STATS 170 Final Project

Evaluating and Forecasting US/UK Exchange Rate Volatility During Geopolitical Events Using GARCH

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Abstract

This project investigates the extent to which asymmetric GARCH models outperform symmetric GARCH models in explaining forecasting the volatility of the US/UK exchange rate during major geopolitical events. Utilizing monthly exchange rate data from 1971 to 2026, an ARMA(1,0) was applied model alongside standard GARCH(1,1), EGARCH(1,1), and GJR-GARCH(1,1) models. Geopolitical shocks were incorporated as external regressors. The results demonstrate that the asymmetry parameters in both the EGARCH and GJR-GARCH models lack statistical significance, indicating that the US/UK exchange rate does not exhibit the classic leverage effect. Furthermore, forecasting over an 80/20 data split yielded negligible differences in Root Mean Squared Error (RMSE) between the complex models and the standard model. The standard symmetric GARCH(1,1) was identified as the optimal framework for evaluating and forecasting the volatility in the US/UK exchange rate.

1 Introduction

Volatility is a cornerstone metric of financial econometrics, particularly for capturing the unique clustering behavior in asset returns. With financial data, volatility often exhibits asymmetric behavior. This behavior is is referred to as the "leverage effect", where negative shocks generate a larger increase in volatility than positive shocks of the same magnitude. This report examines whether the expectation of asymmetric behavior translates to exchange markets, specifically the US/UK exchange rate. By analyzing periods of extreme market stress, this study seeks to answer the following research question: To what extent do asymmetric GARCH models outperform symmetric models in explaining historical variance and forecasting volatility of the US/UK exchange rate during major geopolitical events? By comparing the historical explanatory power and predictive accuracy of symmetric and asymmetric models, this analysis tests whether modern crises induce directional panic or if currency markets maintain a structurally symmetric response to both appreciation and depreciation.

2 Methodology

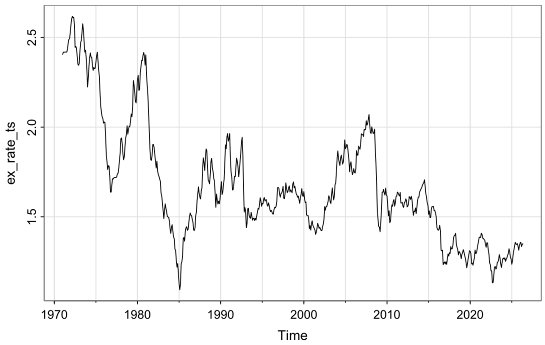
2.1 Preprocessing and Transformation

The dataset consists of monthly US/UK exchange rate observations beginning in January 1971. To achieve stationarity and calculate continuous compounding, the data was transformed into log returns and differenced.

To evaluate the impact of specific historical shocks, a dummy variable matrix was constructed to flag the following geopolitical events:

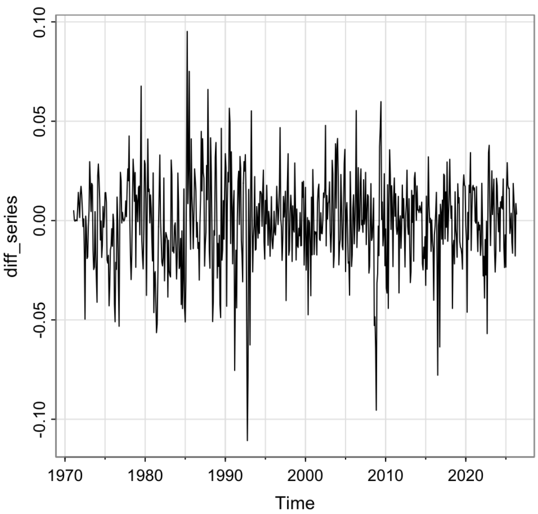
- End of Bretton Woods (August 1971)
- The Plaza Accord (September 1985)
- Black Wednesday (September 1992)
- Global Financial Crisis (September 2008)
- Brexit Referendum (June 2016)
- COVID-19 Market Crash (March 2020)
- UK "Mini-Budget" Crash (September 2022)

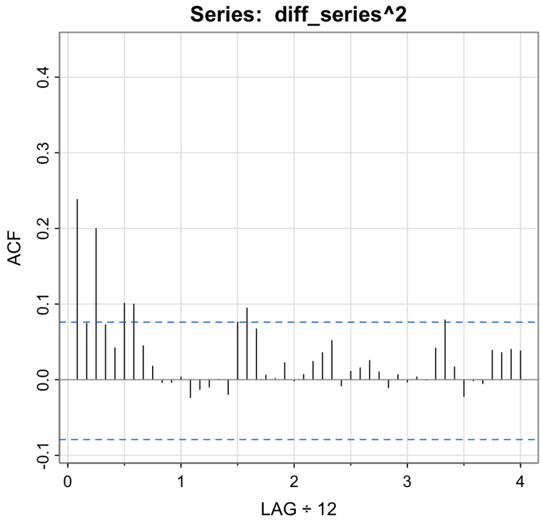
Each event was exhibited a significant peak or drop in the original series in the figure below.



