9-2017

In Which Distributed Ledger Do We Trust? A Comparative Analysis Of Cryptocurrencies

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IN WHICH DISTRIBUTED LEDGER DO WE TRUST? A COMPARATIVE ANALYSIS OF CRYPTOCURRENCIES

Research full-length paper

Track N° 5

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Abstract

This study provides a comparative financial and statistical analysis between the largest and most traded cryptocurrencies. In particular, the exchange rates of Bitcoin, Litecoin, Ripple and Ethereum were collected from August 2010 until May 2017. The raw annualized volatility of cryptocurrencies is compared as well as to fiat currencies and major exchange rates. The results show that Bitcoin is the least volatile cryptocurrency with low correlations with the altcoins, providing possible diversification benefits to cryptocurrency investing. In addition, our results indicate that Bitcoin is the only cryptocurrency that has causality effects on the other cryptocurrencies.

Keywords: Distributed Ledger, Digital Currency, Cryptocurrency, Bitcoin, Litecoin, Ripple, Ethereum, volatility, exchange rate

1 INTRODUCTION

Advances in Information Systems have contributed to transformational changes in the global economy, including in the emergence of cryptocurrencies. Cryptocurrencies or digital currencies are digital, decentralized, anonymous currencies that are not backed by any legal entity or government. Instead, they rely on peer-to-peer networking to facilitate peer-to-peer exchange. Cryptocurrencies and their associated technologies (distributed ledgers based on blockchains) are rapidly evolving, and their future developments are difficult to predict. Bitcoin, being the largest and most widespread of all digital currencies, has received a substantial amount of attention through media, online fora and financial markets.

Digital currencies and their underlying distributed ledger technologies have implications for a wide range of markets and financial market infrastructures. Initially, cryptocurrencies have attracted attention in relation to their capacity to facilitate peer-to-peer exchange while reducing transaction times and costs, especially across borders. Nowadays, attention has also been directed towards distributed ledger technologies and their potentials regarding accurate and secure record keeping system. This can be utilized in a wide area of applications including trade repositories, central securities repositories, security settlement systems, stock exchanges, supply chain management operations and many others.

Since its introduction in 2009, Bitcoin maintains a leading position among cryptocurrencies in terms of the major indicators: market value, total digital currencies market capitalization, number of daily transactions and number of businesses accepting it. The success of Bitcoin has led to the emergence

of many alternative virtual currencies (altcoins), including Litecoin, Peercoin, Auroracoin, Dogecoin, Ripple and other. Most of altcoins rely on the fundamentals introduced in Bitcoin, including the distributed ledger approach and the blockchain technologies. Nonetheless, altcoins provide additional features; for example, Litecoin aims to save the computing power required for the coin mining; Peercoin aims to improve the efficiency of mining and the currency's security; Dash aims at a faster processing of transactions and an enhanced privacy protection; Bitshares and Ethereum also support a digital platform to run smart contracts.

Analysis of factors that influence price formation of cryptocurrencies and especially Bitcoin is often conducted in the literature (Grinberg, 2011; Barber et al., 2012; Kroll et al., 2013; Moore and Christin, 2013; Bouoiyour et al., 2014; Kristoufek, 2015; Ciaian, et al., 2016). These studies have identified a number of determinants of the Bitcoin price development in the long-run, including market forces of the Bitcoin supply and demand (Buchholz et al., 2012; Bouoiyour and Selmi, 2015); the Bitcoin's attractiveness for investors (Kristoufek, 2013; Bouoiyour and Selmi, 2015); and the influence of global macro-financial developments (Van Wijk, 2013). Despite the comparably high market volatility, there is little known about their price formation mechanisms and altcoin interdependencies with the Bitcoin market. Indeed, there are good reasons to believe that Bitcoin and altcoin prices might be interdependent, given that Bitcoin is the dominant virtual currency, similar patterns in Bitcoin and altcoin price developments may exist, as well as other interdependencies might also exist.

This paper intends to fill the gap in our knowledge in these topics by examining and comparing the performance and interdependence of these cryptocurrencies. This study compares and examines the relationship between the four largest cryptocurrencies according to market capitalization: Bitcoin, Ethereum, Litecoin and Ripple. To the best of our knowledge, this is the first study that measures the relationship between the different digital currencies in terms of daily and weekly returns and volatilities, providing diversification implications in investing. Our results show that when comparing Bitcoin to traditional, fiat currencies, it exhibits substantially higher returns and volatility. However, when compared to the altcoins, its return remains high but its volatility values become the lowest of all cryptocurrencies. Our results further demonstrate that the correlations between the different cryptocurrencies is relatively low, with Bitcoin being the only digital currency that depicts statistical significance in offering causality effects on the other altcoins.

