The Relationships among Cryptocurrencies: A Granger Causality Analysis

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ABSTRACT

The topic of Cryptocurrencies is emerging rapidly. Many investors and public want to invest in digital currencies. So, the nature of cryptocurrency and its theoretical understanding is essential currently. The aim of this research is to study major Cryptocurrencies having capitalization above $1bn and construct directed networks. Eleven major Cryptocurrencies are Bitcoin (BTC), Ethereum (ETH), Cardano (ADA), Binance Coin (BNB), Tether (USDT), Ripple (XRP), Doge Coin (DOGE), USD Coin (USDC), Bitcoin Cash (BCH), Chainlink (Link) and Litecoin (LTC). By using returns Granger Causality test was conducted. This test help in concluding that whether change in one price of cryptocurrency cause a change in other Cryptocurrencies or not. After analysis of results, it was concluded that there is a variation in the Cryptocurrencies relation. Some shows a direct cause and effect relation, while some have a unidirectional relation. However, some of them also showed no meaningful relationship. The relationship among these Cryptocurrencies was then showed using directed networks.

1.   Introduction

In this era of high development and advancement in technology industry people want new, unique and more advanced technologies and gadget. Among other fields like e-commerce and virtual world, the Crypto currency is also evolving. In the past decade Cryptocurrency market has grown fast and extensively. This market is being attracted by media, regulators and investors by social media. "Cryptocurrency is a digital asset designed to work as a means of exchange using cryptography to secure transactions without being subject to any government intervention" (Katsiampa, Gkillas, & Longin, 2018). In simple words cryptocurrency is just a digital form of money which allows us to buy goods and services. The working system of digital currency is complex but in simpler terms it uses technology called block chain (a decentralized complex or

technology which managers use to record transactions). Many companies also have introduced their own currencies from which public can trade for good and service. These currencies are often called tokens or chips like in casinos, of course real money will be required in exchange to acquire these chips and then get goods or services.

Cryptography (a process in which legible information is translated into codes that cannot be broken). The fundamental objective of cryptography is to enable two people, usually referred to as Alice and Bob, to communicate over an insecure channel in such a way that an opponent, Oscar, cannot understand what is being said (Stinson & Paterson, 2018). Cryptocurrency was first officially introduced in 2009 when Bitcoin stated operating being the first decentralized cryptocurrency (Hileman & Rauchs, 2017). Two years later in 2011 Namecoin emerged as a second cryptocurrency. Today there are thousands of cryptocurrencies in the database and hundreds of them have a market value and being traded. Transaction or other data related to cryptocurrencies is maintained in a block chain. There are so many cryptocurrencies and most of them are like each other, they are usually a clone of others like BTC and just have simple differences in terms of currency supply, and issuance scheme. Mostly these cryptocurrencies have no innovation and are sometimes referred as "Altcoins."

New Cryptocurrencies are emerging after BTC, "Dash" which focuses on privacy was launched in the early 2014 that has experienced an extensive increase in market value since the beginning of 2017, Ethereum (ETH) featuring its own Turing-complete programming language was launched in 2015 is legal in Japan, Gibraltar, Malta, Ukraine, Switzerland, Netherland and Estonia and got a peak market value several times, Monero (XMR) is a cryptocurrency which aims to provide private transaction and secrecy addresses to camouflage the origin it was launched in 2014 in NY and experienced great market value in 2016, Ripple (XRP) uses a global consensus ledger (ledger maintained by independent participant of global XRP community) instead of having a block chain, Litecoin (LTC) launched in 2011 is often referred as "Silver" and BTC as "gold" because LTC cloned concepts of BTC and altered some parameters to be an independent cryptocurrency (Hileman & Rauchs, 2017). CEO of Ripple named Japan, Singapore and the UK as the countries with preferential crypto regulations.

From years multiple approaches are being used to study the effect of one variable over the other. These approaches include network analysis, financial analysis, affect and cause relationships and so on. One the famous and reliable approach is Granger Causality. Granger Causality is a statistical concept that is based on predictions, if a signal X granger-causes a signal Y then past value of X should contain information that helps predict Y above and beyond the information contained in past value of Y alone (Seth, Barrett, & Barnett, 2015). Granger causality is used by many researchers to study the casual relationship of cryptocurrency to understand risk and volatility factors to help investors and general public. These studies focused on finding the risks, affects, attention of investors to Cryptocurrencies. Analyzed the causal relations of cryptocurrency and investors' attention and the effect of past returns on future performance $ attention using granger causality (Lin, 2021). Research was conducted to examine the role of trading volume in predicting the returns and volatility by using granger causality (Bouri, Azzi, & Dyhrberg, 2017).

