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Bitcoin and Gold Prices: A Fledging Long-Term Relationship

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Abstract

This study applies threshold regression model in a bivariate framework to explore the nonlinear long-term relationship among Bitcoin and gold prices over the period 2010-2018. Results are threefold: first, we show that gold is a significant predictor of Bitcoin prices. Second, we find evidence of a non-linear relationship between Bitcoin and gold prices characterized rather by a two-regime relationship with a structural break occurring in October 2017. Third, before the break, there is significant, negative but weak causality indicating that Bitcoin is a speculative asset. After the break, the relationship becomes significantly positive revealing diversifier and hedge properties of Bitcoin.

Keywords

BitCoin, Gold Prices, Structural Break, Threshold Regression

1. Introduction

Bitcoin has been the focus of many recent studies in the literature, mainly because of noticeable price development and market capitalization since 2016. Launched in November 2008 by [1], this first open source digital currency is in its most innovative form.

Its popularity has been keeping on growing particularly during the Great Recession in 2008-2010. Since then, different lines of enquiry of Bitcoin have been dominating in previous literature. There is especially a significant strand of the literature focusing on price formation ([2]-[7] among others). Such focus on price formation is particularly motivated by the drastic price fluctuations faced by the crypto-currency since its creation. Bitcoin became also a prominent variable of interest in portfolio and investment management literature [8] [9] [10].

In that sense, several studies focus on the digital currency as a speculative or investment vehicle [11], as an alternative monetary system [12], as a diversifier to major stock indices [4] or even as a safe haven asset, in reference to any investment expected to retain or increase in value during market downturns [8].

Such analyses about the abilities of Bitcoin led to a more recent strand in the literature that aims to compare Bitcoin with gold properties [13]-[18]. They found commonalities and differences between Bitcoin and gold, developed well in [16] especially. These commonalities lead [19] to call the Bitcoin the digital gold. Besides, both commodities have a debatable intrinsic value that some authors discuss specifically [2] [17] [18] [20]. While gold is primarily used for its store of value abilities, his safe haven abilities are often considered in the literature. Bitcoin abilities remain even more uncertain.

Our paper aims to assess the predictive power of gold prices for Bitcoin prices and brings two main contributions to the previous literature. Firstly, it brings a methodological contribution since we use a threshold regression to take into consideration potential structural breaks, after testing for the structural stability of the parameters based on recursive residuals and the cumulative sum of square (CUSUM) statistic. The paper appears therefore to complement the recent wave of studies using mainly GARCH models [16] [20] or OLS and quantile approaches [21]. [21] for instance found a significant but weak negative causality that they explain by the fact that as a choice of an investment, risk-averse investors may prefer gold, while investors with speculative motive may prefer Bitcoin. Secondly, we use the largest time span in the literature, from July 19. 2010 to December 31. 2018 which allows us to take into account recent variations in the Bitcoin prices that were not included in previous studies.

The rest of the paper is organized as follows. Section 2 provides a data description. In Section 3, we present the methodology, while in section 4 we discuss empirical findings in light with the recent literature. Section 5 concludes.

2. Data Description

We use daily data covering the period from the 19th of July 2010 to the 31stof December 2018 (3088 observations for each series). Bitcoin price data are collected from *Coindesk*[1] *Price Index* while gold price data is sourced from *World Gold Council*. All data are labeled in U.S. dollars. **Table 1** provides some summary statistics, and accordingly the average of Bitcoin over the period is 1525 dollars ranging from 0.05 in July 2010 to 18960.5 in December 2017, while it reaches 1354 dollars for gold ranging from 1049.4 in July 2015 to 1855 in August 2011. Mean returns are higher for Bitcoin than for gold. Standard deviation which stands for unconditional volatility shows that Bitcoin exhibits maximum volatility.

Figure 1 clearly shows an increase in the Bitcoin price, appearing as breaks in

[1]With its headquarters in New York, USA, coindesk is a news site, founded by Shakil Khan, specializing in bitcoin and digital currencies. https://www.coindesk.com/

Table 1. Descriptive statistics.

	Mean	St. Dev.	Skewness	Kurtosis	Min.	Max.	Obs.
Bit_pr	1525.1	2981	2.6	6.94	0.05	18,960.5	3088
Gold_pr	1354	185	0.9	−0.24	1049.4	1895	3088

Source: Authors' computation. Notes: St. Dev. = Standard Deviation, Min. = Minimum, Max. = Maximum, Obs. = Number of observations.

