The Market Efficiency of Bitcoin: A Weekly Anomaly Perspective

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Abstract

Bitcoin is a cryptocurrency. It is not a legal currency but a private monetary system that manages itself and does not depend on central banks or governments. Since the development of Bitcoin, its trading volume has been increasing largely and rapidly. Some fear the increase in Bitcoin usage as it is quite different from traditional currencies; however, its use is spreading all over the world. This paper examines empirically whether or not weekly price anomalies exist by checking the market efficiency of Bitcoin. The empirical results show that the Bitcoin market is not efficient. However, the empirical results show that Bitcoin transactions are becoming and can become more efficient. The results suggest that Bitcoin returns will be random in the future.

1   Introduction

Bitcoin is a cryptocurrency. This currency was first outlined in [1]. Bitcoin is not a legal currency but a private monetary system that manages itself and does not depend on central banks or governments (see, e.g., [2]). Since the introduction of the currency, it has received much attention. The volume of this currency has been increasing rapidly. Some serious incidents have occurred; however, Bitcoin may overcome such serious conditions. Bitcoin is a different kind of currency from any other currencies used around the world. It is not digital cash, which has prevailed all over the world. Unlike central bank- and government-issued currency, Bitcoin can be inflated at will, the supply of Bitcoin is limited to a certain volume, which cannot be changed. Instead, the use of Bitcoin allows one to send or receive any amount of money to anyone at very cheap cost compared to

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other financial instruments. Bitcoin payments are impossible to block, and Bitcoin wallets cannot be closed. Short of turning off the Internet, and keeping it turned off, the Bitcoin network is unstoppable. Although Bitcoin confers much freedom, it also demands user responsibility, but the rewards are well worth the user's time (Bitcoin homepage, retrieved on January 3, 2017). These characteristics meet users' demands and Bitcoin has been accepted with strong demand by users all over the world. No other similar financial instruments are available to date.

Most people believe that Bitcoin is very risky money for transactions. However, Bitcoin has been used for many types of transactions and investments and has been accepted by many users.

Bitcoin has received much attention not only from academic fields but also from real world. [3] suggested that less than 50% of all Bitcoin in circulation is used in transactions. [4] showed that Bitcoin provides diversification of financial instruments for investors. [5] showed that Bitcoin provides a hedging instrument for other financial transactions. However, as noted by [6] and [7], it has been also used for speculation and unusual transactions for trading goods and services. [8] indicated that the fundamental price of Bitcoin is zero and Bitcoin exhibits speculative bubble elements. Moreover, [9] indicated that Bitcoin appears to move more like a speculative financial instrument than like a usual currency transaction. Some Bitcoin characteristics, such as a speculation and a system run by itself, have influenced used to regard this currency as an extremely risky one.

[10] indicated that the price volatility of Bitcoin is higher than that of gold or some foreign currencies in reality. [11] found that Bitcoin prices are usually characterized by large price fluctuations such as those found in newly emerging markets. [12] showed that Bitcoin price bubbles deviate from normal price fluctuations and are large. [13] indicated that Bitcoin has characteristics that fit well to complement to the currencies of emerging markets and that prices of currencies in emerging markets are more stable than Bitcoin.

Price stability of Bitcoin is important because it is relates to economic activity. In a market economy, market participants make a lot of decisions about whether to invest or consume by using currencies including Bitcoin. If Bitcoin prices fluctuate or lose value strongly, participants avoid its use, which can damage efficient allocation of resources in the economy. Also, Bitcoin users should take considered measures to reduce systemic risk, the possibility that a failure of one participant in a payment or settlement system will spread, through a chain of settlement failures, to other systems or to the overall financial system. A sound payment system is necessary to maintain and boost the market economy. A stable currency and financial system promotes economic growth; on the other hand, instability may cause serious economic turmoil and risks serious damage to economies. To examine the prices of Bitcoin is necessary; however, few studies have tackled this problem..

This paper examines the price efficiency of Bitcoin. [14] showed that Bitcoin follows the hypothesis of efficient markets. On the other hand, in a recent study, [15] indicated that until recently, the Bitcoin market has been inefficient.

Of course, many papers have investigated foreign exchange markets and exchange rates as the same currency prices not only from the view of theoretical aspects but also from empirical ones. Among them, market efficiency has received much attention and many analyses have been conducted. Whether CIP (covered interest parity) or UIP (uncovered interest parity) holds or not has been analyzed much (see, e.g., [16][17][18][19]). Also, the focus on efficiency in foreign exchange markets are analyzed based on effects of interventions in foreign exchange markets (see, e.g. [20][21][22][23]).

