Journal of Contemporary Issues in Business and Government Vol. 27, No.5,2021
https://cibg.org.au/

P-ISSN: 2204-1990; E-ISSN: 1323-6903

DEPENDENCE STRUCTURE AMONG CRYPTOCURRENCIES

[1]Ahmad Raza, [2]Naeem Javed,[3]Rabeea Aftab,[4]Anum Shafique,[5]Farwa Batool

[1]MS (Finance), IQRA University Islamabad Campus,ahmad.phd29@gmail.comPhD Scholar, Hamdard Institute of Management Sciences, Hamdard University,

[2]Islamabad.naeemjavedrajput@gmail.com

[3]University Institute of Management Sciences, PMAS-UAAR, rabeeaaftab2@gmail.com

[4]University Institute of Management Sciences, PMAS-UAAR, an_shafique@yahoo.com

[5]University Institute of Management Sciences, PMAS-UAAR, farwabatool868@gmail.com

ABSTRACT

This research paper studies the dependence structure among cryptocurrencies. In this study, secondary data of five cryptocurrencies is used for five years (2015-2020), which was gathered from the coin market cap website. On the basis of most market capitalization, five cryptocurrencies,bitcoin, ethereum, tether, ripple and lite coin are selected. Descriptive statistics, copulas methodology, spearman and kendal tau correlation are the techniques used for hypothesis testing. This study finds that there is dependence among log-returns of selected five cryptocurrencies except for three pairs; "Bitcoins and Ethereum, Bitcoins and Litecoin, Ethereum and Litecoin". All other combinations showed results that there is dependence among cryptocurrencies. Value of akaike information criterion is used to choose the copula that best fit the model. Results show that t-student copula is the best fit model withsymmetric tail dependence. All findings are helpful for investors, researchers, financial analysts and policy makers for future predictions.

Keywords: *Cryptocurrencies, dependence, bitcoin, ethereum, tether, ripple, lite coin*

INTRODUCTION:

Cryptocurrency is known as digital currency, which was used for the first time in 2008 for investment and payments. The dependence structure among cryptocurrencies is very important because each market has some impact on other markets. If the price in the oil market decreases, it must impact other markets like gold or digital currency. Bitcoin is the first type of crypto currency introduced by computer scientist named "Satoshi Nakamoto" stated by Kaya (2018). The major aim behind the invention of cryptocurrencies is to introduce a way of exchange that doesn't need the approval of any central authority. Cryptocurrency helped in the creation of cheap and early transactions without any need fora bank or intermediary as a third party. The idea for cryptocurrency is based on the idea of electronic currency introduced many years ago. Cryptocurrency is considered as a channel of exchange like rand in South Africa, taka in Bangladesh, rupee in India. But the difference is that cryptocurrency don't back up by another asset like gold. Marta et al. (2020) point out some reasons why crypto currency cannot be treated under the definition of money because crypto currency doesn't have any intrinsic value and physical existence. All crypto currency transactions are done in a decentralized way, which depicts that no central bank can regulate its supply and demand. Samet et al. (2020) also find that cryptocurrency can draw the interest of practitioners and other people as it was a substitute for electronic payments.

P-ISSN: 2204-1990; E-ISSN: 1323-6903

Andrychowicz et al. (2014) insist that cryptocurrencies proved as a solution for cryptographic problems like trusted third party and double-spending. Vigna and Casey (2016) find that new concepts are also generated with the invention of cryptocurrencies such as blockchain and decentralization of money to provide help in changing world's economy. Cryptocurrency is an advanced resource design to function as a medium of exchange. Where particular coin proprietorship account is being put away in a record prevailing in type of computerized information base developing strong cryptography, ensuring interchange accounts, controlling the making of extra coins, and confirming the exchange of coin proprietorship. Research gap found in previous studies that there are very fewstudies on dependence of cryptocurrencies. Mostly the studies are being found on the macroeconomics variables and stock returns. Nguyen et al. (2019) discussed the dependence of following cryptocurrencies "Bit coin, lite coin, Ripple, Stellar, Monero, Dash, and Bytecoin" by utilizing the GARCH method but the underline study discuss the dependence among cryptocurrencies by utilizing Copula method.

The information beyond question is related among selected cryptocurrencies (bit coin, Ethereum, ripple, tether, lite coin) and their dependency on each other positively or negatively. In recent years, usage of cryptocurrency has been increased due to changing world conditions. This study chooses to discuss the cryptocurrency market and no other markets because this market is emerging and will hold great market share in the future. If there is dependence proved in the study, then the policymakers for future will make policies according to the findings of research in this matter.

Research Questions

In this study, the following are the research questions:

What is the dependence structure between Bitcoin and Ethereum?

What is the dependence structure between Bitcoin and Tether?

What is the dependence structure between Bitcoin and XRP?

What is the dependence structure between Bitcoin and Lite coin?

What is the dependence structure between Ethereum and Tether?

What is the dependence structure between Ethereum and XRP?

What is the dependence structure between Ethereum and Lite coin?

What is the dependence structure between Tether and XRP?

What is the dependence structure between Tether and Lite coin?

What is the dependence structure between XRP and Lite coin?

The basic aim behind this research is to check the dependence structure of cryptocurrencies. Supposethere is a relationship than either a positive or negative relationship. Cryptocurrencies have gained greater shares in the market of digital currency. Cryptocurrencies have made their place as they don't need any intermediary to start their transaction. This study provides help to know about the dependence structure of cryptocurrencies. This study can benefit investors of cryptocurrency. Investors will get to know whether change in one cryptocurrency will affect the other cryptocurrency too or not.

P-ISSN: 2204-1990; E-ISSN: 1323-6903

2. LITERATURE REVIEW

Portfolio diversification theory shows that to what extent investors are risk-averse and go to the path where they can avoid risk as much as possible. This theory introduced a framework for the reduction of risk for investors. This theory depicts that if there are two portfolios for the same return, investors will go towards the portfolio that gives less risk. On the other hand, this theory also suggests that investors will only compromise on risk factor if he is getting more return, as Yonghyeon (2017) commented. The history of bitcoins tells that its nature is positive and uncorrelated and it can be used for diversification in the portfolio. Not only bitcoins but all the cryptocurrencies can also be taken into consideration for diversification of portfolio. These cryptocurrencies are giving high returns today's world and can cover losses incurred due to investments in other sectors. Also, if an investor wants to invest in cryptocurrencies, he has the option to invest in different cryptocurrencies such as bitcoins, ethereum, ripples and many others. There are also chances that investors can invest some amount in bitcoins and other in ripples to diversify theirportfolio.

