Research on the Pricing Strategy of the CryptoCurrency Miner's Market

Liping Deng[1,2(✉)], Jin Che[1,2], Huan Chen[1,2], and Liang-Jie Zhang[1,2]

[1] National Engineering Research Center for Supporting Software of Enterprise Internet Services, Shenzhen, China
[2] Kingdee Research, Kingdee International Software Group Company Limited, Shenzhen, China
liping_deng@kingdee.com

Abstract. Although the attitudes of governments and the general public on virtual currencies vary greatly, the prices of virtual currencies have grown at an extremely exaggerated rate since 2016, attracting more and more investors and media attention. Not only that, while virtual currency prices have increased, mining has turned into a profitable business, and many people have purchased miners to invest in the mining industry. This article examines the stability of the two time series of bitcoin's price and miner's hashrate from 2016 to the present. Research shows that price changes are the Granger cause of changes in hashrate. By establishing a distributed lag model, the quantitative relationship between hashrate and price is analyzed. Combined with the follow-up investigation of the miner's market, it discovered the pricing strategy of the miner's market, that is, the current miner's price is determined by the price of the previous cryptocurrency, and the lag period is calculated.

Keywords: Cryptocurrency · Miner · Pricing strategy · Granger causal Distributed lag model

1 Introduction

With the development and extensive application of blockchain technology, cryptocurrencies represented by bitcoin are also gradually known. Figure 1 is a trend graph of the frequency with which bitcoin was retrieved as a keyword in Google [1]. Bitcoin's attention has been increasing since 2016. Although people and government have different attitudes toward cryptocurrency, and different kinds of virtual currency prices fluctuate greatly, some investors' enthusiasm for investing in cryptocurrency remains unabated.

Different from the traditional currency issuance strategy, the addition of virtual currency requires the miners to contribute computing resources to compete for additional currency per unit of time. This process is called mining, and professional mining tools are called miners. Mining maintains the issuance and circulation of the entire virtual currency. As the virtual currency prices have risen, mining has turned from the small profits of the past to a business that can be turned over, and more and more

S. Chen et al. (Eds.): ICBC 2018, LNCS 10974, pp. 228–240, 2018.
https://doi.org/10.1007/978-3-319-94478-4_16

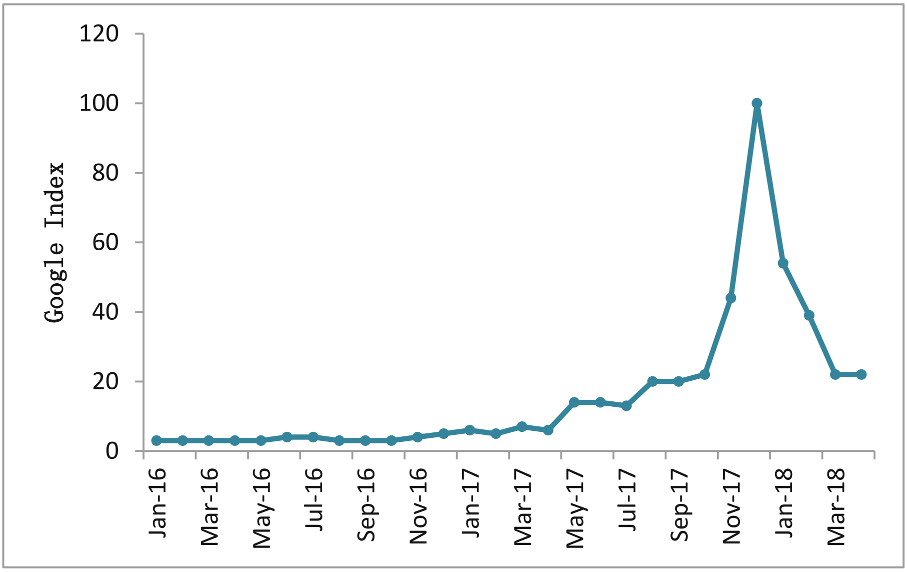

Fig. 1. Google trends of Bitcoin

people are starting to purchase large quantities of miners for professional mining. Naturally, the miner's price and even the price of the video card have also skyrocketed.