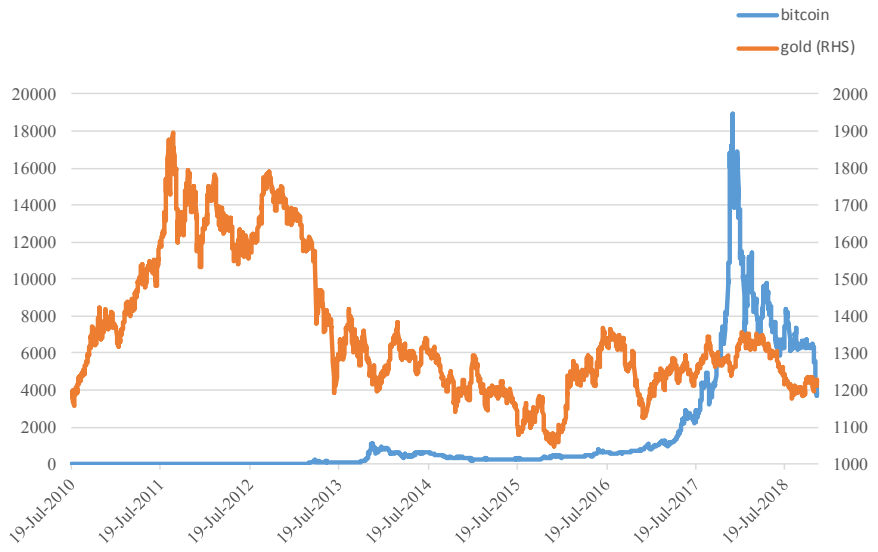

Figure 1. Graphical price comparison (July 19.2010-December 31.2018).

the data series trend in the beginning of 2017. The year 2017 appears a year of significant and rapid development of the Bitcoin. In August, the Bitcoin for the first time, traded above $4000. On the 18th of December, it reached $19,000, before starting to drop and to reach roughly an average of $8000 during 2019. The main drivers of this rise are to find in the sudden rising Asian demand for the cryptocurrency, especially from China and Japan [22]. The Japanese government accepted in April 2011 Bitcoin as a legal payment method. Besides, Russian authorities announced their approval to legalize the use of cryptocurrencies such as Bitcoin and Norway's largest online bank *Skandiabanken* decided to integrate Bitcoin accounts. The drop in late December 2017 is mainly related to the lack of confidence of investors in the first upgrading phase of the blocksize.

The evolution in the gold price is volatile over the entire period but to a less extent. We distinguish a turning point in 2013. Before this turning point, the regime is characterized by a high mean, while after that we note a downward slope associated with a low mean. From pictorial analysis, it is reasonable to expect 1) the presence of a deterministic trend for both series on one hand and 2) one or more structural breaks on the other.

3. Methodology

Most of the macroeconomics temporal variables could inhibit structural breaks

and an ignorance to the same could results into misleading results [23]. This study uses the threshold regression model employed by [24] and [25] to investigate the relation between Bitcoin and gold prices using time as the threshold variable. Such model is essentially concerned with modeling non-linearity. Besides, this model is robust to unknown forms of heteroscedasticity, something that cannot be said of the traditional Chow test [26].

We conduct a two-step approach. As a first step, we estimate the linear relation between Bitcoin and gold prices, and continue by testing for its structural stability based on recursive residuals. Recursive residuals are defined as the difference between BIT and the first $t-1$ observations and can be used both to test for non-linearity and to test for structural breaks. The CUSUM (cumulative sum of squares) test [27] is used in this study. Such new test for parameter stability in time series regressions helps indicate when and in what way breaks occur. It is expressed as follows:

$$W_t = \sum_{j=k+1}^{T} \frac{w_t}{\hat{\sigma}} \tag{1}$$

with

$$\hat{\sigma}^2 = \frac{\sum_{j=k+1}^{T} \left(w_t - \overline{w}\right)^2}{T-k-1} \tag{2}$$

and

$$\overline{w} = \frac{\sum_{j=k+1}^{T} w_t}{T-k} \tag{3}$$

where W_t is the cumulative sum of recursive residuals, T represents the number of observations, k represents the minimum sample size for which we can fit the model, w_t is the t^{th} standardized recursive residual.

