensable because a large coefficient indicates that any ordinary change may cause a compelling fluctuation in the cryptocurrency market.

The effect on the cryptocurrency market provides new information for investors and miners. The results of this study can be a reference when choosing or investing in cryptocurrencies. Nevertheless, some unexpected phenomena still require deeper investigations to find out causes and patterns. Further studies can investigate the dynamics of the cryptocurrency market and macroeconomic variables. In the future, cryptocurrencies can be used for banks, trades as well as financial assets.

References

[1] **Allen, Franklin, Xian Gu, and Julapa Jagtiani**. 2020 "A survey of fintech research and policy discussion.". https://doi.org/10.21799/frbp.wp.2020.21

[2] **Benet, J.** 2017. Filecoin Research Roadmap for 2017.

[3] **Chohan, U. W**. 2017. A history of Dogecoin. Discussion Series: Notes on the 21st Century. https://doi.org/10.2139/ssrn.3091219

[4] **Cvetkova, I.** 2018. Cryptocurrencies legal regulation. *BRICS LJ*, 5, 128. https://doi.org/10.21684/2412-2343-2018-5-2-128-153

[5] **Dyhrberg, A. H.** 2016. Bitcoin, gold and the dollar–A GARCH volatility analysis. *Finance Research Letters*, 16, 85-92. https://doi.org/10.1016/j.frl.2015.10.008

[6] **Liu, Jinan, and Apostolos Serletis**. 2019 "Volatility in the cryptocurrency market." *Open Economies Review* 30.4: 779-811. https://doi.org/10.1007/s11079-019-09547-5

[7] **Noda, A.** 2021. On the evolution of cryptocurrency market efficiency. *Applied Economics Letters,* 28(6), 433-439. https://doi.org/10.1080/13504851.2020.1758617

[8] **Perkins, D. W**. 2018. Cryptocurrency: The Economics of Money and Selected Policy Issues. *US Congressional Research Service*, R45427.

[9] **Qin, M., Su, C. W., & Tao, R**. 2021. BitCoin: a new basket for eggs?. *Economic Modelling*, 94, 896-907. https://doi.org/10.1016/j.econmod.2020.02.031

[10] **Schär, F.** 2021. Decentralized finance: On blockchain-and smart contract-based financial markets. *FRB of St. Louis Review*. https://doi.org/10.20955/r.103.153-74

[11] **Shahzad, S. J. H., Bouri, E., Roubaud, D., Kristoufek, L., & Lucey, B.** 2019. Is Bitcoin a better safe-haven investment than gold and commodities?. *International Review of Financial Analysis*, 63, 322-330. https://doi.org/10.1016/j.irfa.2019.01.002

[12] **Shi, Ye, and Shucheng Zhou**. 2020 "Central Bank Digital Currencies: Towards a Chinese Approach: Design Choices of Digital Currency Electronic Payment.".

[13] **Szetela, Beata, et al.** 2021 "The relationship between trend and volume on the bitcoin market." *Eurasian Economic Review* 11.1: 25-42. https://doi.org/10.1007/s40822-021-00166-5

[14] **Tan, C. Y., Koh, Y. B., Ng, K. H., & Ng, K. H. 2021.** Dynamic volatility modelling of Bitcoin using time-varying transition probability Markov-switching GARCH model. *The North American Journal of Economics and Finance*, 56, 101377. https://doi.org/10.1016/j.najef.2021.101377

[15] **Wilson, Matthew, and Aaron Yelowitz**. 2014. "Characteristics of Bitcoin users: an analysis of Google search data." https://doi.org/10.2139/ssrn.2518603

[16] **Wood, G**. 2014. Ethereum: A secure decentralised generalised transaction ledger. *Ethereum project yellow paper,* 151, 1-32.

[17] **Yelowitz, Aaron, and Matthew Wilson**. 2015. "Characteristics of Bitcoin users: an analysis of Google search data." *Applied Economics Letters* 22.13: 1030-1036. https://doi.org/10.1080/13504851.2014.995359 .

[18] **Yi, S., Xu, Z., & Wang, G. J.** 2018. Volatility connectedness in the cryptocurrency market: Is Bitcoin a dominant cryptocurrency?. *International Review of Financial Analysis*, 60, 98-114. https://doi.org/10.1016/j.irfa.2018.08.012