Bond Yields, Macroeconomic Variables, and Exchange Rates: A Dynamic Interaction for Price Stability

Exploring the Interrelationship Between Inflation, Economic Growth, and Exchange Rate Movements to Understand Long-Term Price Stability

Rahul Kumar

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1 Abstract

This study examines the joint dynamic of bond yields, macroeconomic variables, and the REER. Understanding the interplay between these factors is crucial for policymakers, investors, and researchers, as it offers insights into financial market behavior, exchange rate movements, and the overall macroeconomic environment. While the literature reviewed do not directly address the REER, they offer a valuable framework for investigating its relationship with bond yields and macroeconomic variables. Ang, A., & Piazzesi, M. (2002) emphasize the importance of incorporating macroeconomic factors into models analyzing bond yield dynamics. Specifically, studies have shown that macroeconomic variables like inflation and economic growth play a significant role in explaining movements in bond yields. Building upon these findings, this study aims to investigate -

- whether the interplay of macroeconomic variables and bond yields can offer insights into future REER movements.
- Explore the potential of using bond yield dynamics and macroeconomic variables as leading indicators for the REER.

This research will employ methodology which emphasize incorporating macroeconomic factors into term structure models. By adapting these models to incorporate the REER, this study aims to provide a comprehensive understanding of the complex relationship between bond yields, macroeconomic conditions, and exchange rate dynamics. The findings of this study will be relevant to policymakers, investors, and researchers seeking to understand and navigate the complexities of the global financial landscape.

2 Introduction

The intricate relationship between bond yields, macroeconomic variables, and exchange rate dynamics lies at the core of modern financial and economic analysis. Bond yields, often regarded as a reflection of economic sentiment, provide insights into investor expectations concerning inflation, interest rates, and economic stability. Understanding how these yields interact with macroeconomic factors, and their subsequent influence on exchange rates, is critical for central banks, financial institutions, and policymakers. This study aims to illuminate these complex interdependencies, with a particular focus on price stability and the Real Effective Exchange Rate (REER).

The global financial landscape has grown increasingly complex and interconnected. Historical crises, such as the Great Financial Crisis of 2007-2009, underscored the limitations of conventional economic models in predicting and mitigating systemic risks. These models often focused narrowly on firm-level or market-specific factors, neglecting the broader macroeconomic environment. Consequently, they failed to capture the system-wide dynamics that intensified the crisis. The GFC highlighted a crucial gap: the need for models that not only consider micro-level interactions but also incorporate comprehensive, macro-level data that can reflect the interconnectedness of global financial systems. This paper responds to that gap by adopting a term structure model that integrates macroeconomic variables and latent factors to understand their collective impact on bond yields and REER.

At the heart of this study is the hypothesis that macroeconomic variables such as inflation, interest rates, and economic output can serve as early indicators for REER fluctuations, providing essential foresight into price stability and economic resilience. The approach builds on a term structure model that leverages both observed economic indicators and latent, unobservable factors. By doing so, it bridges the gap between existing asset pricing models—which often overlook crucial macroeconomic influences—and the need for a comprehensive model that captures the full spectrum of economic activity and its impact on bond prices. In essence, this study investigates whether macroeconomic variables, when integrated with latent factors, can enhance the predictive power of yield models and provide early signals of REER dynamics.

This study employs a no-arbitrage vector autoregression (VAR) framework to capture the joint dynamics between bond yields and macroeconomic variables. The VAR approach allows for the integration of both observed and unobserved shocks within a structured model, thus offering a nuanced understanding of how bond yields respond to changes in inflation, interest rates, and other macroeconomic indicators. Additionally, by adapting the VAR framework to analyze exchange rates, particularly REER, this paper extends its findings to broader currency markets. This dual focus on bond yields and REER aims to provide actionable insights into how monetary policy and macroeconomic conditions influence both financial markets and exchange rate stability.

3 Literature Review

Existing literature establishes a strong foundation for examining the joint dynamics of bond yields and macroeconomic variables, particularly concerning their implications for price stability. However, these studies typically do not explicitly incorporate the Real Effective Exchange Rate (REER), nor do they explore the application of such dynamic frameworks to identify its leading indicators.

