“The study of bubbles in bitcoin behavior”

AUTHORS	Usama Adnan Fendi http://orcid.org/0000-0002-3252-7822 Asem Tahtamouni http://orcid.org/0000-0002-1218-3620 Yaser Jalghoum http://orcid.org/0000-0003-4786-7309 Suleiman Jamal Mohammad http://orcid.org/0000-0002-7430-3691

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Usama Adnan Fendi (Jordan), **Asem Tahtamouni** (Jordan),
Yaser Jalghoum (USA), **Suleiman Jamal Mohammad** (Jordan)

THE STUDY OF BUBBLES IN BITCOIN BEHAVIOR

Abstract

Bitcoin is an online communication system that facilitates the use of virtual currency, including electronic payments. This paper aims at analyzing the behavior of Bitcoin returns as a proposal for future currencies while making a comparison between Bitcoin and other conventional currencies.

This paper uses quantitative approach to analyze the time series of Bitcoin and that of other conventional currencies during the period 2010–2018. It uses 1) a descriptive statistics for the weekly returns for Bitcoin which includes the mean, standard deviation, maximum value, minimum value, skewness, kurtosis, and Jarque-Bera normal distribution test statistics, and 2) duration dependence test on Bitcoin weekly returns by extracting the weekly returns for the Bitcoin that behave in irregular way of the general Bitcoin return level through autocorrelation regression, and taking the residuals for this regression as a time series for irregular returns.

This paper has confirmed no empirical evidence for the existence of a speculative bubble in the Bitcoin values and returns. In addressing the question of whether Bitcoin can act as a reliable substitute for conventional currencies, the returns based analysis shows a huge difference between the behavior of Bitcoin returns from conventional currency returns when comparing both aspects of level and stability. The paper concluded that bitcoin is more an investment than a currency.

This paper represents a significant contribution in the path of financial economics and financial risk management, and represents a contribution to the stability of the financial system around the world and mitigating financial crises.

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Usama Adnan Fendi, Ph.D., American University of Madaba, Jordan.

Asem Tahtamouni, Ph.D., American University of Madaba, Jordan (corresponding author).

Yaser Jalghoum, Ph.D., The University of Texas, USA.

Suleiman Jamal Mohammad, Ph.D., Princess Sumaya University for Technology, Jordan.

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Introduction

Bitcoin first appeared in January 2009 and was the first cryptocurrency to enter the market. Cryptocurrencies, sometimes called virtual currencies, are decentralized currencies whose values are created through a complicated coded decentralized process at a predetermined rate (Nakamoto, 2008). Bitcoin facilitates cash flows between beneficiaries without the need for intermediation from a third party. The cryptocurrency system differs from traditional systems as it does not rely on a reference economy or sovereign state. Such an instrument and a payment system seem to be favorable and attractive to users because they look less expensive and more instant.

In addition, conventional currencies around the world can be fixed in value and can be floating. The latter can fluctuate in value based on supply and demand, or based on information available on the economies of these currencies. However, the size and severity of the fluctuations can be limited for these currencies compared to the fluctuations in the market value of common stocks, for example, or any investment in the capital market (Brooks & Katsaris, 2003).

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The creation of cryptocurrencies presented challenges for economics and financial systems, on the one hand, and for the regulatory authorities, on the other, due to the fact that this type of currency is different from all other previously known currencies, since there is no tangible reserve or wealth to back the amount of currency created. With no gold or other foreign currency backing, and even with no balance of trade to represent the demand and supply for these currencies, it is difficult to assess their actual value and stability (Bouoiyour, Selmi, & Tiwari, 2014).

Moreover, the complicated way of generating and evaluating the values of cryptocurrencies makes it vulnerable to cyber risk that can be posed by hardware, software, or human factors. This complicated the method of mining. In addition, the regulatory authorities, represented by monetary authorities, cyber security controllers, and even investment analysts and researchers, find it quite difficult to track and control the value of bitcoins. In other words, these parties can find it difficult to monitor and follow up the transactions, exchange, and the value creation processes of these new currencies (Bouri et al., 2017).

