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ECOM5001: Econometric Theory and Application

Project

Analyzing the adoption and Growth of Bitcoin in relation to scarcity

1 Executive summary

The study shows the relationship between the bitcoin growth and adoption in relation to its scarcity. The total supply of Bitcoin capped at 21 million, this digital currency shows unique case for finding out how scarcity affects its volume and price (Symitsi & Chalvatzis, 2019). Using Hypothesis testing and different models, the research explores the factors affecting dynamics of Bitcoin market, specially focused on market capitalization and Stock to flow value.

2 Introduction to the problem

On 31 October,2008, the word Bitcoin was introduced by an anonymous figure called Satoshi Nakamoto in some white paper titled as Bitcoin (Nakamoto, 2008). Bitcoin works on cryptocurrency protocol which is supported by blockchain technology and records every transaction in network as a secure and transparent ledger (Sahoo et al., 2019).

Users can globally carry out their transactions and their Bitcoin wallets are connected to addresses which are unique. The importance of scarcity of Bitcoin is highlighted by halving event in which mining new blocks reward is halved nearly each one four years(Senarathne, 2019). The mechanism of controlled supply plays an important role in value proposition of Bitcoin and dynamics of market.

3 Hypotheses

The purpose of this case study is to examine the relationship between adoption of Bitcoin and its scarcity and while doing so, the other factors like number of active addresses and bitcoin market cap have been taken into consideration. The hypothesis is stated as:

H1: The stock flow value has a significant impact on the increase in price and demand of Bitcoin.

H2: The price of bitcoin is significantly impacted by the increase and decrease of the market cap of bitcoin.

H3: The active address and stock flow value has a significant effect on growth and price of Bitcoin.

4 Methodology

The methodology shows different statistical measures to identify, analyze and study the adoption and growth of Bitcoin in relation to scarcity which is measured by stock flow value. Multiple linear regression model and linear regression model are employed which utilizes various variables that can affect demand and price of Bitcoin. Hypothesis test is also conducted to measure the compatibility and robustness of model.

4.1 Data set:

The historical price data of bitcoin starting from July 2010 is taken from "coinmarketcap.com". The block subsidy and block size are taken from "blockchain.com". By using stock flow, we will measure stock and flow from block subsidy and total amount of blocks per month.

Stock which is equals to the total existing supply of bitcoin.

Flow which is equal to the additional number of blocks produced annually.

Stock flow = stock / flow

The Market cap is calculated using formula:

Market Cap = Price * Circulating Supply

The stock flow of monthly Bitcoin is measured from July 2010 - Feb 2019 and the 105 total data points. The production of bitcoin is reduced by miners every four years, and it is decreased by half. At the time of bitcoin launch, the reward was 50 bitcoins per block. In 2012, it halved to 25 bitcoins. In 2016, it was reduced to12.5 bitcoins. The higher the ratio, the scarcer the asset is.

Statistics	Price	Stock Flow	Market Cap
Mean	1600.9	11.23	26,590,000,000
Median	372.5	9.10	5,101,000,00
Q1	12.7	3.10	114,700,000
Q3	1070.0	21.30	15,550,000,000
Minimum	0.1	0.50	232,400
Maximum	13863.0	28.10	232,000,000,000
No of observations	105	105	105

Table 1: Dataset

5 Interpretation of the Results:

5.1 Price and stock flow:

Scatter plot is used to study the association between stock flow and price. Logarithmic values for both stock flow and price have been utilized to plot the graph.