Mining [2] is the process of a node that participating in maintaining the cryptocurrency network obtains a certain amount of new cryptocurrencies through assisting in generating new blocks. Mining is also a very hot profitable industry. From ordinary CPUs, GPUs, and FPGAs, to ASIC miners, and to mining pools formed by numerous miners. In just a few years, the technology of miners has gone through the evolution of integrated circuit technology over the past decades. At present, mining is mainly concentrated in China. Driven by huge profits, the Chinese miner's market has developed rapidly and is favored by investors. This paper, through the follow-up investigation of the miner's market, the pricing strategy of the miner's market was discovered. That is, the current miner's price is determined by the price of the previous cryptocurrency. The results of this study have important guiding significance for investors to purchase miners and avoid risks.

2 Research Background

On October 31, 2008, Satoshi Nakamoto first proposed the concept of bitcoin in Bitcoin: *A Peer-to-Peer Electronic Cash System* [3]. Bitcoin is a cryptocurrency and worldwide payment system. It is the first decentralized digital currency, as the system works without a central bank or single administrator. An alternative, the numerous among of other cryptocurrencies have been created. In cryptocurrency, miner is a computer or group of computers searching for cryptocurrency. They constantly verify transactions and as an incentive, they get rewarded with cryptocurrency.

2.1 Bitcoin

Researchers have conducted in-depth research on whether or not bitcoin has monetary functions and obtained many valuable results. In 2015, Kristoufek [4] used the continuous wavelet framework to study the evolution of bitcoin in both time and frequency domains, showing that bitcoin formed a unique asset with standard financial assets and speculative assets. In 2016, Bouri [5] used the dynamic conditional correlation model to analyze the relationship between bitcoin and major world equity indices, bonds, oil, gold, general commodity indices and US dollars. From the perspective of research assets, bitcoin can be seen as a digital currency. In 2017, Indera [6] proposed a Multi-Layer Perceptron based Non-Linear Autoregressive model. Use bitcoin's historical price trend to predict the future price of bitcoin and achieve better results.

2.2 Cryptocurrency

A cryptocurrency is a digital asset designed to work as a medium of commutation that uses cryptanalytics to secure its transactions, to control the introduction of additional unit of measurement, and to verify the transfer of assets. Cryptocurrency is based on cryptography and network P2P technology, generated by computer programs, and distributed and circulated on the Internet. The cryptocurrency [7] has received increasing attention from the media, the public, scholars and the government. In addition to research from computer science, cryptography, etc., more and more scholars have begun to pay attention to the economic analysis of cryptocurrency, its currency or asset characteristic, and the innovation of cryptocurrency to traditional currency theory and payment methods.

In 2013, Ahamad [8] criticized the legal currency issued by the government, gave a detailed introduction to various virtual currencies, and proposed a feasible scheme to replace the legal currency with virtual currency. Recently, the perspective of the central bank, the design of cryptocurrency should not only consider protecting people's privacy, but also need to pay attention to social security and social order. In short, cryptocurrency is still in its early stages of development, and many new ideas have emerged. However, there are obvious argument that guarantee deep research.

2.3 Miner

Mining is the process of confirming the transactions that occur in the bitcoin system over a period of time and recording the formation of new blocks on the blockchain. Bitcoin may be obtained through mining, with objective benefits. In 2016, Bouiyour [9] made a quantitative analysis of the sharp declination in price of bitcoin from 2015 to mid-2016 using Asymmetric-power GARCH. Researchers showed that the bitcoin market was very immature and had an impact on price fluctuations in the miner's market. In 2015, Hayes [10] analyzed 66 virtual currencies and conducted regression analysis from the three dimensions: the difficulty in mining for coins, the rate of unit production and the cryptographic algorithm. Researches showed that bitcoin production was similar to the highly competitive commodity market. Theoretically, miners will always produce until their marginal cost is equal to their marginal turnout.

Anything that helps to reducing bitcoin's production costs will have a negative impact on its price, such as increasing the energy efficiency of mining hardware or lowering global electricity prices. At the same time, the increased computing power of the global mining network will increase the difficulty of mining and will have a positive impact on prices.

Hayes's researchers showed that bitcoin's price was related to miner's hashrate. On this basis, this paper used Granger causality relation test and distributed lag model, quantitatively expounded the impact of bitcoin price changes on the changes of hashrate.