The CUSUM statistic is calculated for each t and is plotted under the null hypothesis of model stability, given by the following form:

$$H_0 : E\left(W_t\right) = 0 \tag{4}$$

If the sum goes outside a critical bound, it advocates that there is a structural break at the point at which the sum begins its movement toward the bound. Therefore, the null hypothesis is rejected and the alternative one is accepted, suggesting that there are structural breaks in the series.

As a second step, once the presence of one or more structural break(s) is confirmed, we run the regression. We assume here that we identified one structural break—a two-regime regression. The two-regime threshold regression equation is therefore expressed as follows:

$$BIT_t = \left(\alpha_1 gold_t\right) \times f\left(k_t \le c_1^*\right) + \left(\alpha_2 gold_t\right) \times f\left(k_t > c_1^*\right) + \varepsilon_t \tag{5}$$

where BIT_t is the Bitcoin price in time t, $gold_t$ is the gold price in time t, $f(.)$ is an indicator function, ε_t is an error term. We assume that if the relation (.) is true, then $f(.)$ equals 1, otherwise $f(.)$ equals 0. k_t and c_1^* represent the threshold variable and the optimal threshold value, respectively.

The optimal threshold value c_1^* in the model can be determined by choosing the smallest residual variance of Equation (1):

$$c_1^* = \arg\min \hat{\sigma}^2(c_t), \quad t = 1, \cdots, n \tag{6}$$

$$c_1^* \in [c, \bar{c}] \tag{7}$$

where $\hat{\sigma}_t(c_t)$ is the residual variance from Equation (1) with optimal threshold value c_1^*.

For robustness check, we run the Chow first test [25] for parameter stability, commonly used in time series analysis despite its drawback in detecting unknown forms of heteroscedasticity. The test allows determining whether a single linear regression is more efficient than two separate regressions involving splitting the data into two sub-samples, from the break point. The test consists in estimating three different regressions, one over the whole period and then two for each sub-period. We obtain three sums of squared residuals that are used to run an F-test, with the parameter stability being null hypothesis. We compute log differences for all the series to approximate their respective growth rate.

4. Results and Discussion

We first start by using a basic linear model to examine the relation between Bitcoin and gold prices. Results displayed in **Table 2** indicate a significantly negative but weak ($\beta = -0.30$) relation between Bitcoin and gold prices, confirming that gold is a predictor of Bitcoin prices. The negative coefficient indicates that an increase in the price of gold lessens the price of Bitcoin. Such result is consistent with [21]. The underlying reason could be explained in two ways: first, investors prefer to invest in gold over Bitcoin, when gold prices show rising trends and second investors prefer to take lower risks with gold than with Bitcoin.

While the F-stat points out that all the variables are significant, the Ramsey RESET test shows that we can reject the null hypothesis that there are no neglected nonlinearities in the model. It indicates a preliminary evidence of a nonlinear relation between Bitcoin and gold prices and on a bias in these linear results.

Table 2. Linear model's results.

	Coefficient	p-value	*t*-statistics	Standard errors
Gold_pr	−0.30	0.00***	−2.62	0.11
Constant	0.004	0.00***	3.63	0.006
R-squared = 0.32				
Adj. R-squared = 0.33				
Number of observations: 3056				
F test (H_0: The fit of the intercept-only model equals the model)				
F(1, 3054) = 6.84				
Prob > F = 0.009				

Source: Authors' computation. Notes: *** denotes 1% level of significance.

Going deeper into the analysis, we plot the recursive cumulative sum in Figure 2 and run a unit root test with structural break to statistically confirm the presence of one or more breaks in the relation, and to identify the period of this (these) potential break(s).

Figure 2 shows the results of the recursive cumulative sum test plot which includes a 95% confidence band around the null value. It indicates that the curve structurally drifts outside the confidence band in the end of the plot, from the middle of 2017 to December 2018, which suggests that there are structural breaks in the relationship seemingly occurring around October-November 2017. The shape of the curve advocates for a hinge threshold, with a close-to-zero slope before the break.

Table 3 provides the output of the recursive cumulative sum test and reveals that the test statistic is larger than the 1% critical value so we would reject the null hypothesis that the mean is constant over time. This result confirms the nonlinear relation between Bitcoin and gold prices.