The remaining of this paper is structured as follows. Section 2 presents a comprehensive literature review. Section 3 discusses the data and the methodology employed; whereas section 4 presents and discusses the findings. The paper concludes with the main contributions of this paper and directions for future work.

2 LITERATURE REVIEW

A thorough introduction to digital currencies as well as a comparison of fiat money to cryptocurrencies may be found in (IMF 2016). A major direction in recent literature on digital currencies focuses on the legal aspects of their use and the on-going debate as to whether Bitcoin and its counterparts are currency, a commodity or an investment. The economic literature of Bitcoin and its implications to the financial markets are rather scarce. In this study, the value of Bitcoin, Ethereum, Ripple and Litecoin exchange rates will be compared along with their annualised volatility. The most prominent studies on the financial aspects of digital currencies and their price formation are outlined below.

The majority of studies in the current academic literature focus on Bitcoin and its implications within blockchain technologies. A number of studies have focused on the price formation of Bitcoin (Buchholz et al., 2012; Kristoufek, 2013; Van Wijk, 2013), which may be affected by economic demand and supply, speculation and various macroeconomic and financial variables. Without a doubt, Bitcoin and the other cryptocurrency have experienced a considerable amount of media attention that would have played a great role in their continuous changes in price values, and thus their volatilities.

The use of Bitcoin and any other digital currency has raised questions on the security applied and its implications from the ethical perspective. Dierksmeier et al. (2016) undertook a study to address the impact of blockchain technology on the nature of financial transactions from a business ethics perspective. Apart from offering numerous advantages, such as transparency and low transaction costs, there are moral questions that arise, such as tax evasion and shadow banking (Van Alstyne, 2014), money laundering and transactions on the 'dark web' (Janze, 2017). Generally, the use of internet security and safety, especially targeting the youth, may be a concern, an area that has been studied in depth by Ktoridou et al. (2012).

As for the financial markets and investments, Briere et al. (2013) show that Bitcoin provides substantial diversification benefits within a portfolio of traditional and alternative assets, primarily due to its low correlation with the other securities. Nevertheless, a number of studies focus on examining the volatility levels of Bitcoin in order to ascertain that Bitcoin is a risky security or means of investment. A recent study by Blau (2017) concentrates only on the year 2013 and tests the high volatility levels of the value of Bitcoin. The author finds that speculative trading is not directly associated with Bitcoin's unusual level of volatility. Conversely, Sapuric et al. (2014) find that the volatility of Bitcoin is high when compared to major exchanges using raw data. However, once taking into account the volume of trading that occurred in order to calculate the adjusted volatility, the results show that the volatility of Bitcoin subsides substantially.

In any case, studies on other digital currencies are scarce. A recent study by Ammous (2016) compares five cryptocurrencies on a macroeconomic level and studies their supply growth, credibility and stability to evaluate whether these currencies can serve as money. The results indicate that only Bitcoin may serve as a store of value while the other cryptocurrencies are substantially unstable to be used as a unit of account.

In addition, Chan et al. (2017) provide a statistical comparison of a number of digital currencies providing their parametrical distributions. Their results indicate that the return distributions of the cryptocurrencies under study are non-normal, while for most the hyperbolic distribution gives the best fit, providing scope from risk management perspective.

This paper attempts to fill the gap by providing a comparative analysis of Bitcoin with other digital currencies that have had a growing share in market capitalization and popularity. The analysis is based on the performance of these currencies in relation to the change in their exchange rates and volatilities.

3 DATA AND METHODOLOGY

This study aims at providing a comparative analysis of Bitcoin with other digital currencies, as well as the major, fiat exchange rates. In particular, we measure the performance of Bitcoin, Ripple, Ethereum and Litecoin exchange rates in US dollars. Further, we assess the relationship between the largest digital currencies through statistical modelling. This will provide scope for various trading strategies with the focus on diversification.

3.1 Data

Apart from comparing the various digital currencies, we also provide a comparison of Bitcoin's exchange rate, the largest of the cryptocurrencies, with that of the major exchange rates around the globe and the London price of gold. Specifically, the study uses the exchange rates of Bitcoin, Litecoin, Ethereum and Ripple in US dollars with the selection of data, starting from 1 August 2010 up to the 30 May 2017. In addition, due to the unavailability of some of the digital exchange rates, the study uses two frequencies of data: daily and weekly. The data range for the daily and weekly analyses between the digital currencies commences from 10 April 2014 until 30 May 2017, providing us with 1,144 daily observations and 162 weekly observations. Due to a greater availability of data for

the major exchange rates, we used the weekly exchange rate against the US dollar as well as the volume of trades, starting from the 1 August 2010 up to the 30 May 2017 (357 observations). However, it should be noted that Ethereum only started trading in 2015. We include Ethereum in our analysis as it is the second largest digital currency and has experienced substantial growth in the last year.

