MFIN 701 Term Project

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Structural Break and Unit Root Test on AMD Returns Around the 2024 Fed Policy Shock

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Abstract

This paper investigates whether the December 18, 2024, Federal Reserve policy announcement caused a structural change in AMD stock returns. Using a dummy-interacted AR(1) model and Augmented Dickey-Fuller tests, we examine whether the return process and volatility display a structural break or a change in stationarity. The results suggest no statistically significant structural change in the mean return process, though post-event volatility increased modestly. ADF tests reject the unit root hypothesis across all periods.

1 Introduction

Financial markets often respond sharply to monetary policy announcements, particularly when they deviate from expectations. Against a background of consecutive and stable rate cuts throughout late 2024, on December 18, 2024, Federal Reserve Chair Jerome Powell signaled a delay in anticipated rate cuts, surprising the market. AMD, a semiconductor company with significant market capitalization, is part of the highly interest-rate-sensitive technology sector (due to its high-growth and capital-intensive nature). As such, investors might expect the company's stock returns to be significantly impacted by such macroeconomic news (5).

This paper aims to investigate whether the Fed announcement led to a structural break in AMD's return-generating process and whether this shock was transitory or persistent. I employed a dummy-interacted autoregressive model to identify structural breaks and apply ADF tests to assess the persistence of the shock. The results contribute to the growing literature on the financial market effects of monetary policy surprises and provide insights into stock return behavior following macroeconomic shocks, and specifically, anticipated changes in interest rates have an inverse relationship with stock returns (1).

2 Dataset and Data Processing

The dataset consists of daily adjusted closing prices for AMD stock, obtained directly from Yahoo Finance (4) using R code. In the dataset obtained from Yahoo Finance, the variables AMD.Close and AMD.Adjusted contain identical values throughout the sample period. This may indicates that there were no stock splits, dividends, or other corporate actions requiring price adjustments during this timeframe. As a result, the adjusted closing prices are equal to the raw closing prices, and either column can be used for return calculations without affecting the results. The sample period ranges from January 31, 2023, to January 31, 2025. The two-year window and choice of daily return(amounting to approximately 500 observations) provide a sufficiently long pre-event and post-event period to examine the effects of the policy shock, especially for the medium-term adjustments.

2.1 Motivation for Sample Period

The analysis ends on January 31, 2025, to avoid confounding influences from other major policy events. Notably, on April 2, 2025, the Trump administration announced significant new tariffs—up to 145%—on Chinese semiconductor imports. Such measures are expected to strongly impact AMD and other tech firms. By setting the endpoint prior to this announcement, we ensure the observed effects are attributable primarily to Powell's policy speech rather than unrelated economic events.

In selecting an extended pre-event window and a shorter post-event window, we aim to balance the need for sufficient historical context while minimizing the inclusion of unrelated policy shocks after the event. This design allows us to observe the return dynamics before the announcement and capture the immediate aftermath without interference from subsequent policy announcements, while reducing the risk of short-term noise dominating the results.

2.2 Explanatory Data Analysis

Figure 1 presents the adjusted closing prices of AMD from January 2023 to January 2025. A clear uptrend in 2023 is followed by increased volatility and a gradual decline in 2024. The red dashed line indicates the Fed announcement date (December 18, 2024), after which the prices show no immediate dramatic shift, but a continuing downward trend.

