Article

Not peer-reviewed version

Bitcoin Price Dynamics: An Approach with Macroeconomic and Microeconomic Variables

Varona Castillo Luis * and Gonzales Castillo Jorge R.

Posted Date: 22 May 2026

doi: 10.20944/preprints202605.1522.v1

Keywords: Bitcoin; liquidity; interest rate; volatility; monetary police; ARDL

doi:10.20944/preprints202605.1522.v1

Article

Bitcoin Price Dynamics: An Approach with Macroeconomic and Microeconomic Variables

Varona Castillo Luis [1,*] and Gonzales Castillo Jorge R. [2]

[1] Comillas Pontifical University
[2] Public University of Piura
* Correspondence: luvar8@hotmail.com

Abstract

This research examines the determinants of Bitcoin (BTC) valuation from January 2011 to December 2025 using Autoregressive Distributed Lag (ARDL) models. The empirical evidence supports the hypothesis that the monetary policy of the United States Federal Reserve—specifically liquidity expansion and interest rate adjustments—drives price dynamics, confirming a *pro-cyclical nexus*. At the microeconomic level, the density of active institutional addresses and the marginal cost of production significantly influence price trajectories. Furthermore, heightened market volatility, represented by the VIX, exerts a statistically significant negative impact on BTC returns. The findings suggest that Bitcoin has transitioned into a sophisticated value asset, underpinned by production efficiencies and an expanding institutional base. Consequently, Bitcoin represents a viable alternative to centralised financial systems, offering a potential hedge against inflation and the erosion of purchasing power. The study concludes that digital assets warrant inclusion within conservative institutional portfolios, notwithstanding the inherent speculative nature of the market.

Keywords: Bitcoin; liquidity; interest rate; volatility; monetary police; ARDL

---

1. Introduction

Digital currencies represent a profound financial innovation within contemporary capital markets. The widespread adoption of such currencies is increasingly significant, both as a medium of exchange and, predominantly, as a strategic asset within the portfolios of professional investors. While Bitcoin remains the pre-eminent currency in terms of valuation and market volume, a diverse array of alternative assets exists, including Ethereum (ETH), Solana (SOL), XRP, and Binance (BNB), as well as stable-coins such as Tether (USDT).

Originally proposed by Nakamoto (2008) and launched in 2009, Bitcoin was developed as a technical solution to a fundamental question within the cryptographic community: the feasibility of a fully decentralised digital currency. Such a decentralised cash system enables individuals to execute monetary transactions without the intervention of third-party intermediaries or a central authority capable of directing monetary policy.

Historically, the limitations of Bitcoin were associated with *the risk of double-spending*, wherein digital coins could be duplicated and utilised multiple times. However, this challenge has been systematically addressed through three primary mechanisms: (i) the application of a timestamp within a digital document on the blockchain or transaction record (Haber and Stornetta 1990); (ii) the prevention of network abuse through a proof-of-work (PoW) mechanism (Dwork and Naor 1992); and (iii) the achievement of consensus regarding the validity of transactions via the longest chain rule (Halaburda, Haeringer et al. 2020).

The existence of a broader Bitcoin ecosystem is acknowledged; for a comprehensive discussion concerning its historical development, cryptographic foundations, and conceptual frameworks, reference is made to (Böhme, Christin et al. 2015, Narayanan, Bonneau et al. 2016, Andolfatto 2018, Haeringer and Halaburda 2018). In contrast to purely descriptive accounts, this analysis focuses on the dynamic interaction between a selection of explanatory variables—encompassing United States monetary policy, microeconomic characteristics of the Bitcoin cryptocurrency, and market volatility—and the resulting price behaviour (Jiang and Huang 2024, Luo, Tsai et al. 2026). This relationship is examined with specific attention to temporal lags, reflecting the period required for policy implementation to manifest in market valuations, which empirical observations suggest typically spans two to three months.

The econometric strategy employs the Autoregressive Distributed Lag (ARDL) framework (Pesaran and Shin 1998, Pesaran, Shin et al. 2001). This model is utilised to examine the relationship between variables within a time series and their respective lags, facilitating the identification of key indicators that investors may monitor to interpret the behaviour of Bitcoin and discern potential investment opportunities.

Stylised facts illustrate the substantial increase in the returns of Bitcoin during the 2010–2025 period. When benchmarked against the Standard and Poor 500 Index (S&P 500), which monitors the five hundred leading companies in the United States economy, the disparity in performance is significant. While the S&P 500 grew by a factor of 5.2, Bitcoin increased by more than 15,000 times, using January 2012 as the base period (2012.01 = 100). Within this timeframe, the average monthly price growth rate remained robust, yielding an average annual return of 437 per cent and an average monthly return of 22 per cent, figures that substantially exceed those of comparable assets (**Appendix A**).

Theoretically, this research builds upon literature establishing the macroeconomic drivers of Bitcoin **(**Yermack 2013**,** Böhme, Christin et al. 2015**,** Biais, Bisiere et al. 2019**,** Bolt and Van Oordt 2020**,** Othman, Alhabshi et al. 2020**,** Polizu, Oliveros-Rosen et al. 2023**,** Zhao, Zhang et al. 2023**,** Buthelezi 2025**,** Tosun and Uğurlu 2025**).** Furthermore, the microeconomic dimensions are informed by the contributions of (Koutmos 2018**,** Halaburda, Haeringer et al. 2020**,** Farrugia and Deguara 2025**,** Liu, Manahov et al. 2025)**.**

Drawing upon the preceding theoretical review and empirical evidence, this research seeks to address the following questions: (i) which factors explain the returns of Bitcoin; (ii) what is the impact of United States monetary policy, specifically the interest rate of the Federal Reserve, the density of active institutional users, and the production costs of miners, on the returns and market volatility of Bitcoin; and (iii) is Bitcoin a viable alternative asset for inclusion in investment portfolios as either a store of value or a speculative instrument?

The primary objective of this research is to analyse the causal determinants of the returns of Bitcoin from January 2011 to December 2025, utilising monthly data. The article is structured into six sections followed by a conclusion. The second section provides a concise review of the literature. The third section presents stylised facts. The fourth section details the methodology and defines the econometric model. The fifth section reports the primary results, while the sixth section offers a discussion of these findings. Finally, the study concludes with a summary of its contributions and implications.

2. Materials and Methods

Data

The price of the cryptocurrency BTC and several explanatory variables will be used: the interest rate, the FED's liquidity, the number of active institutional addresses, and the cost of mining or production (Blockchain). Since the prices of the selected indices differ significantly from those of other financial assets, logarithmic rates of return were used to calculate the price data, thus preventing excessively large parameter values.

The return series generated for each financial asset uses historical data, where B_t represents the asset price and the logarithmic rate of return is estimated by the model. **Table 1** presents the details of each variable according to its source. We have five (5) explanatory variables with data from the period January 2011 to December 2025, with 180 monthly observations per variable (**Appendix C**).

 doi:10.20944/preprints202605.1522.v1

Table 1. Summary of variables.

Variable [1]	Short name	Details	Source
Bitcoin price	**B**	Market Price Bitcoin in USD (BTC).	COINMARKETCAP
FED – Liquidity	**L**	Total Assets, Millions of USD (WALCL).	the St Louis Fed data centre (FRED).
Interest rate	**R**	Federal Reserve Funds Effective Rate (FEDFUNDS).	the St Louis Fed data centre (FRED)
Active addresses	**N**	Number of active addresses.	COINMARKETCAP
Production cost	**H**	Means Hash rate.	BLOCKCHAIN
Market volatility	**V**	CBOE Volatility Index.	Chicago Board Options Exchange (CBOE).

[1] Monthly variables have a base year of 2012.01=100, except for the interest rate. The Fed Interest Rate would be the only variable entering the model without transformations. Source: Authors with own compilation extracted from sources.