The theory of behavioralfinance studies the effect of sentiments and emotions of the investor while making investment decisions. This theory states that investors take the decision on the basis of market information as well as according to their psychology. Bitcoinisthe most famous cryptocurrency as compared to others like ripple and ethereum. This is also a state of mind that if any other cryptocurrency is giving more return than cryptocurrency, some investors would still go for bitcoins due to its market capitalization and publicity. Sometimes investors will take only bitcoin as a cryptocurrency because of least flexible and rigid nature. So, it depends upon the personality and behavior of the investor to which he belongs for decision making.

2.1 BITCOIN

Bitcoin is a type of online payment based on software whose source code is free and open for the public. As Samuel et al. (2019) commented, this currency got famous so much that results from 2017 showed 324 Billion total results from search engines related to bitcoins. Furthermore,Nigeria, Ghana, South Africa, Singapore and Slovenia are the most fascinated countries in the trade of Bitcoins. Morisse and Ingram (2016) showed that bitcoins are cryptographic, while Ram et al. (2016) also stated that bitcoins are virtual. Plassaras (2013) showed that bitcoins are private and digital. So,bitcoin can be defined as a computer-based type of currency that has no apparent counterpart that can be used as exchange medium by networks of open system. Goldrush of 21st century is called bit coin. Prices of bitcoin fluctuates from 5-7% per day as studied by Morrison (2017). There is no need of any third party or broker to make the deal and transactions of bitcoinsare safe because everybody can see the transaction by distributed network in a world so that chances of fraud havebeen minimized. Bitcoins are the largest and finest type of cryptocurrency with market capitalization of 355.48 billion till December, 2020. Anonymity and limited market supply are the main features of bitcoin.

ETHEREUM

Ethereum is a decentralized open-source blockchain including unique agreement usefulness. Ether (ETH) is the local digital currency of the stage. After bitcoin, ethereum is the another-biggest digital currency by market capitalization, stated by Michaels (2018). It is the best effectively utilized blockchain which software engineer Vitalik Buterin developed in 2013. Popper (2017) insisted that ethereum virtual machine (EVM) can perform turing-complete contents and run decentralized requests. Ethereum is utilized for decentralized account, and has been used for some underlying currency contributions. In 2016, a programmer abused a blemish in an outsider venture called The DAO and took $50 million of ether as Waters (2016) elaborated. Therefore, the ethereum people group casted a ballot to hard fork the blockchain to switch the robbery stated by Leising (2017). De Jesus (2016) also showed that ethereum classic (ETC) proceeded as the first chain. Ethereum is not

P-ISSN: 2204-1990; E-ISSN: 1323-6903

same asbitcoin. Bitcoin is a uniqueshape of virtualcashwhichcustomers can send, take, and preservethe simplestbit coins. Ethereum is a cleversettlement stage that lets in entities leverage block chain era to create severeone of a kindvirtual ledger and may be used to create extracryptocurrencies that run on pinnacle of its blockchain as supported by Fauvel (2017). Ethereum is now executing a progression of repairs called ethereum 2.0, which incorporates a change to confirmation of stick and an expansion in exchange output utilizing sharding (Del Castillo, 2020).

TETHER

Tether is the third largest cryptocurrencyon the basis of market capitalization. Robinson and Schoenberg (2018) discussed that tether is disputed digital money with tokens gave by tether limited. It once in the past guaranteed that every token was sponsored by one United States dollar, yet on 14 March 2019, changed the support to incorporate loans to associate organizations mentioned by Coppola (2019). The Bitfinex trade was charged by the New York Attorney General of utilizing Tether's assets to conceal $850 million in assets missing since mid-2018 documented by Vigna (2019). Tan et al. (2018) suggested that tether is known as a stable coin because it was initially intended to always be worth $1.00, keeping up $1.00 for possible later use of tether issued. Lyons and Viswanath-Natraj (2020) stated that a large purchase of bit coins followed tether. Tether issuances affect the trading volume but not the returns of bitcoin. Tether limited expresses that proprietors of tethers have no authoritative right, other legal claims, or assurance that tethers will be reclaimed or traded for dollars found by Kaminska (2017). Baur and Hoang (2021) claimed that bitcoin price drops raise tether trading volume and suggest that stable coin is used as a safety. Dinkins (2017) stated that there is a serious doubt by individuals from the network that everything is real. Bullmann et al. (2019) explained tether as advanced unit of significant worth that is not a type of particular money but depends on a bunch of adjustment devices that should limit fluctuation of their cost. Innovational unbiased, stability and discouraging comparative unpredictability are the main features of tether**.**

RIPPLE

Takashima (2018) defined ripple by both the concept of cryptocurrency XRP and protocol of digital payment that are using by different banks and financial institutions in thewhole world. Ripple was firstly introduced in 2012. It is more famous for the solution of its payment rather than a cryptocurrency. By ripple, user can transfer money in its preferred form. System of ripple allows trading in any currency such as pounds, dollars, ether, bitcoinand many others. It helps ripples to easily integrate into different protocols and countsas an advantage for ripple users. Ripple Labs is a US-based technology company that created a network of remittance and real-time gross settlement system for transfers of funds. Ripple labs were considered one of the 50 smartest companies to create and develop ripple protocol stated by Bergstein (2014). In this system, money can be transferred from one bank to another bank and payment will be made on the basis of one-to-one. Ripple claimed to enable transactions that are secure, almost free with no chargebacks. The ledger called this currency as XRP. While Arnold (2018) claimed that Banks are not using XRP cryptocurrency because it contains volatility problems. Cointelegraph (2019) called ripple as a platform which allows cheap and fast transactions. Less energy is required for transactions of ripple as compared to Bitcoins. Its cost of transaction is very low as compared to bitcoins. Speed of confirmation of the transaction of ripples is much higher than bitcoins (Frankenfield, 2019).

2.5 LITE COIN

Lite coin is a cryptocurrency token buying and sellingbeneath the ticker image LTC. It is a top-appearing altcoin because itbecame first debuted in 2011. Lite coin is a peer-to-peer cryptocurrency and provides open-source

P-ISSN: 2204-1990; E-ISSN: 1323-6903

software project. The Lite coin is the second most established crypto currency and is expected to be an unrivaledbitcoin. Lite coinwas created by a former Google and coin base engineer Charlie Lee and is now maintained via lite coin foundation. The lite coin foundation works closer to the improvement and adoption of the cryptocurrency asset. For example, the muselatelyfashioned a partnership with the ultimate fighting championship to turn out to be the legitimatecryptocurrency of the UFC. The altcoin is mostly amain indicator for the relaxation of the cryptocurrencymarketplace. The network claimed that lite coinlightingis the course that leads the manner to alt season. Lee (2011) stated that lite coin is an open-source model. According to Steadman (2013), lite coins have faster transaction speed than bitcoin. Lite coin speed is 2.5 minutes rather than bitcoin speed is 10 minutes.

