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An Analysis of Bitcoin Price Determinants Based on the Chow Test

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Abstract

This study investigates structural changes and breakpoint detection in Bitcoin prices during the period from October 1, 2014, to November 30, 2022. By employing Ordinary Least Squares (OLS) regression analysis, this paper constructs a linear relationship model between Bitcoin price and time, and finds that time (Date) as an independent variable exerts a significant positive influence on Bitcoin price (BTC), with the model's explanatory power (R^2) reaching 0.572, indicating that the time factor explains 57.25% of the variation in Bitcoin price. Furthermore, through examination of the F-statistic (F=3191.034, p=0.000), the study confirms that time has a statistically significant impact on Bitcoin price, with the model formula being: Bitcoin price BTC = -8459.383 + 14.301*Date. To identify potential breakpoints in the price series, this paper plots a scatter diagram of Bitcoin prices and preliminarily estimates six possible breakpoint time points (t01=1179, t02=1567, t03=1746, t04=2014.5, t05=2462, t06=2581), which mark significant turning points in price movements. To verify the existence of these breakpoints and their statistical significance, this study adopts the Chow Test for structural change analysis. Through grouped regressions and comparing differences in regression coefficients across different time periods, the results demonstrate that both the coefficient of the time variable and the intercept term differ significantly across different periods, thereby validating the presence of structural changes in the data. Specifically, the F-statistics after grouped regressions are all highly significant ($p<0.01$), further supporting the existence of breakpoints and their impact on model parameters. In summary, this paper not only reveals the linear growth trend of Bitcoin price over time, but also identifies key turning points in price movements through structural breakpoint testing, providing an important reference for understanding dynamic changes in the Bitcoin market. The research methodology and conclusions of this paper hold certain reference value for financial market stability analysis, risk management, and investment strategy formulation.

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Full Text

Analysis of Factors Influencing Bitcoin Price Based on Chow Test

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Abstract

This study investigates structural changes and breakpoint detection in Bitcoin prices from October 1, 2014, to November 30, 2022. Using ordinary least squares (OLS) regression analysis, we construct a linear relationship model between Bitcoin price (BTC) and time (Date). The results indicate that time as an independent variable has a significant positive impact on Bitcoin price, with the model achieving an explanatory power (R^2) of 0.572, suggesting that time explains 57.25% of Bitcoin price variation. Further examination of the F-statistic ($F = 3191.034$, $p = 0.000$) confirms the statistically significant influence of time on Bitcoin price. The model is specified as: Bitcoin Price (BTC) = -8459.383 + 14.301 × Date.

To identify potential breakpoints in the price series, we plot a scatter diagram of Bitcoin prices and preliminarily estimate six possible mutation time points ($t_{01} = 1179$, $t_{02} = 1567$, $t_{03} = 1746$, $t_{04} = 2014.5$, $t_{05} = 2462$, $t_{06} = 2581$), which mark significant turning points in price movements.

To verify the existence and statistical significance of these breakpoints, we employ the Chow test for structural change analysis. Through grouped regression and comparison of regression coefficient differences across various time periods, the results demonstrate significant differences in both the coefficients and intercept terms of the time variable across different periods, thereby confirming the presence of structural changes in the data. Specifically, the F-statistics from the grouped regressions are all highly significant ($p < 0.01$), further supporting the existence of breakpoints and their impact on model parameters.

In conclusion, this study not only reveals the linear growth trend of Bitcoin prices over time but also identifies key turning points in price movements through structural breakpoint testing, providing important insights for understanding the dynamic changes in the Bitcoin market. The research methodology and findings offer valuable references for financial market stability analysis, risk management, and investment strategy formulation.

Keywords: Chow test; Bitcoin price; Grouped regression; Stability analysis;

Structural breakpoint test

1.1 OLS Regression

Table 5 .1 OLS Regression Analysis Results

Variable	Coefficient	Std. Error	t-statistic	p-value	95% CI
Intercept	-33.087	0.000***	-	-	-8960.489 ~ -7958.277
Date	56.489	0.000***	-	-	13.805 ~ 14.798

Dependent variable: Bitcoin price (BTC)
Note: p < 0.1, ** p < 0.05, *** p < 0.01*
F(1, 2981) = 3191.034, p = 0.000
Adjusted R^2 *and D-W values are reported in the analysis.*

The sample period spans from October 1, 2014, to November 30, 2022, comprising 2,983 observations. The OLS regression analysis using Date as the independent variable, with robust standard errors, yields an R^2 of 0.572, indicating that Date explains 57.25% of the variation in Bitcoin price (BTC). The model passes the F-test (F = 3191.034, p = 0.000*** < 0.05), confirming that Date significantly influences Bitcoin price. The model equation is: Bitcoin Price (BTC) = -8459.383 + 14.301 × Date. Specifically, the regression coefficient for Date is 14.301, which is significant at the 0.01 level (t = 56.489, p = 0.000 < 0.01), demonstrating a significant positive relationship between Date and Bitcoin price (BTC).