Method

The theoretical framework posits a mathematical model underpinned by variables identified throughout the literature review and supported by empirical evidence concerning the determinants of Bitcoin (BTC) pricing. It is hypothesised that BTC price fluctuations are driven by factors such as the Federal Reserve's monetary policy instruments, microeconomic metrics inherent to the Bitcoin network, and broader environmental variables—specifically market volatility as represented by the VIX index. The functional relationship, incorporating the operational variables, is expressed in **Equation (1)** as follows:

$$B_t = f\ (L_t, R_t, N_t, H_t, V_t\ ), \tag{1}$$

where:

- B_t: The natural logarithm of the Bitcoin (BTC) market price, denominated in US Dollars.
- L_t: The natural logarithm of the Federal Reserve's Total Assets (expressed in millions of US Dollars), serving as a proxy for liquidity.
- R_t: The Federal Funds Effective Rate, expressed in decimal form.
- N_t: The natural logarithm of the number of active institutional addresses within the network.
- H_t: The natural logarithm of the mean Hash Rate, representing the network's computational power.
- V_t: The CBOE Volatility Index (VIX), utilised as a measure of broader market risk and investor sentiment.

Equation (1) defines the empirical specification for the BTC price variable. Consequently, the primary model under consideration is formulated in **Equation (2)** as follows:

$$\ln(B_t) = \beta_0 + \beta_1 \ln(\mathrm{L_t}) + \beta_2 \ln(\mathrm{R_t}) + \beta_3 \ln(\mathrm{N_t}) + \beta_4 \ln(\mathrm{H_t}) + \beta_5 \ln(\mathrm{V_t}) + \varepsilon_t, \tag{2}$$

Autoregressive Distributed Lag (ARDL) econometric models are linear specifications designed for time-series analysis, wherein dependent and independent variables are related both contemporaneously and through their respective lagged values (Pesaran and Shin 1997, Pesaran and Shin 1998, Pesaran, Shin et al. 2001, Narayan 2004). The general ARDL (p, q_1, q_2, q_3… q_k), framework facilitates the estimation of growth rates (denoted in lowercase) for the Bitcoin price variable (B), represented here by the endogenous variable $\boldsymbol{b_t}$ an endogenous variable. The corresponding

 doi:10.20944/preprints202605.1522.v1

exogenous variables—l, r, n, h, and v—are detailed in **Table 1** and expressed in simplified form in **Equation (3)**.

$$b_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{p} \psi_i b_{t-i} + \sum_{j=1}^{k} * \sum_{l_j=0}^{q_j} \beta_{j,l_j} x_{j,t-lj} + \varepsilon_t \quad (3)$$

where: ε_t represents innovations, α_0 is a constant term, α_1 is the coefficient associated with a linear trend, ψ_i is the coefficient associated with lags of b_t, and $\beta_{j,lj}$ are the coefficients associated with lags of k repressors $x_{t,j}$ for $j= 1,2,3,\ldots,k$.

The initial stage of the ARDL application involves the estimation of intertemporal dynamics. These models are estimated using Ordinary Least Squares (OLS), whereby the endogenous variable is regressed on a set of exogenous factors and their respective lags. Empirical evidence shows that the optimal lag structure is subsequently determined by selecting the specification that minimises the Schwarz Criterion (SC), ensuring a parsimonious balance between model fit and complexity (Gonzales and Varona 2023, Varona, Gonzales et al. 2024, Varona and Gonzales 2025).

A bounds testing procedure is employed to ascertain the existence of a long-run relationship, thereby facilitating the derivation of the Error Correction Model (ECM) to capture short-run dynamics. The F-test is conducted under the null hypothesis of no cointegration among the variables. The resulting test statistic is compared against two asymptotic critical value bounds, corresponding to cases where the regressors are purely (H_0), purely (H_1), or mutually cointegrated. If the calculated F-statistic exceeds the upper critical bound, the null hypothesis (H_0) is rejected, confirming a stable long-run equilibrium.

3. Results

The preliminary findings indicate that the variables are stationary in their first differences, thereby justifying the application of ARDL estimation frameworks (**Appendix B**). **Table 2** presents the results of the bounds testing procedure for cointegration. The empirical evidence confirms the existence of a long-run cointegrating relationship across all four proposed models, significant at the 5% level.

Table 2. Cointegration with Bounds test.

Model	Bounds test[1]	Cointegration	Method
1	3.96 > 3.38**	Yes	ECM
2	3.52 > 3.38**	Yes	ECM
3	3.53 > 3.38**	Yes	ECM
4	3.87 > 3.38**	Yes	ECM

[1] ** Indicates statistical significance at 5%. Note: Model 1 specifies the estimation of Equation (2) with a single lag; Model 2 incorporates dummy variables and two lags for corrective purposes. Model 3 extends the lag structure to include up to three lags. Finally, Model 4 employs the Akaike Information Criterion (AIC) for the automatic selection of up to twelve lags, with the VIX index treated as a fixed regressor.

3.1. ARDL Estimation

Table 3 presents the estimation results for the ARDL framework. In **Model 1**, the findings provide evidence of a positive causal relationship between liquidity and the BTC price, yielding a coefficient of 2.21, which is statistically significant at the 1% level. Conversely, the Federal Reserve's interest rate exhibits a direct relationship with a coefficient of 0.02, though this is only significant at the 14% level. Furthermore, both the proliferation of institutional addresses and the marginal cost of mining are significant at the 1% level, with coefficients of 0.97 and -0.29, respectively. Finally, the VIX volatility index confirms an inverse relationship with the BTC price (coefficient of -0.24, significant at the 1%). While the model satisfies most diagnostic requirements, it fails the normality test.

Consequently, **Model 2** was estimated, incorporating dummy variables to account for specific periods of high BTC volatility and the COVID-19 pandemic. This modification marginally enhances both the results and the parametric stability tests; however, as the normality assumption remains unsatisfied, this limitation is acknowledged and accepted. Both specifications are based on the Schwarz Information Criterion (SIC).

"In **Model 3**, the lag structure was extended. The impact of liquidity reflects a marginal improvement, yielding a coefficient of 2.59, which remains statistically significant at the 1% level. Notably, the Federal Reserve's interest rate, when lagged by one period, appears to weaken, with a coefficient of 0.02 (significant only at the 15% level). Overall, this specification does not yield substantial departures from the previous models.

Model 4 further extends the lag length utilising the Akaike Information Criterion (AIC), which serves as a less restrictive selection criterion than the Schwarz Information Criterion. Under this specification, contemporaneous liquidity remains stable with a coefficient of 0.26, significant at the 1% level. Furthermore, the results indicate that the interest rate, after a two-period lag (equivalent to approximately 90 days), achieves a coefficient of 0.76, which is statistically significant at the 1% level.

Furthermore, the proliferation of institutional addresses maintains a statistically significant coefficient of 0.96 (significant at the 1% level), while the marginal cost of BTC production remains significant at the 10% level with a coefficient of -0.60. The VIX volatility index continues to exhibit an inverse relationship with the BTC price, yielding a coefficient of -0.15, significant at the 5% level. Notably, Model 4 satisfies the requisite diagnostic and parametric stability tests—specifically the CUSUM and CUSUM of Squares procedures; however, the normality assumption remains violated.

Model 4 serves as a robust sensitivity analysis, given that the Akaike Information Criterion (AIC) is less parsimonious than the Schwarz Criterion regarding lag selection. Despite the variation in magnitude, the signs associated with monetary policy variables remain consistent across all specifications, with liquidity coefficients of +2.21, +2.58, +2.59, and +0.26 for **Models 1** through **4**, respectively. Of particular interest is the interest rate, which demonstrates a positive impact at the second lag (coefficient of +0.76). The AIC framework thus facilitates the identification of lagged transmission effects that the Schwarz Criterion may overlook. Specifically, the AIC results suggest that while Federal Reserve liquidity exerts an immediate impact within the current month, the influence of interest rate adjustments only materialises in the second month, thereby providing a more nuanced understanding of monetary policy dynamics.

The AIC specification further functions as a robustness check; the inclusion of twelve lags confirms that while Bitcoin exhibits pronounced short-term volatility, the long-run equilibrium (cointegration) remains resilient. Consequently, both the Bounds test and the joint F-statistic validate the collective explanatory power of the variables. The results confirm that Bitcoin cointegrates with the selected determinants, as evidenced by the F-statistics (31, 19.80, 21.34, and 8.97), which are all statistically significant at the 1% level across both selection criteria (Schwarz and Akaike).