2.6 DEPENDENCE OF CRYPTOCURRENCIES

In every market, determining the dependence structure is very important and critical factor. Dependence structure helps each market to understand the behavior, trend and demand of other market. Some markets like oil, stock, gold, and petroleum are used to check the dependence. Saha (2018) examined the dependency among cryptocurrencies which choosen by current market capitalization and found positive price movement associatedwith high volatility. Naeem et al. (2020) showed dependence among different cryptocurrencies and found that trading and return volume depend on each other by using the copula method. And copula model is used to allow the dependence structure between various market conditions. Tail dependence of return volume is irregular in gumbal and clayton copulas also, by using copula methods technique, Tiwari and Adewuyi (2020) analyzed the dependence and contagion risk between three cryptocurrencies;bitcoin, lite coin and ripple (XRP), from daily price data of time span 2013-2018.

HYPOTHESIS STATEMENT

H_1: *There is dependence between bitcoin and ethereum.*

H_2: *There is dependence between bitcoin and tether.*

H_3: *There is dependence between bitcoin and ripple.*

H_4: *There is dependence between bitcoin and lite coin.*

H_5: *There is dependence between ethereum and tether.*

H_6: *There is dependence between ethereum and ripple.*

H_7: *There is dependence between ethereum and lite coin.*

H_8: *There is dependence between tether and ripple.*

H_9: *There is dependence between tether and lite coin.*

H_{10}: *There is dependence between ripple and lite coin.*

3. METHODOLOGY

3.1 DATA

In this study, secondary data of five major cryptocurrencies,bitcoin, ethereum, tether, ripple and lite coin is used on the basis ofthe highest market capitalization. The data is freely accessible online at the “coin market

P-ISSN: 2204-1990; E-ISSN: 1323-6903

cap" website for cryptographic forms of money. The dataset contains log-returns of closing prices of selected cryptocurrencies from a period of 2015-2020. More explicitly, the dataset comprises of the daily closing costs for the cryptocurrencies. Furthermore, copula methods are used to check the dependence structure among cryptocurrencies.

TABLE 1: MARKET CAPITALIZATION

Cryptocurrencies	Market Capitalization
Bit coin	$428,927,988,195
Ethereum	$66,236,764,837
Tether	$20,528,039,416
Ripple	$12,199,494,818
Lite coin	$6,892,480,368

Note. This table shows the market capitalization of cryptocurrencies.

3.2 COPULA METHODS

Copula-based models give a lot of adaptability in showing multivariate disseminations. This permits the researcher to regulate the models for the peripheral conveyances independently from the reliance structure that joins them to shape a mutual conveyance. From an inferential viewpoint, the copula portrayal encourages the assessment of the model in phases, reducing the computational weight. Kurowicka et al. (2011) claimed to a forward-thinking study on copula and vine copula applications. Sklar proposed copula methods in 1959, which now turned into a compelling apparatus for demonstrating the dependency of irregular factors. Copula capacity can be characterized along these lines, and the copula is a capacity that ties an-dimensional total conveyance capacity to its single-dimensional edges and is separated from everyone else, a steady dissemination work portraying the reliance of the model. The copula structure can investigate joint dissemination between factors by changing the minor conveyance into a uniform distribution. so, any aggregate circulation can be transformed into minimal dispersion. The equation for this cycle can be composed as follows:

$$F(F1 \dots., F_K: O_1 \dots \dots O_{K,dc}) = C(F(X_1, O_1) \dots ., F(X_1, O_K): \delta_C) \quad \text{..... Eq.1}$$

Where $X_1 \dots X_K$ indicates irregular factors of joint appropriation F and C is utilized to show copula work. δ_C is being used for copula boundaries and $O_1 \dots O_K$ addresses the minimal circulations boundaries.

The investigation intends to catch the reliance structure by utilizing the bivariate copula approach. In which it is accepted that all joint conveyance is differentiable. The joint bivariate conveyance can be composed as:

$$(X_1, X_2, \theta_1, \theta_2, \delta_C) = \vartheta^2(F_1(X_1; \theta_1), F_2(X_2; \theta_2);\ \delta_{C/\vartheta} X_{1.\vartheta} X_2 \quad \text{..... Eq.2}$$

$$\int (X_1, X_2, \theta_1, \theta_2, \delta_C) = C(F_1(X_1, \theta_1), F_2(X_2, \theta_2); \delta_C). \Pi^2_{(k=1)} fk(x_{(k;)\delta_C)} \quad \text{..... Eq.3}$$

If $C(u_1, u_2; \delta_C = \vartheta^2 C(u_1, u_2, \delta_{C/\vartheta})\ u_{1.\vartheta} u_2$

At that point, dispersion work X_1 and X_{215} the result of copula capacities and the two-minor distributions $F_1(X_1;\vartheta_1)$ and $F_2(X_2;\vartheta_2)$. The log probability can be written as:

$$log\ f(X_1, X_2; \theta_1, \theta_2, \delta_C) = log\ C(F_1(X_1, \theta_1), F_2(X_2, \theta_2); \delta_C) + \Sigma^2_{(K=1)} log f_{(k)(x_k;\delta_C)} \quad \text{..... Eq.4}$$

$$L(\theta_1, \theta_2, \delta_C) = L_C(\delta_C) + \Sigma^2_{(K=1)} L_K(\theta_k)$$

P-ISSN: 2204-1990; E-ISSN: 1323-6903

L_K and L_C depicts the log-probability capacity of the copula and X_K

Copula boundaries are determined by utilizing deduction elements of the edges. The derivation elements of the edges give the consistency and asymptotically ordinarily circulated. The analyst generally utilizes this technique to figure the copula boundaries. IFM system follows a two-venture measure for anticipating the copula boundaries.

In the principal stage, the greatest logprobability is utilized to gauge the boundaries of the marginal distribution for assessment reasons. This can be composed as follows:

$$\theta_1 = arg\ max\ \Sigma_{(t=1)}^{T}\ logf_1(x_{1,t;o_2}) \quad \text{..... Eq.5}$$

$$\theta_2 = arg\ max\ \Sigma_{(t=1)}^{T}\ logf_2(x_{2,t;o_2}) \quad \text{..... Eq.6}$$

Secondly, we apply the boundaries which are determined in the first step to decide the copula boundaries:

$$\delta_C = arg\ max\ \Sigma_{(t=1)}^{T}\ logC(\mu_{1,t;\delta_C}) \quad \text{..... Eq.7}$$

After assessing copula boundaries, the best copula is chosen, which depicts the example of dependence structure. Various specialists have utilized distinctive choice measures for model choice. This examination applies the akaike data model procedure for choice. The copula which contains the base Akaike information criterion (AIC) esteem is liked for translation purposes. AIC can be characterized as follows:

$$AIC = -2(log - likelihood + K) \quad \text{..... Eq.8}$$

Where *K* is utilized to signify the identification motivation behind the boundaries that are utilized in the model.