1.2 Breakpoint Identification

The scatter plot of Bitcoin prices is shown in Figure 5 [Figure 5: see original paper].1. Based on the extreme points visible in the scatter plot, we estimate six potential breakpoints where price mutations may occur. Across the total sample of 2,983 observations, from left to right these are: $t_{01} = 1179$, $t_{02} = 1567$, $t_{03} = 1746$, $t_{04} = 2014.5$, $t_{05} = 2462$, $t_{06} = 2581$.

1.3 Chow Test

The Chow test is used to examine whether structural changes exist in the data, typically conducted through grouped regression. The essence of the method involves performing linear regression under different conditions—first analyzing the entire sample, then examining regression results for different subsamples, or analyzing the significance of differences in regression coefficients.

1.3.1 Model-Level Chow Test **Table 5.2 Chow Test Results**

Test	SSE (Residual Sum of Squares)	Sample Size (n)	Parameters	df	p-value
Full Model	0.0	1.0	2	-	<0.05

The Chow test results in Table 5.2 show a p-value less than 0.05, indicating significant differences in regression coefficients between the two grouped regression models, which confirms the presence of structural changes in the model.

1.3.2 Breakpoint-Specific Chow Test 1. Structural Change Test for t_{01} = 1179

Table 5.3 Chow Test Results for Breakpoint t_{01}

Interval Variable	Coefficient	Std. Error	95% CI	p-v
Interval_{1179}.0_{1229}.0_t	-	-	-	0.00
Interval_{1179}.0_{1189}.0_t	-	-	-	0.00
Interval_{1179}.0_{1181}.0_t	-	-	-	0.00
Interval_{1179}.0_{1567}.0_t	-	-	-	0.00
Interval_{1179}.0_{1179}.1_{{{Interval}}*{{1179}}}.0*{1181}.0_t	-	-	-	0.00

F(1, 2981) = 2211.691, p = 0.000

The analysis uses OLS regression with robust standard errors, treating the interval variables as independent variables. For the continuous curve connecting Bitcoin price scatter points with breakpoints, we iteratively bisect the interval containing the breakpoint, gradually converging the interval endpoints toward the breakpoint to obtain its approximate value. Based on the F-test results showing a p-value of 0.000, the Chow test is statistically significant, leading us to conclude that a structural change in Bitcoin price occurred at t_{01}.

2. Summary of Conclusions

Using the Chow test methodology based on t_{01}, we tested the remaining five breakpoints. All passed the Chow test, indicating that structural changes in Bitcoin prices occurred at each of these six time points. Further confirmation of these mutations is examined through Perron tests in the following section.

1.4 Perron Test for Structural Breaks

Perron (1989) discusses two types of structural breaks: the AO model (Additive Outlier model) describing instantaneous mutations, where the deterministic trend changes immediately after the shock without a lag period; and the IO model (Innovation Outlier model), where structural breaks appear in the innovation process after the shock, with effects gradually manifesting in the time series. The data generating process (DGP) for the AO model is:

=(1,t), + = 1, 2 + 表示确定项，为结构突变虚拟变量，1 = , β (1),1 = 变，Bt 描述在 TB 发生斜率 (趋势) 突变，DUt=1(t>TB)，DUt=0(t TB)，Bt=(t-TB)

where TB is the known (exogenous) structural break point, the dummy variable DUt describes intercept changes occurring at TB (t > TB), and Bt = 0 (t ≤ TB). {ut} satisfies A(L)ut = B(L) where A(L) and B(L) are polynomials of order p+1 and q in the lag operator L, A(L) i.i.d(0,), with A(L) = L)A*(L). The roots of A*(L) and B(L) lie strictly outside the unit circle, meaning both A*(L) and B(L) are stationary. The null hypothesis is H0: [unit root process]. The alternative hypothesis is H1: $ $1; accepting the null indicates ut is a unit root process and yt is also a unit root process, while rejecting the null indicates ut is a stationary process and yt is also stationary.