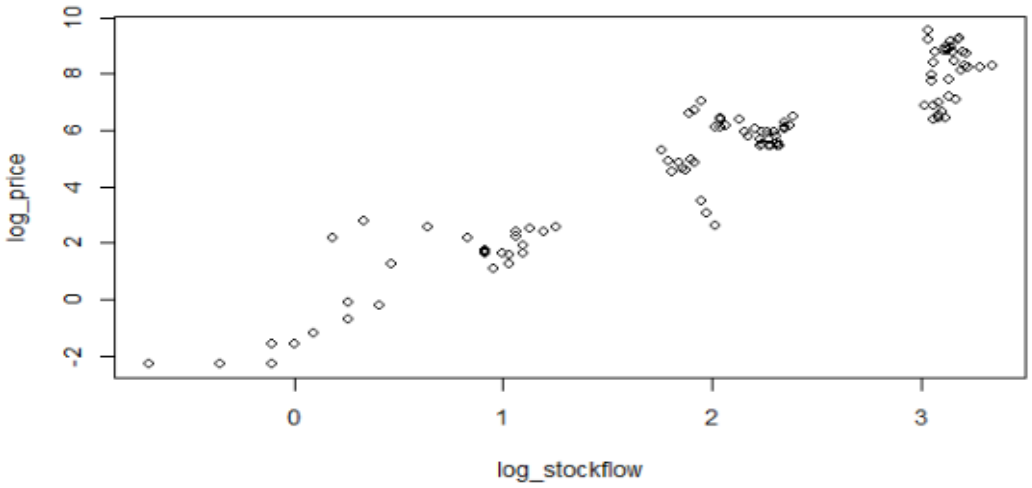

Figure 1: Scatter plot of price and stock flow

A clear positive relationship is seen from data points which indicate that prices increase as stock flow increases. The data points follow trend line and there is no important deviation in this trend which suggests that association among price and stock flow is consistent throughout the observed range.

5.2 Price and Market cap:

Since market cap is calculated using price, scatter plots are indicating a perfect linear relationship indicating market cap is good price predictor as shown is Figure 2

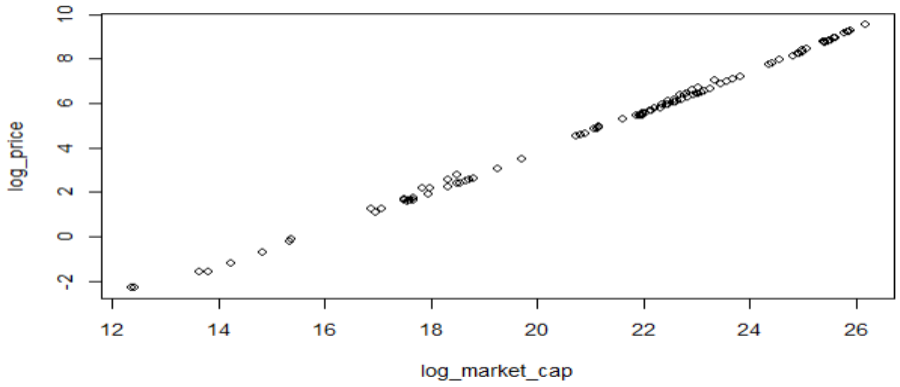

Figure 2: Scatter plot of Price and market cap

5.3 Linear Regression Model:

$$log(price)=\beta 0+ \beta 1\ log\ (stock\ flow) +\epsilon$$

These residuals showed the difference between the predicted values and observed values from model. Around median, the residuals are symmetrically distributed which indicates reasonable fit model. -0.6659 intercept shows the estimated price of log when ratio of log stock to flow is zero. The stock flow 2.8365 logarithm of coefficient shows positive relationship among price of bitcoin and stock to flow ratio. This shows link with hypothesis H1 that scarcity of bitcoin is positively related to the demand and Bitcoin's price increase.

