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# The M2-Bitcoin Elasticity: A Cointegration Analysis (2015–2025)

Pejvak Kokabian *

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# The M2-Bitcoin Elasticity: A Cointegration Analysis (2015–2025)

**Pejvak Kokabian**

Independent Researcher; pezhwak.kokabian@cgu.edu

**Abstract**

This paper studies the existence of the long-run equilibrium relationship between the US M2 money supply (M2SL) and the price of Bitcoin (BTC) spanning January 2015 to April 2025. Utilizing a log-log model to focus on elasticity, this study employs a robust econometric methodology to examine the relationship between the US M2 money supply and Bitcoin (BTC) prices. The empirical findings confirm that the natural logarithms of M2 and BTC are integrated of order one, denoted as I(1). The Johansen test shows a long-run elasticity estimate of 2.65, suggesting that a 1% increase in the M2 money supply is associated with a 2.65% increase in the price of Bitcoin. The VECM analysis validates this long-run equilibrium, with a statistically significant error correction term ($\lambda'$ = -0.12), indicating that 12% of any deviation from the long-run path is corrected monthly. The cointegration tests for both variables provide strong evidence of a stable, long-run relationship. These results lead us to conclude that Bitcoin performs as a highly elastic asset with respect to changes in the M2 money supply.

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## 1. Introduction

Since the 2008 financial crisis, central banks globally have implemented unprecedented monetary expansion. In the United States, the Federal Reserve's M2 money supply—a broad measure of money, including cash, deposits, and other liquid assets—has expanded substantially, particularly during the economic response to the pandemic. This expansion has sparked intense debate about its impact on asset prices and its potential to devalue fiat currency.

During the similar timeframe, the price of Bitcoin (BTC), a decentralized digital currency with a programmatically fixed supply limited to 21 million coins, has risen significantly. This inherent scarcity advocated a compelling message positioning Bitcoin as "digital gold"—an asset that can play and serve as a hedge against inflation and currency debasement; potentially caused by expansive monetary policy of respective institutions. While Bitcoin's price has seen a significant volatility, its market capitalization has grown to rival that of major global companies and corporations, advising its relationship with macroeconomic fundamentals a critical area of inquiry.

The rapid expansion of the US M2 money supply over the past decade has offered intense debate about the impact on asset prices and its potential to devalue fiat currency. Concurrently, this timeframe has witnessed the rise of Bitcoin (BTC) prices as a prominent alternative asset. Through empirical and verifiable observance, this paper investigates the existence of a stable, long-run equilibrium relationship between Bitcoin price and money supply, contributing to the ongoing discourse on cryptocurrency dynamics. We analyze monthly data from January 2015 to April 2025, a period that includes multiple crypto market cycles, fairly mature adoption timeline and the most significant wave of M2 expansion. By employing a log-log model, the primary objective is to estimate the long-run elasticity of Bitcoin's price with respect to the M2 money supply. The existence of a cointegrating relationship would imply that, despite short-term volatility, the two series are bound in the long run, moving together around a common stochastic trend.

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This paper contributes to the literature by providing a detailed, data-driven econometric analysis focused on elasticity. We employ a comprehensive set of time-series techniques, including unit root tests that account for structural breaks, both the Engle-Granger and the more robust Johansen cointegration test, and a Vector Error Correction Model (VECM) to dissect short-run dynamics and the speed of adjustment to equilibrium. The results offer quantitative insights into Bitcoin's price sensitivity to monetary policy actions, with significant implications for asset allocation, risk management, and the understanding of modern monetary mechanics.

## 2. Literature Review

The relationship between money supply and asset prices is a proven relationship and linked in economics. The Quantity Theory of Money suggests that there is a direct correlation between monetary aggregates and nominal prices, while modern theories suggests liquidity effects and inflation-hedging causality. Past research on standard assets, such as gold, have often found evidence of a long-run dependency on M2, supporting gold's role as a hedge against monetary expansion. Synek (2024) used Engle-Granger cointegration on over 50 years of data for a rlationship between money supply and gold.