Walsh (2017) states that: "University of Cambridge Centre for Risk Studies and the insurer Lloyd's of London concluded that an attack from an arranged group of hackers to knock off power across major cities like New York and Washington could cost from USD 243 billion to USD 1 trillion." This may affect the currency and cause a huge risk of unexpected losses to the US economy. This indicates that wasn't expected to the USA. All that can give us an approximate for the shape and size of the problem of countering cyber risk in the cryptocurrency industry, and the difficulty of following up and controlling the process of generating and transferring these currencies accurately and securely (Condon, 2013).

In digital and software practices, you can copy and paste all what you want out of your stock of files and folders, whatever they were and whatever the number of copies you wish. If the Digi-cash can be copied and pasted in such manner, then, unwanted huge depreciation in value of this cash will be the case, and its purchasing power will decrease. Bitcoin protocol started to deal with this problem and to find technical solutions for it. The protocol of Bitcoin states that any new transactions become validated through the public ledger, also known as the blockchain, and is verified every ten minutes. In this 10-minute gap, there are many windows open for potential risk, if any two businesses or parties are paid with the same unit of bitcoin and at the same time. If the phenomena of double spending take place during this time gap, the last entity to inform about this transaction would obtain little or no collection on payments. There are many governmental agencies who have issued consumer warnings such as the CFBP, and FINRA for no risky activities to arise. As mentioned previously, Bitcoin is an anonymous commodity, which has no central authority and eliminates financial institutions as being middleman between two parties (Kaminski, 2003). This also eliminates the protections offered by these financial parties, since in the Bitcoin market, there are no laws being perused to protect consumers against fraud, human error, and theft. Unlike the protection offered of chargeback from banks when credit cards are used, once a transaction is in place in the bitcoin market, consumers are irrevocable and have no recourse of resolution (Barber, Boyen, Shi, & Uzun, 2012; FBI Directorate of Intelligence, 2012).

1. LITERATURE REVIEW

1.1. The concept of cryptocurrencies

Simser (2013) and Barber et al. (2012) presented the stages of cryptocurrency evolution, since the electronic currencies began to make an appearance in 1983, when David Chaum conceived "ecash", which was later implemented in the form of "Digicash" in 1995. In 1996, the National Security Agency (NSA) published "How to Make a Mint: The Cryptography of Anonymous Electronic Cash", which described the system for cryptocurrency and how it works. Subsequently, Wei Dai published the description for "b-money" and Nike Szabo "bit gold", both in 1998. In 2009, the first decentralized cryptocurrency was established, the "Bitcoin", which was created by Nakamoto. At the establishment, one million bitcoins were mined, until the process started to generate value

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through software developers like Gavin Andersen. Buchholz, Delaney, Warren, and Parker (2012) found that although the value of Bitcoin was extremely low at first, with one bitcoin being worth less than one cent in 2010, this value started to increase dramatically later on. In fact, by December 15th 2017, the value had reached USD 17,900.

However, Blanchard and Watson (1982) in their study found that this huge increase in value, in a relatively short period of time, draws attention to the real value of these digital currencies in general. Variability means fluctuations, and fluctuations mean risk. Conventional currencies will rarely show such variability in value, except in cases of financial crisis. It can be seen that such variation in capital markets, particularly in the stock market, may relate to supply and demand variables, but it is an unusual occurrence in currency markets. For this reason, this paper seeks to examine the existence of a speculative bubble in bitcoin prices during the past period.

1.2. Currency vs investment

Although Bitcoin came into being eight years ago, it failed to hit the target of USD 1,000 until the first quarter of 2017. In December 2017, the value reached the record of USD 18,737 (an increase of 1,774%). By February 2018, a couple of months later, the value had decreased to USD 7,386 (a decrease of 61%). Therefore, Tasca, Hayes, and Liu (2017) state that this huge increase in the value, followed by a sharp drop in a short time span, was considered questionable by many economists and observers. It is important that the regulatory authorities decide clearly if the cryptocurrencies are investments, because such conclusion will have different implications and effects on the stability of the economy, like the financial panic might arise due to sharp drop in investment values (Fendi, 2017). This requires different techniques to analyze its effect on the financial system and the economy as a whole as early as possible (Fendi, Sawalha, & Shamieh, 2017). Nakamoto (2008) found that the speculation on this type of currency leads to these fluctuations in value, resulting in a discussion of whether Bitcoin can be considered a currency like traditional currencies that are used to store value and facilitate the exchange of goods and services, or rather as an investment that can be used to generate profits from capital appreciation. Bitcoin exhibits a substantial price risk that is 7 times larger than gold, which is set to 18%, 18 times larger than the US dollar at 7%, and 8 times larger than the S&P 500, which is at 15.5%.