3 The Relationship Between Hashrate and Price

This section examines the relationship between hash rate and price. The information of bitcoin from 2016.01.01 to 2018.03.31 is obtained from bitinfocharts.com, and the average price and hash rate are calculated monthly. Figure 2 shows that prices and hash rates have risen in synchrony. So, is there a stable relationship between them? Is there a causal relationship with "who causes changes"? The following applies the principles of econometrics to answer this question.

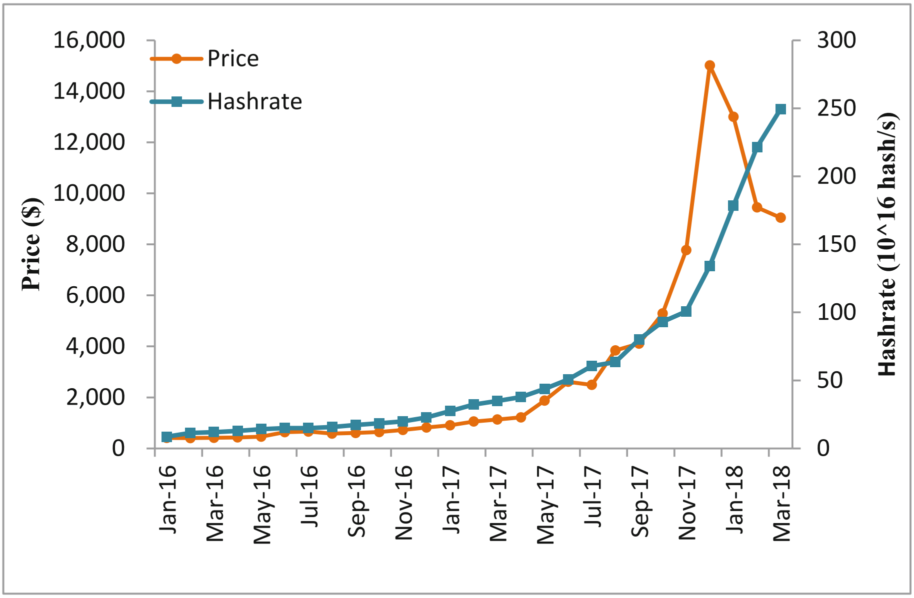

Fig. 2. The trend of Bitcoin's price and hashrate

3.1 Unit Root Test

In econometric theory, finding the relationship between variables requires a stability test. If it is a stationary time series given that a classical model such as a regression model can be constructed; if it is not a stationary time series, a stationary series is constructed by difference, and then a cointegration relationship between variables is established. Unit root test [11] is often used to verify the smoothness of the variables.

Using Eviews 9.0 [12], the unit root test results for the hash rate series is shown in Fig. 3. Prob = 1.0000 > 0.05 accepts the null hypothesis. That is, the hash rate series has a given unit root and is an unstable series.

Null Hypothesis: HASHRATE has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		3.766186	1.0000
Test critical values:	1% level	-3.737853	
	5% level	-2.991878	
	10% level	-2.635542	

*MacKinnon (1996) one-sided p-values.

Fig. 3. The results of unit root test for hashrate

If a time series is smoothed by a difference, the original series is said to be integrated of order 1 and denoted as I(1). The differential operation and unit root verification are performed on the sequence of hashrate. Studies have shown that the hashrate series is not integrated of order 1 but integrated of order 2. Prob = 0.0028 < 0.05, rejecting the null hypothesis that the second-order difference of the hashrate series is a stationary sequence (Fig. 4).

Null Hypothesis: D(HASHRATE,2) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.315153	0.0028
Test critical values:	1% level	-3.752946	
	5% level	-2.998064	
	10% level	-2.638752	

*MacKinnon (1996) one-sided p-values.

Fig. 4. The results of unit root test for hashrate I(2)

A unit root test of the price series makes it easy to know that the price series is not a sequence of I(0) and I(1). In Fig. 5, with Prob = 0.0029 < 0.05, the price series is integrated of order 2.

Null Hypothesis: D(PRICE,2) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.387867	0.0029
Test critical values:	1% level	-3.808546	
	5% level	-3.020686	
	10% level	-2.650413	

*MacKinnon (1996) one-sided p-values.

Fig. 5. The results of unit root test for price

3.2 Cointegration Test

The cointegration test is a causality test for non-stationary sequences. If the linear combination of non-stationary sequences is stationary, this combination reflects the long-term stable proportional relationship between variables.