BIVARIATE COPULAS

Characterizing the dependence structure between arbitrary factors is an unpredictable cycle due to asymmetric behavior in monetary information. For evading this complexity, this investigation applies the bivariate methodology of copula to decide the reliance structure between irregular factors. Bivariate capacity comprises the elliptical copula (Gaussian copula and student t-copula) and Archimedean copula (Clayton copula and Gumbel copula). Elliptical copula is utilized to decide the symmetric reliance on the two tails while Archimedean copula is utilized to portray the lower and upper tail reliance between arbitrary factors. Diverse bivariate copulas which are set up to find out the reliance structures between the unrefined markets are characterized as follows:

BIVARIATE GAUSSIAN COPULA

Gaussian copula is the unit cube distribution which is determined from a typical multivariate appropriation by using the likelihood fundamental change. Numerically, Gaussian copula could be described as follow:

$$C^{Gauss}(u) = \Phi P\Phi^{-1}(u_1), \dots\dots, \Phi^{-1}(u_d) \quad \text{..... Eq.9}$$

$$C_{(u,v)} = \int_{-\infty}^{\theta-1(u)} \int_{-\infty}^{\theta-1(u)} \frac{1}{2\pi\sqrt{1-\delta^2}} \frac{x^2 - 2\delta xy + y^2}{exp\{-\ 2(1-\delta^2)\ \}\, dx.dy} \quad \text{..... Eq.10}$$

BIVARIATE T-STUDENT COPULA

P-ISSN: 2204-1990; E-ISSN: 1323-6903

T-student copula discusses the straight coefficient of relationship and the level of opportunity is under 30. T-student copula has more in tails than Gumbel copula. This copula work shows the reliance between arbitrary variables on the two tails. It tends to be expounded as follow:

$$C_{(u,\upsilon;\delta)} = \int_{-\infty}^{t_u^{-1}(u)} \int_{-\infty}^{t_\upsilon^{-1}(\upsilon)} \frac{1}{2\pi.\sqrt{1-\delta^2}} \frac{x^2 - 2\delta xy + y^2}{\{- \quad 2(1-\delta^2 \quad \}^{-(\upsilon+2)/2} dx.dy} \quad \text{..... Eq.11}$$

GUMBEL COPULAS

The Gumbel copula is created by Clayton, an unbalanced archimedean copula that shows more reliance on the negative tail than the positive tail. Gumbel copula numerically can be shown as :

$$C_C\,(u,\upsilon;\delta) = exp\,\{-(-1\,n\,u)^2 + \,[(-1\,n\,\upsilon)\delta\,]\,\}, \delta\epsilon(1,\infty) \quad \text{..... Eq.12}$$

Clayton Copulas

Clayton copula is proposed by Clayton which is portrayed as an asymmetric archimedean copula. Generally shows the tail reliance on the positive tail instead of negative tail. Condition for Clayton copula can be developed as:

$$C_C(u,\upsilon;\delta) = max\,\{(u^{-\delta} + \upsilon^{-\delta} - 1)\tfrac{-1}{\delta}, 0\}\,, \delta \in [-1,\infty]\{0\} \quad \text{..... Eq.13}$$

FRANK COPULAS

Frank copula is the copula utilized for displaying codependency between irregular factors and is also called an interchangeable copula. It can accept a numerical structure as follow:

$$C_\theta^{Fr}(u_1 \dots \dots u_k) = \frac{1}{-\theta} \frac{\Pi_i(exp(-\theta u_1)-1)}{log\,(1+\,exp\,(-\theta)-1)} \quad \text{..... Eq.14}$$

In the event that we accept the θ=0, at that point, the cutoff is utilized for the association of copula. All the above notice copula capacities catch the different reliance structuresfrom low reliance to extreme reliance which might be either on positive or negative tail or lower and upper tail reliance.

SPEARMAN CORRELATION

Correlation is a diverse analysis that measures the direction and strength between variables. Power can be between +1 and -1. If the value is close to +1 then there is a perfect positive relationship between the variables and when the value is close to -1 then there is a perfect negative relationship between the variables. In this study, two correlation tests; kendal tau and spearman, are used to measure the relationships between variables. Kendal tau correlation is a non-parametric test used to determine the strength of dependence on variables. However, the correlation of Spearman rank is assigned to estimate the degree of association between the variables.

P-ISSN: 2204-1990; E-ISSN: 1323-6903

4. DATA ANALYSIS

4.1 DESCRIPTIVE STATISTICS

	Bitcoin	Ethereum	Tether	XRP	Lite coin
Minimum	-0.2251	-0.4123	-0.0572	-1.0274	-0.5104
1st quartile	-0.0171	-0.0275	0.0000	-0.0176	-0.0205
Median	-0.0021	0.0000	0.0000	0.0023	0.0000
Mean	0.0029	0.0005	0.0000	-0.0025	0.0007
3rd quartile	0.0109	0.0228	0.0000	0.0195	0.0191
Maximum	9.8578	6.4034	0.4916	0.6163	4.4909
Standard Deviation	0.2274	0.1609	0.0061	0.0664	0.1157
Skewness	41.9964	32.7786	-0.2905	-2.9677	30.0728

In table 2, descriptive statistics represent the values of mean, median, maximum, minimum, standard deviation, and skewness to show the variables' characteristics. Histogram of log-returns of cryptocurrencies are also given. (See Appendix)

4.2 Dependence Structure of Ethereum and Lite coin

TABLE 3: ESTIMATES OF DEPENDENCE STRUCTURE OF ETHEREUM AND LITE COIN

	Normal	T-Student	Clayton	Frank	Gumbel
Initial	0.8915	0.8915	1.4235	N/A	1.7117
Final	0.5597	0.6188/ Df=2.5222	0.7899	4.5341	1.7271
Log likelihood	360.7402/ Df=1	490.3007/ Df=2	228.5228/ Df=1	397.3578/ Df=1	475.7327/ Df=1
AIC	-719.4805	-976.6013	-455.0456	-792.1466	-949.4654
Tail Dependence	L= 0 U= 0	L=0.6152 U=0.6152	L=0.4158 U=0.00	L= 0 U= 0	L= 0 U= 0.5062

Note. This table shows the estimates of copulas, including log likelihood, initial final parameter, AIC and tail dependence for the combination of Ethereum and Lite coin.

Results show that t-student has minimum AIC value as -976.6013 which depicts that t-student is the best fit model. Statistical results show the symmetric response for tail dependence and identical structure indicates that log-returns of Ethereum and Lite coin are moving with the same frequency. The degree of freedom of t-student is 2.5222, indicating the fat tail dependence between log-returns of ethereum and lite coin.