Glaster, Zimmermann, Haferkorn, Weber, and Sieiring (2014) empirically investigated whether the users of bitcoin are driven by the sack of new currency system or just seeking new investment asset. The paper has found that most of bitcoin users, especially the non-sophisticated (non-informed ones), are seeking for new investment asset and not for new currency system.

Kristoufek (2013) explored the relationship between Bitcoin prices and the search queries on Google and Wikipedia. He found more than a connection between Bitcoin prices and search queries, he found asymmetry between the increased searches (interest) on bitcoin and being above or below the trend of Bitcoin prices. This can support the argument that considers the Bitcoin as an asset rather than a currency.

Accordingly, many scholars argue that cryptocurrencies represent an investment instrument rather than a type of currency. The reason lies in the actual role and approach of cryptocurrencies compared to the traditional role of currencies as a store of value and medium of exchange. Thus, this piece of research investigates whether cryptocurrencies are useful as new investment instruments rather than currencies (Ciaian, Rajcaniov, & Kancs, 2016).

1.3. The existence of bitcoin bubble

Williams (2014) found in his study that speculation can occur in the investment market and the currency market. Indeed, it can be the most significant variable to affect the asset price movement represented by demand and supply power. The real problems start when the speculation is exaggerated to an unrealistic level that results in overvaluation of the asset beyond the true value that reflects the intrinsic value of the asset. Some of the capital appreciation of any asset value can be justified by regular increase and booming in that particular market. On other occasions, Phillips, Shi, and Jun (2013) found that the increase is unrealistic compared to the fundamental changes in the market and in the economy as a whole. The contribution of this paper is in differentiating between

the regular increase of the value of Bitcoin, as a proxy for other cryptocurrencies, and the overvaluation of this currency value.

On the other hand, Gurkaynak (2008) found that overvaluation can have a quite dangerous impact on the economy. The negative connotation is present in the use of the word "bubble" to describe the unrealistic sudden change in the market value for any asset. The continuous increase in the price of any asset can be attractive for many speculators to realize capital gain in a very short period of time. This attraction can arouse a marked increase in demand for that asset, which can worsen the problem of mispricing, resulting in the bubble continuing to inflate. The actual problem occurs when the bubble bursts, leading to the sudden disappearance of a huge amount of value, at which point a lot of financial losses must be absorbed by the investors here and there.

Cheah and Fry (2015) discussed the actual fundamental value of bitcoin using economic and econometric models. They found empirical evidence that the fundamental value of the bitcoin is zero, and like many assets, the bitcoin exhibits a speculative bubble. Moreover, Bouoiyour, Selmi, and Tiwari (2014) have addressed the causality relationships between bitcoin prices and some other variables in the Chinese market; they have used Granger causality test to assess these relationships and found an extreme speculative nature for bitcoin but with reserving its usefulness in the economy.

Buchholz et al. (2012) used ARCH/GARCH models in their study to inspect the effect of volatility on the price level; the study divided the analysis into two main stages, one before the peak of the bubble, and the other after the peak. The study proved the existence of bitcoin speculative bubble in the first stage, with higher significance for the positive shocks than the negative ones. For the second stage (after the peak), the same relationship applies but with higher significance for the negative shocks.

Chaim and Laurini (2018) have investigated whether bitcoin is a bubble or not. They used nonparametric method to analyze the volatility of bitcoin prices over time and on a daily basis compared to other conventional financial assets. They have estimated the stochastic volatility depending on the model. The results found evidence for speculative bubble in bitcoin prices for the period from 2013 to the mid of 2014, and the absence of any bubble in 2017. Furthermore, another study by Gerlach, Demos, and Sornette (2018) has analyzed the detailed movement of bitcoin prices compared to USD to detect the existence of bubble in its historical prices. They applied the analysis on the sample period from January 2012 to February 2018 and introduced a robust automatic peak detection method and Lagrange Regularization Method to detect the peaks for the time series. They developed a scheme that can be useful to predict any crises risk out of bitcoin crashes.