A question arises why the cryptocurrencies are gaining popularity? There are several factors seen to affect the popularity of Digital currency. These factors include, thought of cryptocurrency to be future currency and racing to buy them now before they become more valuable, some supporters think that it may manage the money supply and central bank will reduce the price of money due to inflations, secured technology-based system, and price increase in Cryptocurrencies without interests. As discussed earlier Crypto Currency Market is evolving day by day. In the past decade people are getting aware of this asset which is digital mode for transactions. Even though people are getting aware of Crypto Currency there is limited

knowledge about it and the research work is also limited. Many researchers have worked on this topic but most of it is restricted to Bitcoin which is most popular and mature cryptocurrency due its dramatic price changes, transparency and high profit opportunities. Apart from BTC work related to Ethereum (ETH) can also be noticed because of its familiarity among researchers and investors. Keeping in view the academic information related to cryptocurrency our purpose of this study is to examine Cryptocurrency having capitalization above $1bn, currently more than fifteen cryptocurrencies are having capitalization above $1bn.

This study is focused on analyzing Cryptocurrencies having capitalization above $1bn using granger causality. This research will be significant in many aspects like, it will provide academic information for both public and investors as the available information is limited to few famous Cryptocurrencies. We are in a pandemic right now, so this research is significant in understanding weather the pandemics or other disastrous events have some impact on Cryptocurrencies. These are general significant of this paper but, for Pakistan this research will contribute a lot in providing awareness as the work done in Pakistan is limited. After the campaigns of public figure "Waqar Zaka" People of Pakistan have some knowhow of digital currency but still they are less aware of digital currency and its investment opportunities. Analyzing cryptocurrency will give students, researchers as well as investors a better guidance about this topic.

Alongside financial benefits, any unused innovation too comes with a certain number of issues. Crypto currencies are no special case. In any case, the working standards particular to crypto currencies now and then make the issues more likely to happen, and hence more exasperating. In expansion, the same standards are dependable for a certain number of dangers special to crypto currencies. Crypto currencies are found valuable for exchanging techniques and arbitrage, but not being suggested for long term advertises flow. Now days, it is utilized in constrained bunch of individuals, nevertheless, it is getting notoriety as well, thus, getting the fascination of trade circle. On the other hand, it is germane to watch that certain widespread moreover, COVID-19, has impact on it or not?

Consequently, crypto-investment is risky. Companies do not contribute more than they are prepared to lose at any minute. In this manner, they broaden their speculations. Additionally, the money has fizzled to capture the center of trade community. They are still questionable around its status and are hesitant to contribute more. In any case, those are reveled in it have ended up tycoon and presently choice in exchanging on certain crypto money is accessible. There are numerous headings this extend may take, but the prime center of this extend is to investigation crypto cash showcase utilizing granger causality and expectation. In this venture, analyze the exchanging information utilizing conventional and novel showcase examination measurements.

In Asia, particularly in Pakistan, masses are unaware of crypto currency. One main reason could be that less literature is available on the matter. Most of the people are of the view that it is illegal, and it is merely a trap for Muslims. Therefore, they are reluctant to accept it. On the other hand, it is being prompted on social media and people have started exhibiting their interest in it. It is noteworthy to use granger causality to analyze Cryptocurrencies and identify their causal relation with each other. The main objective of this study is to identify the cause and effect relationship of Cryptocurrencies under question and to develop the directed networks.

2. Literature Review

In past few years researchers are seen to be attracted in finding the relationship between cryptocurrencies. Gozgor, Tiwari, Demir, and Akron (2019) examined the relationship of BTC and

the index of trade policy uncertainty. Bouri et al. (2017) observed the relationship between price returns and volatility changes in the BTC market. Similarly, some researchers are interested in finding the causal relation among cryptocurrencies. Dastgir, Demir, Downing, Gozgor, and Lau (2019) studied the causal relationship between BTC attention and BTC returns using granger causality. Even though the work related to area of relationship between cryptocurrency is very less particularly in casual relation. Also, the one available is again limited to BTC.

