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Testing the Weak Form of Efficient Market in Cryptocurrency

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Abstract: The performance of cryptocurrency under efficient market hypothesis is important as it provides understanding to the behavior of its price movement. It is important to determine the cryptocurrency behavior under efficient market theory to ensure that no speculators or investors are able to take advantage as well as to guarantee fair competition and promising growth in the market. This study used Bitcoin and Litecoin time series data. The study analyzed the presence of heteroscedasticity, serial correlation and tested for structural break with bai-perron test. The sample data is model into GARCH (1, 1) unit root model with structural break. The market efficiency is analyzed through the performance of the model in unit root test namely the augmented Dickey-Fuller, DF-GLS, Phillips-Perron, KPSS, ERS and Ng-Perron. The analysis show that the market efficiency hypothesis in Bitcoin and Litecoin market is inconsistent with weak form of efficiency as the unit root test show Bitcoin model is stationary. This is consistent with the cryptocurrency behavior as it is subjected to speculative bubble. Cryptocurrency has no intrinsic value and it depends on the speculation power. Thus, investors might overvalue or undervalue the cryptocurrency which in turn further effect the market price.

Key words: Cryptocurrency, EMH, weak form, GARCH (1, 1), model

INTRODUCTION

Cryptocurrency is a digital currency which uses encryption techniques or cryptography to regulate fund transactions and control generation of its new units. It is used in online purchases as alternative to paper money. The use of cryptocurrency rises due to the introduction of Bitcoin as the first decentralized digital currency to the market in 2009 by Satoshi Nakamoto. It is design to be inflation free as there is no organization controlling the supply of cryptocurrency. Variety of new cryptocurrencies are being developed such as Litecoin, peercoin, primecoin and others. Cryptocurrency market is still in its early stage. Therefore, the market requires more scientific studies in understanding the market. There are many uncertainties exist in the market.

The known problem in cryptocurrency is the extreme volatility in its price. The volatility of cryptocurrency is often overestimated and the volatility of should have decrease overtime as the market grows larger. A study is needed to explore the behavior of cryptocurrency especially regarding its volatility. The high volatility indicates the unpredictability and fluctuation of cryptocurrency price (Kim *et al*., 2016). This question the ability of market participant in estimating the real value of cryptocurrency. This can be tested using the theory of Efficient Market Hypothesis (EMH). Bitcoin market behavior under efficient market hypothesis usually explored by applying the regression analysis using error correction model. Mostly the Bitcoin market is efficient and the market price react immediately to new information (Bartos, 2015). However, there is another way to explore market efficiency which is through unit root test and ljung-box test.

Literature review

Cryptocurrency: Bitcoin is a decentralized trading tools opposite to how paper money is govern by central bank (Hobson, 2013). This cryptocurrency is run by a block chain technology where it contains full series of bitcoin (Kristoufek, 2015; Yli *et al*., 2016).

Cryptocurrency required peer-to-peer network to process any activities involving of its coin transaction (Malkiel, 1992). It is called mining process which is done digitally using specific software. Mining involve gathering block which comprise of several unverified transactions. Then the block will be process and the process duration depends on the computing power of the computer used. Once done, the processed block would reward a new coin for the miner (Hurlburt and Bojanova, 2014)

One of the disadvantages of cryptocurrency is that price volatility greatly affecting cryptocurrency as store of value. The dollar price of Bitcoin is also moved around

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10% on daily basis since its debut in the market and this includes days such as price moved 190% hitting low. The price of bitcoin rose by 50% following legal attitude to a more positive stance towards its role as medium of exchange in the US. This shows the fluctuation of its market price in reacting to new information. In capturing the behavior of cryptocurrency volatility, GARCH Model is proposed to test the market efficiency of cryptocurrency market.

Efficient market hypothesis: Market efficiency has important implication for investment policy as in efficient market finding overprice and underprice asset is impossible. If market is not efficient, investor will to try to find miss-priced asset to enhance portfolio performance (Narayan *et al*., 2016).

A capital market is said to be efficient if it fully and correctly reflects all relevant and known information in determining security prices (Malkiel, 1992). There are three forms of efficient market which is form by a set of variables contained in the information set. For weak form of efficient market hypothesis, the information set comprise only from past and current asset price. Semi-strong form of efficient market hypothesis consists of information from past and current asset price and all publicly available information. Strong form of efficient market hypothesis expands past and current asset price and all publicly available information to include private information (Malkiel, 1992).