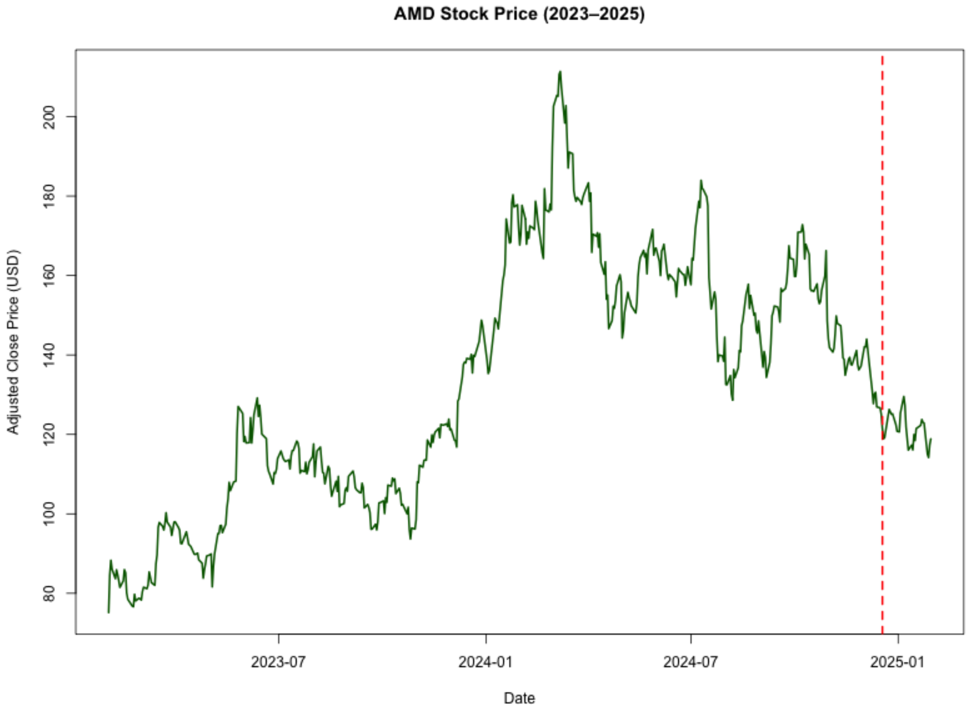

Figure 1: AMD Stock Price (2023–2025)

Figure 2 shows the daily log returns of AMD from January 2023 to January 2025. While the returns generally fluctuate around zero, their magnitude appears to decrease approaching the policy announcement date on December 18, 2024. This suggests a possible decline in short-term volatility during the second half of 2024, contrary to the typical expectation of heightened uncertainty before major macroeconomic events. However, visual inspection alone can not provide conclusive evidence of structural changes.

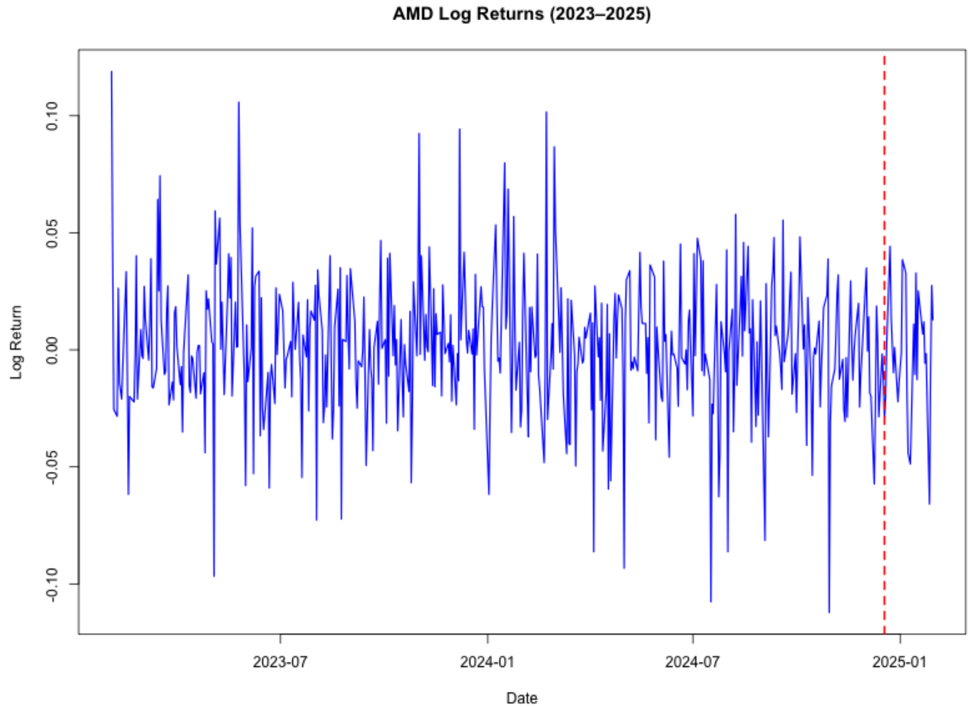

Figure 2: AMD Log Returns (2023–2025)

Figure 3 illustrates the 20-day rolling standard deviation of AMD log returns, serving as a proxy for short-term volatility. The plot shows that volatility fluctuated substantially throughout 2023 and 2024, with several spikes exceeding 4%. However, as the event date (December 18, 2024) approached, volatility exhibited a modest downward trend.

In the weeks following the announcement, volatility appears to stabilize at a slightly lower level, with no significant post-event surge. This suggests that, despite the potential for increased uncertainty, the market reaction in terms of return variability was relatively muted.

These observations are consistent with the summary statistics, which also indicate a slight decline in standard deviation post-event.