1.4.1 Step-by-Step Perron Test for Breakpoint Model Using the first breakpoint t_{01} = 1179 as an example:

Step 1: Conduct OLS regression of the Bitcoin time series according to the breakpoint model expression to determine the intercept term and obtain residuals, denoted as i.

Table 5.4 OLS Regression Results of Bitcoin Price on Time

i (residuals)

Figure 5.2 OLS Regression Results of Bitcoin Price on Time

Step 2: Use OLS to regress the residuals obtained in Step 1 against continuous time around breakpoint t_{01}.

Figure 5.3 OLS Regression Results of Residuals on Time

The curve fitting performance is substantially better than linear fitting, and it is straightforward to conclude that three points are not collinear. Based on the R^2 of 0.7493 < 0.9 from the linear fit, we conclude that no serial correlation exists in the residuals.

Step 3: Test whether residuals show significant differences.

By adding an extended term with new data at t = 1177.5, we obtain residual i = 888799.428. Combining this with the three data points from Table 1 .1 forms Sample 2 containing four time series observations; the three data points from Table 1.1 are defined as Sample 1. A two-sample t-test between Sample 2 and Sample 1 yields t = -28875.8887, indicating that residuals change significantly with increasing sample size.

Step 4: Conduct unit root test on the original series.

Table 5.5 ADF Test for Bitcoin Price

Test	Statistic	p-value
ADF	0	0.000**

The ADF test verifies whether the time series is stationary, with the null hypothesis that the series is non-stationary (contains a unit root). Generally, if $p < 0.1$ (or 0.05), we reject the null hypothesis, indicating stationarity. The p-value for the original Bitcoin price (BIT) series is 0.505, indicating non-stationarity. After first differencing, the ADF test yields $p = 0.000$, confirming that the first-differenced Bitcoin price series is stationary with $t = -9.107$.

Step 5: Determine conclusions by referencing critical values.

Perron simulated critical values for this statistic (see reference tables). We compare absolute values: if the t-statistic is smaller than the critical value, we accept the null hypothesis of a unit root process with structural change. Critical values depend on both significance level and the location of structural change, represented by $\lambda = t_{01}/T$, where T is the total sample size of 2,983. Therefore, $\lambda = 1179/2983 = 0.4$.

For Bitcoin price at the first breakpoint, the corresponding t-value is -9.107. Referencing the table shows that at the 90% confidence level, we can conclude that a structural break occurred in Bitcoin price at this point.

Calculating λ and t-values for the second through sixth breakpoints sequentially produces the results shown in Table 5.6.

Table 5.6 t-Values and Confidence Intervals for Each Breakpoint

Breakpoint	Corresponding t-value	Confidence Interval (%)
$t_{01} = 1179$	-9.107	90
$t_{02} = 1567$	-	-
$t_{03} = 1746$	-	-
$t_{04} = 2014.5$	-	-
$t_{05} = 2462$	-	-
$t_{06} = 2581$	-	-

2. Conclusion Summary

1. $\mathbf{t_{01} = 1179}$ (December 22, 2017): Events—China banned virtual currency trading on September 30, 2017; crackdown on Initial Coin Offerings (ICO) in December 2017.
2. $\mathbf{t_{02} = 1567}$ (January 14, 2019)
3. $\mathbf{t_{03} = 1746}$ (July 12, 2019)
4. $\mathbf{t_{04} = 2014.5}$ (April 8, 2021): Events—Economic instability and stock market crash due to COVID-19 led some to view Bitcoin as a store of value and safe-haven asset; by April 13, 2021, Bitcoin reached $63,000.

Prior to this, the March 2020 stock and cryptocurrency market crash triggered continuous Bitcoin price increases; in May 2021, significant sell-offs occurred in Bitcoin and cryptocurrency markets, after which prices stagnated.

5. **t_{05} = 2462** (June 27, 2021): Event—In June 2021, El Salvador passed the Bitcoin Law, making Bitcoin legal tender in the country, effective ninety days after publication in the government gazette. On September 7, the law took effect, making Bitcoin legal tender in El Salvador and establishing the country as the first to grant legal status to a digital currency.
6. **t_{06} = 2581** (October 25, 2021): Event—On September 24, 2021, the National Development and Reform Commission and other departments issued the "Notice on Rectifying Virtual Currency 'Mining' Activities."

Note: Figure translations are in progress. See original paper for figures.

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