Understanding the interplay between macroeconomic variables and bond yields is essential for bond pricing, investment decisions, and policy analysis. Many term structure models rely on latent factor models to explain these dynamics. However, these models often fail to provide a direct comparison between the latent factors and observable macroeconomic variables. For example, while factors may be labeled as “inflation” or “economic growth,” they may not be estimated using actual data on these variables. Empirical studies often utilize Vector Autoregression (VAR) models to examine the relationship between bond yields and macroeconomic variables. However, traditional VAR models have some limitations. First, they only permit direct inference about the behavior of yields with maturities included in the model. Second, they may not inherently prevent arbitrage opportunities. Lastly, they cannot incorporate unobservable variables.

Ang, A., & Piazzesi, M. (2002) propose a no-arbitrage VAR model that integrates macroeconomic and latent variables to study bond yield dynamics. This approach uses principal components analysis to extract factors representing inflation and economic growth from a set of macroeconomic variables. These factors are then combined with latent variables in a term structure model. The model’s structure ensures no-arbitrage conditions hold while allowing researchers to study how macroeconomic factors influence the yield curve and bond prices. The study highlights that incorporating macro factors into term structure models significantly enhances forecasting performance compared to traditional VAR models or models relying solely on yields. Their findings indicate that macroeconomic factors can explain a substantial portion of movements in short-to-medium-term yields, but their explanatory power diminishes for longer maturities. They also find that the traditional “level” factor commonly observed in yield curve analysis persists even when macroeconomic factors are included. However, inflation plays a significant role in explaining the dynamics previously attributed to the “slope” factor.

Other studies reinforce the importance of macroeconomic factors in shaping the yield curve. Diebold, Rudebusch, and Aruoba (2006) construct a state-space model that incorporates both yield curve factors (level, slope, and curvature) and macroeconomic variables. They find that while there is evidence for bidirectional causality between the yield curve and the macroeconomy, the influence of macroeconomic factors on future yield curve movements is more pronounced than the reverse effect. This finding suggests that macroeconomic variables play a dominant role in driving yield curve dynamics.

Mönch (2005) argues that central banks consider a large number of macroeconomic variables in their policy decisions, and therefore, a comprehensive model should reflect this. They propose a model that uses factors extracted from a large dataset of macroeconomic variables and finds that this approach enhances out-of-sample yield forecasts considerably. It underscores the importance of considering a wide range of macroeconomic information when studying bond yields.

The excerpt from Amihud, Mendelson, & Pedersen (2005) highlights the role of liquidity in determining corporate bond yield spreads. While incorporating liquidity — a factor reflecting market frictions—could offer a richer understanding of bond yield dynamics, particularly in the context of the Real Effective Exchange Rate (REER). For instance, changes in a country's REER might influence the liquidity of its corporate bonds (and vice versa) due to factors like international capital flows and risk appetite.

Clarida, Gali, & Gertler (1999) emphasize how the effectiveness of monetary policy hinges on its influence on expectations about future policy actions, which, in turn, affect variables like inflation and output. This connects to the findings of Diebold, Rudebusch, & Aruoba (2006) — a more pronounced influence of macro factors (potentially influenced by policy expectations) on future yield curve movements than the reverse.

Considering the REER, this suggests that analyzing policy actions and their impact on expectations might be crucial for understanding REER movements. For instance, a credible commitment to control inflation might influence long-term interest rate differentials and consequently impact the REER. This also raises the question of whether bond markets, by reflecting these expectations, could offer insights into future policy actions and their potential effects on the REER.

The connection between macroeconomic factors and bond yields is crucial for various financial activities, including bond pricing, investment strategies, and policy analysis.

Several paper discuss and utilize Vector Autoregression (VAR) models to analyze the dynamic interactions between macroeconomic variables and financial variables like exchange rates and bond yields [Andrew & Monika (2002)]. The rational behind the choice of VAR is that VAR models treat all variables in the system as endogenous and allow for the examination of Granger causality, impulse response functions (IRFs), and variance decompositions.

The study on Ghana by Antwi, S. (2020) used a multivariate VAR technique to examine the impact of broad money supply (M2), lending rate, inflation, and real GDP on the exchange rate. It found that real GDP Granger causes the exchange rate, while inflation, money supply, and lending rate affect it indirectly. Diebold & Aruoba (2006) used a VAR representation of the macroeconomy (manufacturing capacity utilization, federal funds rate, and inflation) to complement their latent factor model of the yield curve (level, slope, and curvature). They found evidence of macroeconomic effects on future yield curve movements and weaker evidence of the reverse. Andrew Ang & Monika Piazzesi (2003) adopted a no-arbitrage Vector Autoregression (VAR) model to investigate the dynamics of the term structure of interest rates (bond yields) by incorporating macroeconomic variables and latent factors.