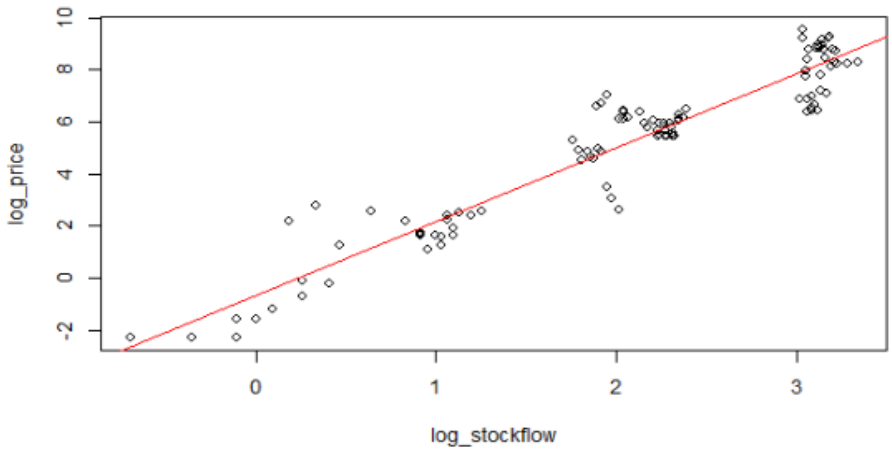

Figure 3: Linear Regression indicated by Red Line

5.3.1 Confidence Intervals:

The confidence interval for 95% stock flow is 2.658449, 3.014654 and the interval does not have zero which further confirms that relationship among price and stock flow is statistically important. We are 95% confident that coefficient stays in this range which increases the reliability and strength of relationship.

5.3.2 t-Statistic

The stock flow coefficient for t-statistics is very high 31.7394. high t-statistic shows that the significant coefficient is different from zero which confirms that stock flow is a high significant price predictor.

5.3.3 Standard Error

The coefficient standard errors for stock flow are low 0.0894, which suggests that coefficient estimation is precise, and the variability of sampling is low.

6 Multi Regression Model:

This regression model stated as:

$$Yi = \beta 0 + \beta 1X1 + \beta 2X2 + . . . + \beta iXi + \varepsilon i$$

Where:

Yi is Target variable.

Xi is an independent variable.

β0 is Y Intercept

βi is Population Slopes

εi is Random Error

The applied model can be shown as:

$$log\_price=\beta 0+\beta 1log\_stockflow+\beta 2log\_active\_addresses+\beta 3log\_market\_cap$$

To study the relationship between different variables such as price, stock flow, market cap and active addresses, we made a Regression model and discovered the factors along with bitcoin scarcity. R square multiple came out 0.9988 which explains that 99.88% difference in price of log is described by model. The high value of r square in the model can create model biasness and introduce multi collinearity in the model.

7 Alternative Model Specification

We have introduced alternative model to ensure the stability of the model and to address muti collinearity:

$$Log\ price = \beta 0+\beta 1log\ stock\ flow+\beta 2log\ active\ addresses$$

In the updated model the y intercept is -7.2081 and standard error is 1.1094 and the t value is -6.497. The coefficient is statistically important as p-value = 3.04e-09. β1 coefficient stock flow is important significantly with p-value= 1.65e-05. The significance could be interpreted as a rise in 1% stock flow is linked with approximately 1.25% log price increase, when active address is kept constant.

The R square has come out to be 0.9307 which indicates that 93.07% variation in price of log can be described by this model using these variables. The high R-squared value is an indication of the strong model fit. The statistic of F is 684.6 and the p-value is 2.2e-16 which indicates the high significance of the model.

The stock flow coefficient has come out to be 1.2511 shows a positive relationship between the stock flow value and bitcoin price which aligns with above hypothesis that stock flow value has a significant impact on the increase in price and demand of Bitcoin and thus we reject the null hypothesis. The coefficient value of active address has come out to be 0.8396 which indicates a positive relationship between the Bitcoin price and active addresses. This shows an increase in usage and demand of the bitcoin network is one of the factor for bitcoin prices to go up which is directly linked to scarcity as well..

It can be concluded that both variables i.e., active address and stock flow in the model, are significant factors which influence the price of Bitcoin. The Multiple Regression model signifies that scarcity of bitcoin indicated by stock flow value along with the network activity indicated by the active addresses has a significantly positive impact on the growth in the price Bitcoin.

7.1 Histogram of Residuals:

The histogram of residuals shows the distribution of frequency of residuals and ideal case scenario for a linear regression model is that there are normally distributed residuals which means that they follow the curve of bell shape which is centered around zero.