1.4. Contribution to welfare

Chiu and Koeppl (2017) investigated the welfare cost of Bitcoin compared to the optimal cost for any cash system. They tried to evaluate the ability of Bitcoin to serve in retail transactions as well as the large denomination transactions. The authors considered the problem of double spending issues in cryptocurrencies and its relation to the size of transactions. They found that cryptocurrencies can contribute better to the low values of volume transactions, rather than large value or denomination transactions, simply because the risk value out of double spending issue will be magnified as the value of the transaction increase.

Bohme et al. (2015) also studied the effect of the bitcoin as a cash system on the current payment system real economy and the conventional financial system. This will be in light of the assessment of the contribution of cryptocurrencies to the welfare and wellbeing of the population in any country.

Williamson (2019) discussed the advantages of creating Central Bank Cryptocurrency and how it can contribute to the improvement of the traditional financial system and safety of the payment system.

2. METHODOLOGY AND OUTCOMES

2.1. Empirical results

2.1.1. Descriptive statistics

Despite the obvious explosive increase in the market value for Bitcoin in 2017, the returns out of this increase are quite stable compared to the previous

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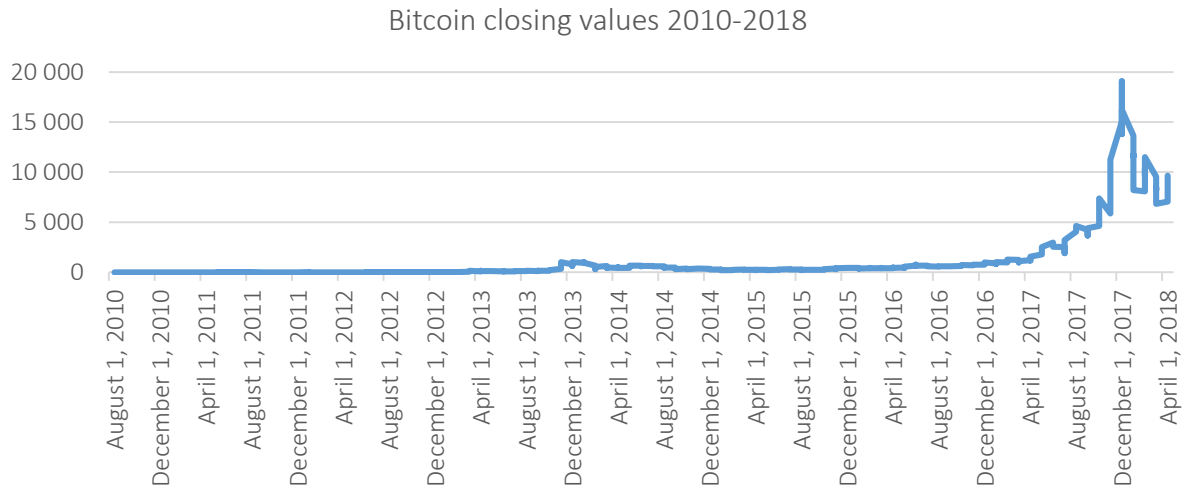

Figure 1. The market value for Bitcoin for the sample

years. These results can contradict the definition of the bubble (see Figures 1 and 2). The values increased over time and looked like non-stationary variables when they are observed on the level, but when one takes the first difference or the growth rate, they appear to be quite stable and start to look like stationary variables. For this reason, it doesn't make sense to judge on the existence of the speculative bubble in Bitcoin values from the shape of the time series of the value without considering the time series of returns (first difference). Figure 2 shows the returns on Bitcoin, which may look like a fluctuating variable, but the fluctuations are not the actual measure of the bubble existence. What we are looking for is the existence of a steep trend in the returns, which does not exist in the chart.

Some descriptive statistics for the weekly returns for Bitcoin are presented in Table 1. It includes the mean, standard deviation, maximum value, minimum value, skewness, kurtosis, and Jarque-Bera normal distribution test statistics.