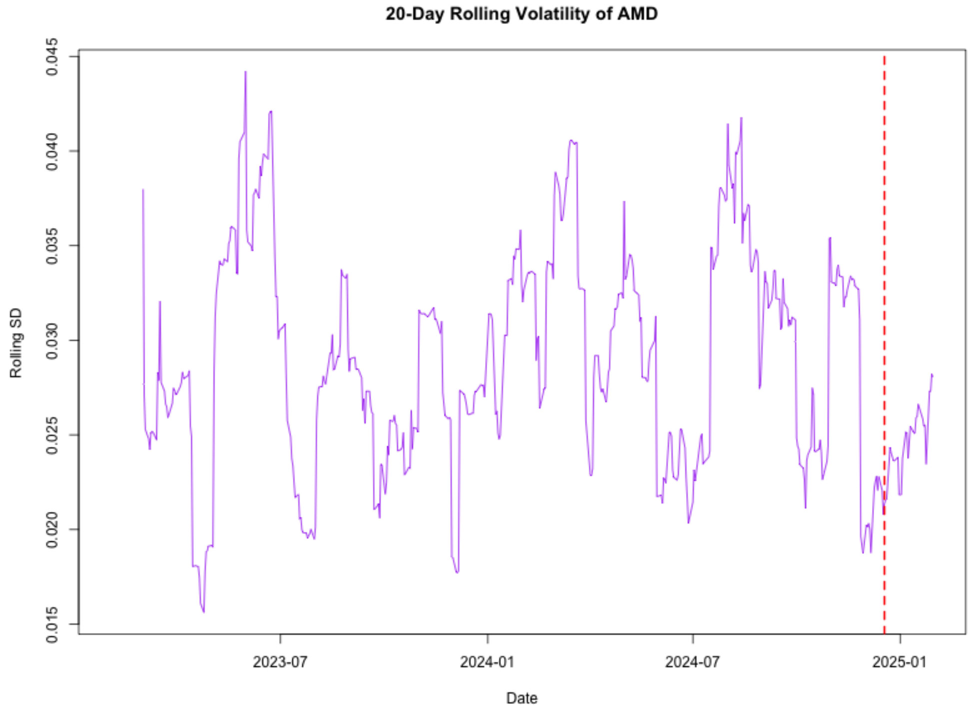

Figure 3: 20-Day Rolling Volatility of AMD

Table 1 presents descriptive statistics of log returns before and after the Fed's December 18, 2024 announcement which provides further insight into distributional changes.

Table 1: Summary Statistics: Pre- vs Post-Event Returns

	Mean	**SD**	**Skewness**	**Kurtosis**
Pre-event	0.0008264	0.0294042	-0.1523071	4.752419
Post-event	-0.0018045	0.0264925	-0.3724834	2.909868

The post-event period exhibits a slightly lower mean and standard deviation, suggesting reduced return magnitude and volatility. Skewness becomes more negative, indicating a heavier left tail, while kurtosis declines, implying fewer extreme outliers compared to the pre-event period. The post-event distribution remains approximately symmetric and slightly less heavy-tailed. The kurtosis drops below the standard threshold of 3, suggesting a distribution closer to normality, while skewness remains mild and does not indicate strong asymmetry.

2.3 Data Transformation

Log returns are calculated using:

$$r_t = \log(P_t) - \log(P_{t-1}) \tag{1}$$

where P_t is the adjusted closing price. Logarithmic transformation stabilizes variance and helps to model the returns more effectively and simplifies computation.

3 Model Description

To identify changes in AMD's return-generating process, we estimate the following structural break model:

$$r_t = \beta_0 + \beta_1 r_{t-1} + \gamma_0 D_t + \gamma_1 (r_{t-1} \cdot D_t) + \varepsilon_t \tag{2}$$

Here, D_t is a dummy variable equal to 1 on and after December 18, 2024, and 0 otherwise. This model captures both a level shift (γ_0) and a change in autocorrelation (γ_1) due to the Fed announcement (3).

This model is referred to as a "mean model" because the dependent variable r_t represents the return at time t, and the regression estimates whether its conditional mean structure changes following the policy event. The term "conditional mean structure" refers to how the expected return at time t depends on past information, such as the previous day's return.