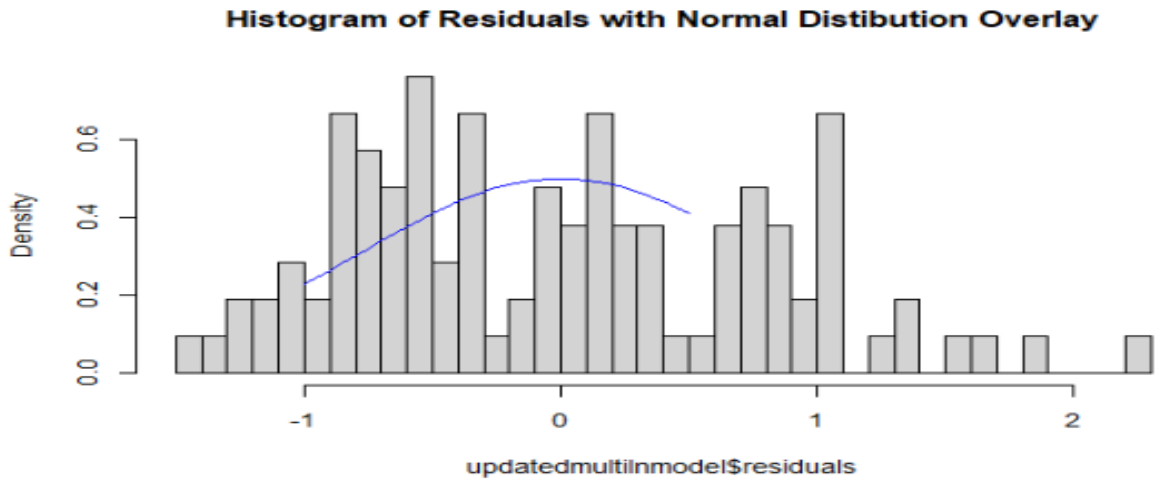

Figure 4: Histogram and skewness

Fewer observations are seen on the left side of histogram which extends out further in comparison to the right side which suggests a slight negative skew or left skew. The residuals of left skewed distribution shows that models sometimes make large negative errors which means that sometimes it underestimates the value significantly and then it overestimates them to leave room for model improvements in future studies. The skew in this case however does not seem to be extreme which means the outliers presence in dataset. The residuals spread is comparatively wide, which ranges from -1.5 to 2. The spread highlights the residual variance. QQ plot was plotted for further verification of claim to test the model normality.

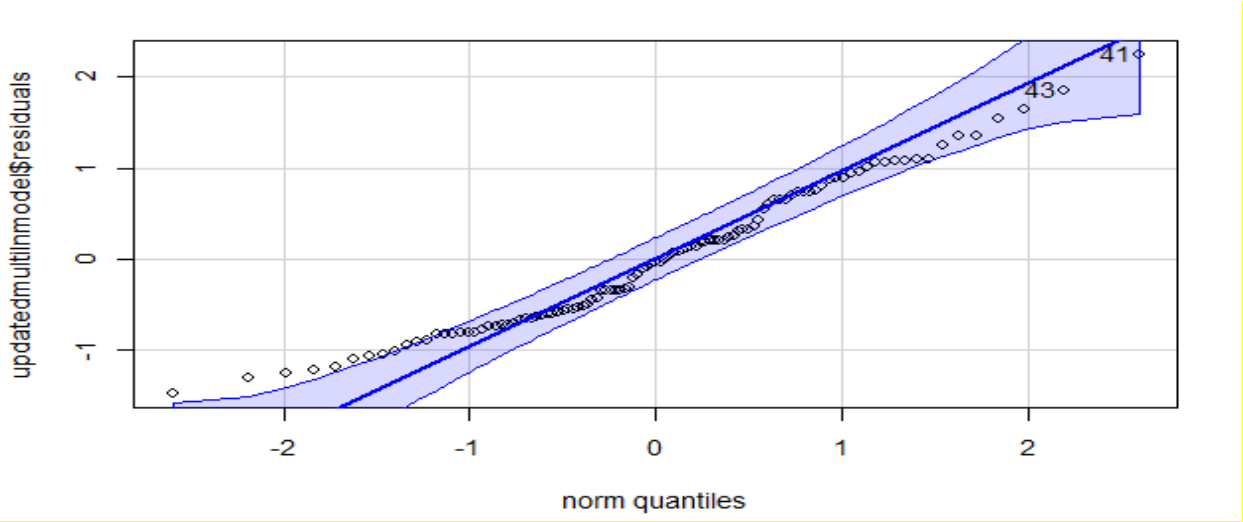

Figure 5: QQ plot

The points mostly in QQ plot follows the linear straight line which suggest that roughly the residuals are distributed normally. At the end the deviation from line shows the skewness presence and potential outliers and while describing histogram, confirms the claim they made. The Q-Q plot middle portion suggests points which are aligned closely with line and shows that residual bulk follows normal distribution very well. It also shows that approximately residuals are distributed normally with less deviation at tail side which shows that linear regression normal assumption is greatly met, also there are some outliers or skewness which affects the distribution.