Table 3. ARDL model.

Method	Model 1	Model 2	Model 3	Model 4
LB(-1)	0.98***	0.98***	0.98***	**0.93*****
LL	2.21***	2.58***	2.59***	**0.26*****
LL(-1)	-2.04***	-2.42***	-2.43***	---
R	0.02 [1]	0.02 [1]	0.02 [2]	- 0.03
R(-1)	---	---	---	-0.29
R(-2)	**---**	**---**	**---**	**0.76*****
R(-3	---	---	---	-0.74**
R(-4)	---	---	---	0.73**
R(-5)	---	---	---	-0.54
R(-6	---	---	---	0.39
R(-7)	---	---	---	-0.52

 doi:10.20944/preprints202605.1522.v1

R(-8)	---	---	---	0.29
R(-9)	---	---	---	-0.24
R(-10)	---	---	---	0.44
R(-11)	---	---	---	-0.56*
R(-12)	---	---	---	0.36**
LN	0.97***	0.98***	0.98***	**0.96*****
LN(-1)	-0.89***	-0.89***	-0.89***	-0.73***
LH	-0.29***	-0.29***	-0.29***	0.20
LH(-1)	0.27***	0.27***	0.27***	0.04
LH(-2)	---	---	---	-0.60
LH(-3	---	---	---	0.39
LH(-4)	---	---	---	-0.22
LH(-5)	---	---	---	0.35
LH(-6	---	---	---	-0.60
LH(-7)	---	---	---	**1.03*****
LH(-8)	---	---	---	-0.96***
LH(-9)	---	---	---	0.35
LH(-10)	---	---	---	-0.07
LH(-11)	---	---	---	-0.12
LH(-12)	---	---	---	0.18***
LV	-0.24***	-0.22***	-0.22***	**-0.16****
Constant	-0.58*	-0.55	-0.56	-2.42**
DUM1: 2020.01	---	0.03	0.03	---
DUM2: 2022:01	---	-0.08	0.08	---
DUM3: 2022:11	---	0.02	-0.02	---
DUM4: 2022:12	---	-0.13	0.14	---
DUM4: 2022:12	---	0.16	---	---
R^2 Adjust	*0.9940*	*0.9941*	*0.9940*	***0.9951***
F	*3138*	*1980*	*2134*	*897*
Schwarz C.	*0.24*	*0.38*	*0.35*	*0.47*
Sample range	*179*	*179*	*179*	*168*
Jarque-Bera	*0.00<0.05*	*0.00<0.05*	*0.00<0.05*	*0.00<0.05*
LM test (1rez)	*0.77>0.05*	*0.90>0.05*	*0.82>0.05*	*0.11>0.05*
ARCH test	*0.10>0.05*	*0.11>0.05*	*0.10>0.05*	*0.30>0.05*
Ramsey test	*0.13>0.05*	*0.17>0.05*	*0.14>0.05*	*0.77>0.05*
Stability	*yes*	*yes*	*yes*	*yes*

Notes: The contrast tests show that the econometric models meet the criteria for absence of a high degree of multicollinearity, serial correlation, and heteroscedasticity, but not for normality. The model is well-specified and stable with the dummy variables in the Ramsey and Cusum tests. The dummy variables are associated with the onset and progression of COVID-19. [1] The coefficients are statistically significant at 14% and 15% respectively.

 doi:10.20944/preprints202605.1522.v1

3.2. Error Correction Model Estimation

Once the cointegration was identified, the error correction model (ECM) was estimated, and its results are presented in **Table 4**. In the short term, robust empirical evidence supports the hypothesis of a positive relationship between the liquidity growth rate, with a coefficient of 2.21, and the returns of BTC. Furthermore, the number of active addresses and the cost of BTC production are statistically significant at the 1% level, with coefficients of 0.97 and -0.29, respectively (**Model 5**). **Models 6** and **model 7** show similar results. In the long term, none of these three models show statistically significant results; therefore, no conclusions can be drawn about the coefficients.

In the case of **Model 8**, in the long term, it is the only model with significant coefficients for contemporaneous liquidity and the FED's lagged interest rate, with statistical significance levels of 2% and 6%, respectively. This confirms that the Fed's monetary policy has a positive impact and a lagged effect (approximately 90 days after the policy's implementation). The impact of institutional addresses is statistically significant at the 12% level.

Furthermore, in the short term, the growth rate of the contemporaneous interest rate becomes statistically significant at the 1% level and at subsequent lags up to lag 11, consistently. Additionally, the number of institutional addresses is statistically significant at the 1% level, and market volatility shows a negative growth rate with a statistically significant coefficient of -0.15 at the 1% level, impacting BTC returns.

According to the empirical evidence obtained, we chose **model 4** (in levels) and **model 8** (in growth rates), which show a robust relationship in levels and growth rates between the variables, confirms how monetary policy affects the price of Bitcoin, shows how microeconomic variables explain its price and how in the environment, volatility has a negative behaviour.

Table 4 also shows that in all the presented models, the error coefficient variable, ECM (-1), meets the three necessary conditions: it has a negative sign, a value less than one, and is statistically significant. In **model 8**, the model variables cointegrate until they reach long-term equilibrium, and in the short term, they are corrected at an adjustment rate of 0.06%.

Table 4. EC Model.

Method	Model 5	Model 6	Model 7	Model 8
LL	*11.11*	*8.15*	*9.23*	*4.25***
R(-1)	*1.50*	*1.25*	*1.38*	*0.87**
LN(-1)	*5.17*	*4.35*	*4.86*	*3.69* [1]
LH(-1)	*-1.67*	*-1.23*	*-1.43*	*-0.59*
LVIX	*-16.03*	*-11.89*	*-13.41*	---
ECM(-1)	*-0.015****	*-0.019****	*-0 .017****	*-0 .062****
dll	*2.21****	*2.58****	*2.59****	---
dr	---	---	---	*-0.03****
dr(-1)	---	---	---	*-0.38***
dr(-2)	---	---	---	*0.37***
dr(-3	---	---	---	*-0.37***
dr(-4)	---	---	---	*0.36***
dr(-5)	---	---	---	*-0.17*
dr(-6	---	---	---	*0.22*
dr(-7)	---	---	---	*-0.30*
dr(-8)	---	---	---	*-0.01*
dr(-9)	---	---	---	*-0.25*
dr(-10)	---	---	---	*0.19*

dr(-11)	---	---	---	-0.36***
dln	0.97***	0.98***	0.98***	0.96***
dlh	-0.29***	-0.29***	-0,29***	0.20
dlh(-1)	---	---	---	0.27
dlh(-2)	---	---	---	-0.32
dlh(-3	---	---	---	0.06
dlh(-4)	---	---	---	-0.16
dlh(-5)	---	---	---	0.19
dlh(-6	---	---	---	-0.41**
dlh(-7)	---	---	---	0.61***
dlh(-8)	---	---	---	-0.34**
dlh(-9)	---	---	---	0.01
dlh(-10)	---	---	---	-0.06
dlh(-11)	---	---	---	-0.18***
lv	---	---	---	-0.15***
dum1	---	0,03	0.03	---
dum2	---	-0,08	-0,08	---
dum3	---	0,02	0,02	---
dum4	---	-0,13	-0,14	---
dum5	---	0.16	---	---
R^2	0.33	0.34	0.33	0.44
Schwarz	0.07	0.20	0.18	0.31
F	29.13***	10.96***	12.41***	4.32***

[1] Indicates statistical significance at 12%.