Both the hash rate series and the price series are integrated of order 2 and denoted as I(2), and the two-variable Engle-Granger test is used to study the assistance relationships between variables. The OLS (Ordinary Least Square) regression was performed on the second-order differential of the hash rate and price to obtain the residual sequence denoted as e. The ADF (Augmented Dickey-Full) test result is shown in Fig. 6.

Null Hypothesis: E has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.716343	0.0010
Test critical values:	1% level	-3.737853	
	5% level	-2.991878	
	10% level	-2.635542	

*MacKinnon (1996) one-sided p-values.

Fig. 6. The results of ADF test for residual sequence

The t-statistic of the residual sequence is −4.716343, Prob = 0.0010 < 0.05, and the residual sequence of the regression model is a stationary sequence, indicating that there is a cointegration relationship between the hash rate and price.

3.3 Granger Causal Relation Test

Clive W. J. Granger, winner of the 2003 Nobel Prize in Economics, proposed Granger's causality relation test. This method is suitable for econometric variables prediction. Granger causality relation refers to the previous changes in variable X that helps to explain the future changes of variable Y.

Cointegration results indicate that there is a long-term equilibrium relationship among variables. In the end, it is "who causes changes"? Granular causality validation can be used for integrated of the same order.

Pairwise Granger Causality Tests
Date: 04/02/18 Time: 11:10
Sample: 2016M01 2018M03
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
DHASHRATE does not Granger Cause DPRICE	25	2.85678	0.1051
DPRICE does not Granger Cause DHASHRATE		16.4283	0.0005

Fig. 7. The results of Granger Causality Tests

In Fig. 7, Prob = 0.105 > 0.05, receiving the null hypothesis. In this Case, the change in hash rate does not Granger cause for price change. Prob = 0.0005 < 0.05, rejecting the null hypothesis. It shows that the change of the price in the previous period helps to explain the change of hashrate in the future. That is to say, the change in price is the Granger cause of change in hashrate.

In the next section, we use the price as an independent variable and the hashrate as a dependent variable to establish a distributed lag model to reveal the Granger causality between the hashrate and the price.

4 Distributed Lag Model

4.1 Model Introduction

In real life, there is widespread time lag effect. A certain variable is not only affected by various factors in current period, but also affected by various factors in the past period or even its own past value. We call this kind of hysteretic variable in the past period a lagged variable. Models with lagged variables are called lagged variable models. The general form of the model [13] is:

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \cdots + \beta_p X_{t-p} + u_t \quad (t = p+1, p+2, \cdots, n) \tag{4.1}$$

Equation (4.1) is called the distributed lag model, which shows the influence of the explanatory variable X over time on the explained variable Y. Where α is a constant term and u_t is the random interference. The coefficient β_i reflects the different degree of influence of the current value of the explanatory variable and the lag value of each period on the explained variable, also known as the multiplier.

p is the lag time interval and is called the lag period. If the length of the lag period is limited, the model is called a finite distributed lag model; if the lag period is infinite, the model is called an infinite distributed lag model.

4.2 Koyck Method

For the infinite distributed lag model [13],

$$Y_t = \alpha + \sum\nolimits_{i=0}^{\infty} \beta_i X_{t-i} + u_t \tag{4.2}$$

The degree of influence of the lag explanatory variable on the explained variable is gradually weakened with the time interval. The Koyck method assumes that the decay is in decreasing geometric order, that is, the coefficient of the lag explanatory variable β_i satisfies (4.3):

$$\beta_i = \beta\gamma^i, \; 0 < \gamma < 1 \quad (i = 0, 1, 2, \cdots) \tag{4.3}$$

γ is called distributed lag decay rate and $1 - \gamma$ is called speed of adjustment. Substituting (4.3) into (4.2) gives:

$$Y_t = \alpha + \beta\left(X_t + \gamma X_{t-1} + \cdots + \gamma^p X_{t-1-p} + \cdots\right) + u_t \tag{4.4}$$

Equation (4.4) is called the Koyck distributed lag model.

$$Y_{t-1} = \alpha + \beta\left(X_{t-1} + \gamma X_{t-2} + \cdots + \gamma^p X_{t-1-p} + \cdots\right) + u_{t-1} \tag{4.5}$$

(4.4) minus the result of γ multiply by (4.5):

$$Y_t - \gamma Y_{t-1} = \alpha(1-\gamma) + \beta X_t + (u_t - \gamma u_{t-1}) \tag{4.6}$$

After finishing:

$$Y_t = \alpha(1-\gamma) + \beta X_t + \gamma Y_{t-1} + v_t, \quad v_t = (u_t - \gamma u_{t-1}) \tag{4.7}$$

From Eq. (4.7), an infinitely distributed lag model can be transformed into an autoregressive model using the Koyck transform. The larger the γ value, the more prolonged effect of lagged variables.