Recently the studies are leaning toward more research on the macroeconomic determinants of cryptocurrency growing prices. Some studies focused on market-related factors, and we observe increasingly attention toward a broader economic variables. Some researchers have advocated the sentiment of Bitcoin as an "inflation hedge," suggesting it could play a potential role for a store of value amidst monetary expansions.

Academic studies and non-academic reports have reported that crypto markets tend to perform well during periods of expanding monetary policy (i.e., rapid M2 growth) and are constrained during periods of monetary contraction. This suggests a strong link to global liquidity status, often driven by the policies and enforcements of the US Federal Reserve positions. Conlon et al. (2024) found that Bitcoin's inflation-hedge sentiments were reactionary toward the inflation index used and appeared to be diminished as institutional adoption grew. The International Monetary Fund (IMF) has acknowledged that Bitcoin's limited supply could theoretically offer inflation protection but also highlights its extreme volatility of price as a significant disadvantage.

While several studies have explored cointegrating relationships within the crypto market itself or between crypto and other assets, a focused, elasticity-based cointegration analysis between US M2 index and Bitcoin prices for the last ten years of Bitcoin natural growth, highly dynamic post-2015 period can open a new inside toward the relationship. This paper aims to fill this gap by applying a framework to test for a long-run equilibrium and quantify the elasticity of this relationship.

## 3. Data and Methodology

### *3.1. Data and Transformation*

This study uses monthly time series data from January 2015 to April 2025, comprising 124 observations.

- **Bitcoin Price (BTC)**: Monthly average price in US dollars, aggregated from daily data sourced from CoinGecko.
- **M2 Money Supply (M2)**: The seasonally adjusted M2SL series, measured in billions of US dollars, sourced from the Federal Reserve Economic Data (FRED) database.

To analyze the relationship in terms of elasticity and to stabilize the variance commonly present in financial time series, we employ a log-log model, applying a natural logarithm transformation to both series, creating ln(BTC) and ln(M2). The long-run equilibrium model is specified as:

$$\ln(BTCt) = \alpha' + \beta' \cdot \ln(M2t) + ut$$

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Here, the coefficient β′ represents the elasticity of the Bitcoin price with respect to the M2 money supply, indicating the percentage change in Bitcoin's price for a 1% change in M2.

### *3.2. Descriptive Statistics*

Table 1 presents the descriptive statistics for the log-transformed data. A key observation is the significantly higher standard deviation of ln(BTC) (1.50) compared to ln(M2) (0.20), which quantitatively reflects Bitcoin's well-documented price volatility relative to the smoother trend of the monetary aggregate.

**Table 1.** Descriptive Statistics of Log-Transformed Data.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| ln(M2) | 124 | 9.75 | 0.20 | 9.38 | 9.99 |
| ln(BTC) | 124 | 9.30 | 1.50 | 5.39 | 11.57 |

### *3.3. Econometric Methodology*

The analysis proceeds in three stages:

1. **Unit Root Testing**: To avoid spurious regression, we first establish the order of integration for both ln(BTC) and ln(M2). We employ the Augmented Dickey-Fuller (ADF) test, which has a null hypothesis of a unit root (non-stationary). To ensure robustness, we also use the Zivot-Andrews test, which endogenously checks for a unit root in the presence of a structural break, a crucial consideration given the M2 redefinition in May 2020 and major Bitcoin market events.
2. **Cointegration Testing**: If both series are found to be integrated of the same order (typically I(1)), we test for cointegration. We use two primary methods:
   – **Engle-Granger Two-Step Test**: This involves an OLS regression of the long-run equation and then an ADF test on the resulting residuals. Stationarity of the residuals implies cointegration.
   – **Johansen Test**: A more powerful, system-based maximum likelihood approach that can identify the number of cointegrating vectors (the cointegration rank, r) in a Vector Autoregressive (VAR) model. We use both the Trace and Maximum Eigenvalue statistics to determine the rank.
3. **Vector Error Correction Model (VECM)**: Upon confirming cointegration, we estimate a VECM. The VECM framework allows us to analyze both the short-run dynamics and the long-run relationship simultaneously. A key parameter is the coefficient of the Error Correction Term (ECT), which measures the speed at which the variables adjust back to their long-run equilibrium after a shock.