There are over 800 different digital currencies in existence as indicated in Web1 (2017) and Web2 (2017). The digital currencies that were used in this study were selected based on their market capitalization value, as per Web3 (2017). This is shown in Table 1.

Digital Currency	Symbol	Market Capitalization
Bitcoin	BTC	$41,959,488,986
Ethereum	ETH	$34,790,569,038
Ripple	XRP	$10,935,892,953
Litecoin	LTC	$2,328,784,089

Table 1. Market Capitalization of Digital Currencies

The currencies that were used in our study as comparison to the Bitcoin are shown in Table 2.

Currency	Country/Continent
Euro	Europe
GBP (Sterling Pound)	UK
Yuan	China
Yen	Japan
Ruble	Russia
Franc	Switzerland

Table 2. Exchange Rate and Country of Domicile

3.2 Methodology

In order to examine the relationship between the various digital currencies, we primarily study the evolution if their exchange rates against the US dollar. In order to develop the daily/weekly change in the exchange rates for each currency of analysis (digital and fiat), the following computation was employed:

$$\Delta \text{ in Exchange Rate} = \left(\frac{ER_t - ER_{t-1}}{ER_{t-1}}\right) \quad (1)$$

In addition, so as to compute the volatility of each exchange rate and the London price of gold, we use the annualised volatilities, as proposed by Yermack (2014). For each of the currency changes in exchange rates and gold, the standard deviation was primarily determined, which represents the 1-day volatility of each exchange rate. Assuming that there are 252 trading days in the year, the volatility can be annualised by multiplying the standard deviation of the exchange rates by the square root of 252. This is shown in equation 2:

$$\text{Annualised Volatility} = \text{Standard Deviation} * \text{SQRT}(252) \quad 1.1.1 \quad (2)$$

Volatility will be calculated for Bitcoin, Litecoin, Ripple and Ethereum. This will provide the relative risk level of the four digital currencies.

Furthermore, with the aim of examining the relationship between Bitcoin, Ethereum, Ripple and Litecoin, we use the simple Pearson's correlation coefficient. This will provide a useful method of creating potential trading strategies based on diversification. In addition, in order to further test the statistical direction of the relationships, regression analyses will be employed.

4 EMPIRICAL RESULTS

This study provides a statistical comparison between four of the largest digital currencies according to their market capitalization. The results of the analyses provide means for investment and portfolio diversification.

4.1 Performance of Bitcoin against Major Currency Exchange Rates

Prior to comparing the four digital currencies (Bitcoin, Ether, Ripple and Litecoin), we examine the performance of Bitcoin, the largest digital currency, in relation to the traditional currency exchange rates. Bitcoin has received tremendous attention since its inception in 2009, where it started trading at $0.05. Since then, numerous events have caused the price of Bitcoin to fluctuate as can be seen in Figure 1, which shows weekly price of Bitcoin in US dollars. In fact, it is from the end of 2013 that Bitcoin's price in relation to the US dollar has experienced the most fluctuations. Adverse effects, such as the closing of a large exchange (MtGox) and the hacking of BitStamp exchange, have been some of the events that have caused its price to decrease. Nonetheless, Bitcoin has remained in the market and, from a price of $217 at the beginning of January, it has reached a staggering amount of over $2,300 by the end of May 2017.