4.3 Model Solving

With 9.0, the Eq. (4.7) is solved by using the OLS method. The time series is constructed from the daily price and hash rate of bitcoin from 2016.01.01 to 2018.03.31. The price unit is $ and the unit of hash rate is 10^{16} hash/s.

Dependent Variable: HASHRATE
Method: Least Squares
Date: 04/03/18 Time: 15:17
Sample (adjusted): 1/02/2016 3/31/2018
Included observations: 820 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.365541	3.655289	1.194308	0.0327
PRICE	0.004325	0.001236	3.497928	0.0005
HASHRATE(-1)	0.974033	0.007902	123.2712	0.0000

R-squared	0.985691	Mean dependent var	587.6415
Adjusted R-squared	0.985656	S.D. dependent var	646.7101
S.E. of regression	77.45297	Akaike info criterion	11.54087
Sum squared resid	4901153.	Schwarz criterion	11.55810
Log likelihood	-4728.757	Hannan-Quinn criter.	11.54748
F-statistic	28140.90	Durbin-Watson stat	2.524593
Prob(F-statistic)	0.000000		

Fig. 8. The results of Least Squares

Figure 8 shows that Adjusted R-squared = 0.985656, DW = 2.5245, p-values for both t-test and F-test are less than 0.05, and given that the model is significant. Substituting the coefficient into (4.7) gives:

$$\mathrm{Y}_t = 4.3655 + 0.0043X_t + 0.9740\mathrm{Y}_{t-1} \tag{4.8}$$

Then, $\beta = 0.0043$, $\gamma = 0.9740$, $\alpha = 167.9038$. Substituting the values of β and γ into (4.3) obtained:

$$\mathrm{Y}_t = 167.9038 + 0.0043X_t + 0.0042X_{t-1} + 0.0041X_{t-2} + 0.0040X_{t-3} + \cdots \tag{4.9}$$

4.4 Research Results

In Eq. (4.1), $\sum_{i=0}^{p} \beta_i$ is called the long-term or equilibrium multiplier. It indicates that when X changes a unit, the total influence of Y on average is caused by lagging effect.

In Eq. (4.9), $\sum_{i=0}^{\infty} \beta_i = \sum_{i=0}^{\infty} \beta\gamma^i = \beta/(1-\gamma) < \infty$. So what should be the lag period? The distributed lag model gives the definition of the average lag period s:

$$s = \left(\sum\nolimits_{i=0}^{\infty} (i+1)\beta_i\right) / \left(\sum\nolimits_{i=0}^{\infty} \beta_i\right) \quad (4.10)$$

The average lag period is defined as the weighted average of all lags. According to the Granger causal analysis, the lag period of early price change affects the future hashrate change is one month. S = 13.92 is obtained by replacing the value of β_i into Eq. (4.10). Which is given that the price modification is the Granger cause of the hash rate change, and the norm lag period of time is about fourteen days.

5 The Pricing Strategy

Bitmain [14] is a Chinese IC design company established in early 2013. It specializes in research, development, and sales of bitcoin-specific mining chips and miner. The AntMiner S9 [15] is a highly available and low power consumption mining equipment developed by Bitmain. The BM1387 chip used by S9 is bitcoin's fifth-generation bitcoin miner chip independently developed by Bitmain. It is by far the lowest power chip in the history of bitcoin chips. For a given type of miner, before they leave the factory, its rated hash rate and power are fixed. The AntMiner S9 has a rated hashrate of 11.85 TH/s (1TH/s equals 10^{12} hash/s) and the power consumption at the wall is 1172 W.

As we derived, since the modification in bitcoin price is a Granger cause of change in hashrate, the average lag period is 14 days. At the same time, the rated hashrate of each mining machine is fixed. Therefore, the price change of the mining machine is caused by the price change of bitcoin. The same lag period is 14 days. In other words, the price of bitcoin 14 days ago is in one-to-one correspondence with the price of the current miner.