7.2 Jarque-Beta Test:

The test statistics of Jarque-Beta is 4.3089 with freedom degree is 2 and the value of p is less than 0.116. The Jarque-beta test null hypothesis shows that there is normal distribution of residuals. The value of p is 0.116 which is higher than commo level of significance such as 0.05 and we fail to reject the hypothesis of null. Which means that there is less evidence to show the normal distribution of residuals. The Jarque-beta test

shows that there us not significance deviation of residuals from normality and this must be consistent with Q-Q plot visual interpretation which shows that there is rough normally distribution of residuals with less deviation at tail.

It seems that residuals are normally distributed and linear regression model assumptions are mostly met which strengthen the result of models' validity and the inferences' reliability made from these models. The value of high R square is 0.9307 and its significant coefficient shows that model describes a substantial proportion of difference in dependent variable.

```
        Jarque Bera Test

data:  updatedmultilnmodel$residuals
X-squared = 4.3089, df = 2, p-value = 0.116
```

Figure 6: Jarque Bera Test

7.3 Joint hypothesis test for coefficients:

The assessment of test shows whether both variables consecutively describe the difference in dependent price and variable.

$$H0: \beta 1 = \beta 2 = 0$$

H0: explains stock flow and active addresses have no significant impact on price.

H1: At least one of the predictors significantly impact price.

There is an assumption of this restricted model that active addresses and stock flow coefficients must be zero. The RSS, which is residual sum of squares for this model, seems to be 952.66 with freedom degree of 104. Both active address and stock flow seem to be predictors in unrestricted model and the RSS of this model is 66.05 and freedom degree is 102. There is high F statistics whish is 684.59 which shows the active address and stock flow unrestricted model explains more difference in price as compared to restricted model which are without such predictors as the value of p is very small like <2.2e-16 which is much less as compared to common level of significance of 0,05. We reject the hypothesis of null as the value of p is less compared to 0.05 which shows that active addresses and stock flow coefficients are not equal to zero simultaneously. Both variables in other words have an impact on price and the joint hypothesis test results strongly show the active addresses and stock flow are significant predictors of price log. Which means that both variables when combined contribute to explaining the Bitcoin price variability. The null hypothesis rejection shows the significance of combining both variables in model to get better understanding of prices of Bitcoin.

7.4 Predicted Vs Actual Prices:

From regression model, the scatter plot given shows the actual transformed log price against price of predicted log transformed.

