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

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

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Abstract: This paper studies the existence and nature of the long run equilibrium relationship between US M2 money supply (M2SL) and the price of Bitcoin (BTC) spanning between January 2015 to April 2025. Utilizing a log-log model to focus on elasticity, this study utilizes a robust econometric methodology, including Augmented Dickey-Fuller (ADF) and Zivot-Andrews unit root tests, Engle-Granger and Johansen cointegration tests, and a Vector Error Correction Model (VECM). The empirical findings confirm that the natural logarithms of M2 and BTC are integrated of order one, I(1). The cointegration tests from both variables provide strong evidence of a single, stable long-run relationship between the two series. 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 (λ' = -0.12) indicating that 12% of any deviation from the long-run path is corrected monthly. These results leads us that Bitcoin performs as a highly elastic asset relative to monetary expansion (M2), providing quantitative support for its role as a liquidity-driven asset and offering significant implications for investors and other stakeholders regarding dynamics of monetary policy and digital assets.

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1. Introduction

Since the 2008 financial crisis, unprecedented monetary expansion has been implemented by central banks globally. 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 [1]. This expansion has raised intense debate about its impact on asset prices and its potential to devalue fiat currency.

In the same time, this timeframe has witnessed the rise of Bitcoin (BTC) price, a decentralized digital currency with a programmatically fixed supply limited at 21 million coins [3]. This inherent scarcity has propelled a powerful narrative positioning Bitcoin as "digital gold"—an asset that can serve as a hedge against the inflation and currency debasement potentially caused by expansive monetary policy [3]. While Bitcoin's price has been marked by significant volatility [7], its market capitalization has grown to rival that of major global corporations, making its relationship with macroeconomic fundamentals a critical area of inquiry [7].

This paper through empirical observation investigates the existence of a stable, long-run equilibrium relationship between the US M2 money supply and the price of Bitcoin. Specifically, we analyze monthly data from January 2015 to April 2025, a period that includes multiple crypto market cycles and the most significant wave of M2 expansion. By employing a log-log model, our 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.

This paper contributes to the literature by providing a detailed, data-driven econometric analysis focused on elasticity. We utilize a comprehensive methods of time-series techniques,

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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 sensitivity to monetary policy, 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 foundational and to some extend a proven concept in economics. The Quantity Theory of Money suggests a direct link between monetary aggregates and nominal prices, while modern theories examine liquidity effects and inflation-hedging behavior. Studies on traditional assets, such as gold, has often found evidence of a long-run dependency on M2, supporting gold's role as a hedge against monetary expansion [5]. Synek (2024), used Engle-Granger cointegration on over 50 years of data to confirm this relationship for gold [9].

The academic attention to the macroeconomic determinants of cryptocurrency prices is unnoticed but growing rapidly. Few studies focused on market-related factors, but attention has increasingly shifted to broader economic variables [7]. Observational studies and industry reports have noted 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 [1]. This suggests a strong link to global liquidity conditions, often driven by the actions of the US Federal Reserve.

More recently few activists and academicians promote the idea of Bitcoin as an "inflation hedge" or "digital gold" due to its fixed supply, a plain contrast to the unlimited nature of fiat currencies [3]. However, empirical evidence remains mixed. Conlon et al. (2024) found that Bitcoin's inflation-hedging properties were sensitive to the inflation index used and appeared to diminish as institutional adoption grew [10]. The International Monetary Fund (IMF) has acknowledged that Bitcoin's limited supply could theoretically offer inflation protection but also highlights its extreme price volatility as a significant drawback [6].

While several studies have explored cointegrating relationships within the crypto market itself or between crypto and other assets 7, a focused, elasticity-based cointegration analysis between US M2 and Bitcoin for the recent, highly dynamic post-2015 period is less noticed. This paper aims to fill this gap by applying a framework to multiple test for a long-run equilibrium and quantify the elasticity of the relationship.

3. Data and Methodology

3.1. Data and Transformation

This study applies monthly time series data from January 2015 to April 2025, comprising 124 observations of a decade time-frame.

- **Bitcoin Price (BTC):** Monthly average price in US dollars, aggregated from daily data sourced from CoinGecko [12]
- **M2 Money Supply (M2):** The seasonally adjusted M2SL series, measured in billions of US dollars, sourced from the Federal Reserve Economic Data (FRED) database [13]

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

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

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.

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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 yields 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).9 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 [11]
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 [15]
    - **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 [7]
3. **Vector Error Correction Model (VECM):** While 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 [20]

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.

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)

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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≤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≤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:

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

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 (λ')	-0.12	<0.01
Δln(M2t−1)	0.80	<0.05

The coefficient on the Error Correction Term (ECT), λ', 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 towards the long-run equilibrium. The magnitude indicates that approximately 12% of 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

The empirical results of this study strongly confirm a stable, long-run cointegrating relationship between the US M2 money supply and the price of Bitcoin for the 2015–2025 period. The convergence of findings from both the Engle-Granger and the more powerful Johansen procedures lends strong

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support to this conclusion. This implies that despite Bitcoin's highly short-term volatility, its price does not drift arbitrarily away from the trend in the broad money supply over the long term.