Katsiampa (2017) examined and compared cryptocurrencies, volatility using GARCH model. A huge growth is witnessed in cryptocurrency market particularly in BTC. Examining BTC volatility is having high importance and is mandatory because of being used for investment purposes. AR-GARCH was found to be the optimal model among several other GARCH models in means of goodness-to-fit to the data. Regarding consumer sentiment analysis, portfolio analysis and risk management BTC creates new possibilities for stakeholders because of being different from other financial market assets. This research is supposed to help investors to make more informed decisions (Katsiampa et al., 2018).

Urquhart (2017) examined the price clustering in BTC. He studied the behavior of BTC by collecting data of daily closing prices of Bit stamp from 01/05/2012 to 30/04/2017 through www.bitcoincharts.com. Found considerable evidence around whole numbers, with over 10% of prices ending with decimal digits one hundred of price clustering. But even though prices after round number showed no predictable patterns which leads to no advantage in form of investment strategy. However, clustering is consistent in Bitcoin reference to hypothesis as price clustering is somehow related to prices and volume. Guizani and Nafti (2019) using ARDL model studied the volatility of Bitcoin. As the data about this complex topic is limited so they studied BTC and identified its volatility using Granger Causality. To estimate the price influence, they identified major determinants of BTC price. It was found that attractiveness indicator, mining difficulty and number of addresses rather than transaction volume, the stock, USD/EUR exchange rate have a significant impact on BTC price with variation over time.

Kaushal, Bagga, and Sobti (2017) studied the security and feasibility of BTC. This research was conducted to give knowledge to people about the true meaning, emergence, the value creation, and security risk in BTC. Based on insufficient knowledge public, marketers and investors cannot make a reliable decision about digital currency and which may tear down economy made of digital currency. The empirical data showed that not all the digital currency and BTC are without risk, Wallet of BTC can be a victim to hackers' attack. BTC was created as currency with no third party involved, peer-to-peer transactions but at current stage BTC lack scalability so the government must be involved to put regulations. Any currency should be considered legal if it is at par with government's money but still there are many countries that are using digital currency because the government has no control over it. The digital currency lacks stability at is highly volatile which will lead to a boom or bust of trust at any time.

DeVries (2016) examined Bitcoin and predicted future. Cryptocurrency can change the way of interaction between internet-connected global markets, but the traditional flat currency is still not likely to be replaced by cryptocurrency or BTC. It can be expected that in this time of high technology and development, by creating a free flow trading system with no fees the cryptocurrency may revolutionize the digital markets. A SWOT Analysis of Bitcoin was developed in this research. Acharya, Thomas, and Pani (2018) worked on the analysis of BTC's volatility. BTC is a digital currency that has a lot of popularity and importance in previous years. This research is done to check the volatility of BTC value related to that of USD and its stability. One of the major reasons for instant popularity and high transactions of BTC is its attribute of being tradable. Governments of many countries have a distinctive response about making BTC as an accepted medium of trade and exchange. The optimism and enthusiasm of investors toward BTC is not enough for BTC to be trusted as it does have risks and USD value of BTC is found highly

volatile in nature. This research was conducted in India and found that the limitations of BTC will not easily allow it to be a currency because it lack feature of a flat currency making it difficult to be used in India as a main currency.

Omane-Adjepong, Alagidede, and Akosah (2019) observed and explained market returns and volatility of cryptocurrencies. Baur and Dimpfl (2021) explained the Volatility of Bitcoin and Its Role As A Medium Of Exchange. They studied the volatility of Bitcoin prices and concluded that it should not be used as a medium of exchange because of extremely high volatility and risk. Ciaian, Rajcaniova, and Kancs (2016) explained the economics of Bitcoin formation. As during the last decade many of the digital currencies have emerged and Bitcoin is the most famous among all so, they conducted research specifically on BTC. They were the first one studying price formation of BTC by considering both determinants of the market force of supply & demand and the digital currencies specific factors. This study found that BTC attractiveness for users/investors and the market forces have an impact on BTC price by having a variation time to time.

