Dynamic Linkages and Monetary Policy Transmission in the Cryptocurrency Market: A Vector Autoregressive Study of Bitcoin, Ethereum, and The Fed's Interest Rate

M Z Azhari[1,*], M A A Ghiffari[1], and A Rozaqi[1]

[1] Raden Mas Said Islamic State University of Surakarta, Indonesia

*Corresponding author's email: muhzaki46@gmail.com

Abstract. The cryptocurrency market, characterized by high volatility, has evolved into a significant financial asset class, attracting both retail and institutional investors. Understanding its interconnectedness with macroeconomic factors is crucial for risk management and financial stability. This study empirically analyzes the dynamic relationships between two primary crypto assets, Bitcoin (BTC) and Ethereum (ETH), and the monetary policy shifts of the U.S. Federal Reserve (The Fed). Using a Vector Autoregression (VAR) model on daily time-series data from January 1, 2022, to June 16, 2025, this research investigates the short-term dynamics, Granger causality, and shock transmissions within this system. The findings reveal a significant one-way causal relationship from The Fed's interest rate changes to both Bitcoin and Ethereum returns, challenging the weak-form Efficient Market Hypothesis. Furthermore, Impulse Response Function (IRF) and Forecast Error Variance Decomposition (FEVD) analyses provide robust evidence of Bitcoin's market leadership, with shocks in Bitcoin explaining nearly 70% of the variance in Ethereum's movements. These results highlight a clear hierarchical structure: The Fed influences broad market sentiment, while Bitcoin leads internal market dynamics, offering critical insights for investors and policymakers navigating the digital asset ecosystem.
Keyword: Bitcoin, Cryptocurrency, Ethereum, Monetary Policy, Vector Autoregressive (VAR)

1. Introduction

The cryptocurrency market has demonstrated dynamic interdependencies with monetary policy instruments, such as the Federal Reserve's interest rates, as explored in various empirical studies over the past decade. Research on this interaction has grown rapidly, often employing Vector Autoregression (VAR) models to analyze dynamics, causality, and spillover effects [3, 5]. These studies build upon foundational works like Sims (1980) on VAR models and Engle & Granger (1987) on cointegration, but extend the analysis to more recent periods, including post-COVID effects [10] and the integration of machine learning [1, 9].

Studies indicate that cryptocurrencies are increasingly integrated with traditional markets [14], challenging full market efficiency. Evidence tends to show that monetary policy has a negative impact on crypto returns during tightening cycles [6, 8], although the effect is often indirect, transmitted through investor sentiment and risk appetite. Within the internal dynamics of the crypto market, Bitcoin consistently demonstrates leadership over Ethereum and other crypto assets [5]. This research aims to test these relationships using high-frequency data from a recent period to provide relevant insights for both investors and policymakers.

2. Research Method

This study employs a quantitative approach using high-frequency time-series data to model the dynamic interactions between the cryptocurrency market and monetary policy. The methodological framework

is structured to rigorously test for stationarity, determine the appropriate model specification, and analyze the structural relationships within the system.

2.1. Data and Variables

This study uses daily time-series data from January 1, 2022, to June 16, 2025. The data consists of:

- Bitcoin Price (BTC): Daily closing price of Bitcoin.
- Ethereum Price (ETH): Daily closing price of Ethereum.
- The Fed Interest Rate (Fed_Rate): The Federal Reserve's benchmark interest rate.

Crypto price data and The Fed's interest rate were obtained from the investment portal investing.com. For analysis purposes, the price data were converted into daily log returns to achieve stationarity and stabilize the variance.

2.2. Analysis Procedure

The analysis was conducted through several systematic methodological stages:

i. Stationarity Test: The Augmented Dickey-Fuller (ADF) test was performed on all variables to check for the presence of a unit root and ensure the data was stationary for VAR modeling.
ii. Cointegration Test: The concept of cointegration (Engle & Granger, 1987) was tested using the Johansen method (1991) to check for a long-term equilibrium relationship. The results showed no evidence of cointegration among the variables, so a Vector Error Correction Model (VECM) was not appropriate.
iii. Vector Autoregression (VAR) Model: Based on the test results above, the VAR model was chosen as the most appropriate analysis method to analyze short-term dynamic relationships.
iv. Optimal Lag Determination: The optimal lag length (p) for the VAR model was determined using a combination of information criteria (such as AIC, BIC) and residual diagnostic tests (e.g., Portmanteau test for autocorrelation).
v. Post-Estimation Analysis: This included the Granger Causality Test to examine predictive ability between variables, the Impulse Response Function (IRF) to track the response of one variable to shocks from another, and Forecast Error Variance Decomposition (FEVD) to measure the contribution of each variable to the forecast error variance of others.