A unit root test with structural break is run to determine the date of the break (Table 4). The Wald statistics has a p-value lower than 1% indicating that we can reject the null hypothesis of no structural break and accept the alternative one. There is a structural break which occurs on the 5th of October 2017. We saw from Figure A1 that such break is nourished by an impressive growing trend in Bitcoin prices and a quite stable evolution in gold prices. Overall, the structural

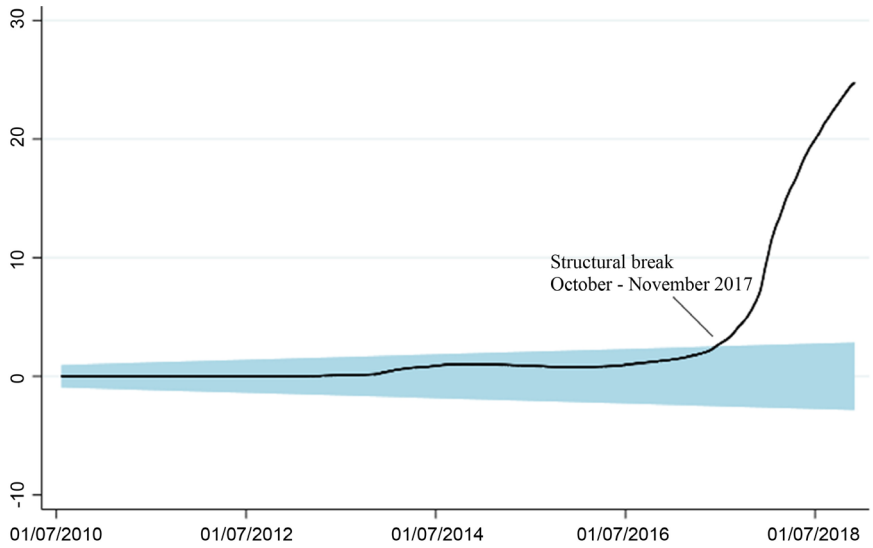

Figure 2. Recursive cumulative sum plot with 95% confidence bands around the null hypothesis (H_0: no structural break). Source: Authors' computation.

Table 3. Results of the cumulative sum test for parameter stability.

	Test statistic	1% critical value	5% critical value	10% critical value
Recursive	0.830	1.1430	0.9479	0.850

Source: Authors' computation. Note: H_0: No structural break. Number of observations: 3056. Sample: July 19. 2010-December 31. 2018.

Table 4. Unit root test with structural break.

	Coefficient	p-value
Wald statistics	16.09	0.00***
Estimated break date	05/10/2017	

Source: Authors' computation. Note: H_0: No structural break; *** denotes 1% significance level; 3056 observations. Sample: July 19. 2010-December 31. 2018.

break can be interpreted as a market correction, a movement towards a different relationship between Bitcoin and gold prices which follows a temporary upswing in market prices.

We can now conduct the threshold regression with two distinct regimes since we identified one optima structural break over the period. Table 5 displays the nonlinear results estimated using date as a threshold variable and the Akaike Information Criterion[2] (AIC) [28]. The Chow test for parameter stability is also run as a robustness check. Results confirm gold as a significant predictor of Bitcoin prices for both regimes. In regime 1, it does have a negative relation with a low coefficient (−0.51 significant at 1% level) similarly to linear regression's results. In regime 2, however, the relation becomes positive associated with a low coefficient (+0.265 significant at 5% level). This means that an increase in demand for gold leads to an increase in demand for Bitcoin. This unveils the significance of this study as the positive relationship of Bitcoin prices with gold prices could be explained as follows: first, it could indicate a concrete mutation of Bitcoin towards a safe haven. Traditionally, an increase in demand for gold is an indicator for an uncertain macroeconomic or financial environment in reference to the flight to safety phenomenon. Per analogy, Bitcoin might have become a hedge like gold despite its higher volatility. Identical features [16] seem to lead to identical properties. Second, it could confirm that Bitcoin became a concrete option for diversifying investors' portfolios. Investors do not secure their capital and preserve value through gold, but also through Bitcoin. After October 2017, one can reasonably assume that Bitcoin belong to the class of alternative investment options.

Table 5 reports the result of the Chow test for parameter stability. We find evidence of a structural break on October 5. 2017 with a p-value equals to 0.0017. Therefore we confidently reject the null hypothesis that parameters are stable over time at the 1% significance level and validate our threshold regression.