4.3Dependence Structure of Ethereum and Tether

P-ISSN: 2204-1990; E-ISSN: 1323-6903

TABLE 4: ESTIMATES OF DEPENDENCE STRUCTURE OF ETHEREUM AND TETHER

	Normal	T-Student	Clayton	Frank	Gumbel
Initial	-0.0072	-0.0072	0.0176	N/A	1.0088
Final	0.0081	0.0114 Df=12.7611	0.0427	0.0789	1.0081
Log likelihood	0.0565 Df=1	6.0452 Df=2	1.7154 Df=1	0.1384 Df=1	0.2066 Df=1
AIC	1.8869	-8.0904	-1.4308	1.7233	1.5869
Tail Dependence	L= 0 U= 0	L=0.0741 U=0.0741	L=8.8474e-08 U=0.0000e+00	L= 0 U= 0	L= 0 U= 0.0109

Note. This table shows the estimates of copulas, includinglog-likelihood, initial final parameter, AIC and tail dependence for combination of Ethereum and Tether.

Results are showing that t-student has minimum AIC value as -8.0904 which means t-student is best fit model. Statistical results are showing the symmetric response for tail dependence and identical structure indicates that log-returns of Ethereum and tether are moving with the same frequency. Degree of freedom of t-student is 12.76 which indicates the fat tail dependence.

4.4 Dependence Structure of Ethereum and Ripple

TABLE 5: ESTIMATES OF DEPENDENCE STRUCTURE OF ETHEREUM AND RIPPLE (XRP)

	Normal	T-Student	Clayton	Frank	Gumbel
Initial	0.0202	0.0202	1.2676	N/A	1.6338
Final	0.4973	0.5954 Df=2.3715	0.7001	4.1861	1.6341
Log likelihood	272.533 Df=1	441.0628 Df=2	180.2951 Df=1	342.7111 Df=1	391.1644 Df=1
AIC	-543.0659	-878.1255	-358.5903	-683.4222	-780.3288
Tail Dependence	L= 0 U= 0	L=0.0799 U=0.0799	L=0.3715 U=0.00	L= 0 U= 0	L= 0 U= 0.4716

Note. This table shows the estimates of copulas which includes log likelihood, initial final parameter, AIC and tail dependence for combination of Ethereum and Ripple.

In results, t-student has minimum AIC value of -878.1255 which shows that t-student is best fit model. Statistical results are showing the symmetric response for tail dependence as upper tail and lower tail structures are same and identical. This identical structure indicates that log-returns of Ethereum and XRP are moving with the same frequency. The degree of freedom of t-student is 2.3715 which indicates the fat tail dependence between log returns.

4.5 Dependence Structure of Ripple and Lite coin

P-ISSN: 2204-1990; E-ISSN: 1323-6903

TABLE 6: ESTIMATES OF DEPENDENCE STRUCTURE OF RIPPLE AND LITE COIN

	Normal	T-Student	Clayton	Frank	Gumbel
Initial	0.0942	0.0942	1.5592	N/A	1.7796
Final	0.5734	0.6455	0.9114	4.9231	1.7941
		Df=2.3581			
Log likelihood	382.809	586.2936	282.2414	451.1303	522.294
		Df=2	Df=1	Df=1	Df=1
AIC	-763.6181	-1168.587	-562.4827	-900.2605	-1042.588
Tail Dependence	L= 0	L=0.0975	L=0.4674	L= 0	L= 0
	U= 0	U=0.0975	U=0	U= 0	U=0.5284

Note. This table shows the estimates of copulas which includes log likelihood, initial final parameter, AIC and tail dependence for combination of Ripple and Lite coin.

In table 6, results show that t-student has minimum AIC value of -1168.587 which represents that t-student is best fit model. Statistical results show the symmetric response for tail dependence as upper tail and lower tail structures are same and identical. The degree of freedom of t-student is 2.3581 which indicates the fat tail dependence.

4.6 Dependence Structure of Ethereum and Bitcoin

TABLE 7: ESTIMATES OF DEPENDENCE STRUCTURE OF ETHEREUM AND BITCOIN

	Normal	T-Student	Clayton	Frank	Gumbel
Initial parameter	0.9264	0.9264	1.2609	N/A	1.6305
Final parameter	0.5291	0.5792	0.7404	4.1701	1.657
		Df=2.4193			
Log likelihood	315.2461	451.7853	215.4459	341.8361	419.9907
	Df=1	Df=2	DF=1	DF=1	DF=1
AIC	-628.4923	-899.5706	-428.8917	-681.6722	-837.9814
Tail Dependence	L=0	L=0.4023	L=0.3923	L=0	L=0
	U=0	U= 0.4023	U=0	U=0	U=0.3866

Note. This table shows the estimates of copulas, includinglog-likelihood, initial final parameter, AIC and tail dependence for combination of Ethereum and Bit coin.

Results show that t-student has a minimum AIC value of -899.5706, representing that t-student is the best fit model. Statistical results show the symmetric response for tail dependence and identical structure which indicates that log-returns of bitcoin and Ethereum are moving with the same frequency. Degree of freedom of t-student is 2.5222.4.7 Dependence Structure of Bitcoin and Tether

TABLE 8: ESTIMATES OF DEPENDENCE STRUCTURE OF BIT COIN AND TETHER

	Normal	T-Student	Clayton	Frank	Gumbel
Initial parameters	-0.0035	-0.0035	0.0319	N/A	1.0159
Final parameters	0.0261	0.0253	0.0746	0.1556	1.0401
		Df=4.2543			
Log likelihood	0.5847	43.3181	5.0975	0.4898	4.8421
	Df=1	Df=2	Df=1	Df=1	Df=1
AIC	0.8306	-82.6361	-8.1949	1.0202	-7.6841
Tail Dependence	L=0	L=0.0731	L=9.2088e-05	L=0	L=0
	U=0	U=0.0731	U=0.0000e+00	U=0	U=0.0526

P-ISSN: 2204-1990; E-ISSN: 1323-6903

Note. This table shows the copulas estimates, includinglog-likelihood, initial final parameter, AIC and tail dependence for combination of Bitcoin and Tether.

In table 8, t-student has minimum AIC value of -82.6361. So, t-student is best fit model. Symmetric response for tail dependence is showing with identical structure which indicates that log-returns of bitcoin and tether are moving with the same frequency. Degree of freedom is showing value of 4.2543.

4.8 Dependence Structure of Bitcoin and Ripple

TABLE 9: ESTIMATES OF DEPENDENCE STRUCTURE OF BITCOIN AND RIPPLE

	Normal	T-Student	Clayton	Frank	Gumbel
Initial parameters	-0.0569	-0.0569	1.1703	N/A	1.5852
Final parameters	0.5011	0.5521	0.6608	3.9381	1.6021
		Df=2.7837			
Log Likelihood	277.3212	400.3461	180.4112	313.7768	378.1816
	Df=1	Df=1	Df=1	Df=1	Df=1
AIC	-552.6425	-796.6927	-358.8224	-625.5535	-754.3633
Tail Dependence	L=0	L=0.3582	L=0.3503	L=0	L=0
	U=0	U=0.3582	U=0	U=0	U=0.4586

Note. This table shows the copulas estimates, includinglog-likelihood, initial final parameter, AIC and tail dependence for combination of Bitcoin and Ripple.