3. Result and Discussion

After conducting a series of prerequisite tests and determining the most suitable optimal lag for the model, the VAR and post-estimation analyses produced interconnected findings that provide a deep insight into market dynamics.

3.1. Causality and Monetary Policy Influence

The Granger Causality Test reveals a strong one-way causal relationship from changes in The Fed's interest rate to Bitcoin and Ethereum returns. With highly significant p-values, this result indicates that historical information regarding U.S. monetary policy has predictive power over crypto market movements. This finding challenges the weak form of the Efficient Market Hypothesis (EMH), which states that past prices cannot be used to predict future prices. This result is consistent with the study by Mahmoudi [2], who identified that monetary policy uncertainty negatively impacts Bitcoin returns, and with Pečiulis and Vasiliauskaitė [9], who found that The Fed's interest rates can explain a significant portion of Bitcoin's price variance. Furthermore, the ability of macroeconomic information to predict crypto returns supports critiques of the EMH, similar to the conclusions of the AIMS study [15], which confirmed Bitcoin's role as a hedge against changes in the money supply.

Table 1. Granger Causality Test Results (α = 5%)

Cause Variable (X)	Effect Variable (Y)	P-Value	Conclusion (α = 5%)
ETH_Return	BTC_Return	2,271	Does Not Cause
Fed_Rate_Change	BTC_Return	87	Causes
BTC_Return	ETH_Return	971	Does Not Cause
Fed_Rate_Change	ETH_Return	57	Causes
BTC_Return	Fed_Rate_Change	1,149	Does Not Cause
ETH_Return	Fed_Rate_Change	7,084	Does Not Cause