4. Discussion

4.1 Robust empirical evidence supports the hypothesis that Federal Reserve (FED) liquidity expansion exerts a positive long-term impact on Bitcoin returns. With a coefficient of 4.25, statistically significant at the 2% level, quantitative easing (QE) has a direct upward effect on Bitcoin's price. The underlying transmission mechanism suggests that as the FED injects capital into the financial system, this *cheap money* flows into equity and cryptocurrency markets—a phenomenon clearly observed globally following the onset of the COVID-19 pandemic and subsequent government stimulus measures. Consistent with prior research (Sadraoui, Nasr et al. 2021, Buthelezi 2025, Tosun and Uğurlu 2025) these findings confirm that Bitcoin reacts positively to shifts in monetary policy, with the impact persisting beyond the second month of implementation

Furthermore, the data corroborates the role of the liquidity channel in driving long-term price increases (Zhao, Zhang et al. 2023). An alternative perspective suggests that Bitcoin appreciates as investors seek a hedge against fiat currency devaluation amidst high economic activity and general optimism (Srinivasan, Maity et al. 2022). Consequently, Bitcoin should be considered not merely as a speculative asset but as a viable inflation hedge. A sophisticated understanding of these liquidity cycles is essential for developing conservative portfolio management and robust financing strategies (Smales 2020).

4.2 Robust empirical evidence supports the hypothesis that the Federal Reserve's benchmark interest rate, when lagged by one period, exerts a positive long-term impact on Bitcoin returns, with a coefficient of 0.87 (statistically significant at the 6% level). In the short term, results indicate both positive and negative adjustments depending on the lag, significant at the 5% level. This

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 22 May 2026 doi:10.20944/preprints202605.1522.v1

suggests a direct relationship between FED interest rate policy and Bitcoin valuation. While existing literature identifies correlations between Bitcoin and macroeconomic variables (Polizu, Oliveros-Rosen et al. 2023, Farrugia and Deguara 2025), few studies employ dynamic econometric models to isolate the specific impact of monetary policy via interest rate and liquidity controls. The positive relationship observed here suggests that interest rate hikes often coincide with economic booms, which typically bolster demand for risk assets (Havidz, Karman et al. 2021, Kumar and Ajaz 2022, Köse, Ünal et al. 2026).

Collectively, liquidity and interest rates establish a pro-cyclical *'virtuous cycle'* for Bitcoin's growth. An expansion in the monetary supply facilitates capital flows into alternative assets; simultaneously, Bitcoin demonstrates resilience toward higher interest rates when accompanied by a robust economy and inflationary pressures that investors seek to hedge against. Consequently, it is recommended that market participants closely monitor Federal Reserve mandates when formulating investment strategies or managing institutional portfolios.

4.3. In the short term, this variable demonstrates a coefficient of 0.98, reaching statistical significance at the 1% level across all four presented models. The prevailing trend indicates that as the active address count increases, price appreciation follows. This expanding user base facilitates higher transaction volumes, consistent with robust correlations identified in existing literature (Koutmos 2018, Liu, Manahov et al. 2025). Furthermore, in accordance with the law of demand, Bitcoin's valuation is positively influenced by the volume of transactions within its evolving market microstructure, leading to long-term price increases.

4.4. In the short term, growth in production costs associated with Bitcoin mining exhibits a negative relationship with returns, demonstrating a coefficient of -0.41 (statistically significant at the 5% level) at the sixth lag. This suggests a significant capacity for unit-cost reduction, reflecting the increasing energy efficiency of mining hardware (Fantazzini and Kolodin 2020), and a unidirectional relationship between these variables. Consequently, stylised data reveal a positive relationship between price and hash rate levels, as well as a positive correlation between the growth rates of both variables. Given that the market has achieved greater maturity and regulatory oversight following the 2017 introduction of the futures market, it is recommended that Bitcoin be promoted as a viable investment asset.

4.5. Increased market volatility exerts a negative impact on Bitcoin returns, with a coefficient of -0.15, statistically significant at the 1% level. Market sentiment, oscillating between fear and euphoria, is systematically linked to Bitcoin's price. This variable is uniquely treated as a fixed regressor, as sentiment is an instantaneous phenomenon; it would be logically inconsistent to assume that market fear from twelve months prior influences current prices. By maintaining it as a fixed component, the model captures the immediate impact of systemic risk on Bitcoin, filtering out idiosyncratic noise and allowing other variables to demonstrate their long-term effects.

Existing studies support the inclusion of volatility as a critical explanatory variable for Bitcoin's behaviour (Jiang and Huang 2024, Pogorelova 2024, Luo, Tsai et al. 2026). Consequently, investors tend to withdraw capital during periods of heightened volatility, adversely affecting returns. Monitoring this indicator is recommended to mitigate risk, facilitate portfolio diversification, and assess market trends within both developed and emerging markets (Vergili and Celik 2023).

5. Conclusions

This research provides robust empirical evidence that the monetary policy of the United States Federal Reserve significantly influences the price dynamics and returns of Bitcoin throughout the 2011–2025 period. The findings confirm a persistent pro-cyclical nexus, suggesting that Bitcoin has evolved into an asset class sensitive to cycles of broader economic expansion. Crucially, the results indicate that the valuation of this cryptocurrency is no longer merely a function of utility as a medium of exchange or a speculative vehicle; rather, it increasingly reflects an underlying intrinsic value linked to network fundamentals. It is demonstrated that the returns of Bitcoin are conditional upon institutional adoption—proxied by the number of unique institutional addresses—and the marginal

 doi:10.20944/preprints202605.1522.v1

cost of production, as determined by the hash rate. Furthermore, the analysis reveals that market-wide uncertainty, captured by the VIX, exerts a significant negative pressure on valuations, reinforcing the integration of Bitcoin into the global financial architecture. These insights suggest that such an asset may serve as an effective instrument for long-term portfolio diversification, offering a potential hedge against monetary debasement and the expansion of sovereign debt. Ultimately, as the market matures, Bitcoin represents a substantive alternative to traditional centralised financial systems, necessitating a re-evaluation of the role of digital assets within modern investment frameworks.

Supplementary Materials: The following supporting information can be downloaded at: Preprints.org, Dataset.

Author Contributions: Conceptualization, L.V. and J.G.; methodology, L.V. and J.G.; software, L.V.; validation, L.V., and J.G.; formal analysis, L.V.; investigation, L.V.; resources, L.V.; data curation, L.V.; writing—original draft preparation, L.V.; writing—review and editing, L.V.; visualization, L.V.; supervision, L.V.; project administration, L.V. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Not applicable.

Data Availability Statement: We present the dataset used in this research, whose electronic sources are available in **Appendix C.**

Acknowledgments: We thank the peer reviewers in advance for their comments.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

BTC	Bitcoin.
HASH	Mean Hash ratio.
FED	The Federal Reserve is the central bank of the United States.
ARDL	Autoregressive Distributed Lag Linear (model).
ECM	Error Correction Model.

Appendix A

Appendix A.1. Stylized Facts

There is evidence of a persistent upward trend in the price of the cryptocurrency BTC. Figure A1 shows the price evolution between 2010 and 2025, with its value fluctuating between USD 0.1 and USD 116,000, experiencing periods of both increases and decreases. It boasts an average annual return of 437% and a monthly average of 22%, significantly higher than other assets. Furthermore, the price of BTC oscillates around its average of USD 19,700, exhibiting an exponential trend and is integrated by order one, I(1).

Figure A2A presents the SP500 index and the price evolution of BTC. Both are based on 2012=100 for comparison. When we compare the SP500 (*benchmarking*), we see that it has only grown 5.2 times, while the price of the cryptocurrency BTC has grown more than 15,000 times, using 2012.01=100 as the base year. Figure A2B allows us to reduce the volatility and scale of the series.