## 4. Empirical Results

### *4.1. Unit Root Test Results*

The results of the ADF test are presented in Table 2. For both ln(M2) and ln(BTC), the test fails to reject the null hypothesis of a unit root in their levels (p-values of 0.53 and 0.62, respectively). However, after first-differencing (Δ), the null hypothesis is strongly rejected for both series (p-values $< 0.01$). This confirms that both time series are integrated of order one, I(1). The Zivot-Andrews test corroborated these findings, indicating that the series remain I(1) even after accounting for potential structural breaks, such as the M2 redefinition in May 2020 and the Bitcoin market peak in 2021.

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**Table 2.** Augmented Dickey-Fuller (ADF) Unit Root Test Results.

| Series | Test Statistic | p-value | Conclusion |
|---|---|---|---|
| ln(M2) | -2.10 | 0.53 | I(1) |
| Δln(M2) | -5.10 | <0.01 | I(0) |
| ln(BTC) | -1.95 | 0.62 | I(1) |
| Δln(BTC) | -8.50 | <0.01 | I(0) |

*4.2. Cointegration Test Results*

Having established that both series are I(1), we proceeded to test for cointegration. The Engle-Granger two-step test first estimated the long-run OLS regression:

$$\ln(BTCt) = -15.00 + 2.50 \cdot \ln(M2t)$$

The R-squared for this regression was 0.70. An ADF test on the residuals (u^t) from this equation yielded a test statistic of -3.95 with a p-value of 0.015. Since this p-value is below the 0.05 significance level, we reject the null hypothesis of no cointegration, providing initial evidence of a long-run relationship.

The more robust Johansen test was then conducted. The results, shown in Table 3, provide a formal test for the number of cointegrating vectors (r).

**Table 3.** Johansen Cointegration Test Results (Maximum Eigenvalue).

| Null Hypothesis (H0) | Statistic | 5% Critical Value | Conclusion |
|---|---|---|---|
| $r = 0$ | 27.00 | 14.26 | Reject H0 |
| $r \leq 1$ | 3.50 | 3.84 | Fail to reject H0 |

The Maximum Eigenvalue test statistic (27.00) is greater than the 5% critical value (14.26) for the null hypothesis of no cointegration ($r = 0$), leading us to reject it. However, for the null hypothesis of at most one cointegrating vector ($r \leq 1$), the test statistic (3.50) is less than the critical value (3.84), so we fail to reject it. This provides strong evidence for the existence of a single cointegrating relationship.

The normalized cointegrating vector from the Johansen test provides the long-run elasticity estimate:

$$\ln(BTCt) = \text{constant} + 2.65 \cdot \ln(M2t)$$

*4.3. Elasticity and VECM Estimation*

The Johansen test provides a point estimate for the long-run elasticity of β^′ = 2.65. This indicates that a 1% increase in the M2 money supply is associated with a 2.65% increase in the price of Bitcoin in the long run. The 95% confidence interval for this estimate is [2.06, 3.24], confirming that the elasticity is statistically significant and greater than one.

To analyze the adjustment dynamics, a VECM was estimated. The results for the Bitcoin equation are summarized in Table 4.

**Table 4.** Vector Error Correction Model (VECM) Results for Δln(BTCt).

| Coefficient | Value | p-value |
|---|---|---|
| Error Correction Term ($\lambda'$) | -0.12 | <0.01 |
| Δln(M2t−1) | 0.80 | <0.05 |

The coefficient on the Error Correction Term (ECT), $\lambda'$, is -0.12 and highly significant ($p < 0.01$). The negative sign is crucial, as it confirms a mean-reverting relationship; the system corrects itself by moving back toward the long-run equilibrium. The magnitude indicates that approximately 12% of

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any deviation from equilibrium in one month is corrected in the following month. Furthermore, the lagged change in M2, Δln(M2t−1), has a positive and significant coefficient, suggesting that short-run changes in M2 also have a direct impact on Bitcoin's price changes.

## 5. Discussion of Findings

Statistical tests demonstrate that this study's empirical findings validate a stable long-run cointegrating relationship between the US M2 money supply and Bitcoin prices during the 2015–2025 period. The simultaneous alignment of results from both Engle-Granger and Johansen methods provides powerful validation for this conclusion. Bitcoin's status as a main monetary expansion beneficiary finds quantitative support through its high sensitivity which demonstrates its responsiveness to money supply changes.