3.2. Shock Transmission and Market Structure (IRF)

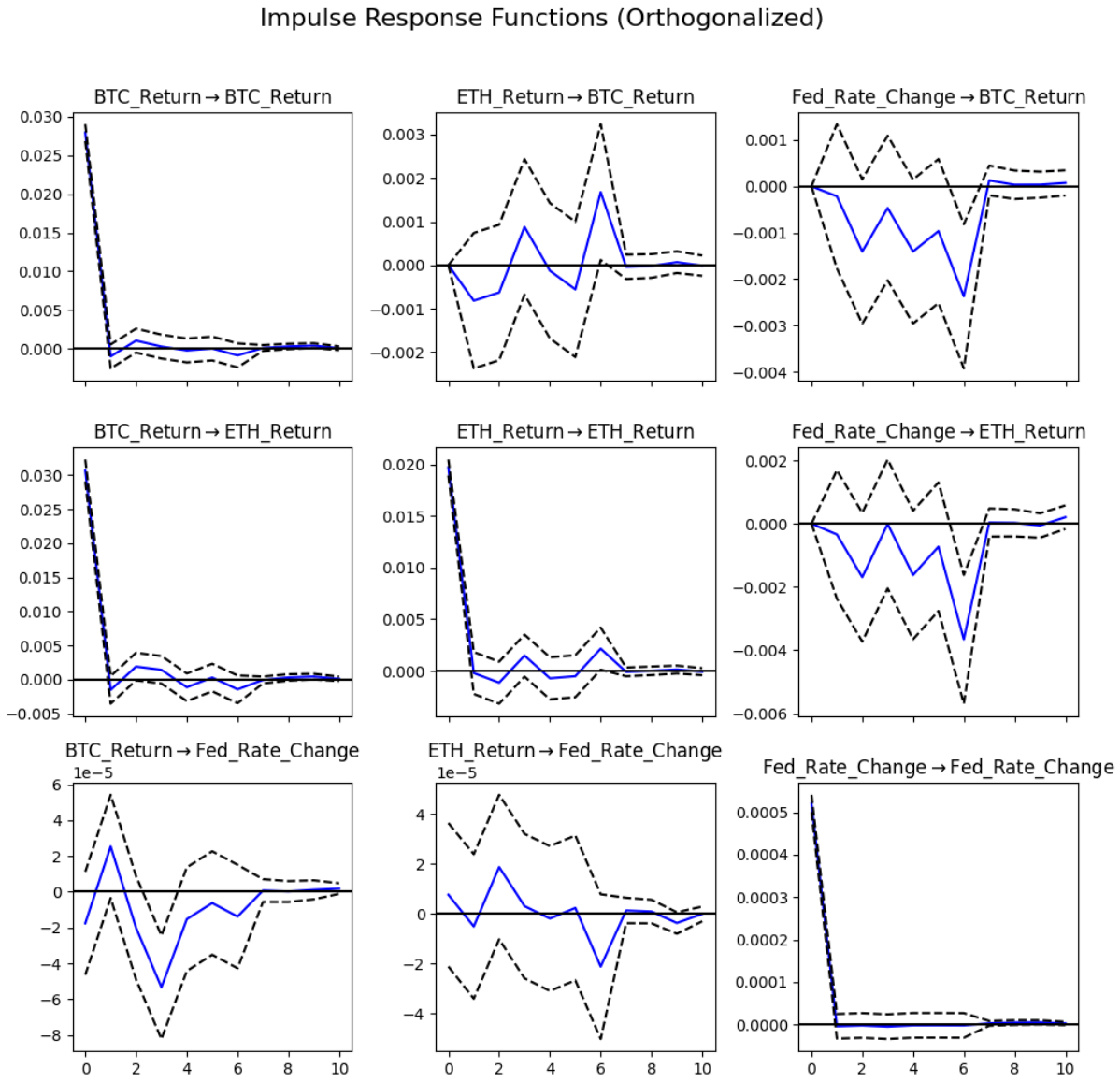

Figure 1. Impulse Response Function Plot

3.2.1. Monetary Policy and Crypto Assets

The Impulse Response Function (IRF) analysis shows that a positive shock to the Fed_Rate_Change variable—representing an unexpected interest rate hike—has a negative and significant impact on BTC_Return and ETH_Return. This is consistent with existing studies that find risky assets tend to perform poorly when global market liquidity tightens. Adams et al. [6], using a structural VAR, attributed 50% of Bitcoin's price decline in 2022 to contractionary monetary policy. Similarly, Suchá [8] found a lagged negative effect from changes in The Fed's interest rate on Bitcoin.

3.2.2. Bitcoin's Dominance in the Crypto Market

In the context of the relationship between Bitcoin and Ethereum, the IRF analysis clearly reveals an asymmetrical relationship. When a positive shock occurs in BTC_Return, it directly and significantly causes a large positive response in ETH_Return. Conversely, a shock to ETH_Return does not show a significant impact on BTC_Return. This provides strong evidence that Bitcoin holds the role of a dominant market leader, while Ethereum acts as a follower, a phenomenon well-documented in crypto finance literature.

Conversely, a positive shock to ETH_Return does not show a significant impact on BTC_Return. This is strong visual evidence that Bitcoin holds the role of a dominant market leader, while Ethereum acts as a follower. This phenomenon reinforces the view, long documented in crypto finance literature, that Bitcoin is the main driving force in the market, with other crypto assets, including Ethereum, often following its movements.

3.3. Quantifying Dependency (FEVD)

The Forecast Error Variance Decomposition (FEVD) quantifies the IRF findings. The results for the 10-day horizon show that nearly 70% of the variance in Ethereum's movement is explained by shocks originating from Bitcoin. This definitively proves Bitcoin's status as the market leader. This finding is very similar to the results of Stanković et al. [5], who found that shocks in Bitcoin explained 46% of Ethereum's variance.

Furthermore, shocks from Fed_Rate_Change explain about 1.4% of the variance in the movements of both Bitcoin and Ethereum. This quantifies the significant external influence of monetary policy. While the percentage seems small, it aligns with other research. For instance, the Bundesbank [11] found that Eurosystem's monetary policy explained less than 10% of Bitcoin's variance. However, Adams et al. [6] argue that while crypto-specific shocks may dominate daily variance, monetary factors are crucial drivers for low-frequency trends, highlighting the nuanced but important role of policy.