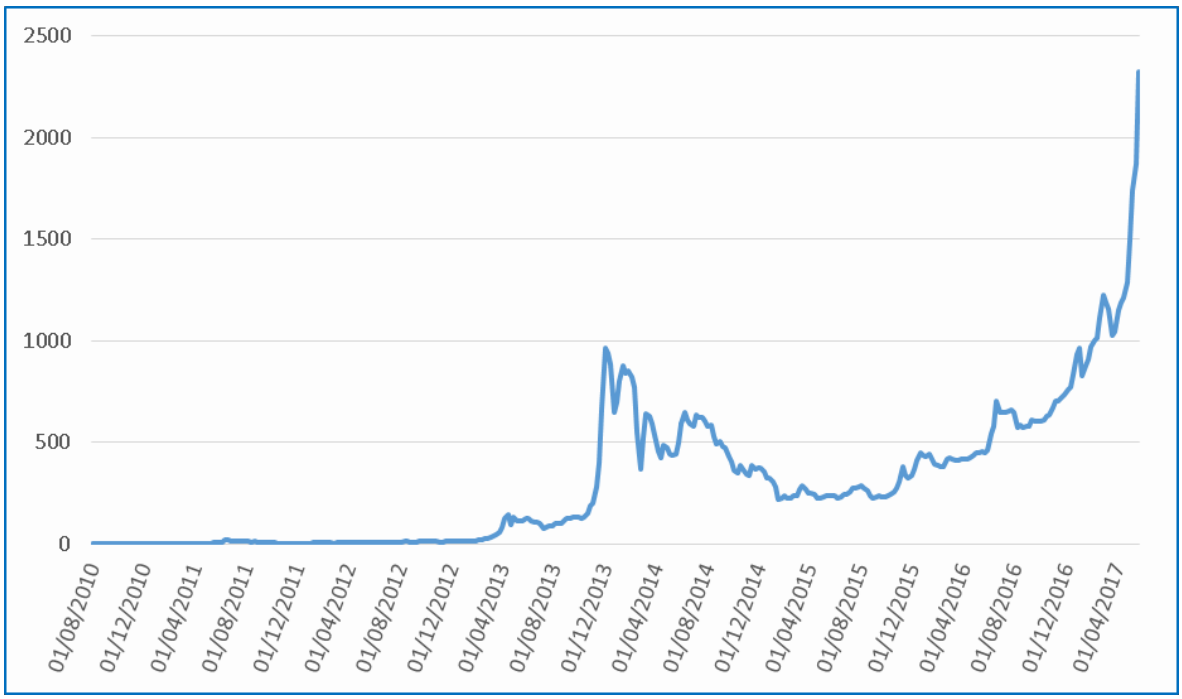

Figure 1. Bitcoin in US Dollars

Indeed, it is in the year 2017, particularly since the month of April, that the value of Bitcoin has risen substantially. The major factor that has contributed to this is the Japanese government legalising Bitcoin as an official method of payment, thus making Asia a key driver in the cryptocurrency boom. Furthermore, uncertainty in the financial markets tend to increase value of Bitcoin. This was the case with the Brexit referendum and the value of Bitcoin increased.

Table 2 shows a comparison of Bitcoin with traditional currencies, in terms of weekly returns, from August 2010 until May 2017. It is evident that Bitcoin's average change in exchange rate is substantially higher than for the other major currencies, as well as gold, yielding 2.92%, whereas the majority of others have shown a negative return for the period.

Currency/Gold	Average Change (%)	Maximum (%)	Minimum (%)
Euro	-0.04	2.98	-3.7
GBP (Sterling Pound)	-0.05	2.53	-7.05
Yuan	-0.004	0.72	-2.37
Yen	-0.007	3.83	-4.01
Ruble	-0.17	16.91	-14.34
Franc	0.02	7.83	-6.25
Bitcoin	**2.92**	**74.31**	**-39.77**
Gold	0.02	5.68	-10.09

Table 3. Average Percentage Change in Exchange Rates of All Currencies and Gold

By taking into account the maximum and minimum values of the changes in the exchange rates, it is evident that Bitcoin exhibits the biggest dispersion in the values. This directly impacts its volatility, which is shown in Figure 2 as an annualized sum for all the exchange rates. Specifically, Bitcoin's exchange rate volatility yields values higher than 200%, whereas the volatility for other currency exchange rates and gold varies between 4% (Chinese Yuan) and 34% (Russian Ruble). This is mainly attributed to the various events that have caused the price of Bitcoin to fluctuate significantly since 2015.