Table 1. Descriptive statistics on Bitcoin

Mean	4.38%
Standard deviation	17.91%
Maximum	98.10%
Minimum	–54.55%
Skewness	165.45%
Kurtosis	645.45%
Jarque-Bera test	766,572.3
	(0.00000)

The series of returns that implies a rational speculative bubble will have negative skewness, excess

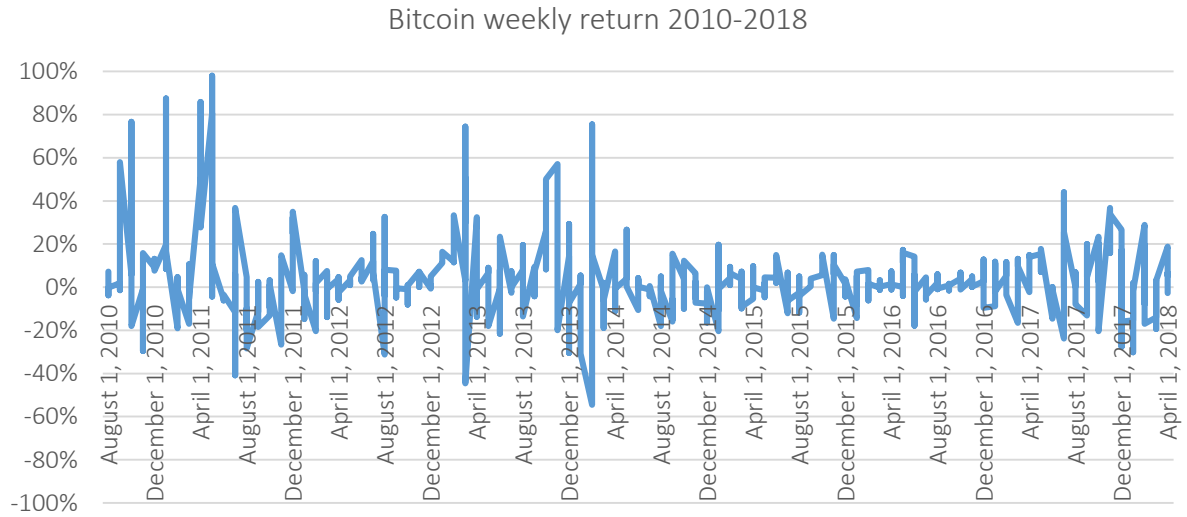

Figure 2. Weekly returns for Bitcoin for the sample

kurtosis, and returns with non-normal distribution. The analysis for Bitcoin data shows that there is a positive skewness equal to 165.45%, the kurtosis is equal to 645.45%, and the returns are non-normally distributed, since the p value for the Jarque-Bera test is almost zero. All these results for descriptive statistics can lead to concluding the absence of any speculative bubble in Bitcoin weekly returns for the period under study, and depending on the descriptive statistics only.

To confirm this conclusion, the paper is going to apply the second methodology mentioned above, which is the duration dependence test for Bitcoin weekly returns, to detect whether there is a speculative bubble or not (McQueen & Thorley, 1994).

2.1.2. *Duration dependence test*

To apply the duration dependence test on Bitcoin weekly returns, the study first needs to extract the weekly returns for the Bitcoin that behave in irregular way of the general Bitcoin return level. This can be done through autocorrelation regression, followed by taking the residuals for this regression as a time series for irregular returns (Tasci & Okuyan, 2009).

Fourth-order autoregressive model on the weekly returns has been applied, and then the residuals for that regression have been obtained. These residuals represent the weekly irregular returns that have not been already explained by the autoregressive model and have no systematic relationship to be explained by the previous data for the Bitcoin returns (Yu & Hassan, 2010) (see equation (1)).

$$R_t = \alpha + \beta_1 R_{t-1} + \beta_2 R_{t-2} + \\ + \beta_3 R_{t-3} + \beta_4 R_{t-4} + \varepsilon_t \ . \quad (1)$$

The next step is to have negative and positive runs for the irregular returns time series. The negative and positive runs have been ordered and counted. There are two identical groups of positive and negative runs, with different run lengths and different patterns. Each run represents the degree of variation of the actual returns on Bitcoin from the auto-regressive forecasted pattern (Zhang, 2008).