5. Conclusions

This study uses cross-sectional data to investigate the Bitcoin-gold prices nexus over the daily period 2010 and 2018. This study contrasts with others in the previous literature, because it uses both linear and nonlinear threshold regression models and tests the structural stability of the parameters based on recursive residuals.

[2]Results using BIC and BQIC available upon request are similar to results using AIC.

Table 5. Results of the threshold regression.

	Coefficient	p-value	z-statistics	Standard errors
Threshold: 5/10/2017				
Regime 1				
gold_pr	−0.51	0.00***	−1.28	0.40
constant	0.017	0.00***	5.92	0.003
Regime 2				
gold_pr	+0.265	0.02***	2.18	0.12
constant	0.018	0.07**	1.78	0.001
Chow test for parameter stability	F(3, 3056) = 5.05 with prob. > F = 0.0017			

Source: Authors' computation. Note: *** denotes 1% significance level. 3056 observations with 2595 observations under regime 1 and 494 observations under regime 2.

Empirical results indicate that gold is a significant predictor of Bitcoin prices. They indicate, however, that this impact is not linear over the period. A structural break occurring on the 5th of October 2017 implies in fact a two-regime relationship between Bitcoin and gold prices. Before the turning point, a significant negative and weak impact of gold on Bitcoin prices is found in line with previous literature [8] [21]. In that sense, Bitcoin was considered by investors more as a speculative asset than a hedge or safe haven one and was not challenging gold as a first-class safe haven asset. Nevertheless, after October 2017, an increase in gold prices predicts a significant, positive impact on Bitcoin prices. A rise in the demand for gold, traditionally motivated by economic or financial uncertainty, increases the demand for Bitcoin. This indicates a radical change in the properties of the cryptocurrency which became a diversifier and a hedge.

Like many other studies, our research presents some room for further improvement. First, such results need to be confirmed by investigating the Bitcoin—gold prices nexus in the future, as at present the second period since October 2017 being six times shorter than the first one in our study. Second, global factors like oil prices or stocks indices which are barometers of macroeconomic and financial environment could also be included to design multivariate approaches and assess the property of safe haven of Bitcoin, beyond hedging.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

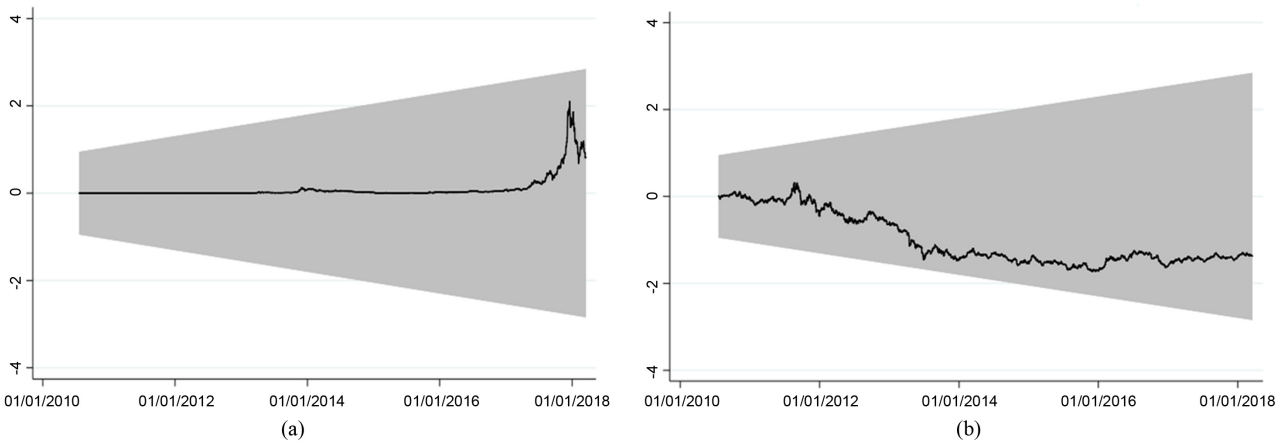

Figure A1. Recursive cumulative sum plot with 95% confidence bands around the null hypothesis (H_0: No structural break) (a) D.bit_pr; (b) D.gold_pr. Source: Authors' computation.