The central finding is the long-run elasticity of 2.65. This value is not only statistically significant but also economically profound. An elasticity greater than one signifies that Bitcoin's price responds more than proportionally to changes in monetary liquidity, plausibly with a delay of a month. This high sensitivity provides quantitative backing for the narrative that Bitcoin acts as a primary beneficiary of monetary expansion and is able to absorb excess liquidity at an accelerated rate. This resonates with the "digital gold" thesis, as the supply of fiat currency increases and investors turn to asset which are scarce store value [3].

Results for VECM can shed additional light on the dynamics of this association. The strongly negative error correction term (0.12) indicates that the system is self-correcting. At the point at which the spot price of Bitcoin strays from its long-term equilibrium level forecasted by M2, market forces converge such that this gap wilts at a monthly pace of 12%. This theoretical framework sees Bitcoin price dynamics, rather than being random walks, as fluctuations around a moving equilibrium driven by macroeconomic liquidity. For investors, this means that, while short-term speculation increasingly drives volatility, long-term trends in M2 can provide a fundamental underpinning for valuation.

For many, the high elasticity highlights an unconventional and strong advocate for monetary policy policies [4]. As crypto assets become more integrated into the financial systems of the world, their noticeable sensitivity to changes in the money supply could have broader implications for financial stability and the effectiveness of available monetary tools.

6. Conclusions

This paper presents robust empirical evidence of a long-run stable cointegrating relationship between the US M2 money supply and Bitcoin price over the period January 2015 to April 2025. By fitting the two series with a log-log model and conducting a battery of econometric tests, we show that both series are non-stationary in isolation, but move together over time.

The main contribution of this paper is to estimate the long-run elasticity equal to 2.65. This suggests that Bitcoin is very elastic with respect to the money supply, and as M2 increases by 1%, the price of bitcoin increases by 2.65%. This result provides quantitative evidence that Bitcoin plays as a liquidity driven assets and a hedge against monetary expansions. Additionally, a Vector Error Correction Model validates the relationship and confirms a statically significant error correction mechanism that returns the system towards its long-run equilibrium at a monthly rate around 12%.

This study is not without limitation. The bivariate model has omitted other possible price-drivers for Bitcoin, such as interest rates, market sentiment, and regulatory news. In addition, the use of monthly data smooths over significant intra-month volatility.

Future studies should include these neglected variables in a multivarite VECM study with the purpose of constructing a more comprehensive model of Bitcoin's price discovery.

Nevertheless, this paper affirm that a fundamental macroeconomic variable—the broad money supply — drives on the price of Bitcoin in long-run.

References

1. Ammous, S., Bariviera, A. F., & Mefteh-Wali, S. (2025). *Geopolitical Risks, Investor Sentiment, and Cryptocurrency Dynamics: Evidence from Bitcoin and Ethereum*. Preprints.org. 11
2. Conlon, T., Corbet, S., & McGee, R. J. (2024). *Is bitcoin an inflation hedge?* ResearchGate. 10
3. 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
4. Engle, R.F.; Granger, C.W.J. Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica* **1987**, *55*, 251–276. https://doi.org/10.2307/1913236.
5. Gabriel, S., & Kunst, R. M. (2024). *Cointegrated portfolios and volatility modeling in the cryptocurrency market*. IHS Working Paper. 7

 doi:10.20944/preprints202506.1963.v1

6. International Monetary Fund (IMF). (2018). Monetary Policy in the Digital Age. *Finance & Development*, June 2018. 6
7. Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12(2-3), 231-254. 18
8. Johansen, S.; Juselius, K. Maximum likelihood estimation and inference on cointegration — with applications to the demand for money. *Oxf. Bull. Econ. Stat.* **1990**, *52*, 169–210, https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x.
9. Kwiatkowski, D.; Phillips, P.C.B.; Schmidt, P.; Shin, Y. Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *J. Econom.* **1992**, *54*, 159–178, doi:10.1016/0304-4076(92)90104-y
10. OSL. (n.d.). *Inflation, deflation and monetary policy in cryptocurrencies*. OSL Academy. 4
11. S&P Global. (n.d.). *Are crypto markets correlated with macroeconomic factors?* 1
12. Synek, R. Cointegration Analysis of US M2 and Gold Price Over the Last Half Century. *Eur. Financial Account. J.* **2024**, *19*, 1–19, https://doi.org/10.18267/j.efaj.283.
13. 21Shares. (n.d.). *Why is Bitcoin a hedge against inflation and currency debasement?* 3
14. 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