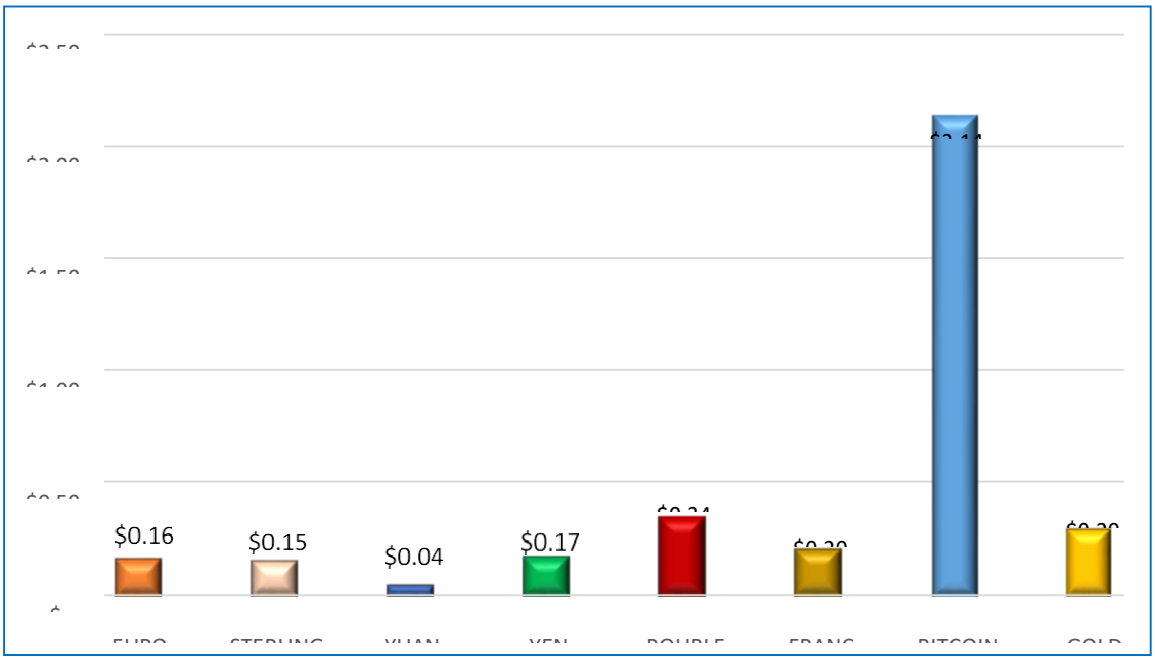

Figure 2. Annualized Volatility of Bitcoin and major Exchange Rates

Briere et al. (2013) have shown that Bitcoin has low correlations with other traditional securities, such as equities and bonds. Our results, shown in Table 3, also indicate this when correlating Bitcoin with traditional exchange rates and gold. The correlation that Bitcoin exhibits with the other currencies, as well as gold, is very low, with values close to zero. Inevitably this suggests potential diversification benefits of investing in Bitcoin in a portfolio of fiat currencies.

	EUR	GBP	YUAN	YEN	RUMBLE	FRANC	GOLD	BITCOIN
EUR	1.0	0.57	0.25	0.27	0.24	0.61	0.32	0.02
GBP		1.0	0.26	0.08	0.21	0.38	0.20	0.05
YUAN			1.0	0.17	0.18	0.22	0.19	0.05
YEN				1.0	0.00	0.35	0.40	-0.02
RUMBLE					1.0	0.15	0.13	0.07
FRANC						1.0	0.40	-0.03
GOLD							1.0	0.03
BITCOIN								1.0

Table 4. Correlation Matrix between Bitcoin and Major Exchange Rates

4.2 Performance of Digital Currencies using weekly data

It has been proven that the largest of the digital currencies, Bitcoin, demonstrates the highest average return or change in its exchange rate when compared to the traditional currencies and gold. The unadjusted volatility levels of Bitcoin are remarkably higher than when compared to the fiat currencies, implying high levels of dispersion and risk. This study attempts to examine how Bitcoin compares to the remaining digital currencies, or altcoins, in terms of returns and volatility, and whether any directional effects are present between the four largest cryptocurrencies. Due to the fact that Ripple's inception started in April 2014, our comparison for the weekly frequency starts from April 2014 and goes until May 2017 for digital currencies Bitcoin, Litecoin and Ripple. Ethereum was introduced in August 2015, and for this reason we have not included it in the comparison of the exchange rates on a weekly basis It is included in the results on a daily comparison analysis. Figures 3 and 4 show the weekly exchange rates in US dollars for Litecoin and Ripple respectively. Both currencies have experienced an increase in their exchange rates from April 2017, onwards. In particular, from January until the end of May 2017, Litecoin and Ripple experienced an increase in their exchange rates of 486% and 4,990% respectively, albeit their price values were substantially lower (over $2,300) than that of Bitcoin.