Hakim das Neves (2020) Quarter concerned conducted research on attractiveness variables and its impact on Bitcoin pricing. The number of Google searches using terms like Bitcoin, Bitcoin crash and crisis between 2012 and 2018 were observed and analyzed the relationship between the prices of virtual currency by using error correction model. Same test was applied on Bitcoin price denominated in different sovereign currencies trade. The Johansen test found pries and number of searches to be co integrated. From this research it was concluded that both terms have a short-term and a long-term dynamic relation with each other. This means that an increase in public interest about BTC would lead to price increase. Similarly, the mistrust or loose of interest would lead to fall of currency prices. It was also found that interest in virtual currency is affected by intense economic crises events e.g., Bitcoin became an alternative investment during the worldwide crises.

Sahoo (2021) Covid-19 Pandemic And Cryptocurrency Markets: An Empherical Analysis From Linear And Non Linear Casual Relationship. The aim of his research was to examine the effect of Covid Pandemic on the cryptocurrency market returns, results showed that there is the existence of unidirectional casuality from the growth of Covid-19 deaths and confirmed cases to cryptocurrency returns. Chu, Chan, Nadarajah, and Osterrieder (2017) studied cyrptocurrencies using Garch model. Cryptocurrency was defined as "A digital asset designed to work as a medium of exchange using cryptography to secure the transactions and to control the creation of additional units of the currency". As there was a very limited or no data/literature related to cryptocurrencies GARCH model so they focused on on GARCH model of seven most known cryptocurrencies. The model fits were asssesed in terms of five criteria using tweleve GARCH models to each cryptocureency on account and conluded the best fitting models, forcasts and accceptibility of value at estimated risk.

Pilar, Jaureguizar Arellano, and Jaureguizar Francés (2018) analyzed 16 Crypto Currencies using Minimum Spanning Tree (MTS) and Hierarchical Analysis by Dendrogram and found that there is correlation between most of the crypto currencies; they also found that the benchmark Cryptocurrency is ETH not Bitcoin as assumed by most of the people due to its popularity and largest capitalization. Schinckus, Duy, and Canh (2021) studied the interdependence between cryptocurrencies. They examined all 1636 crypto currencies of that time and found that Bitcoin being the oldest and most famous Cryptocurrency does not appear as an influential asset on the virtual currency market. Results of their study stated that Cryptocurrencies tend to change their influence over time suggesting a short-term interdependence between them. Ho, Chiu, and Li (2020) found that the overall cross- return correlation among the crypto currencies is weakening from 2013-2016 and then strengthening

after. They also found that until mid-2016, BTC was dominating the market and primarily used for transaction payments, after then ETH alongside other currencies replaced BTC and became benchmark Cryptocurrency.

Motamed and Bahrak (2019) examined Cryptocurrencies transaction graph by quantitative analysis**.** Cryptocurrencies are considered as a new way of secured financial transactions as well as transferring assets by being publicly available and have popularity in recent years; hence the statistical study on crypto currencies on different aspect is possible. Limited studies on BTC not on other digital currencies led to start this research which was based on comparison of transaction graphs and properties of BTC, ETH, Litecoin, Dash, and Z-Cash. Particularly nodes and edges of transaction graphs, and density of these graphs related to prices were observed and found graphs of these currencies to be non-assertive, in all coins the number of edges of transactional graphs increases linearly with respect to the number of nodes.

Phillip, Chan, and Peiris (2018) studied and explained nature of cryptocurrencies. Cryptocurrency complexity was not fully explored. Many diverse facts including long memory and heteroscedasticity of cryptocurrency were suggested by acquired evidence. In this research varied nature of cryptocurrencies were conditionally measured by combining many of these attributes to a single model to evaluate their invest ability. To determine which of the properties truly exist 225 different cryptocurrencies were observed and measured by applying their model. It was found that crypto currencies have several unique properties which also include leverage effect and student-t error distribution.

3.   Methodology

The research design of this study is quantitative and causal. In this paper the directed links among the cryptocurrencies are studied using the technique of Granger Causality. According to coinmarketcap.com there are 7812 Cryptocurrencies available for trading. For this study, cryptocurrencies with a market capitalization of above $1bn were chosen. There are eleven of them that fall under this criterion. Bitcoin, Ethereum, Cardano. Binance Coin, Tether Ripple, Dodge coin, USD Coin, Bitcoin Cash, and Chainlink which are the cryptocurrencies selected for the study. In fact, Bitcoin had the highest market capitalization of $883,886,908,833 at the time of commencement of this research.