The next step is to calculate the hazard rate, which can be done using the following equation:

$$H_t = C_t / \left(C_t + T_t\right), \quad (2)$$

where (H_t) represents the hazard rate at count of run of length (t); C_t is the count of runs of length (t); (T_t) is the summation of count of runs of length (t) and above. Hazard Rate can vary from zero to almost one and it will be one at the last run length; if there is a strong evidence for the existence of speculative bubble, then there must be an inverse relationship between the sample hazard rate and the run length, but the hazard rate itself will vary for each run length (Gan, Nartea, Ling, & Hu, 2012; and McQueen & Thorley, 1994).

Duration dependence test has been applied and reported in Table 2. The sample of Bitcoin's weekly returns consists of 406 weekly returns, and there are 200 total runs, comprising 100 positive runs and 100 negative runs. The longest positive and negative run lasts for 8 weeks. The existence of a speculative bubble is indicated by the inverse relationship between the run length represented in the first column and the hazard rate. In other words, if there is a speculative bubble, then the hazard rate must decrease as the run length increases. The results for the Bitcoin analysis do not show this relationship very clearly. It is obvious from Table 2 that as the run length increases from 1 to 8, the hazard rate sometimes decreases, while at other times it increases. This inconsistent pattern may indicate the absence of a speculative bubble in Bitcoin returns.

Table 2. The duration dependence test

Run length	Positive runs		Negative runs	
	Actual run counts	Sample hazard rate	Actual run counts	Sample hazard rate
1	59	0.5900	45	0.4500
2	22	0.5366	23	0.4182
3	11	0.5789	15	0.4688
4	3	0.3750	8	0.4706
5	3	0.6000	4	0.4444
6	0	0.0000	2	0.4000
7	1	0.5000	2	0.6667
8	1	1.0000	1	1.0000
Total	100		100	
Log-logistic test				
α	0.951669	–	–	–
β	–0.152137	–	–	–
LRT statistic	–4.435915	–	–	–
p-value	0.5817	–	–	–

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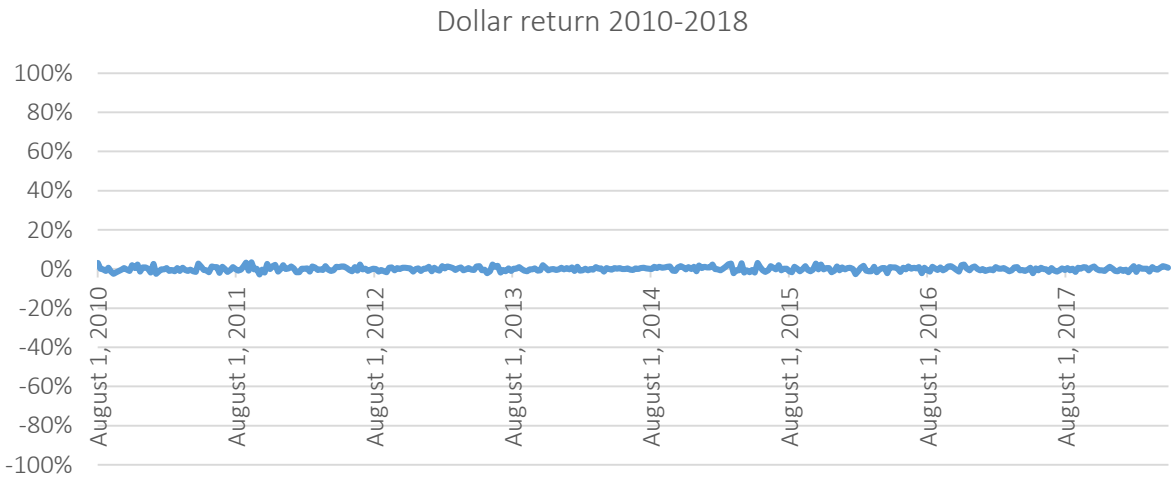