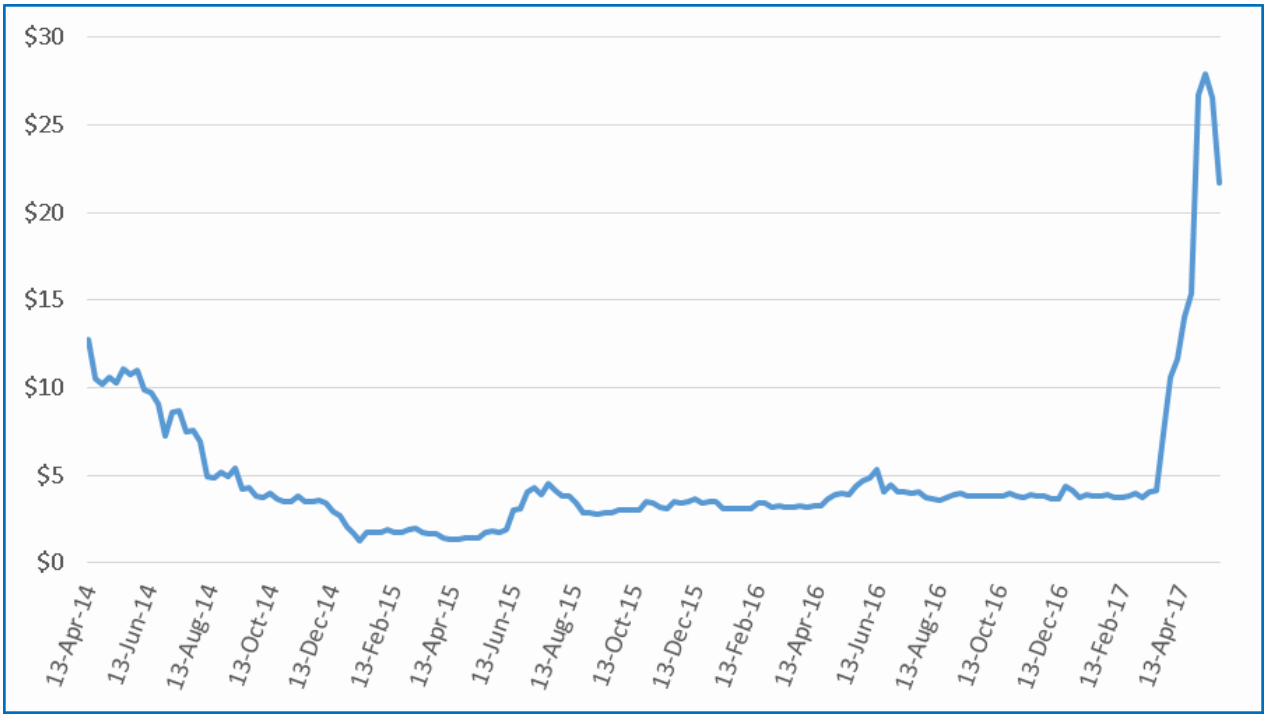

Figure 3. Litecoin weekly exchange rates in US Dollars

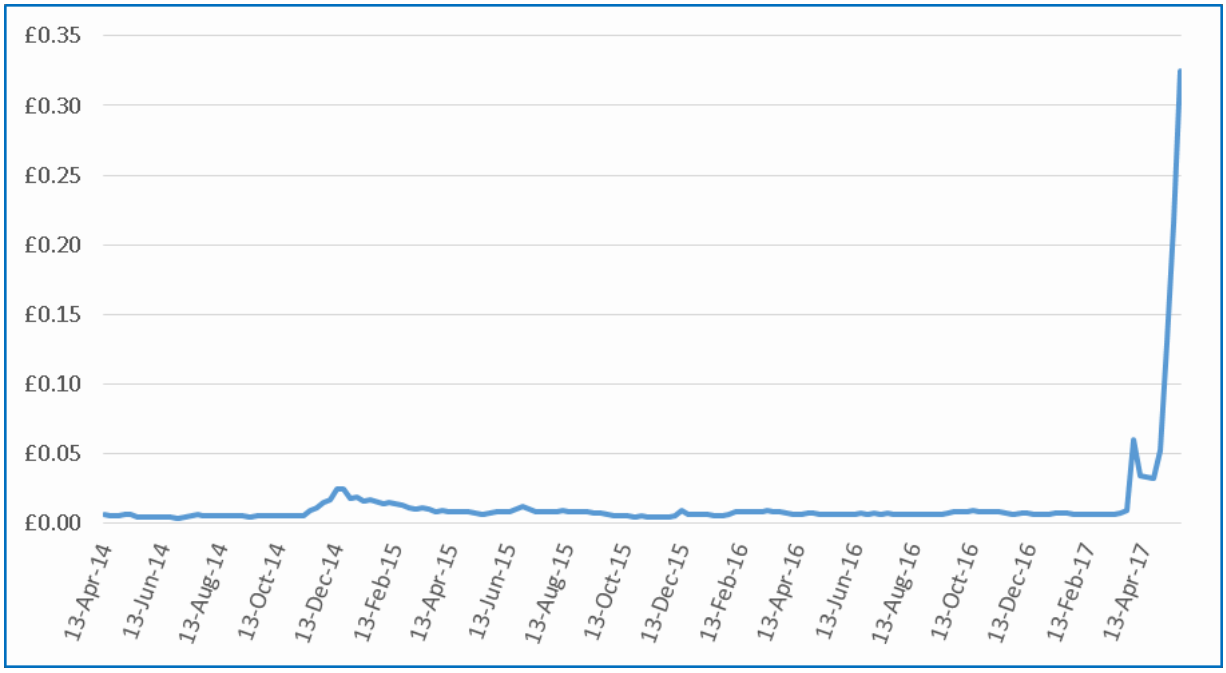

Figure 4. Ripple weekly exchange rates in US Dollars

When taking into account the average change of the three exchange rates, Table 4 shows that Bitcoin does not experience the highest return in its value. In fact, Ripple has earned on average

2.46% for the period of analysis. This is mainly because of the high change in its value at the beginning of April 2017. As a result, the dispersion of Ripple's exchange rate has been the widest during the period of analysis, indicating the highest present volatility in comparison to Litecoin and Bitcoin. Figure 5 further illustrates this point by showing the annualized volatilities for Bitcoin, Litecoin and Ripple using the weekly data.

Currency/Gold	Average Change (%)	Maximum (%)	Minimum (%)
Litecoin	0.28	53.85	-24.62
Bitcoin	0.33	11.15	-17.77
Ethereum	0.80	38.30	-31.01

Table 5. Daily Average Percentage Change in Digital Currencies Exchange Rates (8 Aug. 2015 – 30th May 2017)