Table 9 shows that t-student has minimum AIC value of -796.6927 which shows that t-student is best fit model. Statistical results are showing the symmetric response for tail dependence. Identical structure indicates that log-returns of bitcoin and XRP are moving with the same frequency. Degree of freedom of T-student is 2.7837.

4.9 Dependence Structure of Bitcoin and Lite coin

TABLE 10: ESTIMATES OF DEPENDENCE STRUCTURE OF BITCOIN AND LITE COIN

	Normal	T-Student	Clayton	Frank	Gumbel
Initial parameters	0.9234	0.9234	2.3275	N/A	2.1637
Final parameters	0.7164	0.7491	1.2551	6.6731	2.2391
		Df=2.457			
Log likelihood	692.6814	863.2575	457.106	716.2782	869.3985
	Df=1	Df=2	Df=1	Df=1	Df=1
AIC	-1383.363	-1722.515	-912.212	-1430.556	-1736.797
Tail Dependence	L=0	L=0.5257	L=0.5756	L=0	L=0
	U=0	U=0.5257	U=0	U=0	U=0.6372

Note. This table shows the estimates of copulas, includinglog-likelihood, initial final parameter, AIC and tail dependence for combination of Bit coin and Lite coin.

Results show that t-student has minimum AIC value of -1736.797 which means Gumbel is best fit model. Statistical results show the symmetric response for tail dependence. This identical structure indicates that log-returns of bitcoin and Lite coin are moving with the same frequency. Degree of freedom of T-student is 2.457.

4.10 Dependence Structure of Ripple and Tether

P-ISSN: 2204-1990; E-ISSN: 1323-6903

TABLE 11: ESTIMATES OF DEPENDENCE STRUCTURE OF RIPPLE AND TETHER

	Normal	T-Student	Clayton	Frank	Gumbel
Initial parameter	-0.0244	-0.02436	0.00089	N/A	1.00045
Final parameter	-0.0024	-0.0027 Df=3.9935	0.0631	0.0029	1.0221
Log Likelihood	0.0048 Df=1	47.7584 Df=2	3.7522 DF=1	0.00017 DF=1	1.7553 DF=1
AIC	1.9903	-91.5168	-5.5043	1.9996	-1.5106
Tail Dependence	L=0 U=0	L=0.0705 U=0.0705	L=1.6808e-05 U=0	L=0 U=0	L=0.000 U=0.0296

Note. This table shows the estimates of copulas, including log-likelihood, initial final parameter, AIC and tail dependence for the combination of Ripple and Tether.

In table 11, t-student has minimum AIC value of -91.5168. So, t-student is best fit model. Statistical results show the symmetric response for tail dependence. This identical structure indicates that log-returns of tether and XRP are moving with the same frequency. Degree of freedom of T-student is 3.9935.

4.11 Dependence Structure of Lite coin and Tether

TABLE 12: ESTIMATES OF DEPENDENCE STRUCTURE OF LITE COIN AND TETHER

	Normal	T-Student	Clayton	Frank	Gumbel
Initial parameters	-0.0193	-0.01934	-0.0172	N/A	1.6305
Final parameters	-0.0164	-0.0139 Df=3.8257	0.0418	-0.08566	1.0211
Log Likelihood	0.2315 Df=1	47.5529 Df=2	1.7603 Df=1	0.1466 Df=1	1.4281 Df=1
AIC	1.5311	-91.1058	-1.5206	1.7068	-0.8561
Tail Dependence	L=0 U=0	L=0.0716 U=0.0716	L=6.3048e-08 U=0.0000e+00	L=0 U=0	L=0.000 U=0.02699

Note: This table shows the estimates of copulas, including log-likelihood, initial final parameter, AIC and tail dependence for combination of Lite coin and Tether.

In results, t-student has minimum AIC value of -91.1058. T-student is best fit model. Statistical results show the symmetric response for tail dependence. Identical structure indicates that log-returns of tether and Lite coin are moving with the same frequency. Degree of freedom of T-student is 3.8257.

4.12 Spearman Correlation

TABLE 13: ESTIMATES OF SPEARMAN CORRELATION

	Bit coin	Ethereum	Tether	XRP	Lite coin
Bit coin	1				
Ethereum	0.9	1			
Tether	-0.04	-0.07	1		
XRP	-0.06	0.02	-0.02	1	
Lite coin	0.92	0.89	-0.02	0.09	1

P-ISSN: 2204-1990; E-ISSN: 1323-6903

Note. This table shows the Spearman correlation among all five selected currencies.

The spearman correlation results show a strong positive relationship between bit coin and Ethereum with value of 0.9264. Positive sign shows that increase in returns of one bitcoin results in increase in returns of ethereum. Correlation between Bitcoin and Tether shows that there is no relationship between these two currencies with value of 0.0035 which means if there is a minute relationship then the least and have negative relationship. Bitcoin and XRP correlation shows the value of -0.0569. This means that there is middle level of correlation between XRP and bitcoin. But the negative sign shows direction of association is opposite. It means that if returns of bitcoins are increasing then returns of XRP are decreasing. The correlation value of bitcoin and Lite coin is 0.9234. This shows strong association between bitcoin and lite coin. Positive relation shows that if returns of bitcoinare increasing, then lite coin returns will move in the same direction. Ethereum and tether show negative and least correlation between each other. Results of tether and XRP shows anegative and slight relationship with each other. Correlation is very less and both move in different direction. Results of Lite coin and XRP show the little or no relationship on each other. Positive sign is showing movement in same direction.

4.13 Kendal Tau Correlation

TABLE 14: ESTIMATES OF KENDAL TAU TEST

	Bitcoin	Ethereum	Tether	XRP	Lite coin
Bit coin	1				
Ethereum	0.39	1			
Tether	0.02	0.01	1		
XRP	0.37	0.39	0.00	1	
Lite coin	0.54	0.42	-0.01	0.44	1

Note. This table shows the values of kendal tau test.

In this table, results show that returns of each currency are dependent on other. Spearman correlation approves the results of first finding except three. It shows that most cryptocurrencies have weak relationship that indicates strong dependence. The three combination that are violating results of copulas are “Bitcoin& Ethereum”, “Bitcoin&Lite coin” and “Ethereum &Lite coin”.