The daily prices from November 2018 to June 2021 of all these currencies were taken from coinmarketcap.com and then their daily returns were calculated using the following estimation method:

$$r_{i,j} = ln\left(\frac{p_{i,j}}{p_{i-1,j}}\right) \tag{1}$$

where, $r_{i,j}$ is the logarithmic return of the cryptocurrency$_j$ on day i and $p_{i,j}$ is the daily closing price of the cryptocurrency$_j$ at time i and $p_{i-1,j}$ is the last day closing price of the cryptocurrency$_j$ at time $i - 1$.

On daily returns unit root test was performed to verify the stationarity in the data. Price characteristics and causal relationships of these Cryptocurrencies were analyzed using granger causality using the following regression model:

$$X_1(t) = \sum_{j=1}^{p} A_{11j}X_1(t-j) + \sum_{j=1}^{p} A_{12j}X_2(t-j) + E_1(t) \tag{2}$$

Where p is the maximum number of lagged observations included in the model (the model order), the matrix A contains the coefficients of the model (i.e., the contributions of each lagged observation to the predicted values of $X_1(t)$ and $X_2(t)$, and E_1 are residuals (prediction errors) for each time series. The granger causality test was run on Eviews software. After that, directed networks were developed from the significant values of granger causality using Gephi.

4.   Results

From the data analysis it can be concluded that Ethereum (XRP) has the lowest mean return while Doge coin has the highest mean return. We can also notice that Doge Coin has highly volatile returns as indicate by the value of standard deviation. This indicates that the values of Doge Coin are spread around the mean in a vast range, which shows the prices fluctuate frequently in a brief time. Among these Cryptocurrencies USDC has the lowest Standard deviation value. From this analysis we can also see that ADA, BNB, USDT, DOGE, USDC, BCH and LINK have a positive skewness which shows that the distribution will have a long right tail. The positive right tail indicates that these Cryptocurrencies will give few but extreme gains with smaller number of losses. On the other hand, LTC, XRP, ETH and BTC have negative skewness indicating a log left tail distribution, which obviously shows that these Cryptocurrencies provide extreme loses with fewer gains. Kurtosis values in three are considered normal. But this data points towards highly abnormal returns. This could be because of high volatility among these Cryptocurrencies. Kurtosis of Doge coin is highest among all.
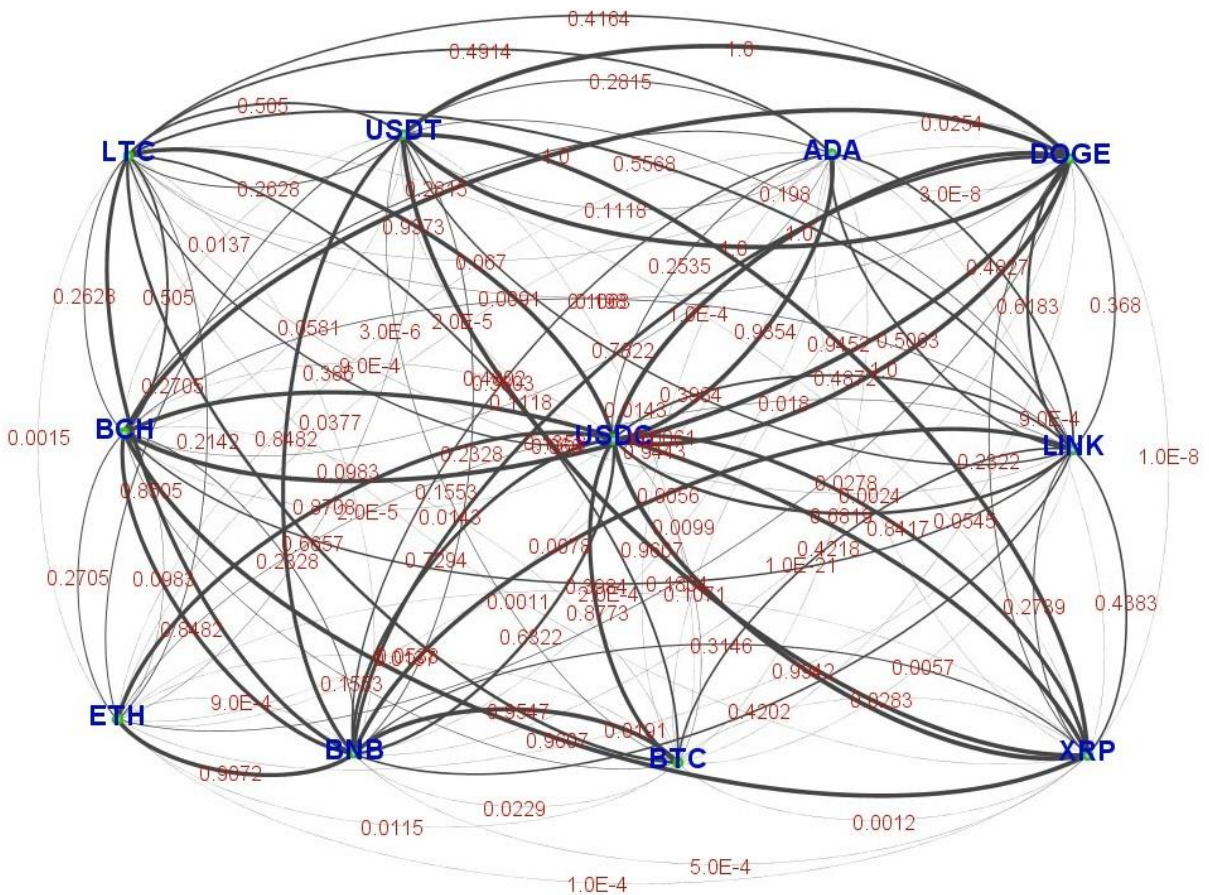
Figure 1: Directed Network of Cryptocurrencies: 11 nodes