4. Conclusion

Based on the analysis conducted, it can be concluded that there is a complex dynamic relationship between Bitcoin, Ethereum, and The Fed's interest rate. The crypto market is not isolated from the macroeconomic financial system, as evidenced by the strong one-way causality from changes in The Fed's interest rate to Bitcoin and Ethereum returns, a finding supported by a growing body of literature [2, 9, 14]. This suggests that the crypto market is not efficient with respect to monetary policy information. Furthermore, Bitcoin holds the role of an absolute leader in the crypto market, where shocks to Bitcoin are instantly and massively transmitted to Ethereum; nearly 70% of Ethereum's movement can be explained by Bitcoin, a finding consistent with other empirical work [5]. This asymmetric relationship shows that influence flows from Bitcoin to Ethereum, and from The Fed to the crypto market, but not the other way around. Thus, The Fed influences overall market sentiment, while Bitcoin leads internal movements within the crypto market, creating a clear hierarchical structure.

References

[1] Shiryaev, A. A. (2022). *Evaluation of VAR-LASSO for Cryptocurrency Price Prediction: An Empirical Review*. Umeå University (Bachelor Thesis).

[2] Mahmoudi, M. (2023). *Examining the Effect of Monetary Policy and Monetary Policy Uncertainty on Cryptocurrencies Market*. arXiv (preprint).
[3] Bathla, V., & Narwal, K. P. (2024). From Digital to Sustainable: Unveiling the Complex Interactions Between Cryptocurrencies, Traditional Markets and Sustainable Finance in India. *International Journal of Research and Analytical Reviews*.
[4] Daruwala, Z. (2025). Exploring External Influences on Cryptocurrency Prices: Using A Multi-Analytical Approach. *International Journal of Economics and Financial Issues*.
[5] Stanković, S., Đorđević, B., & Milojević, N. (2023). Application of the VAR model in examining the determinants of returns of selected cryptocurrencies. *BizInfo (Blace)*.
[6] Adams, A., Ibert, M., & Liao, G. (2024). *What Drives Crypto Asset Prices?* (Working paper)
[7] Auer, R., Cornelli, G., Doerr, S., Frost, J., & Gambacorta, L. (2022). Crypto trading and Bitcoin prices: evidence from a new database of retail adoption. *BIS Working Papers*.
[8] Suchá, M. (2024). *Cryptocurrencies and financial uncertainty*. Charles University (Bachelor Thesis).
[9] Pečiulis, T., & Vasiliauskaitė, A. (2024). EFFECT OF MONETARY POLICY DECISIONS AND ANNOUNCEMENTS ON THE PRICE OF CRYPTOCURRENCIES: AN ELASTIC-NET WITH ARIMA RESIDUALS APPROACH. *ECONOMICS AND CULTURE*.
[10] ALTAY, O. (2025). Analysis of Federal Reserve Policy Rates and Bitcoin Prices: Pre and Post-COVID-19 Differentiations. *Tesam Akademi Dergisi*.
[11] Tosun, T. T., & Uğurlu, E. (2025). The Impact of the Fed's Monetary Policy on Cryptocurrencies: Novel Policy Implications for Central Banks. Journal of Risk and Financial Management, 18(7), 1-14.
[12] Ibrahim, A. (2024). *Understanding BITCOIN Market Mechanics Using Feature Engineering, Data Modeling, and Forecasting Methods*. University of Westminster (PhD Thesis).
[13] Kusumastuty, C. A., Wulandari, D., Narmaditya, B. S., & Kamaludin, M. (2019). Do Monetary Variables Affect to Cryptocurrency Price? Lesson from Indonesia. *Jurnal Ekonomi dan Studi Pembangunan*.
[14] Aldasoro, I., et al. (2025). The Influence of Federal Reserve Monetary Policy on the Crypto Ecosystem.
[15] Buthelezi, E. M. (2025). Cryptocurrency Responses to U.S. Monetary Policy Shocks: A Data-Driven Exploration of Price and Volatility Patterns. The American Economist, 70(1), 94-119.

Official Statistics