Other aspects of the Bitcoin market have benefited from some attention. For example, [24] indicated that strong contemporaneous correlation between order flows and exchange rate changes essentially disappear on days when the Ministry of Finance (Bank of Japan) intervenes in the foreign exchange market. [25] and [26] also examined these issues and showed that the relationship between exchange misalignment and forecast heterogeneity is important in examinations of the so-called coordination channel of intervention.

Many papers about intervention have been published; however, unique among these, this paper examines day-of-the-week effects in the Bitcoin market. Some studies have considered foreign exchange rate anomalies (e.g., [27][28]); however, no or only a few studies have performed empirical analysis from the view of day-of-the-week anomalies for Bitcoin. To investigate to what extent the transaction mechanism matters, [27] examined the daily returns of 29 foreign exchange rates in the New York market and found that the day-of-the-week effect existed in the 1980s for some but not all currencies. The fact that the day-of-the-week effect existed for only some currencies suggests that the US transaction mechanism alone cannot explain the anomaly. Furthermore, this paper finds that the day-of-the-week effect disappeared for almost all currencies in the 1990s. This latter result is consistent with previous studies on anomalies in the stock markets. The phenomenon of anomaly disappearance over time is and should be examined carefully.

Efficient stock market literature dates back at least to [29][30][31][32], and there are now many studies that have focused on particular areas of the finance literature; however, this paper stresses currency, namely, Bitcoin.

This article is structured as follows: Section 2 provides a model for Bitcoin market efficiency. Section 3 explains the data employed here. Section 4 reveals the empirical method and provides empirical analyses. Finally, section 5 gives a brief conclusion.

2 Empirical Analyses

Bitcoin returns are calculated as follows:

$$Rt = ln\,(Pt/Pt\text{-}1) \tag{1}$$

where Rt is the return of Bitcoin and ln(Pt) and ln(Pt-1) are the natural logs of Bitcoin prices at time t and t-1. Data used in this paper are daily.

$$Rt = \alpha 0 + \sum_{i=1}^{7} \alpha\ iDit + \varepsilon t \tag{2}$$

where D1t, D2t, D3t, D4t, D5t, D6t, D7t are day-of-the-week dummy variables for Sunday, Monday, Tuesday, Wednesday, Thursday, and Friday, and Saturday respectively (1 or 0) as a reference point.

3 Data

The Bitcoin data are from www.bitcoinaverage.com, which is the first aggregated Bitcoin index that aggregates daily prices from all available Bitcoin markets. First, data that are converted level into rate are examined for each day. All of the data are stationary according to an augmented Dickey-Fuller (ADF) test. The log of the Bitcoin return rate is integrated at order one and thus becomes stationary. The sample period is from 7/17/2010 to 12/29/2016. The descriptive statistics of Bitcoin for whole period are shown in Table 1.

Table 1: Descriptive statistics of Bitcoin

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Average	0.00564	0.00546	0.00535	0.00540	0.00547	0.00550	0.00564
S.D	0.00544	0.05388	0.05357	0.05351	0.05345	0.05342	0.05448
Variance	0.00296	0.00290	0.00287	0.00284	0.00285	0.00285	0.00296
Kurtosis	13.0310	12.5516	12.6012	12.6505	12.7047	12.7582	13.0310
Skewness	0.98281	0.85918	0.80990	0.82303	0.82828	0.83931	0.98289

There seems not to be only small differences among the days. The mean return, kurtosis, and skewness are all positive.

4   Empirical Analysis

This section examines empirically whether or not the anomaly of Bitcoin prices exists. The estimated equation is (2) as shown in section 3. Adding to the standard OLS, robust least squares (RLS) estimation is also used for estimation. RLS is unlike maximum likelihood estimation. OLS estimates for regression are sensitive to the observations that do not follow the pattern of the other observations. This is not a problem if the outlier is simply an extreme observation from the tail of a normal distribution; however, if the outlier is from non-normal measurement error or some other violation of standard OLS, it compromises the validity of the regression results if a nonrobust regression method is employed. Moreover, the Ljung-Box test is performed to examine the null hypothesis of no autocorrelation.

The sample period is divided into two parts (first and second). The empirical results are in shown in Table 2.