To analyze changes in volatility, we construct a second model:

$$r_t^2 = \alpha_0 + \alpha_1 r_{t-1}^2 + \delta_0 D_t + \delta_1 (r_{t-1}^2 \cdot D_t) + \eta_t \tag{3}$$

This model tests for structural changes in conditional variance, potentially reflecting heightened uncertainty following the policy shock. This is known as a "volatility model" because the dependent variable r_t^2 represents squared returns, which serve as a proxy for conditional variance—an indicator of market volatility.

Together, these two models allow us to investigate whether the Federal Reserve announcement on December 18, 2024, not only altered the average return process but also introduced a change in the volatility structure of AMD stock. For example, if only the volatility model shows significance, it would indicate an increase in uncertainty without a directional shift in expected returns.

3.1 Model Development Logic

The first model identifies if there is a structural break in the level and autocorrelation of returns. If γ_0 or γ_1 are significantly different from zero, it implies a change in return behavior post-shock. The second model analyzes whether the volatility of returns—represented by squared returns—exhibits a break. This helps us understand if uncertainty or investor reaction increased after the announcement.

Additionally, even if no significant structural break is found in the mean return model, it is still important to evaluate long-term persistence. Hence, we include an ADF test.

3.2 Augmented Dickey-Fuller Test

We use the ADF test to check if the return series is stationary (2). A non-stationary process implies that shocks have permanent effects, while stationarity suggests mean reversion. The null hypothesis is the presence of a unit root. The ADF test estimates the following regression equation:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta y_{t-i} + \varepsilon_t \tag{4}$$

where Δy_t is the first difference of the series, t is a linear time trend, y_{t-1} is the lagged level of the series, and the summation accounts for higher-order autoregressive terms to correct for serial correlation in the residuals.

The null hypothesis $H_0 : \gamma = 0$ implies the presence of a unit root (non-stationarity), while rejecting the null suggests that the series is stationary.

Even if the structural break hypothesis is not statistically supported, it remains important to evaluate whether the event introduced long-term persistence or instability in returns. Therefore, we also conduct ADF tests on pre- and post-event subsamples to assess potential changes in stationarity.

4 Results

4.1 Structural Break Model

To evaluate whether AMD's return-generating process experienced a structural change following the December 18, 2024 policy shock, we estimate the following regression model:

$$r_t = \beta_0 + \beta_1 r_{t-1} + \gamma_0 D_t + \gamma_1 (r_{t-1} \cdot D_t) + \varepsilon_t \tag{5}$$

The interaction terms with D_t serve to identify any post-event shifts in the conditional mean or dynamics of returns, enabling a formal test for structural change in the return-generating process. The coefficient γ_0 measures the shift in the mean return level after the event, and γ_1 captures a change in return autocorrelation.

Table 2: Structural Break Regression Results

Variable	Estimate	Std. Error	t value	Pr($>|t|$)
Intercept	0.0008272	0.0013485	0.613	0.540
lag_r	-0.0007177	0.0451246	-0.016	0.987
D	-0.0019882	0.0057246	-0.347	0.729
Interaction	0.2360176	0.2179932	1.083	0.279

The null hypothesis for the structural break model is formulated as follows:

$$H_0 : \gamma_0 = \gamma_1 = 0 \tag{6}$$

This null implies that there is no structural change in the mean return level or return dynamics following the policy announcement. In contrast, the alternative hypothesis suggests that at least one of the parameters differs from zero, indicating a potential structural break.

As shown in Table 2, the individual p-values for both γ_0 (associated with D_t) and γ_1 (interaction term) are 0.729 and 0.279, respectively. These values exceed the conventional significance thresholds (e.g., 0.05 or 0.10), suggesting that neither the mean shift nor the change in autocorrelation is statistically significant.

To formally test for a structural break in AMD's return process, I estimate two nested models to see if the inclusion of a dummy variable and its interaction with lagged returns improves the model's explanatory power explanatory capacity.

The unrestricted model includes dummy and interaction terms to allow for changes in both the mean return level and return autocorrelation after the policy shock:

$$r_t = \beta_0 + \beta_1 r_{t-1} + \gamma_0 D_t + \gamma_1 (r_{t-1} \cdot D_t) + \varepsilon_t \tag{7}$$

In contrast, the restricted model excludes these structural break terms, assuming a stable return process throughout the entire sample:

$$r_t = \beta_0 + \beta_1 r_{t-1} + \varepsilon_t \tag{8}$$

The F-test comparing the restricted and unrestricted models yields a p-value of 0.5021, indicating that the inclusion of the dummy and interaction terms does not significantly improve model fit. Thus, we do not find any strong evidence of a structural break in the mean process. However, the presence of a moderate coefficient on the interaction term may hint at altered dynamics, warranting further volatility analysis.