The efficient market can be defined as a market where a large number of rational market participants actively competing with each other while maximizing profit and predicting future market values of financial instruments using important current information available to the market participants (Fama, 1995). In an efficient market, actual price of a financial instruments will be a good estimate of its intrinsic value given at any point of time. The difference between price and intrinsic value is systematic in nature, future movement of the prices can be predicted and the value is moving towards the intrinsic values. If the difference between price and intrinsic value is random in nature, the future movement of the price prediction is not feasible.

In efficient market, prices react immediately to the new information in intrinsic values. The immediate affect gives two implications to the price movement. The first implication is that it is often the reaction of price to new information will simply over estimate or under estimate against the intrinsic value. The second implication is that the first difference of asset price is independent to the new intrinsic value. This means it is a random walk market. GARCH (1, 1) model can also be applied with Unit Root test with two endogenous structural break in the study of efficient market (Soon *et al*., 2015). The form of efficient market hypothesis is determined through augmented Dickey Fuller test and Phillip and Perron test, unit root test and structural breaks. Structural is needed to ensure more accurate result in unit root null hypothesis (Soon *et al*., 2015). This is also can be done with additional unit root test which is Kwiatkowski Phillips Schmidt Shin test or better known as KPSS test where it just a matter of additional result to confirm the analysis (Gupta and Yang, 2011).

MATERIALS AND METHODS

In testing for market efficiency, we proposed on using Auto Regressive Conditional Heteroscedasticity (GARCH) model-based test in testing the presence of unit root. Thus, the GARCH (1, 1) unit root model is expressed as the following form Narayan *et al*. (2016). Bitcoin model:

$$Y_t = \alpha_0 + \pi Y_{t-1} + B_1 D_{1t} + B_2 D_{2t} + B_3 D_{3t} + B_4 D_{4t} + \varepsilon_t \quad (1)$$

Litecoin model:

$$Y_t = \alpha_0 + \pi Y_{t-1} + B_1 D_{1t} + B_2 D_{2t} + \varepsilon_t \quad (2)$$

Where:

α_0 = The constant and variable

Y_{t-1} = The lag 1 dependent variable of Y_t

The log return of average daily price of cryptocurrency. Dummy variable D_{it} represent the structural break point with Bi as the dummy variable coefficient (Eq. 4):

$$\varepsilon_t = \eta_t \sqrt{h_t}$$

Where:

$$h_t = x + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \quad (3)$$

where, η_t is an independent and uniformly distributed random variables, zero means and variance and variables $x>0$, $\alpha \geq 0$ and $\beta \geq 0$. Variable x is a constant, ε_t is the error term and h_t is the sample standard deviation (Table 1).

Experimental result: Variable α and β both represent the estimated coefficient of last period volatility and forecast variance. The random walk theory in efficient market is determined using stationarity test such as augmented Dickey fuller test, Dickey-fuller-generalize least square test, Phillips Perron test, Kwiatkowski-Phillips-Schmidt-

Table 1: Result of GARCH (1, 1) unit root model with structural break

	Bitcoin		Litecoin	
Test	10/4-2/11/2015	2/11-10/4/2016	10/4-16/6/2015	16/6-10/4/2016
ADF	-4.02*	-3.55**	-2.44	-14.37*
DF-GLS	-4.04*	-0.21	-2.34	-0.58
PP	-3.98**	-3.48**	-1.70	-16.58*
KPSS	0.12***	0.25*	0.19**	0.31*
ERS	3.25	212.65***	8.70***	1635.96***
NP	-28.29*	-0.11	-11.81	-0.81

*, **, ***Significant level at 0.01, 0.05, 0.1. The null hypothesis is the presence of unit root with the exception of KPSS test where presence of unit root is the alternative hypothesis

Shin test, Elliot-Rothenberg-Stock Point Optimal test and Ng-Phillips test. The weak form of efficient market is test using ljung-box test.

Based on the stationarity test, Bitcoin model reject the null hypothesis that there is presence of unit root in the model as the calculated t-statistic is lesser than its critical values. The Bitcoin Model has stationarity or trend-stationarity. This means economic shocks have transitory effect to the Bitcoin market and has mean reverting process.