Table 2: Regression Analysis for Anomaly

Period	whole		First half		Second half	
Method	OLS	RLS	OLS	RLS	OLS	RLS
Sunday	0.0032	0.0003	0.0046	-0.0142	0.0019	0.0023*
	(1.1078)	(0.2816)	(0.9164)	(-0.5665)	(0.6272)	(1.6552)
Monday	0.0057*	0.0005	0.0079	0.0018	0.0035	0.0004
	(1.9428)	(0.4061)	(1.5571)	(0.7320)	(1.1840)	(0.7607)
Tuesday	0.0059**	0.0026**	0.0070	0.0055**	0.0049	5.64E-05
	(2.0104)	(1.9901)	(1.3786)	(2.2109)	(1.6169)	(0.0397)
Wednesday	0.0067**	0.0047***	0.0124**	0.0074***	0.0010	0.0037
	(2.2747)	(3.5831)	(2.4387)	(2.9644)	(0.3613)	(0.6227)
Thursday	0.0100***	0.0043***	0.0164***	0.0115***	0.0037	0.0003
	(3.3915)	(3.3023)	(3.2207)	(4.5966)	(1.2368)	(0.2377)
Friday	0.0048	0.0018	0.0081	0.0038	0.0014	-0.0005
	(1.6161)	(1.4260)	(1.5941)	(1.5380)	(0.4825)	(-0.3613)
Saturday	0.0029	0.0029**	0.0050	0.0052**	0.0007	0.0016
	(0.9778)	(2.2637)	(0.9821)	(2.1034)	(0.2620)	(1.1991)
Adj.R2	-0.0008		-0.0015		-0.0037	
Rw-squared		0.0063		0.0204		0.0083
D.W.	1.6036		1.5317		1.8274	
Rn-squared		35.1076		42.4532		11.3384
(probability)		(0.0000)		(0.0000)		(0.1245)
Ljung-Box test	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note. *** denotes significance at 1%, ** at 5%, and * at the 10% level. Figures in parentheses are t-statistics (OLS) and Z-statistics (RLS).

The results are interesting and almost all of them are clear. The weak-form informational efficiency of Bitcoin can be rejected, as the null hypothesis of randomness is rejected. The results show significant inefficiency in Bitcoin, especially in the first period. On the weekends, anomalies of the prices tend to occur.

[28] examined foreign exchange rates and found some kinds of anomalies occurred on Monday and Friday. The results shows that the foreign exchange market also is not efficient and the market's closing days may cause anomalies. Different from foreign exchange markets, the Bitcoin market is open every day. However, the trading volume on weekends is smaller than on weekdays. The reason that anomalies occur is difficult to judge; however, it may affect these results. Table 3 shows the average trading volume of Bitcoin. On weekends, the trading volume is smaller than on weekdays.

Table 3: Trading volume of Bitcoin

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
70203.82	70224.58	70245.01	70270.87	70306.94	70338.86	70183.63

Note. All of the data are from www.bitcoinaverage.com.

One interesting result surfaced: The anomalies seem to disappear in the second half of the sample period. There seems some possibility that markets begin to make themselves more and more efficient. This result is the same as that in [27].

5   Conclusions

The results show that the Bitcoin market is not weakly efficient. However, Bitcoin will become more efficient, as indicated by the empirical results. One might guess that Bitcoin returns will be random in the future at the daily level. However, the empirical results are not very robust. There seems some possibility that the selected price, the sample period examined, and the empirical method or theoretical model employed could change the results.

Bitcoin is surely related with some kinds of financial assets. For example, coordination channeled through foreign exchange market interventions may be effective in that they attract the fundamentals if the original prices of Bitcoin are efficient. Some studies have shown that central bank interventions tend to increase exchange rate volatility. There may be some room for further research on Bitcoin.

[33] indicated that the network and financial services related to Bitcoin are not regulated and that customers must take appropriate measures to protect their Bitcoin holdings. On the other hand, as indicated by [34], Bitcoin must overcome reduced regulatory issues as they contain legal or regulatory problems. [35] stated, "There exists a rather prominent possibility that the U.S. government will take legal steps to constrain or banish the Bitcoin system". [36] indicated that Bitcoin transactions have grown rapidly, which may spur for regulation measures or legal approval of governments. However, Bitcoin could provide new hope for greater freedom in terms of volume, payment methods, anonymity, and so on. For the various kinds of information, the share will be dynamic and evolves significantly over time [37]. Sound trading and boosting economies via Bitcoin is expected.

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