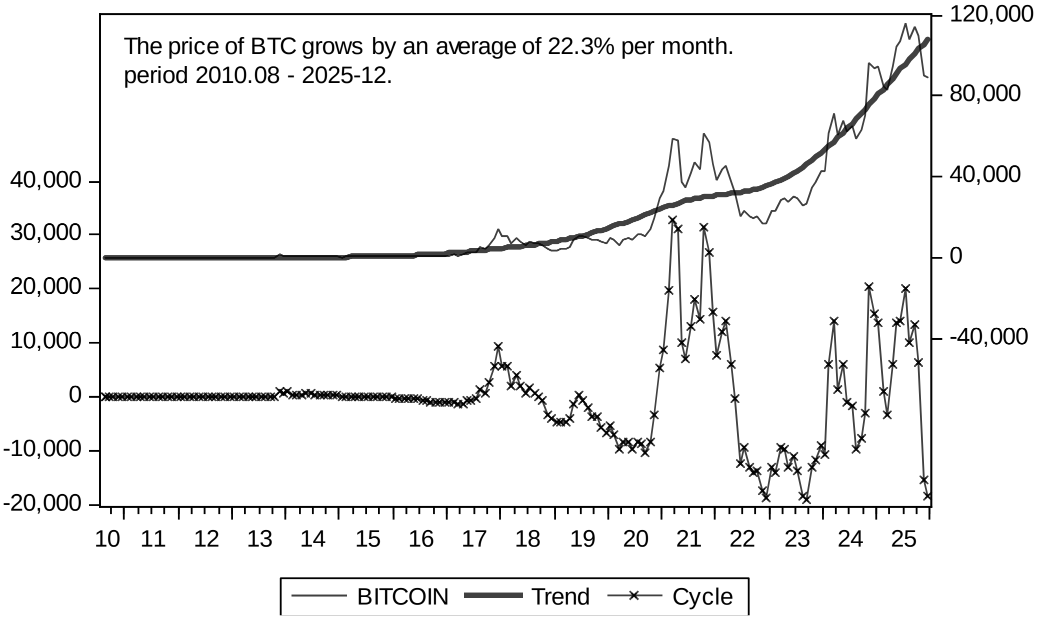
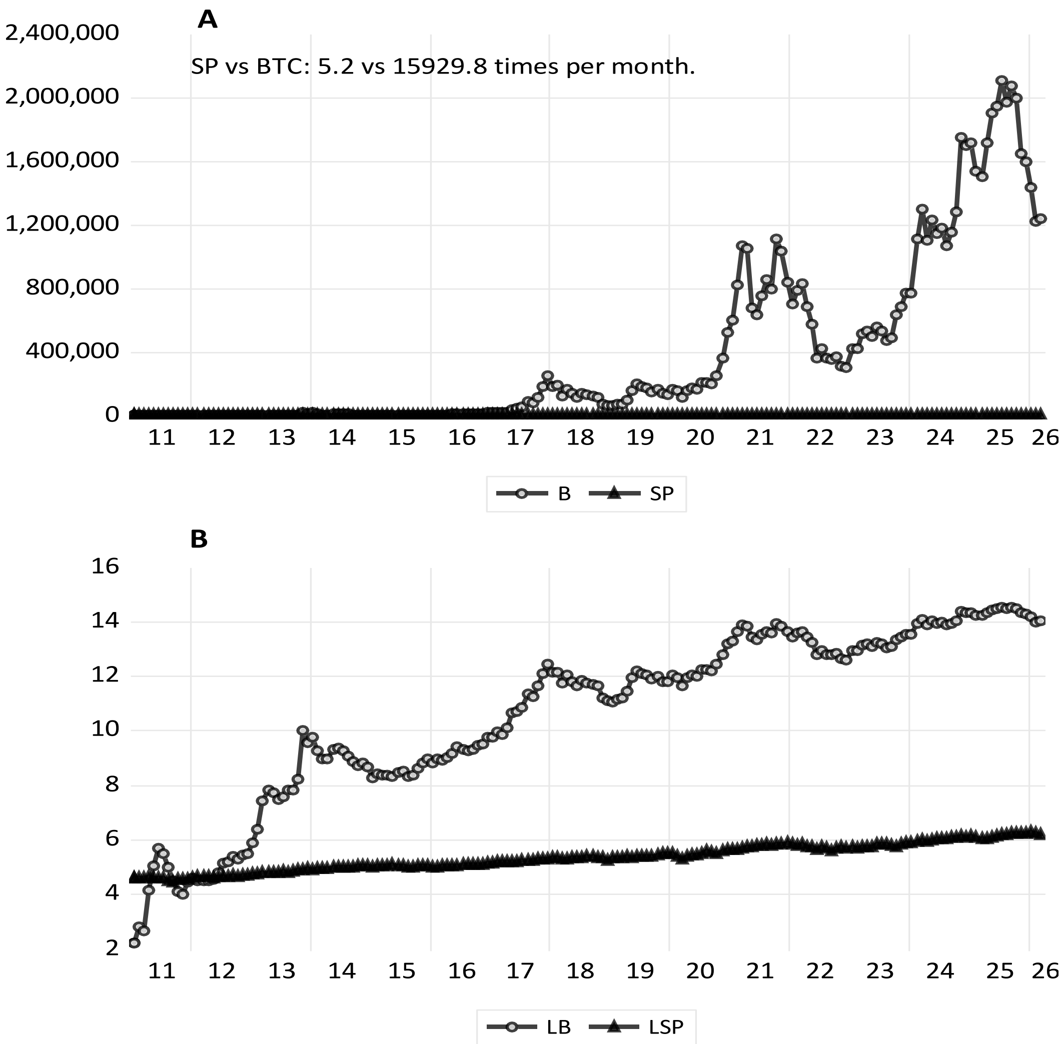


Figure A1. Evolution, Trend, and Cycle of Price of Bitcoin (BTC), period 2010.08-2025.12. Note: Apply *Filter Hodrick-Prescott.*



 doi:10.20944/preprints202605.1522.v1

Figure A2. Evolution of Price of Bitcoin (BTC) with SP500, period 2011.01-2025.12. Notes: 1/ Both variables are on a base year-monthly 2012.01=100. 2/ **Figures A and B** are presented to show how many times Bitcoin (B) has increased compared to the SP500 (SP). The increase is so significant that it is not visible in **Figure A**. However, it is visible in **Figure B**. L indicates the application of the logarithm. 3/ This graph also helps to understand that the BTC market is still relatively new compared to the mature SP500 market.

Appendix A.2. Descriptive Statistics

Table A1 shows descriptive statistics of the model's exogenous variables with 180 monthly data points. It is identified as a stylized fact that the price of the LB variable analyzed in the 2011-2025 period exhibits a significant, explosive, similar to the evolution of the Hash ratio; therefore, a logarithm is applied. The FED interest rate is the most volatile variable (123). Furthermore, during the analysis period, volatile behaviour is identified as a stylized fact, as shown by the coefficient of variation, for both the production cost variable (Hash ratio) and the price of BTC, at 37.14 and 3.14 respectively, in contrast to the lower volatility of the FED system's liquidity, with a coefficient of 3.82.

Furthermore, the correlation between the variables was estimated. The level of association between the interest rate and the BTC price was found to be a coefficient of +0.62. For the liquidity level and the Bitcoin price, the association coefficient was +0.87. In the case of the number of institutional addresses and the production cost, the coefficients were +0.92 and +0.96, respectively, all statistically significant at the 1% level. Only volatility was not statistically significant, with an association coefficient of +0.04.

Table A1. Descriptive statistics.

Details [1]	LB	LL	R	LN	LH	LV
Mean	10,58	9,77	1,50	7,90	16,80	4,45
Standard deviation	3,14	0,37	1,84	1,42	6,24	0,30
Coefficient of variation	29,64	3,82	123,08	17,94	37,14	6,64
Observations	180	180	180	180	180	180

[1] Where Bitcoin price (LB), Liquidity (LL), number of proprietary addresses (LN), Hash capacity (LH), and market volatility (LV) in logarithmic levels. Interest rate (R) in percent.