Thus, Bitcoin market do not have weak form of efficient market. The Litecoin model on the other hand shows different result. This means there is a period where economic shocks receive by Litecoin market would permanently affecting the volatility. Presence of structural break may have increase the bias in unit root. While it may seem the period of weak form efficient market span within 2 months from April-June, Litecoin Model is concluded to be stationary.

The auto-correlation and Q-statistic is shown to be significant at 95% confidence interval at all lag. This means historical data can be used to predict future value and weak form of efficient market does not hold for both cryptocurrencies.

Table 2: Auto-correlation and Q-statistic

Model	LAG 1	LAG 2	LAG 3	LAG 4
Bitcoin 1st break				
AC	000.85	0.7200	0.6100	0.5300
Q-stat	152.21	261.64	340.76	400.44
p-value	000.00	0.0000	0.0000	0.0000
Bitcoin 2nd break				
AC	0.2100	0.1700	0.1100	0.1000
Q-stat	7.1200	11.730	13.820	15.550
p-value	0.0000	0.0000	0.0000	0.0000
Bitcoin				
AC	000.94	0.8700	0.8100	0.7500
Q-stat	325.20	607.07	850.19	1061.7
p-value	000.00	0.0000	0.0000	0.0000
Litecoin 1st break				
AC	0.660	0.3300	0.1300	-0.0600
Q-stat	31.05	38.760	40.010	40.310
p-value	0.000	0.0000	0.0000	0.0000
Litecoin 2nd break				
AC	0.9400	0.8700	0.8100	0.7600
Q-stat	266.61	498.23	699.90	875.19
p-value	0.0000	0.0000	0.0000	0.000
Litecoin				
AC	0.6500	0.3800	0.1800	-0.010
Q-stat	157.40	211.72	223.77	224.33
p-value	0.0000	0.0000	0.0000	0.0000

If p-value of Q-statistic is <0.05, the null hypothesis of auto-correlation equal to zero is rejected and weak form of efficient market hypothesis does not hold

RESULTS AND DISCUSSION

Results of the analysis show that the market efficiency hypothesis in cryptocurrency market, Bitcoin and Litecoin market is inconsistent with weak form of efficiency as the Q-statistic is significant at 95% confidence interval. This means the cryptocurrency market react instantly to new information. This result is consistent with previous study on the efficient market hypothesis in Bitcoin which indicate immediate effect of new information to the market price (Bartos, 2015).

The behavior of cryptocurrency differs from stock market as they have different market efficiency where by stock market has weak-form of efficiency. This means cryptocurrency market has higher predictability power than stock market. This is due to the fact that cryptocurrency value has not backed with any commodity thus it is more sensitive to the information flow in the market which in turn affect the supply and demand interaction while stock market depended on commodity price which means it has two sources of information which can affect its price, the backed commodity and the stock, making it more complex for market participant to estimate the market value (Bartos, 2015).

In the GARCH Model, the variance coefficients show that there is certain period of time where the market is nervous. During this period, market participants are being careful with the price fluctuation. Since, the market react to new information in the market, a spike change in the market price would increase the speculation in the market.

This is consistent with the cryptocurrency behavior as it is subjected to speculative bubble. Cryptocurrency has no intrinsic value and depends on speculation power. Depending on the behavior of the market price, investors might overvalue or undervalue the cryptocurrency which in turn further effect the market price (Table 2).

However, there are also disadvantages on the cryptocurrencies where the extreme volatility in cryptocurrency price making the price fluctuation unpredictable (Rogojanu and Badea, 2014). The records of cryptocurrency transactions are made public has the risk of fail anonymity protection as it is possible to match and associate transactions addresses with cryptocurrency users. Another disadvantage is that cryptocurrency can be use in speculative attacks. At global scale, this can generate large negative effects to the market and no organization has the capabilities to intervene if such event occurs.

CONCLUSION

There is also a risk in cryptocurrency security breach in which is cause from online environment. Since, there is no third party involve in the savings security users cannot be recompense from their losses. The disadvantage of cryptocurrency can also be the initial investments cost for new investors in the market as for purchasing adequate technology and utilities involved.

Further study on the cyber risk on cryptocurrencies should be discussed as it can be used to further plan a standard operating procedure on cryptocurrencies trading as well as its risk mitigation.

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