Compared with bitcoin prices, miner prices are lagging behind. The main selling of the miner market is the miner futures. In other words, the future miner's price is determined by the price of bit coin in the previous period. The market phenomenon is consistent with our findings.

5.1 Survey and Forecast

On February 28, 2018, the survey results of the Shenzhen Huaqiangbei miner's market revealed that the AntMiner S9 had a futures price of 3018.03 dollars. Bitcoin prices and tracking surveys of miner's prices are shown in the Table 1 below:

Table 1. The price of bitcoin and miner futures

Date	Bitcoin's price ($)	Price of miner futures ($)
2018/2/28	10607.00	3018.03
2018/3/10	9252.00	2382.66
2018/3/20	8641.00	2223.81

On April 1, 2018, the price of bitcoin was 6,826 dollars. Using the linear regression model, the forecasted miner's futures price is 1432.77 dollars.

Figure 9 is the scatter plot of bitcoin's price and price of miner futures, and the bitcoin's price is expressed by abscissa, and the price of miner futures is expressed by ordinate. The straight line in Fig. 9 is linear regression line. When the bitcoin's price is 6826 dollars, the price of the miner futures will be 1432.77 dollars.

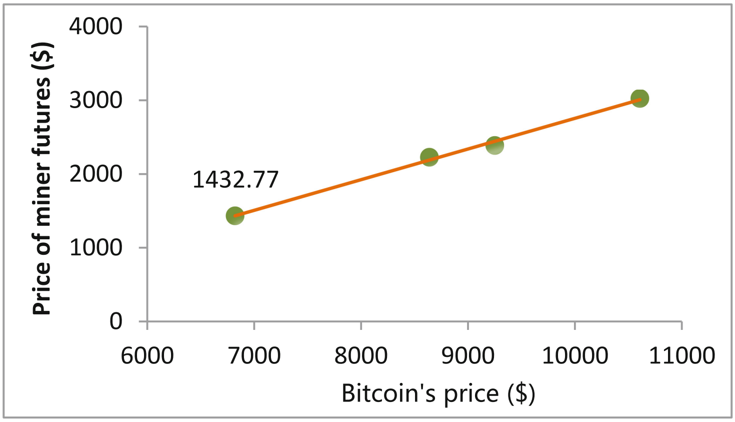

Fig. 9. The linear regression model between bitcoin's price and the price of miner futures

5.2 Verification of Results

According to the inquiry from the official website of Bitmain, the latest futures price of the AntMiner S9 is 1509.01 dollars. In Fig. 10, the broken line represents the prediction price of the miner futures, and the diamond square dot represents the actual price of the current miner futures.

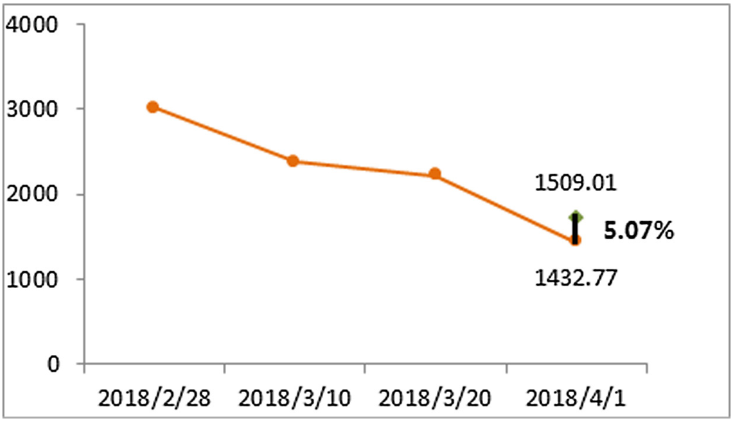

Fig. 10. The price trend chart of miner futures

$$\text{the error rate} = \frac{|\text{predicted value} - \text{actual value}\,|}{\text{actual}\ \ \text{value}} \times 100\% \tag{4.11}$$

In April 1st, the prediction price of AntMiner S9 is 1432.77 dollars, and the actual price is 1509.01 dollars. In the form of (4.11), the error rate is 5.07%.