It was apparent the correlation matrix that XRP has a weak correlation with DOGE, a negative correlation with USDT, USDC and BCH, while having moderately high correlation with other Cryptocurrencies. The values indicates that both USDC and USDT have a good correlation with each other while having weak or negative correlation with other Cryptocurrencies. LTC has a strong correlation with ETH, ADA and BTC and a moderate strong correlation with link. Link has a moderately strong correlation with ADA and ETH while having weak correlation with Doge, and BCH. Doge on the other hand has a very weak correlation with BTC, BNB, and ADA and a negative with BCH. BTC shows moderately strong correlation with BNB and ADA, while weak with BCH. Lastly BCH has weak correlation with ADA.
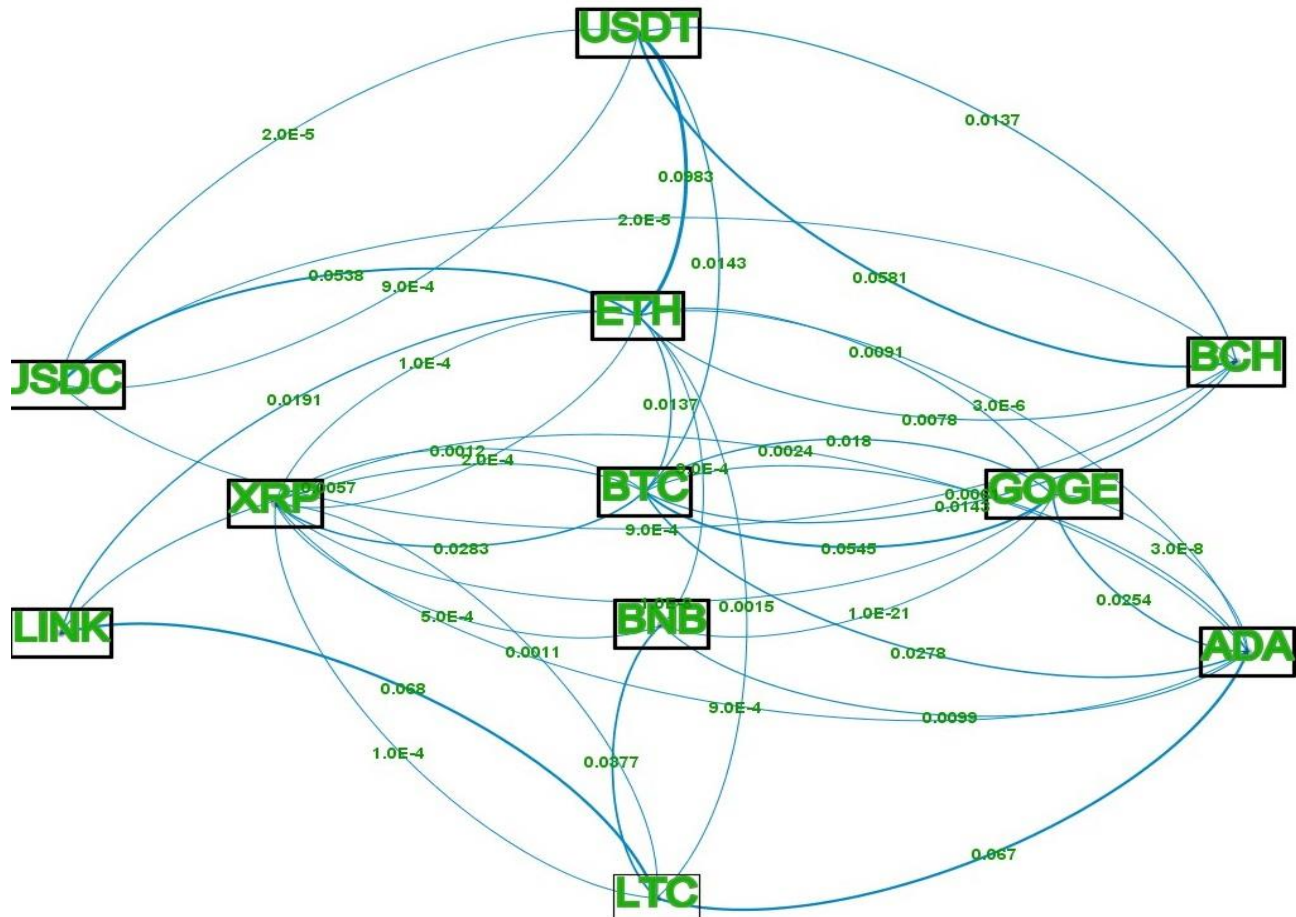
Figure 2: Directed Network of Cryptocurrencies having significant relation