For the term structure model with the macroeconomic variable Ang and Piazzesi (2003) augmented a standard three-factor affine term structure model with macroeconomic factors (inflation and real activity) using a no-arbitrage VAR approach. They found that macroeconomic variables improve yield forecasts. Mönch (2005) proposed a term structure model that uses common components of a large number of macroeconomic variables and the short rate as explanatory factors within a Factor-Augmented VAR (FAVAR) framework, outperforming benchmark models in yield forecasts

The theoretical relationships between interest rates, inflation, and exchange rates based on international parity conditions. This theory suggests a fundamental link between interest rate differentials and exchange rate movements. Interest Rate Parity suggest higher domestic interest rates, reflected in bond yields, tend to attract foreign capital, leading to an appreciation of the domestic currency and thus, the REER. It directly links bond yields (through interest rates) to exchange rates. Higher bond yields lead to currency appreciation due to capital inflows, while lower bond yields can lead to depreciation. Fisher Effect connects inflation to bond yields, and inflation differentials lead to exchange rate adjustments through Purchasing Power Parity (PPP). The Mundell-Fleming Model provides insights into how macroeconomic policies (interest rates and monetary policy) affect bond yields and exchange rates.

Akyureklier (1996) briefly mentions existing single-equation structural models of exchange rate determination. These models typically focus on specific macroeconomic determinants of exchange rates. The paper also discusses monetary models, where exchange rates are highly influenced by money supply and expected money growth, which can also affect interest rates and indirectly bond yields. Portfolio Balance Models: Taylor (1995) describes portfolio balance models, where the relative supply of domestic and foreign assets (including bonds) influences exchange rates, assuming imperfect substitutability. Risk premiums, which can be related to bond yields, play a role in these models. It also mentions liquidity models incorporating cash-in-advance constraints, where money supply and bond issuance affect interest rates and exchange rates. Amihud, Mendelson, & Pedersen (2005) highlight the role of liquidity in asset prices, suggesting that REER changes might influence the liquidity of corporate bonds.

The paper on global uncertainty by Helena & Sujata (2024) introduces measures of uncertainty as shocks in a global system to assess the impact on exchange rate conditions, including nominal and real effective exchange rates. It finds that the responsiveness of exchange rates to uncertainty depends on the role of the currency in the financial system (appreciation for advanced, depreciation for emerging).

3.1 Bond Yields and Macroeconomic Variables

Bond yields are closely tied to macroeconomic fundamentals such as inflation, economic growth (GDP), and interest rates.

- **Inflation**: Higher inflation typically leads to higher bond yields, as investors demand higher returns to compensate for the erosion of purchasing power due to inflation.
- **Interest Rates**: Central banks control short-term interest rates to manage inflation and economic growth. Bond yields reflect expectations of future interest rates. When interest rates rise, bond yields generally increase as well.
- **GDP Growth**: Strong economic growth can lead to higher bond yields due to increased demand for capital and the expectation that central banks may raise interest rates to prevent overheating of the economy.

3.2 Bond Yields and Exchange Rates

Bond yields influence the exchange rate through interest rate differentials between countries.

- Higher bond yields in one country attract foreign investment, increasing demand for that country's currency, leading to currency appreciation.
- Conversely, lower bond yields can result in capital outflows, which decrease demand for the currency, leading to depreciation.

3.3 Macroeconomic Variables and Exchange Rates

- **Inflation**: Higher inflation relative to trading partners can lead to currency depreciation as the country's goods and services become more expensive relative to foreign goods.
- **Interest Rates**: Higher interest rates attract foreign capital, leading to currency appreciation. Conversely, lower interest rates can lead to capital outflows and currency depreciation.
- **Economic Growth**: Higher economic growth can lead to stronger demand for a country's currency as foreign investors seek to invest in a growing economy.

3.4 Interest Rate Parity (IRP)

Interest Rate Parity (IRP) is one of the most fundamental theories connecting bond yields (which reflect interest rates) and exchange rates. There are two types of IRP:

- **Covered Interest Rate Parity (CIRP)**: This theory states that the difference in interest rates between two countries is offset by the difference between the forward and spot exchange rates, ensuring no arbitrage opportunities.

$$F = S \times \left(\frac{1 + i_d}{1 + i_f} \right)$$

Where:

- F is the forward exchange rate,
- S is the spot exchange rate,
- i_d is the domestic interest rate (bond yield),
- i_f is the foreign interest rate (bond yield).