Figure 3. Returns for the USD 2010–2018

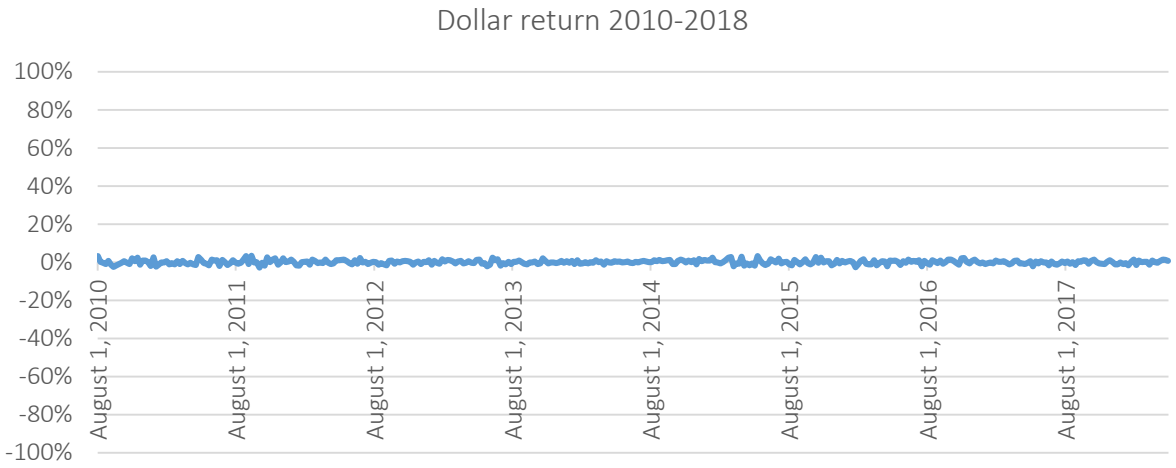

Figure 4. Returns for the Euro 2010–2018

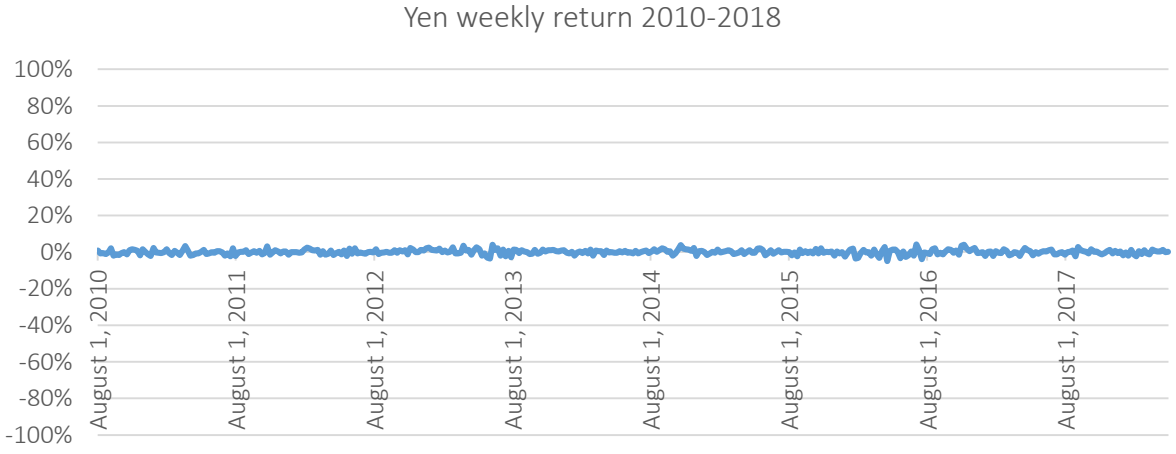

Figure 5. Returns for the Yen 2010–2018

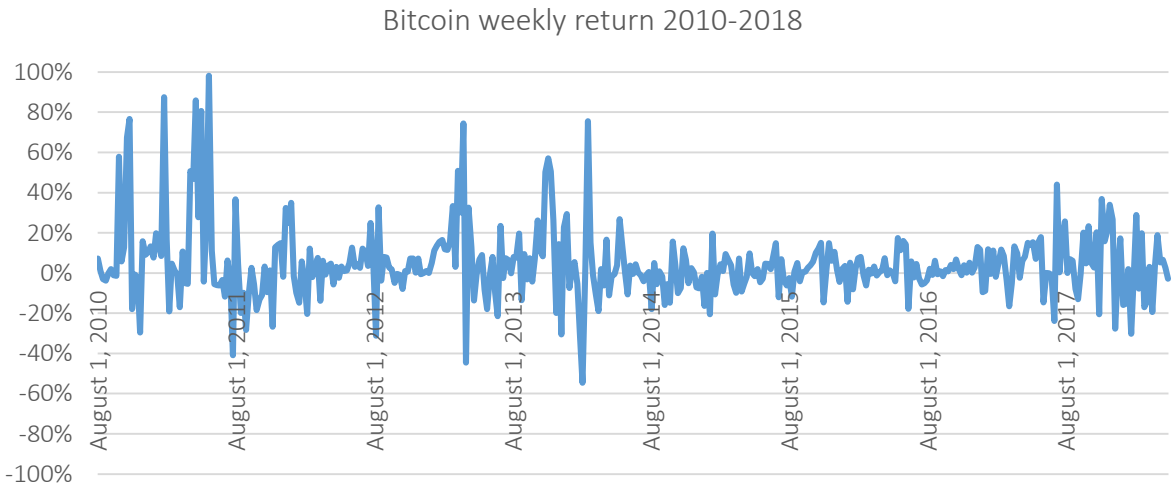

Figure 6. Returns for the Bitcoin 2010–2018

To apply the duration dependence test, it is essential to select a form for the function, and the most suitable one is the log-logistic function. The dependent variable in this model will be 1 if the run from a certain sign will die in the next period, and 0 if the run will survive, while the independent variable will be the log of run length.

Constant hazard rate or zero β indicates the absence of the speculative bubble, while the negative β will indicate the existence of the speculative bubble. The results presented in Table 2 show that β is negative but insignificant, where the p-value for it is 0.58. Having studied the Bitcoin returns data from 2009 to 2018, one can find no significant empirical evidence for the existence of a speculative bubble.

It is obvious from the figures above that the weekly returns for Bitcoin are quite different from the returns for the conventional currencies. In terms of return levels, the conventional currencies show a steady stream of weekly returns over the stated period. The weekly returns for any of the currencies rarely went beyond 3%, and only in extreme cases, and they never went beyond 5%, while in the Bitcoin weekly returns, it is quite regular to see a 50% weekly return, and rates of almost 100% are frequently found.

These differences clearly illustrate that there are many differences between Bitcoin and conventional currencies in terms of stability, the ability to reserve value and to operate as a store of value and a reliable medium of exchange.

Thus, the analysis comparing the returns of the bitcoin with those of the USD, the euro, and the yen argues that the bitcoin is too simplistic and obvious.

CONCLUSION