The granger causality test shows that Cryptocurrencies have some sort of cause and effect relationship with each other. It was concluded that some Cryptocurrencies have no relation with other and some does have. The networks of cryptocurrencies were developed usisng the results of granger causality. Figure 1 represents the network of different cryptocurrencies with each other. This networks shows that there is no significant relation between XRP and some other cryptocurrencies (Link, USDT, USDC and BCH). However there is a significant relationship with remaining cryptocurrencies. Also one way causality is also founded i.e. from Doge towards XRP. In case of USDT coin there is a significant relation with USDC and BCH and no cause-effect relationship with other cryptocurrencies. USDC also have a significant realtion with only BCH. LTC shows no significant relation with BTC, BCH and Doge and shows a partialy or one way cause effect relation with LINK ETH, BNB and ADA. Chainlink shows no sifnificant effect on ADA, BCH,

BNB and DOGE. So, we can see that all of these cryptocurrencies have different type of cause relation with each other. All the significant relations are shown in directed network (figure 2).

5. Conclusion

The aim and objective of this research was to develop directed networks to show the presence of granger causality among Cryptocurrencies. It shows the type of relationship among them and the direction of this relationship. First, the daily prices of the Cryptocurrencies were taken and then converted to daily returns. After that unit root test was run on these returns to analyze the stationarity in data. Further Granger Causality test was run on each Cryptocurrencies. The results of granger causality shows that cause and effect relationship of Cryptocurrencies vary in all manner. Some have direct effect; some do not, and while some of them have a uni-directional cause effect relation.

5.1 Policy Implications and Directions for Future Research

This research provides a guideline to the policy makers about the awareness and importance of Cryptocurrencies. The authorities must provide information about the Cryptocurrencies to the public. The policy makers must make regulations and prompt decisions about the legalization of the Cryptocurrencies because of the rapid growth and their adaptation in the world. Further research can be conducted by adding more Cryptocurrencies and studying their links. Other network analysis techniques can be adopted to study the properties of Cryptocurrencies.

5.2 Research Novelty & Contribution

This research adds new value to the literature by studying the directed networks existing among the Cryptocurrencies and is an attempt to create awareness about Cryptocurrencies in the people of Pakistan.

Authors Contribution
Nadir Khan: Idea generation and data analysis
Muhammad Zohair Durrani: Review of the literature
Naila Mushtaq: Paper write-up
S M Nabeel ul Haq: Results and Conclusion
Babar Ijaz: Data collection

Conflict of Interests/Disclosures
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