2.2 Diagnostic Testing

Initial diagnostics confirmed the presence of volatility clustering. An Autocorrelation Function (ACF) plot of the squared differenced series revealed significant autocorrelation. Furthermore, an initial ARMA(1,0) mean model was fitted, and the residuals exhibited leptokurtic (fat-tailed) behavior, which justifying the use of a Student-t distribution for subsequent modeling.





2.3 Model Specification

Three distinct volatility models were evaluated to test for the leverage effect, all utilizing an ARMA(1,0) mean equation and a Student-t distribution:

- Standard GARCH(1,1)
- EGARCH(1,1)
- GJR-GARCH(1,1)

2.4 Model Fitting

To evaluate the historical presence of asymmetric volatility and the impact of geopolitical shocks, the models listed above were fitted to the entire dataset (1971–2026). Model selection for historical explanatory power was determined using the Bayesian Information Criterion (BIC) and parameter significance.

2.5 Forecasting

To evaluate predictive accuracy, an 80/20 chronological split was applied. The three models were re-specified and re-estimated using the training data. A 1-step ahead dynamic filter was then applied to the testing data. The forecasted conditional variance from these structurally models was compared against the true variance of the test window using Root Mean Squared Error (RMSE).

3 Results

3.1 Explanatory Model

When evaluating the complete 1971–2026 dataset, the models revealed a lack of statistical evidence for asymmetric volatility. The asymmetry parameters in both the EGARCH and GJR-GARCH models yielded p-values well above the 0.05 significance threshold. Because the asymmetric parameters failed to provide explanatory value, the BIC heavily penalized the complex models. The standard GARCH(1,1) achieved the most optimal BIC, confirming it as the best historical fit for the complete timeline. Furthermore, the external regressor testing for geopolitical shock dates lacked strict significance, indicating that the baseline GARCH mechanics were sufficient to explain the market chaos without an artificial crisis multiplier.

Table 1: Bayesian Information Criterion (BIC) Model Comparison

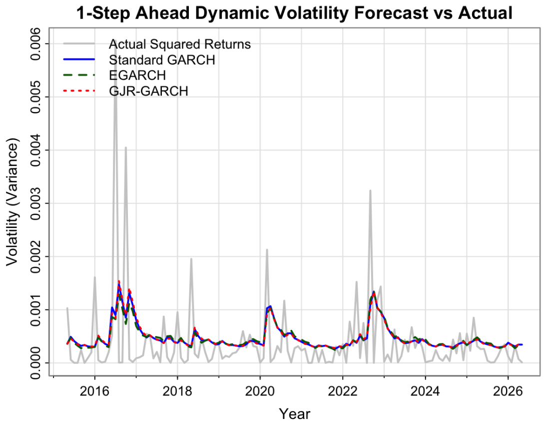
Volatility Model	**BIC**
Standard GARCH(1,1)	-4.781571
EGARCH(1,1)	-4.775152
GJR-GARCH(1,1)	-4.770372

3.2 Forecasted Model

The calculated RMSE for the models were: Standard GARCH RMSE: 0.000754 GJR-GARCH RMSE: 0.000754 EGARCH RMSE: 0.000750 While the re-fitted EGARCH technically achieved the lowest RMSE during the test window, the margin of improvement over the standard GARCH was negligible (0.000004). Graphically overlaid against the actual realized variance, the forecasts generated by all three models were visually indistinguishable. Because the asymmetry parameters were proven statistically insignificant during the full-sample inference phase, the EGARCH's microscopic predictive advantage likely represents minor overfitting rather than a true breakthrough. As a result the standard GARCH(1,1) remains the optimal model for evaluating both historical and future variance.

Table 2: Forecasting Performance (RMSE)

Volatility Model	**RMSE**
Standard GARCH	0.0007258317
EGARCH	0.0007255749
GJR-GARCH	0.0007330791



4 Discussion

The findings of this project offer insights into the mechanics of the US/UK foreign exchange market. Most notably, the results strongly reject the presence of the leverage effect in this specific currency pair. Unlike traditional markets, which succumb to asymmetrical panic during downturns, the US/UK exchange rate behaves purely symmetrically. A sudden appreciation of the Pound causes the exact same level of market variance as a sudden depreciation of equal size.

Furthermore, while geopolitical events undoubtedly caused massive spikes in the exchange rate, the volatility generated during these periods was proportionally standard. The models did not require statistically significant dummy variables to explain the chaos; the standard GARCH architecture successfully interpreted the sheer magnitude of the price movements and adjusted the conditional variance accordingly.

Ultimately, with the negligible difference in RMSE, we favor the simpler standard GARCH model. Additionally, since the asymmetry parameters were statistically insignificant during the exploration phase, the microscopic predictive advantage of the EGARCH model in the testing phase likely represents minor overfitting. Therefore, the standard GARCH(1,1) is the optimal, model for both explaining and forecasting geopolitical volatility in the US/UK exchange rate.

Acknowledgements

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