Appendix B

Appendix B.1. Unit Root of the Time Series (Level and First Difference)

Method [1]	Variable	t-statistic	(C,T,L/B) [2]	First difference	t-statistic	(C,T,L/B) [2]
ADF	ln(B)	-3.14** (0.03)	(C,0,0)	Δln(B)	-10.56*** (0.00)	(0,0,0)
PP	ln(B)	-2.88** (0.04)	(C,0,4)	Δln(B)	-10.41*** (0.00)	(0,0,9)
KPSS	ln(B)	1.62 (—)	(C,0,10)	Δln(B)	0.36** (—)	(C,0,2)
ADF	ln(L)	-1.62 (.46)	(C,0,2)	Δln(L)	-7.24*** (0.00)	(0,0,0)
PP	ln(L)	-1.80 (0.37)	(C,0,7)	Δln(L)	-6.75*** (0.00)	(0,0,8)
KPSS	ln(L)	1.42 (—)	(C,T,10)	Δln(L)	0.20*** (—)	(C,0,7)
ADF		-2.70 (0.23)	(C,T,3)		-3.50*** (0.00)	(0, 0,2)

PP	**R**	-2.08 (0.59)	(C,T,9)	**Δ(R)**	-5.71*** (0.00)	(0, 0,4)
KPSS		0.16 (—)	(C,T,10)		0.08*** (—)	(C,0,9)
ADF		-4.07 (0.01)	(C,T,0)		-10.10*** (0.00)	(0,0,0)
PP	**ln(N)**	-4.07 (0.01)	(C,T,0)	**Δln(N)**	-9.92*** (0.00)	(0,0,5)
KPSS		0.41 (—)	(C,T,10)		0.94*** (—)	(C,0,5)
ADF		-0.66 (.97)	(C,T,2)		-7.57*** (0.00)	(0,0,0)
PP	**ln(H)**	-1.16 (0.91)	(C,T,7)	**Δln(H)**	-10.37 (0.00)	(0,0,0)
KPSS		0.39 (—)	(C,T,10)		0.06* (—)	(C,0,8)
ADF		-4.50*** (0.002)	(C,T,7)		-14.05*** (0.00)	(C,0,0)
PP	**ln(V)**	-4.38*** (0.003)	(C,T,7)	**Δln(V)**	-23.05*** (0.00)	(C,0,46)
KPSS		0.13 (—)	(C,T,9)		0.14*** (—)	(C,0,7)

[1] The unit root test methods used are: Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS), respectively. The null hypothesis of the ADF and PP tests is that the series has a unit root; the null hypothesis of the KPSS test is that the tested series is stationary. [2] (C, T, L/B) refer to the intercept, trend, and lag length (ADF)/bandwidth (Bartlett Kernel of PP) specified in the tests. Intercept and trend were determined experimentally in EViews, which automatically selects the lag length.

Appendix C

Appendix C.1. Times Series Level Monthly (2011-2025) [1]

Details	B	L	R	N	H	V
2011M01	9,09	83,33	0,17	15,27	15,43	85,62
2011M02	16,36	86,24	0,16	25,62	29,57	86,16
2011M03	14,55	89,59	0,14	38,53	56,49	102,42
2011M04	63,64	92,32	0,10	41,52	7,51	80,28
2011M05	158,18	93,85	0,09	85,49	19,15	83,59
2011M06	292,73	97,48	0,09	195,20	75,53	94,66
2011M07	243,64	99,00	0,07	224,56	130,85	95,06
2011M08	149,09	100,29	0,10	180,78	137,23	173,16
2011M09	92,73	99,78	0,08	134,36	128,72	180,57
2011M10	60,00	99,51	0,07	101,70	97,87	162,28
2011M11	54,55	98,52	0,08	94,93	86,17	157,88
2011M12	85,45	100,03	0,07	84,22	88,30	123,83
2012M01	**100,00**	**100,00**	**0,08**	**100,00**	**100,00**	**100,00**
2012M02	89,09	101,16	0,10	104,83	108,51	91,05
2012M03	89,09	99,83	0,13	107,75	119,15	79,93
2012M04	89,09	99,48	0,14	119,42	117,02	88,09

doi:10.20944/preprints202605.1522.v1

2012M05	94,55	97,62	0,16	217,81	122,34	103,81
2012M06	121,82	98,30	0,16	288,92	127,66	104,45
2012M07	170,91	98,56	0,16	304,32	138,30	86,85
2012M08	185,45	99,28	0,13	377,01	180,85	77,56
2012M09	225,45	97,83	0,14	310,76	223,40	75,53
2012M10	203,64	97,74	0,16	336,04	234,04	80,47
2012M11	229,09	100,05	0,16	298,61	255,32	82,55
2012M12	245,45	101,06	0,16	331,05	237,23	85,57
2013M01	370,91	102,66	0,14	420,91	235,11	66,78
2013M02	607,27	107,14	0,15	417,58	287,23	69,55
2013M03	1690,91	110,29	0,14	511,31	446,81	64,41
2013M04	2530,91	112,45	0,15	709,92	702,13	69,06
2013M05	2341,82	115,68	0,11	596,95	925,53	66,68
2013M06	1772,73	119,56	0,09	499,60	1500,00	85,37
2013M07	1930,91	122,36	0,09	527,85	2329,79	69,06
2013M08	2563,64	126,50	0,08	692,80	4531,91	70,24
2013M09	2580,00	128,59	0,08	584,31	9787,23	72,61
2013M10	3840,00	133,11	0,09	715,96	23404,26	76,17
2013M11	21921,82	136,18	0,08	1138,93	47872,34	63,87
2013M12	14652,73	137,97	0,09	1211,91	86170,21	70,14
2014M01	17069,09	137,95	0,07	1077,77	148936,17	70,39
2014M02	10434,55	141,03	0,07	1225,77	255319,15	76,47
2014M03	8085,45	143,04	0,08	1426,94	361702,13	73,36
2014M04	8101,82	143,96	0,09	1313,98	553191,49	70,19
2014M05	11416,36	144,17	0,09	1278,83	755319,15	61,69
2014M06	11547,27	147,49	0,10	1304,58	1106382,98	57,04
2014M07	10718,18	148,80	0,09	1390,95	1393617,02	60,80
2014M08	8760,00	149,44	0,09	1474,68	1819148,94	66,68
2014M09	7058,18	148,70	0,09	1520,23	2446808,51	66,58
2014M10	6143,64	149,08	0,09	1637,40	2797872,34	89,27

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 22 May 2026 doi:10.20944/preprints202605.1522.v1

2014M11	6816,36	150,71	0,09	1671,04	3063829,79	66,29
2014M12	5785,45	151,60	0,12	1835,60	3053191,49	80,52
2015M01	3972,73	148,54	0,11	1893,95	3297872,34	94,51
2015M02	4620,00	149,93	0,11	1776,76	3510638,30	78,60
2015M03	4438,18	153,37	0,11	1957,71	3617021,28	73,21
2015M04	4287,27	151,41	0,12	1939,98	3627659,57	66,68
2015M05	4178,18	147,68	0,12	2037,13	3617021,28	65,94
2015M06	4801,82	147,45	0,13	2264,65	3755319,15	70,88
2015M07	5158,18	147,82	0,13	2454,65	3936170,21	70,93
2015M08	4172,73	149,53	0,14	2297,71	4148936,17	96,05
2015M09	4289,09	151,00	0,14	2459,73	4468085,11	120,51
2015M10	5658,18	152,03	0,12	2588,88	4787234,04	83,00
2015M11	6872,73	151,42	0,12	2918,96	5425531,91	80,13
2015M12	7818,18	145,63	0,24	3517,30	7127659,57	89,13
2016M01	6723,64	144,14	0,34	3685,73	9148936,17	117,25
2016M02	7930,91	146,43	0,38	3878,71	12021276,60	111,32
2016M03	7558,18	147,34	0,36	3669,16	12553191,49	78,35
2016M04	8154,55	147,70	0,37	3432,07	13617021,28	70,69
2016M05	9616,36	145,97	0,37	3426,55	15000000,00	73,41
2016M06	12181,82	145,61	0,38	3702,84	15819148,94	87,84
2016M07	11307,27	144,54	0,39	3540,95	15851063,83	65,05

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 22 May 2026 doi:10.20944/preprints202605.1522.v1