This paper analyzed the behavior of Bitcoin returns as a proposal for future currencies. The analysis was based on the comparison between Bitcoin and other conventional currencies. It evaluated the tendency of Bitcoin toward being a currency or an investment, as well as the value of Bitcoin and the recent accelerated appreciation in its value, and whether there is a bubble in this value. The paper used a quantitative approach to analyze the time series of Bitcoin and for other conventional currencies during 2010–2018. The descriptive statistics on the level values show some tendency toward adopting the bubble existence hypothesis, due to the observed huge appreciation and depreciation in value in a fixed period of time compared to other currencies. However, on the first difference analysis, or the rate of return level, these variations disappeared and the return time series shows some stationarity. The duration dependence test on weekly returns could not prove the existence of any speculative bubble in Bitcoin weekly returns.

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It did show a negative beta for the log-logistic function, but this beta value was not significant enough to apply the hypothesis.

It is worth noting that different studies may have different results due to the differences in the sample used in the analyses, and due to the different methodology used.

Considering the question of whether Bitcoin can act as a reliable substitute for conventional currencies, the return-based analysis showed a huge difference in the behavior of Bitcoin returns from the conventional currencies returns, either on the level side or on the stability side. This significant difference violates the main two goals for any currency (to store value and to intermediate the exchange of goods and services). It also left the main goal of the economic objective (to attract foreign investors) unfulfilled, and thus significantly threatens the trust and reliability of local and foreign investment in the economy of any country. Thus, based on the above discussion, it can be clearly concluded that bitcoin is more an investment than a currency.

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