5. CONCLUSION AND LIMITATIONS

It is concluded that there is no dependence between the returns of bitcoins and ethereum. The correlation between both cryptocurrencies were 0.92. Another finding that there is dependence between returns of bitcoin and tether shows that returns of one are dependent on the other. The value of their spearman correlation is -0.03. So, second hypothesis is accepted. Moreover, there is dependence between returns of bitcoin and ripple. Value of their spearman correlation is -0.05 which shows minimum and no correlation. But there is no dependence among the returns of bitcoin and lite coin. Their value of Spearman correlation is 0.92 showing strong positive correlation between these two cryptocurrencies. This hypothesis is rejected. This study showed dependence between ethereum and tether as their value of spearmen correlation is -0.07 which shows no and negative relation. Another finding showed that there is dependence between ethereum and ripple as showing correlation value of 0.02. So, the last two hypotheses have been accepted. Ethereum’s combination with lite coin showed that there is no dependence between these two cryptocurrencies as showing correlation of 0.89. This hypothesis is rejected. Tether shows negative and no correlation with lite coin and ripple. Value of correlation is -0.02 and -0.01 respectively. So, both these hypotheses have been accepted. Last finding showed that there is dependence between ripple and lite coin returns as 0.094 is the

P-ISSN: 2204-1990; E-ISSN: 1323-6903

value of Spearman correlation. It is also concluded that t-student is best fit copula model for checking dependence among cryptocurrencies.

Luu Duc Huynh (2019) suggested that the t-student copula is better than other copulas but it eliminates the error of serial dependence and error can be minimized by value-at-risk. Also t-student copula model doesn't involve the changes due to variation in time in dependence structure. This error can be fixed by applying time-varying copulas. Results would be better if there were more cryptocurrencies. Researchers will also try GARCH model and cointegration for checking the dependence structure, authorization and volatility of cryptocurrencies.

P-ISSN: 2204-1990; E-ISSN: 1323-6903

REFERENCES

[1] Andrychowicz, M., Dziembowski, S., Malinowski, D., & Mazurek, Ł. (2014, September). Modeling bit coin contracts by timed automata. In *International Conference on Formal Modeling and Analysis of Timed Systems* (pp. 7-22). Springer, Cham.

[2] Arnold, M. (2018). Ripple and Swift slug it out over cross-border payments. Financial Times. Available at https://www. ft. com/content/631af8cc-47cc-11e8-8c77-ff51caedcde6 (accessed 15 January 2020).

[3] Baur, D. G., & Hoang, L. T. (2021). A crypto safe haven against Bit coin. *Finance Research Letters*, *38*, 101431.

[4] Bergstein, Brian. (2014). "50 Smartest Companies".

[5] Bullmann, D., Klemm, J., & Pinna, A. (2019). In search for stability in crypto-assets: are stablecoins the solution? ECB Occasional Paper, (230).

[6] Coppola, F. (2019). Tether's US Dollar Peg Is No Longer Credible. Dosegljivo: https://www. forbes. Com/sites/francescoppola/2019/03/14/tethers-us-dollar-peg-is-no-longer-credible/# 22d9d749451b.

[7] De Jesus, Cecille. (2016). "The DAO Heist Undone: 97% of ETH Holders Vote for the Hard Fork".

[8] Del Castillo, Michael. (2020). "Ethereum Cofounder Joe Lubin Talks Trump, Blockchain's 'Frankenstein' And Willingness To Work With China".

[9] Dinkins, D. (2017). Tether Really Isn't a Scam, Company Promises.

[10] Frankenfield, J. (2019). Ripple (Crypto currency).

[11] Kaminska, I. (2017). Crypto tethers as the new eurodollars. Financial Times. Available at: https://ftalphaville. ft. com/2017/09/15/2193370/crypto-tethers-as-the-new-eurodollars.

[12] Kaya, Y. (2018). Analysis of Crypto currency Market and Drivers of the Bit coin Price: Understanding the price drivers of Bit coinunder speculative environment.

[13] Lee, Timothy B. (2018). Funny Money — why experts are worried about Tether, a dollar-pegged crypto currency.

[14] Leising, Matthew. (2017). Ether thief remains mystery year after $55 million heist.

[15] Luu Duc Huynh, T. (2019). Spillover risks on crypto currency markets: A look from VAR-SVAR granger causality and student'st copulas. Journal of Risk and Financial Management, 12(2), 52.

[16] Lyons, R. K., & Viswanath-Natraj, G. (2020). *What keeps stablecoins stable?* (No. w27136). National Bureau of Economic Research.

[17] Michaels, Dave. (2018). World's Second Most Valuable Crypto currency Under Regulatory Scrutiny. Wall Street Journal.

[18] Morisse, M., & Ingram, C. (2016). A mixed blessing: Resilience in the entrepreneurial socio-technical system of bit coin. JISTEM-Journal of Information Systems and Technology Management, 13(1), 3-26.

P-ISSN: 2204-1990; E-ISSN: 1323-6903

[19] Morrison, R. (2017). Bit coin:The 21st Century's Gold Rush Nvidia, AMD Offer Slightly Less Risk. Canadian Money saver, 16-18.

[20] Naeem, M., Saleem, K., Ahmed, S., Muhammad, N., & Mustafa, F. (2020). Extreme return-volume relationship in cryptocurrencies: Tail dependence analysis. Cogent Economics & Finance, 8(1), 1834175.

[21] Plassaras, N. A. (2013). Regulating digital currencies: bringing Bit coin within the reach of IMF. Chi. J. Int'l L., 14, 377.

[22] Popper, N. (2017). Understanding Ethereum, Bit coin's virtual cousin. The New York Times, 1, 2017.

[23] Ram, A., Maroun, W., & Garnett, R. (2016). Accounting for the Bit coin: accountability, neoliberalism and a correspondence analysis. Meditari Accountancy Research.

[24] Robinson, M., & Schoenberg, T. (2018). Bit coin-Rigging Criminal Probe Focused on Tie to Tether. Bloomberg News.

[25] Saha, K. (2018). An investigation into the dependence structure of major cryptocurrencies. Available at SSRN 3241216.

[26] Samet Gunay, Walid Bakry, Somar Al-Mohamad. (2020). Can Cryptocurrencies Be a Future Safe Haven for Investors? A Case Study of Bit coin.

[27] Steadman, I. (2013). Wary of Bit coin? A guide to some other cryptocurrencies. Ars Technica, 11.

[28] Takashima, I. (2018). Ripple: The Ultimate Guide to the World of Ripple XRP, Ripple Investing, Ripple Coin, Ripple Crypto currency, Crypto currency.

[29] Tan, A., Robertson, B., & Leising, M. (2018). Why crypto traders are so worried about tether. Viitattu, 3, 2018.

[30] Vigna, P., & Casey, M. J. (2016). The age of crypto currency: how bit coin and the blockchain are challenging the global economic order. Macmillan.

[31] Vigna, Paul. (2019). Bitfinex Used Tether Reserves to Mask Missing $850 Million, Probe Finds. The Wall Street Journal.

[32] W. Fauvel. (2017). Blockchain Advantages and Disadvantages.