2016M08	10434,55	145,63	0,40	3828,47	16595744,68	61,30
2016M09	11056,36	142,48	0,40	3919,07	18191489,36	70,29
2016M10	12703,64	137,57	0,40	4571,79	19574468,09	72,12
2016M11	13500,00	138,84	0,41	4867,72	21063829,79	75,33
2016M12	17516,36	136,55	0,54	5338,71	23936170,21	61,64
2017M01	17554,55	138,71	0,65	5335,36	28829787,23	57,39
2017M02	21623,64	142,11	0,66	5038,91	34042553,19	56,99
2017M03	19620,00	147,11	0,79	5605,78	36914893,62	58,82
2017M04	24580,00	148,32	0,90	5493,39	47446808,51	64,95
2017M05	41878,18	145,11	0,91	6576,31	46170212,77	53,68
2017M06	45101,82	145,00	1,04	5954,30	53723404,26	51,95
2017M07	52423,64	146,37	1,15	5665,29	63936170,21	50,72
2017M08	86092,73	149,56	1,16	5861,68	67340425,53	59,22
2017M09	79283,64	148,87	1,15	5712,46	84255319,15	51,61
2017M10	117294,55	147,41	1,15	6779,18	98297872,34	50,07
2017M11	180850,91	149,44	1,16	7343,75	107021276,60	52,10
2017M12	251825,45	148,42	1,30	9164,25	140957446,81	50,72
2018M01	186643,64	147,02	1,41	8330,31	186489361,70	54,67
2018M02	187889,09	147,77	1,42	6250,86	235106382,98	111,02
2018M03	126149,09	145,79	1,51	6055,35	263723404,26	94,02
2018M04	168092,73	143,97	1,69	4794,42	301170212,77	90,31

2018M05	136410,91	141,23	1,70	5023,56	333085106,38	69,80
2018M06	116343,64	140,86	1,82	4641,09	395531914,89	67,62
2018M07	140534,55	139,78	1,91	5456,32	421382978,72	65,00
2018M08	127887,27	137,83	1,91	5149,48	516702127,66	62,04
2018M09	120640,00	136,74	1,95	4989,88	545531914,89	63,82
2018M10	115743,64	134,90	2,19	5440,35	545425531,91	95,65
2018M11	73449,09	133,96	2,20	5269,80	472446808,51	95,85
2018M12	67443,64	131,97	2,27	5038,53	408617021,28	123,33
2019M01	62494,55	129,87	2,40	4944,55	444893617,02	96,74
2019M02	69392,73	129,59	2,40	4967,24	465212765,96	75,28
2019M03	74587,27	130,73	2,41	5665,35	477234042,55	71,63
2019M04	96741,82	128,23	2,42	5954,16	487340425,53	64,01
2019M05	155605,45	125,61	2,39	6623,18	538510638,30	82,65
2019M06	196701,82	128,05	2,38	6660,94	597021276,60	78,30
2019M07	183309,09	127,21	2,40	6064,24	709148936,17	65,79
2019M08	174443,64	128,60	2,13	5956,96	791595744,68	93,82
2019M09	150623,64	128,33	2,04	5827,41	938936170,21	76,92
2019M10	166410,91	129,73	1,83	5821,97	1010531914,89	76,47
2019M11	137210,91	131,89	1,55	5868,95	974893617,02	61,89
2019M12	130843,64	134,38	1,55	6029,05	1014042553,19	68,02
2020M01	169983,64	134,34	1,55	6136,50	1160319148,94	68,91

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 22 May 2026 doi:10.20944/preprints202605.1522.v1

2020M02	155340,00	133,26	1,58	6175,06	1174680851,06	97,03
2020M03	116590,91	149,95	0,65	6258,23	1139361702,13	285,42
2020M04	156890,91	193,86	0,05	6667,72	1183723404,26	204,89
2020M05	171905,45	203,52	0,05	7497,47	1122765957,45	152,74
2020M06	166098,18	198,39	0,08	7102,15	1187872340,43	153,83
2020M07	206061,82	185,57	0,09	7921,86	1300851063,83	132,67
2020M08	211712,73	187,79	0,10	8052,80	1315531914,89	113,15
2020M09	195929,09	191,25	0,09	7748,34	1442659574,47	136,68
2020M10	250860,00	192,60	0,09	7798,73	1405851063,83	145,53
2020M11	358147,27	199,06	0,09	8298,42	1373936170,21	123,58
2020M12	526352,73	203,90	0,09	8827,57	1452446808,51	110,58
2021M01	601965,45	203,21	0,09	9461,19	1586276595,74	123,13
2021M02	821163,64	209,40	0,08	8583,99	1650000000,00	114,38
2021M03	1068430,91	226,50	0,07	9219,60	1697553191,49	107,96
2021M04	1049460,00	238,09	0,07	8527,24	1674148936,17	86,11
2021M05	678156,36	237,45	0,06	8572,06	1728404255,32	97,68
2021M06	636852,73	235,55	0,08	6624,34	1273404255,32	83,84
2021M07	755521,82	235,85	0,10	6545,30	1068936170,21	87,00
2021M08	856916,36	242,35	0,09	6906,73	1280000000,00	86,36
2021M09	796787,27	246,14	0,08	6955,65	1451702127,66	97,97
2021M10	1114720,00	246,46	0,08	7759,10	1587978723,40	88,33

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 22 May 2026 doi:10.20944/preprints202605.1522.v1

2021M11	1034234,55	246,88	0,08	7518,86	1710851063,83	91,45
2021M12	840354,55	247,41	0,08	7536,16	1842340425,53	105,54
2022M01	699974,55	238,69	0,08	7029,25	1994893617,02	114,58
2022M02	785240,00	232,26	0,08	6609,90	2104361702,13	127,29
2022M03	827727,27	236,32	0,20	7253,76	2136489361,70	133,32
2022M04	684545,45	229,45	0,33	6929,01	2223617021,28	120,46
2022M05	578061,82	216,74	0,77	7199,66	2327340425,53	144,88
2022M06	362301,82	213,20	1,21	6682,88	2272446808,51	139,55
2022M07	423698,18	214,43	1,68	6557,02	2128191489,36	123,58
2022M08	364434,55	215,49	2,33	6905,68	2238936170,21	109,59
2022M09	353145,45	209,53	2,56	6776,40	2429042553,19	135,15
2022M10	372660,00	208,86	3,08	6941,10	2789574468,09	148,34
2022M11	312070,91	211,19	3,78	7344,07	2717234042,55	115,18
2022M12	300680,00	211,19	4,10	7241,80	2643404255,32	107,66
2023M01	420456,36	210,81	4,33	7435,77	2905638297,87	99,70
2023M02	420554,55	206,15	4,57	6852,91	3159680851,06	99,46
2023M03	517703,64	215,50	4,65	7690,46	3530212765,96	106,97
2023M04	531856,36	217,63	4,83	7552,90	3644255319,15	88,09
2023M05	494838,18	215,37	5,06	6697,86	3838191489,36	87,20
2023M06	554052,73	216,36	5,08	7483,64	3931914893,62	69,20
2023M07	531498,18	212,32	5,12	8055,89	4027021276,60	68,86

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 22 May 2026 | doi:10.20944/preprints202605.1522.v1

2023M08	471587,27	210,37	5,33	7880,52	4108510638,30	78,35
2023M09	490230,91	211,78	5,33	8548,85	4333191489,36	74,99
2023M10	630010,91	212,87	5,33	7597,04	4713617021,28	93,38
2023M11	685689,09	216,09	5,33	8349,58	5030957446,81	69,30
2023M12	768590,91	220,14	5,33	7357,68	5396489361,70	62,88
2024M01	774190,91	221,49	5,33	7603,75	5551702127,66	66,19
2024M02	1112169,09	221,61	5,33	6821,34	6115531914,89	69,11
2024M03	1296945,45	221,60	5,33	7423,30	6367872340,43	68,17
2024M04	1103029,09	218,80	5,33	6214,24	6651489361,70	79,78
2024M05	1227820,00	214,64	5,33	5284,12	6381276595,74	64,56
2024M06	1140987,27	216,07	5,33	4965,69	6172340425,53	62,63
2024M07	1175018,18	213,84	5,33	5741,18	6533510638,30	71,03
2024M08	1072338,18	214,48	5,33	5599,51	6715851063,83	95,45
2024M09	1151621,82	212,49	5,13	5407,89	6820744680,85	87,30
2024M10	1277850,91	210,18	4,83	5505,69	7478510638,30	98,67
2024M11	1752830,91	211,08	4,64	6315,62	7774255319,15	79,19
2024M12	1701040,00	210,47	4,48	6524,18	8279468085,11	78,45
2025M01	1718838,18	211,99	4,33	6010,12	8308617021,28	82,85
2025M02	1534203,64	209,60	4,33	5300,39	8622978723,40	83,89
2025M03	1500887,27	216,27	4,33	5624,72	8690744680,85	107,96
2025M04	1712443,64	216,91	4,33	5497,70	9252553191,49	158,03

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 22 May 2026 doi:10.20944/preprints202605.1522.v1

2025M05	1901781,82	212,61	4,33	5729,00	9540744680,85	101,14
2025M06	1948565,45	216,82	4,33	5370,32	9237021276,60	90,95
2025M07	2104818,18	216,82	4,33	5730,46	9597127659,57	80,97
2025M08	1967760,00	214,52	4,33	5733,18	10103191489,36	77,85
2025M09	2073609,09	207,93	4,22	5445,20	10990000000,00	78,05
2025M10	1992778,18	202,60	4,09	5696,23	11540744680,85	89,42
2025M11	1643167,27	199,13	3,88	5436,02	11588553191,49	97,73
2025M12	1592983,64	201,87	3,72	5328,01	11099574468,09	76,87

[1] Base year monthly 2012.01=100.