Figure 5 shows the annualized volatilities for Bitcoin, Ethereum and Litecoin from August 2015 until May 2017. Once again, Bitcoin is the least volatile digital currency for the period of analysis. In fact, Ethereum has shown the highest amount of volatility of 130%, which is predominantly due to the high changes in the exchange rate that it has experienced during 2017.

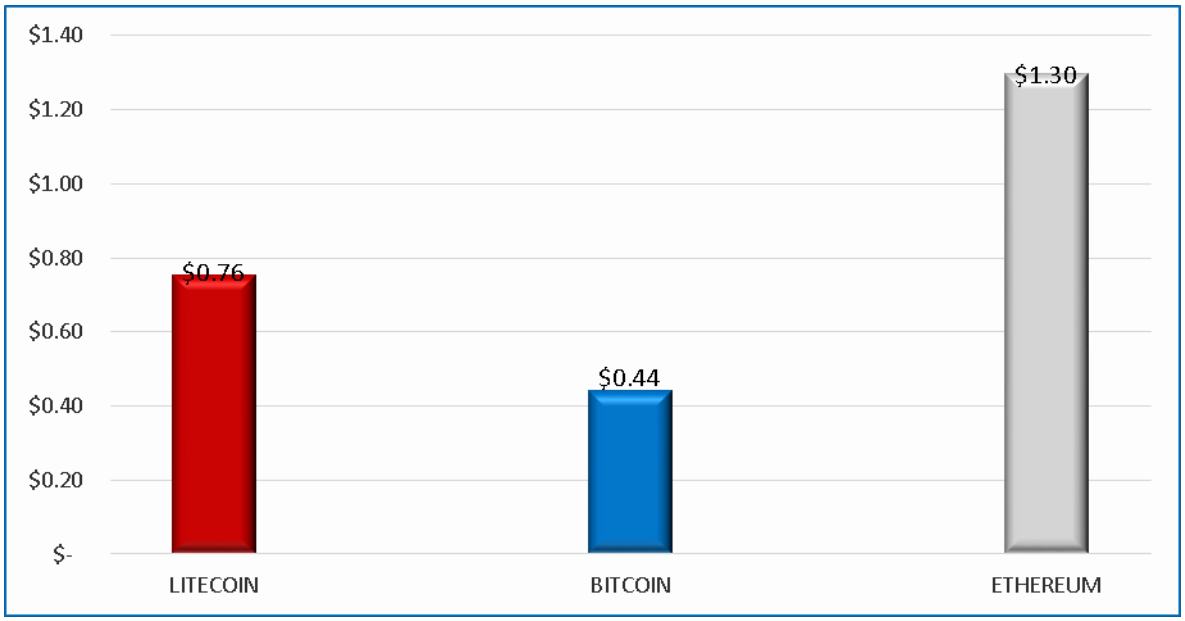

Figure 5. Ripple weekly Annualized Volatility of Bitcoin, Litecoin and Ethereum

The correlation results between Bitcoin, Ethereum and Litecoin are shown in Table 6, which indicate a low correlation of Ethereum with the other two digital currencies. It is interesting to note that the positive correlation between Bitcoin and Litecoin has increased during this period of analysis, in comparison to the weekly output results (Table 5). Nonetheless, the results of Ethereum's low correlation with Bitcoin and Litecoin may provide investment strategies in terms of diversification achievement.