The error rate is small, which indicates that our distributed lag model is scientific and reasonable. We can predict the price of future miners based on the early price of cryptocurrency.

From the perspective of economics, the cryptocurrency miner can be used to mine and bring huge gains, which is the value of the cryptocurrency miner. In the cryptocurrency miner market, value determines prices, prices are affected by supply and demand, and they fluctuate around value. When supply is constant and demand increases, prices will rise; when demand does not change and supply increases, prices will fall.

For miner's suppliers, the goal of pricing strategy is to obtain profits and to raise the market share. Profit is the most important reference of funds for suppliers. When suppliers have a dominant position in the product market place, they will object to maximize net gains. This pricing strategy is based on a comprehensive consideration of various factors within a certain period of time. Based on the maximum difference that equals the total revenue minus the total cost, the price of a unified product is determined to obtain the maximum profit. The maximum profit is the maximum total profit that the supplier may be prepared to realize in a certain period of time, not the highest price of the unit product. The maximum price may not be able to obtain the maximum profit.

For a given miner, its profit and rate of return are determined by the price of the cryptocurrency. In essence, the price of miners is based on the price of the previous cryptocurrency, and the lag period is 14 days. This is the pricing strategy for the miner's market.

For investors, they are the consumers of the miner's market. Investors are also buying miners for maximum profit. The profits made by investors are affected by both the price of the cryptocurrency and miner. The higher the price of the cryptocurrency, the shorter the return period of the investment, the higher the profit and the lower risk; the higher the price of the miner, the longer the return period of the investment, the lower the profit and the greater risk. This paper studies the law of cryptocurrency price that determines the price of miners. Based on this strategy, investors can more accurately determine the future price trend of the miner's market, so as to effectively avoid investment risks, and make the investment's profits tend to maximize.

5.3 Conclusion

The current cryptocurrency price determines the future price of miners, and the lag period is 14 days, which is a common pricing strategy for the cryptocurrency miner's market.

Acknowledgement. This work is partially supported by the technical projects No. 2017YFB08 02703, No. 2016YFB1000803, No. 2017YFB1400604, No. 2012FU125Q09, No. 2015B0101 31008 and No. JSGG20160331101809920.

References

1. https://trends.google.com/trends/explore?q=bitcoin. Accessed 03 Apr 2018
2. Yang, B., Chen, C.: The Principle, Design and Application Of Blockchain, pp. 80–82. China Machine Press (2018)
3. Nakamoto, S.: Bitcoin: A peer-to-peer electronic cash system. Consulted (2008)
4. Kristoufek, L.: What are the main drivers of the Bitcoin price evidence from wavelet coherence analysis. PLoS ONE **10**(4), e0123923 (2015)
5. Bouri, E., Molnár, P., Azzi, G., et al.: On the hedge and safe haven properties of Bitcoin: is it really more than a diversifier. Finance Res. Lett. **20**, 192–198 (2016)
6. Indera, N.I., Yassin, I.M., Zabidi, A., et al.: Non-linear autoregressive with exogeneous input (NARX) Bitcoin price prediction model using PSO-optimized parameters and moving average technical indicators. J. Fundam. Appl. Sci. **9**(4S), 791–808 (2017)
7. Xie, P., Shi, W.: A literature review of cryptocurrency. J. Financ. Res. 1–15 (2015)
8. Ahamad, S., Nair, M., Varghese, B.: A survey on crypto currencies. In: International conference on Advances in Civil Engineering AETACE (2013)
9. Bouoiyour, J., Selmi, R.: Bitcoin: a beginning of a new phase. Econ. Bull. **36**(4), 1430–1440 (2016)
10. Hayes, A.: Cryptocurrency value formation: an empirical analysis leading to a cost of production model for valuing Bitcoin. In: Mediterranean Conference on Information Systems (2015)
11. Cao, Y., Mao, J., Li, X.: Applied Econometrics, pp. 250–265. China Social Sciences Press, Beijing (2016)
12. Zhao, G., Fan, H.: Eviews/Stat Econometrics Primer, pp. 119–131. China Renmin University Press (2014)
13. Wang, B.: Econometric Model and Application of R Language, pp. 191–196. Peking University Press (2015)
14. https://www.bitmain.com. Accessed 03 Apr 2018
15. https://shop.bitmain.com/product/main?locale=zh. Accessed 03 Apr 2018