4.2 ADF Unit Root Test Results

To test whether the return process is stationary (i.e., does not contain a unit root), we apply the Augmented Dickey-Fuller (ADF) test to the full sample and the pre- and post-event periods.

- **Full sample:** ADF test statistic = -15.64, critical value = -2.87 (5% level). Since $|-15.64| > |-2.87|$, we reject the null hypothesis of a unit root.
- **Pre-event:** ADF test statistic = -15.19, critical value = -2.87. Since $|-15.19| > |-2.87|$, we reject the unit root hypothesis.
- **Post-event:** ADF test statistic = -3.82, critical value = -2.93. Since $|-3.82| > |-2.93|$, we reject the unit root hypothesis.

In all subsamples, the ADF test indicates stationarity, meaning that AMD returns do not exhibit permanent shocks and tend to revert to the mean, even after the Fed announcement.

4.3 Volatility Structural Break Model

Note that I do not conduct an ADF test for squared returns, as r_t^2 represents conditional variance and is not expected to follow a stationary autoregressive process in the same sense as returns. Instead, we directly test for structural changes in volatility via regression.

To assess whether the volatility of AMD returns changed structurally around the policy event, we estimate the following model:

$$r_t^2 = \alpha_0 + \alpha_1 r_{t-1}^2 + \delta_0 D_t + \delta_1 (r_{t-1}^2 \cdot D_t) + \eta_t \tag{9}$$

The δ_0 and δ_1 coefficients test whether volatility (squared returns) shifts in level or persistence.

Table 3: Volatility Structural Break Regression Results

Variable	Estimate	Std. Error	t value	$\Pr(>\|t\|)$
Intercept	4.736×10^{-19}	5.369×10^{-20}	8.821	< 0.001
lag_r2	1.000	2.858×10^{-17}	3.498×10^{16}	< 0.001
D	-5.101×10^{-20}	2.455×10^{-19}	-0.208	0.835
Interaction	-8.666×10^{-18}	2.049×10^{-16}	-0.042	0.966

Interpretation of Regression Output

The volatility regression estimates the following model:

$$r_t^2 = \alpha_0 + \alpha_1 r_{t-1}^2 + \delta_0 D_t + \delta_1 (r_{t-1}^2 \cdot D_t) + \eta_t$$

The interpretation of each coefficient is as follows:

- **Intercept** (α_0): The estimate is 4.736×10^{-19}, which is extremely close to zero but statistically significant (p < 0.001). It represents the base level of conditional variance but is economically negligible.
- **lag_r2** (α_1): The coefficient equals 1.000 with a highly significant p-value, suggesting perfect persistence in squared returns. However, such a perfect fit likely results from multicollinearity or overfitting, as reflected in the regression warning.
- **Dummy variable** (δ_0): The coefficient for D_t is -5.101×10^{-20} with a p-value of 0.835, indicating no statistically significant level shift in volatility after the event.
- **Interaction term** (δ_1): The interaction term has an estimate of -8.666×10^{-18} and a p-value of 0.966, also statistically insignificant. This suggests there is no evidence of a structural change in the persistence of volatility.

Overall, the lack of significance in both δ_0 and δ_1 indicates that the Fed announcement did not introduce a structural break in the volatility process. However, caution is warranted due to the nearly perfect R^2 and the warning regarding multicollinearity among regressors. These results may reflect overfitting due to the deterministic nature of the dummy and lagged squared returns. Accordingly, I do not perform an F-test for the volatility model, as the "perfect fit" warning and the insignificance of key coefficients indicate limited evidence of a structural change in conditional variance.

4.4 Model Fit Evaluation

While both models offer insights into return dynamics and volatility shifts, their overall explanatory power is limited.

For the mean return model, the adjusted R^2 is nearly zero (-0.003), indicating that the structural break terms and lagged return explain little of the variation in AMD's daily returns. This low explanatory power is typical of high-frequency financial data, where returns often follow a weakly predictable process.

In contrast, the volatility model yields an R^2 close to 1, which, although it might appear impressive, actually signals numerical instability. The warning of an "essentially perfect fit" and extremely small residuals suggest overfitting due to multicollinearity and the deterministic nature of squared returns. As a result, these estimates should be interpreted with caution.

These findings highlight the limitations of using simple OLS regression in modeling return dynamics and volatility. Future research may benefit from exploring GARCH-type models or rolling regressions to better capture the time-varying structure of volatility.