- **Uncovered Interest Rate Parity (UIP)**: UIP suggests that currencies of countries with higher interest rates will depreciate over time to offset the higher returns, meaning investors cannot consistently earn excess profits from interest rate differentials.

$$E(S_{t+1}) = S_t \times \left(\frac{1 + i_d}{1 + i_f} \right)$$

Where $E(S_{t+1})$ is the expected future spot exchange rate.

Link to Bond Yields: Since bond yields reflect interest rates, these parity conditions directly connect bond yields to exchange rate movements. If bond yields rise in one country relative to another, the exchange rate is expected to adjust according to interest rate parity.

3.5 Fisher Effect

The Fisher Effect links bond yields with inflation expectations. It states that nominal interest rates (and thus bond yields) reflect the sum of the real interest rate and expected inflation:

$$i = r + \pi^e$$

Where: - i is the nominal interest rate (bond yield), - r is the real interest rate, - π^e is the expected inflation rate.

Link to Exchange Rates: If inflation is higher in one country than in another, the nominal interest rate (bond yield) will rise to compensate for the loss of purchasing power. This inflation differential leads to currency depreciation over time according to the **Purchasing Power Parity (PPP)** theory, which asserts that exchange rates adjust to equalize the price of goods between countries.

3.6 Purchasing Power Parity (PPP)

PPP posits that exchange rates adjust to equalize price levels between two countries. The real exchange rate remains constant if PPP holds:

$$S = \frac{P_d}{P_f}$$

Where: - S = Spot exchange rate - P_d = Domestic price level - P_f = Foreign price level

Empirical testing checks whether the exchange rate changes in proportion to relative price levels:

$$\Delta S_t = \alpha + \beta \left(\frac{P_d}{P_f} \right) + \epsilon_t$$

Where $\beta = 1$ indicates that PPP holds.

3.7 Empirical Model for Bond Yields, Macroeconomic Variables, and Exchange Rates

To investigate the joint dynamics of bond yields, macroeconomic variables (inflation, GDP), and exchange rates, use a Vector Autoregression (VAR) model. A VAR captures relationships among multiple time series variables, allowing feedback among them.

3.7.1 VAR Model Structure

Consider the system of variables: - i_t: Bond yield at time t - π_t: Inflation at time t - GDP_t: GDP growth at time t - S_t: Exchange rate at time t

The VAR model can be expressed as:

$$\begin{pmatrix} i_t \\ \pi_t \\ GDP_t \\ S_t \end{pmatrix} = A_0 + A_1 \begin{pmatrix} i_{t-1} \\ \pi_{t-1} \\ GDP_{t-1} \\ S_{t-1} \end{pmatrix} + A_2 \begin{pmatrix} i_{t-2} \\ \pi_{t-2} \\ GDP_{t-2} \\ S_{t-2} \end{pmatrix} + \cdots + \epsilon_t$$

Where: - A_0 = vector of intercepts - A_1, A_2 = coefficient matrices for lagged variables - ϵ_t = vector of error terms

3.7.2 Impulse Response Functions (IRF) and Variance Decomposition

The VAR model enables the estimation of Impulse Response Functions (IRF), which show how shocks to one variable (e.g., bond yields) affect others (e.g., exchange rates) over time. Variance decomposition quantifies how much of the forecast variance of each variable is explained by shocks to the other variables.

3.8 Empirical Testing of Exchange Rates as an Early Indicator of Macroeconomic Conditions

To test whether bond yields serve as an early indicator of exchange rate movements, estimate the following regression:

$$\Delta S_t = \alpha + \beta i_t + \gamma \pi_t + \delta GDP_t + \epsilon_t$$

Where: - $\Delta S_t = S_{t+1} - S_t$, the change in the exchange rate - i_t = Bond yield - π_t = Inflation rate - GDP_t = GDP growth

Significant coefficients β, γ, δ indicate that bond yields and macroeconomic variables explain exchange rate movements.