Currency/Gold	Litecoin	Bitcoin	Ethereum
Litecoin	1.0	0.43	0.08
Bitcoin		1.0	0.12
Ethereum			1.0

Table 6. Correlation between Bitcoin, Ether and Litecoin

In addition, we further tested the relationship between Bitcoin, Ethereum and Litecoin through regression analysis, which may indicate possible causality effects between the cryptocurrencies. In particular, we regress the daily exchange rates of Bitcoin and Litecoin on Ethereum in order to determine whether the former two cryptocurrencies have an effect on the performance of Ethereum. We also test whether Ethereum and Bitcoin have an effect on the return of Litecoin. The results of the multiple regression are shown in Appendix Tables 1 and 2, which reveal that it is only Bitcoin that is statistically significant in both cases, causing a positive increase in the value of Ethereum and Litecoin respectively, albeit small in magnitude. This is not surprising as Bitcoin is the market leader in value and its performance is expected to have an effect on the performance of other altcoins. We also carried out tests with Bitcoin as the dependent variable to determine whether altcoins affect the return of Bitcoin, and the results were statistically insignificant.

5 CONCLUSION

The amount of cash that is present in digital currencies has increased tremendously, reaching almost $100 billion, up from $20 billion at the beginning of 2017 (Web 2017). The leading factor that has contributed to this up trend is the Japanese government proceeding to make Bitcoin legal in April. This has caused the value of Bitcoin and other altcoins, particularly Ethereum, to increase, and has given a green light to other Asian markets that they may follow in Japan's footsteps. In addition, another possible reason for the surge in the value of cryptocurrencies is the introduction of initial coin offerings (ICOs), which start- ups use to create new digital currencies. Lastly, speculation cannot be ignored, and it may have played a vital role in the price and market capitalization of the cryptocurrencies to escalate. Investors in cryptocurrencies are more concerned in the future value of the cryptocurrencies and may be holding the currencies, further adding to the growing trend. As the results of our study indicate, the trend of all the cryptocurrencies in the analysis seem to depict a bubble, and it is uncertain whether this is in fact the case and if/when the market will adjust.

Indeed, the cryptocurrency market has become widespread, and it is of practical value to compare the most prominent digital currencies in the market. Even though Bitcoin is by far the leader of the cryptocurrency market, the other altcoins, Ethereum, Litecoin and Ripple, have also shown a tremendous rise in their values. Our results indicate that when compared to traditional currencies, Bitcoin exhibits the highest returns and volatility. Nonetheless, when compared to the altcoins in our study, its return remains on the higher scale, but the volatility drops. Furthermore, our analyses depict a low correlation between the cryptocurrencies for daily and weekly frequency of data employed, giving possible diversification opportunities for investing. In particular, it would not be advisable to 'put all your eggs in one basket' and spread one's investment in different cryptocurrencies.

Whether the recent surge in prices of cryptocurrencies is a bubble remains to be examined. In spite of this, Bitcoin and the other altcoins are gaining a momentum in the financial markets and as our results indicate, the comparison of each of the currencies is of the utmost importance.

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3 APPENDIX A

Table 1: Ethereum Regression Output

Regression Statistics	
Multiple R	0.1196
R Square	0.0143
Adjusted R Square	0.0113
Standard Error	0.0812
Observations	659

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.0629	0.0314	4.7657	0.0088
Residual	656	4.3332	0.0066		
Total	658	4.3965			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.006	0.0031	2.1388	0.0328
Litecoin	0.0621	0.0738	0.841	0.4001
Bitcoin	0.2929	0.1263	2.3183	0.0207

Table 2: Litecoin Regression Output

Regression Statistics	
Multiple R	0.431
R Square	0.186
Adjusted R Square	0.183
Standard Error	0.042
Observations	659

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.2772	0.1386	75.076	4.36E-30
Residual	656	1.2113	0.0018		
Total	658	1.4886			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.00021	0.0016	0.125	0.89979
Bitcoin	0.73115	0.0606	12.046	2.47E-30
Ethereum	0.01737	0.0206	0.841	0.40012