References

Andolfatto, D. (2018). “Blockchain: what it is, what it does, and why you probably don’t need one.” SSRN paper.

Biais, B., C. Bisiere, M. Bouvard and C. Casamatta (2019). “The blockchain folk theorem.” The Review of Financial Studies **32**(5): 1662-1715.

Böhme, R., N. Christin, B. Edelman and T. Moore (2015). “Bitcoin: Economics, technology, and governance.” Journal of economic Perspectives **29**(2): 213-238.

Bolt, W. and M. Van Oordt (2020). “On the value of virtual currencies.” Journal of Money, Credit, and Banking **52**(4): 835-862.

Buthelezi, E. M. (2025). “Cryptocurrency responses to us monetary policy shocks: a data-driven exploration of price and volatility patterns.” The American Economist **70**(1): 94-119.

Dwork, C. and M. Naor (1992). Pricing via processing or combatting junk mail. Annual international cryptology conference, Springer.

Fantazzini, D. and N. Kolodin (2020). “Does the hashrate affect the bitcoin price?” Journal of Risk Financial Management **13**(11): 263.

Farrugia, F. and C. Deguara (2025). Mapping Market Mood: A Data-Driven Analysis of Sentiment and Cryptocurrency Price Dynamics. CLOUD Computing–CLOUD 2025. Springer. Hong Kong, China, September 27–30, 2025.

Gonzales, J. R. and L. Varona (2023). “Food import demand in Peru, 1980-2021.” Applied Economics **56**(28): 3371-3384.

Haber, S. and W. S. Stornetta (1990). How to time-stamp a digital document. Conference on the Theory and Application of Cryptography, Springer.

Haeringer, G. and H. Halaburda (2018). “Bitcoin: a revolution?” Economic analysis of the digital revolution, FUNCAS.

Halaburda, H., G. Haeringer and J. Gans (2020). “The Microeconomics of Cryptocurrencies.” Journal of Economic Literature.

Havidz, S. A. H., V. E. Karman and I. Y. Mambea (2021). “Is bitcoin price driven by macro-financial factors and liquidity? A global consumer survey empirical study.” Organizations Markets in Emerging Economies **12**(2): 399-414.

Jiang, J. and B. Huang (2024). The Impact of Bitcoin on Gold: Analysis Based on Autoregressive Distributed Lag, Quantile Regression, and Ordinary Least Squares Models. Proceedings of the International Conference on Digital Economy, Blockchain and Artificial Intelligence.

Köse, N., E. Ünal and S. Gayaker (2026). "The role of global factors in Bitcoin dynamics: Evidence from the TVP-VAR-SV model." Empirical Economics **70**(3): 51.

Koutmos, D. (2018). "Bitcoin returns and transaction activity." Economics Letters **167**: 81-85.

Kumar, A. S. and T. Ajaz (2022). Determinants of Bitcoin price: Evidence from asymmetrical analysis. Studies in International Economics and Finance: Essays in Honour of Prof. Bandi Kamaiah, Springer**:** 557-569.

Liu, K., V. Manahov and D. Stafylas (2025). "An investigation into the relationship between cryptocurrency active addresses and prices during major geopolitical conflicts." The European Journal of Finance **31**(18): 2323-2351.

Luo, J., W.-C. Tsai and K.-C. Yen (2026). "Volatility Transmission to Bitcoin: The Role of VIX Term Structure and Crypto Options Markets." SSRN paper.

Narayan, P. (2004). Reformulating critical values for the bounds F-statistics approach to cointegration: an application to the tourism demand model for Fiji. Australia, Discussion Papers Monash University. **02/04:** 1-32.

Narayanan, A., J. Bonneau, E. Felten, A. Miller and S. Goldfeder (2016). Bitcoin and cryptocurrency technologies: a comprehensive introduction, Princeton University Press.

Othman, A. H. A., S. M. Alhabshi, S. Kassim and A. Sharofiddin (2020). "The impact of cryptocurrencies market development on banks' deposits variability in the GCC region." Journal of Financial Economic Policy **12**(2): 161-184.

Pesaran, M. H. and Y. Shin (1997). An autoregressive distributed-lag modelling approach to cointegration analysis. Symposium at the Centennial of Ragnar Frisch, The Norwegian Academy of Science and Letters, Oslo, March 3-5, 1995., England.

Pesaran, M. H. and Y. Shin (1998). "An autoregressive distributed-lag modelling approach to cointegration analysis." Econometric Society Monographs **31**: 371-413.

Pesaran, M. H. and Y. Shin (1998). An autoregressive distributed-lag modelling approach to cointegration analysis. Econometrics and Economic Theory in the 20"' Century: the Ragnar Frisch Centennial Symposium. A. C. Steinar Strøm, Matthew Jackson. Cambridge University. **31:** 371-413.

Pesaran, M. H., Y. Shin and R. J. Smith (2001). "Bounds testing approaches to the analysis of level relationships." Journal of applied econometrics **16**(3): 289-326.

Pogorelova, P. (2024). "Investigation of the impact of uncertainty indices on Bitcoin volatility using the ARDL model." Applied Econometrics **74**: 35-50.

Polizu, C., E. Oliveros-Rosen, M. de la Mata, T. Kanaster, S. Gupta, L. Guadagnuolo and A. Birry (2023). "Are crypto markets correlated with macroeconomic factors." SP Global.

Sadraoui, T., A. Nasr and N. Mgadmi (2021). "Studding relationship between bitcoin, exchange rate and financial development: A panel data analysis." International Journal of Managerial Financial Accounting **13**(3-4): 232-252.

Smales, L. A. (2020). "One cryptocurrency to explain them all? Understanding the importance of bitcoin in cryptocurrency returns." SSRN paper **39**(2): 118-132.

Srinivasan, P., B. Maity and K. Krishna Kumar (2022). "Macro-financial parameters influencing bitcoin prices: Evidence from symmetric and asymmetric ARDL models." Review of Economic Analysis **14**(1): 143-175.

Tosun, T. T. and E. Uğurlu (2025). "The Impact of the fed's monetary policy on cryptocurrencies: Novel policy implications for central banks." Journal of Risk Financial Management **18**(7): 393.

Varona, L. and J. R. Gonzales (2025). "Human Development, Productivity, and Economic Growth." Journal of Human Development and Capabilities: 1-16.

Varona, L., J. R. Gonzales, B. García and L. Gismera (2024). "Economic growth and the foreign sector: Peru 1821–2020." Cambridge Journal of Economics: 1-39.

Vergili, G. and M. S. Celik (2023). "The relationship between the indices of volatility (VIX) and sustainability (DJSEMUP): An ARDL approach." Business Economics Research Journal **14**(1): 19-29.

 doi:10.20944/preprints202605.1522.v1

Yermack, D. (2013). Is Bitcoin a real currency? An economic appraisal. Handbook of digital currency, Elsevier**:** 29-40.

Zhao, Y., M. Zhang, Z. Pei and J. Nan (2023). "The effects of quantitative easing on Bitcoin prices." Finance Research Letters **57**: 104232.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.