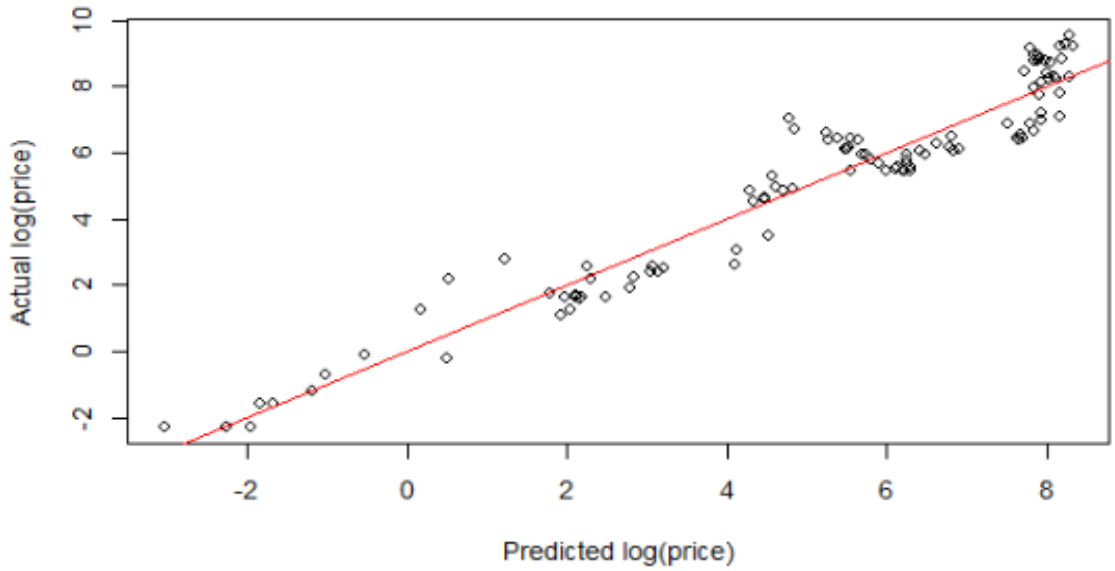

Figure 7: Fitted values for price vs Actual values.

Some points deviate significantly from the line, especially at the higher and lower ends of the predicted price log. The points can be potential outlier or where assumption of model does not hold. The ideal line is represented by redline and the predicted value is equal to the actual values shown.

7.5 Higher order terms of the predicted values:

Adding the terms like fits 2 and fits 3 to the model has not significantly improved the model fit which is indicated by high values of p. however there is not much difference among r squared value after and before polynomials terms fitting. This shows the relationship among predictor and price variables of active addresses and stock flow are significantly captured by linear model with out having the need of higher terms order.

```
Call:
lm(formula = log_price ~ log_stockflow + log_active_addresses +
    fits2 + fits3, data = sfdata)

Residuals:
    Min      1Q  Median      3Q     Max
-1.3184 -0.6420 -0.1103  0.6783  2.4333

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)         -7.464450   1.146327  -6.512 3.01e-09 ***
log_stockflow        0.800287   0.384942   2.079   0.0402 *
log_active_addresses 0.898797   0.151619   5.928 4.39e-08 ***
fits2                0.007094   0.031227   0.227   0.8208
fits3                0.001010   0.003084   0.327   0.7441
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.8013 on 100 degrees of freedom
Multiple R-squared:  0.9326,    Adjusted R-squared:  0.9299
F-statistic: 345.9 on 4 and 100 DF,  p-value: < 2.2e-16
```

Figure 8: Higher Order Results

7.6 White test & Breusch-Pagan test:

White's test and the Breusch-Pagan test has been done to find out heteroscedasticity in the regression model.

	t-value	**p-value**
White Test	8.22	0.14446656
Breusch-Pagan test	1.011	0.6032

Table 2: White test & Breusch Pagan Test results

The white’s test null hypothesis is homoscedasticity which is constant difference of residuals, and the other hypothesis is heteroscedasticity. The value of p of 0.1445 shows insufficient evidence for null hypothesis rejection at conventional level of significance. So based in white’s test we don’t have much evidence significantly of heteroscedasticity in residual model. However, Breusch-Pagan test fails to give heteroscedasticity significant evidence in residual model.

8 Conclusion:

The research was done to study the scarcity impact on bitcoin price. We also studied different variables such as active addresses and market cap which might impact bitcoin price. We also use multiple and linear regression models with OLS estimator. The analysis also shows the significant effect of active addresses and stock to flow ratio on prices of Bitcoin. The model’s initial strong performance shows the scarcity of bitcoin which is measured by SF ratio is important factors in showing its value. The study

introduces the additional variables like market capitalization and active addresses which increases the explanatory power of model.

Moreover, market capitalization inclusion faces challenges due to very strong relationship with price which leads to issues of potential multicollinearity. Excluding market capitalization, the refined model includes only active addresses and stock flow which keeps balance among model stability and explanatory power and achieves value of R squared of 0.9307. The refined model residuals show nearly normal distribution and Jarque beta test confirms the normal assumption which is p-value = 0.116 which suggests that this model is very well specified

White test and Breusch-Pagan test were also conducted to test the residuals heteroscedasticity in the final model. The results suggest that the scarcity of bitcoin has a very important role in overall asset valuation of bitcoin. But while the stock flow value provides some key insights on the value proposition of bitcoin, the model suggests that other variables and factors should be kept into account like market cap, network activity or general volumes. The model is powerful but limited and could be affected by events like swan events or war which could be accounted for as a limitation of this model and should be kept in mind for future analysis and studies.

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