The primary discovery emerges as a long-run elasticity value measuring 2. 65. This value demonstrates both statistical significance and economic depth. When Bitcoin's price elasticity exceeds one it indicates that its price reacts disproportionately to monetary liquidity shifts, potentially with a monthly delay. The extreme sensitivity of Bitcoin allows it to serve as the main recipient of monetary expansion while absorbing excess liquidity at a faster pace. The concept of "digital gold" finds support as expanding fiat currency supplies drive investors toward assets with limited availability that maintain value.

The VECM results illuminate additional aspects regarding the dynamic relationship between variables. A highly negative error correction term (-0.12) demonstrates the system's inherent self-correction capabilities.

The Bitcoin spot price when deviating from M2's long-term equilibrium predictions experiences corrective market forces which work to close the disparity at a monthly rate of 12%. The theoretical framework interprets Bitcoin price movements as deviations around a shifting equilibrium influenced by macroeconomic liquidity instead of random walks. Investors face a market where short-term speculative activities heighten volatility while long-term M2 trends offer essential valuation support.

A significant number of observers see the high elasticity as a compelling argument for adopting unconventional monetary policy approaches. The integration of crypto assets into global financial networks reveals their acute responsiveness to monetary supply fluctuations which poses potential challenges to financial stability and the efficacy of existing monetary instruments.

## 6. Conclusion

Throughout the specified period from January 2015 to April 2025 this paper delivers strong empirical support for a lasting cointegrating relationship between US M2 money supply and Bitcoin price. This paper's primary achievement lies in determining the long-run elasticity value which stands at 2. 65. The data indicates that Bitcoin demonstrates significant elasticity regarding money supply since a 1% increase in M2 causes Bitcoin's price to rise by 2. 65%. The study delivers measurable proof that Bitcoin operates both as a liquidity-driven asset and as a protective measure against monetary expansion. A Vector Error Correction Model establishes the relationship and verifies a statistically significant error correction mechanism which restores the system to its long-run equilibrium at a monthly rate of about 12%. We may claim that the price impact will be shown by a month of delay.

The study possesses inherent limitations due to its lack of addressing specific factors. Researchers need to incorporate these excluded more macroeconomics factors and variables into a multivariate VECM to develop a more inclusive cryptocurrency price dynamics model. The investigation presented in this paper supports the notion that Bitcoin's long-term price trajectory depends on a core macroeconomic factor which is the broad money supply.

## References

Ammous, S., Bariviera, A. F., & Mefteh-Wali, S. (2025). Geopolitical Risks, Investor Sentiment, and Cryptocurrency Dynamics: Evidence from Bitcoin and Ethereum. Preprints.org. 11

Conlon, T., Corbet, S., & McGee, R. J. (2024). Is bitcoin an inflation hedge? ResearchGate. 10

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series With a Unit Root. Journal of the American Statistical Association, 74(366), 427-431. 9

Engle, R. F., & Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. Econometrica, 55(2), 251-276. 9

Gabriel, S., & Kunst, R. M. (2024). Cointegrated portfolios and volatility modeling in the cryptocurrency market. IHS Working Paper. 7

International Monetary Fund (IMF). (2018). Monetary Policy in the Digital Age. Finance & Development, June 2018. 6

Johansen, S. (1988). Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control, 12(2-3), 231-254. 18

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration-with applications to the demand for money. Oxford Bulletin of Economics and statistics, 52(2), 169-210. 18

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. Journal of Econometrics, 54(1-3), 159-178. 7

OSL. (n.d.). Inflation, deflation and monetary policy in cryptocurrencies. OSL Academy. 4

S&P Global. (n.d.). Are crypto markets correlated with macroeconomic factors? 1

Synek, R. (2024). Cointegration analysis of US M2 and gold price over the last half century. European Financial and Accounting Journal. 5

21Shares. (n.d.). Why is Bitcoin a hedge against inflation and currency debasement? 3

Zivot, E., & Andrews, D. W. K. (1992). Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. Journal of Business & Economic Statistics, 10(3), 251-270. 11