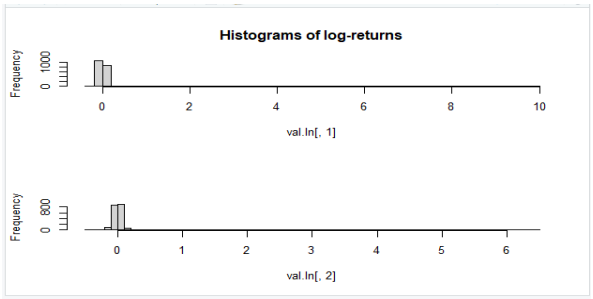
[33] Waters, Richard. (2016). Ether' brought to earth by theft of $50m in crypto currency. Financial Times.

[34] Yonghyeon, N. (2017). A New Opportunity of Bit coin for Improving Portfolio Efficiency in Japan.

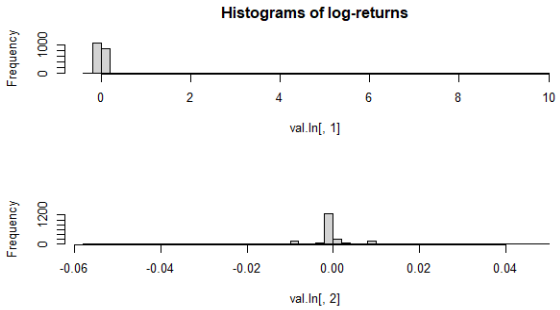
P-ISSN: 2204-1990; E-ISSN: 1323-6903

6. Appendix

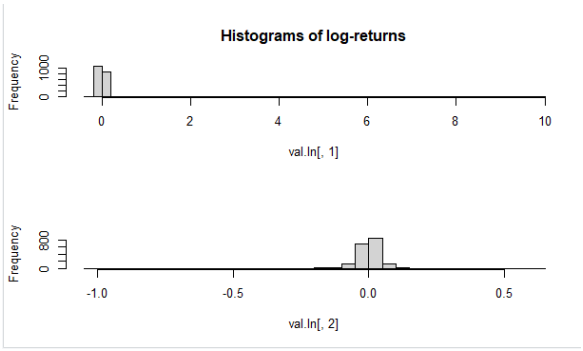
6.1 Histogram of Bit coin and Ethereum



6.2 Histogram of Bit coin and Tether

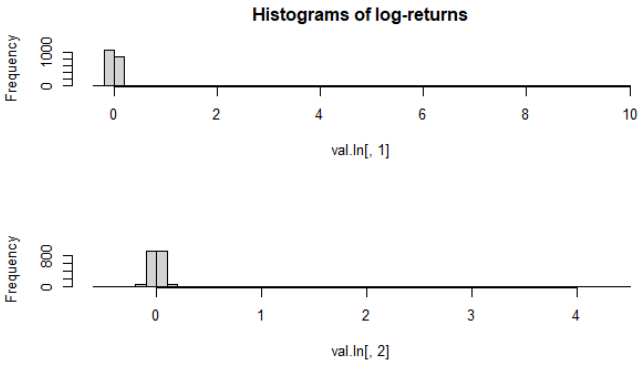


6.3 Histogram of Bit coin and Ripple

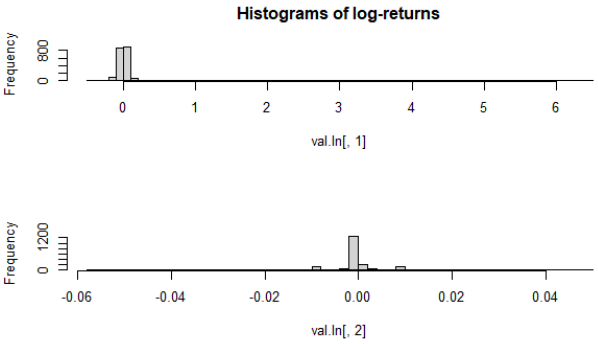


6.4 Histogram of Bit coin and Lite coin

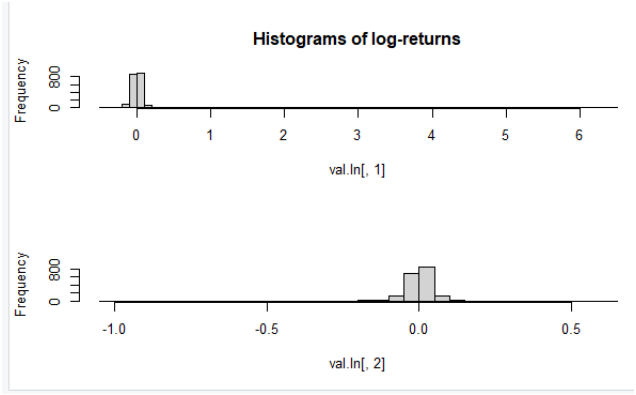
P-ISSN: 2204-1990; E-ISSN: 1323-6903



6.5 Histogram of Ethereum and Tether

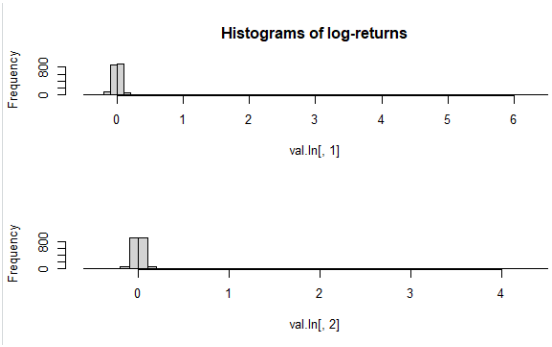


6.6 Histogram of Ethereum and XRP

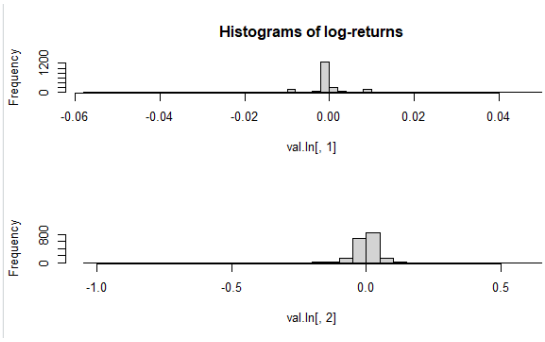


6.7 Histogram of Ethereum and Lite coin

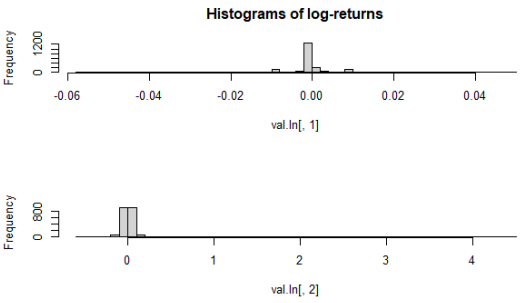
P-ISSN: 2204-1990; E-ISSN: 1323-6903



6.8 Histogram of Tether and Ripple (XRP)



6.9 Histogram of Tether and Lite coin



6.10 Histogram of Ripple (XRP) and Lite coin