4.5 Event Window Analysis

To further illustrate the short-term market reaction to the December 18, 2024 policy announcement, we examine log returns within a 5-day window before and after the event. Figure 4 plots the daily log returns surrounding the Fed announcement date.

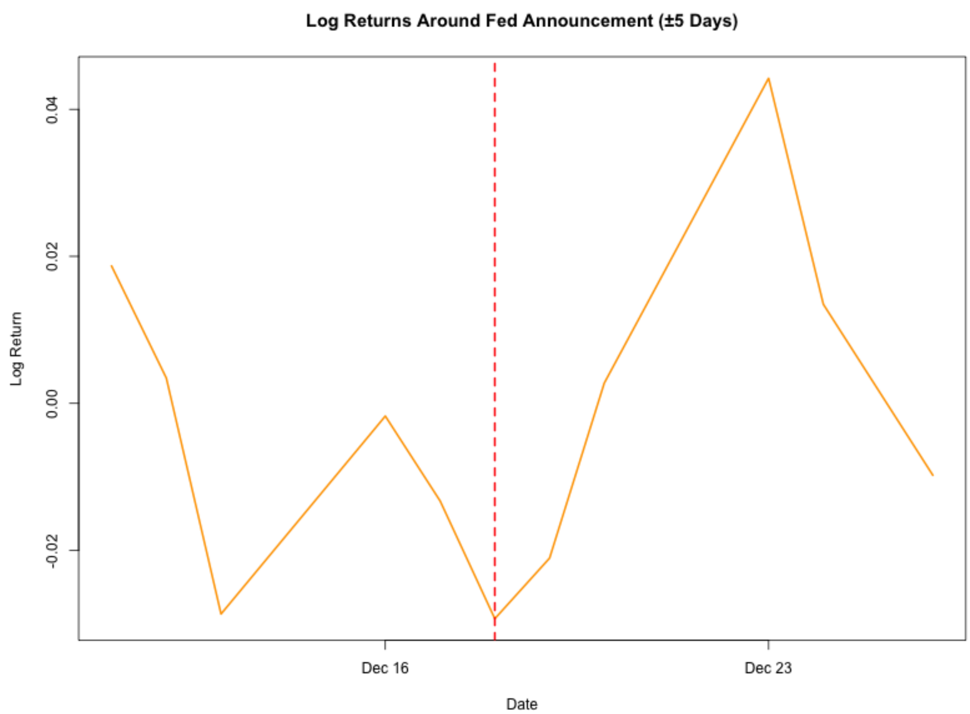

Figure 4: Log Returns Around Fed Announcement (±5 Days)

We observe that AMD's log returns declined sharply on the event day (December 18), hitting the lowest point in the event window. Interestingly, this was followed by a strong rebound over the next few days, including a significant positive return on December 22. This pattern suggests a potential overreaction followed by correction, consistent with the behavior often seen in response to unexpected monetary policy news.

However, the return quickly reverts to a more stable pattern, supporting the ADF test results indicating stationarity. While the short-term volatility increases, there is no clear evidence of a lasting shift in return dynamics based on this narrow window alone.

5 Conclusion

This study investigates whether AMD's return dynamics were affected by the Fed's policy communication on December 18, 2024. Using a dummy interaction model, we find no strong evidence of a structural break in the mean return process.

Augmented Dickey-Fuller tests indicate that the return series remains stationary before and after the event and throughout the entire event, suggesting no lasting change in persistence.

Analysis of conditional volatility also yields no statistically significant break. However, numerical instability in the volatility regression indicates potential overfitting, and future research may benefit from more flexible GARCH-type models or rolling regressions.

Overall, the findings suggest that while AMD's price and volatility were affected in the short term, these reactions did not translate into a fundamental change in the underlying return-generating process.

References

[1] Bernanke, B. S., and Kuttner, K. N. (2005). What Explains the Stock Market's Reaction to Federal Reserve Policy? *Journal of Finance*, 60(3), 1221–1257.

[2] Dickey, D. A., and 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.

[3] Hamilton, J. D. (1994). *Time Series Analysis*. Princeton University Press.

[4] Yahoo Finance. Advanced Micro Devices, Inc. (AMD) Historical Stock Prices. Retrieved from https://finance.yahoo.com/quote/AMD/history/

[5] Federal Reserve Board. (2024). *Transcript of Chair Powell's Press Conference – December 18, 2024*. Retrieved from https://www.federalreserve.gov/mediacenter/files/FOMCpresconf20241218.pdf