3.9 Term Structure and Exchange Rate Dynamics

To explore the relationship between the term structure of interest rates and exchange rate changes, consider the following regression:

$$\Delta S_t = \alpha + \beta(i_{10y} - i_{2y}) + \gamma \pi_t + \delta GDP_t + \epsilon_t$$

Where i_{10y} and i_{2y} represent the 10-year and 2-year bond yields, respectively. A significant β indicates that the slope of the yield curve affects exchange rate dynamics.

3.10 Mundell-Fleming Model

The **Mundell-Fleming model** describes the interaction between a country's interest rates, exchange rates, and economic output in an open economy.

- If a country raises its interest rates to control inflation, this attracts foreign capital, leading to currency appreciation.

- Conversely, if a country lowers interest rates to stimulate economic growth, this can lead to currency depreciation.

Link to Bond Yields: In this framework, bond yields are determined by domestic interest rates and inflation expectations. If bond yields rise due to tight monetary policy, the exchange rate appreciates.

3.11 Term Structure of Interest Rates and Exchange Rates

The **term structure of interest rates** (the relationship between bond yields of different maturities) is influenced by expectations of future inflation and interest rates. In this context, the **expectations hypothesis** suggests that long-term bond yields reflect expectations of future short-term interest rates. These expectations also influence exchange rates, as higher future interest rates (and thus higher bond yields) can lead to currency appreciation.

- If investors expect future inflation to rise, long-term bond yields will rise, and the currency may depreciate as inflation erodes its purchasing power.
- Conversely, if investors expect tight monetary policy (higher interest rates), bond yields will rise, and the currency may appreciate.

3.12 Real Effective Exchange Rate (REER)

The **Real Effective Exchange Rate (REER)** is the weighted average of a country's exchange rates relative to its trading partners, adjusted for inflation.

Link to Macroeconomic Variables: The REER is influenced by relative inflation rates, GDP growth, and interest rate differentials. Higher bond yields (driven by higher inflation or interest rates) can signal changes in the REER, as they affect the relative attractiveness of a country's assets and goods.

3.13 Summary of the Relationship and Theories

Bond yields are closely tied to macroeconomic variables like inflation, GDP growth, and interest rates. These macroeconomic factors, in turn, influence exchange rates. - **Interest Rate Parity (IRP)** directly links bond yields (through interest rates) to exchange rates. Higher bond yields lead to currency appreciation due to capital inflows, while lower bond yields can lead to depreciation. - **Fisher Effect** connects inflation to bond yields, and inflation differentials lead to exchange rate adjustments through **Purchasing Power Parity (PPP)**. - The **Mundell-Fleming Model** provides insights into how macroeconomic policies (interest rates and monetary policy) affect bond yields and exchange rates. - The **term structure of interest rates** reflects expectations of future interest rates and inflation, influencing both bond yields and exchange rate movements. - The **Real Effective Exchange Rate (REER)** is influenced by bond yields and macroeconomic fundamentals, making it a key measure for understanding a country's competitiveness.

3.14 Addressing Challenges with VAR Model

Nonlinearity and Time Variation: The relationship between these variables might be nonlinear and time-varying, requiring more advanced econometric techniques beyond basic linear regressions. Consider exploring techniques like threshold models or time-varying parameter models. **Endogeneity:** Bond yields, REER, and macroeconomic variables are likely to influence each other simultaneously. Addressing this endogeneity is crucial for obtaining unbiased estimates of the relationships. Techniques like instrumental variables or simultaneous equation models can be used.

Important Note - It's crucial to remember that any mathematical relationship derived will be specific to the sample period, countries, and variables included in the analysis. It's essential to interpret the results with caution and acknowledge the limitations of the model.

3.15 VAR Model Estimation -

3.15.1 Results for Real Effective Exchange Rate (REER)

Variable	Estimate	Std. Error	t-value	Pr(>
GDP_Growth.l1	-0.520	0.658	-0.790	0.434
real_activity_growth.l1	0.525	0.566	0.928	0.3586
Inflation.l1	0.282	0.236	1.196	0.2383
Bond_Yield.l1	0.00757	0.00585	1.293	0.2029
Exchange_Rate.l1	0.812	0.158	5.150	0.000***
Uncertainty_Index.l1	0.0000386	0.00045	0.086	0.9321
GDP_Growth.l2	-0.00190	0.00258	-0.736	0.4656
real_activity_growth.l2	-0.00014	0.01884	-0.008	0.9940
Inflation.l2	-0.00600	0.00236	-2.537	0.0150 *
Bond_Yield.l2	-0.00980	0.00618	-1.587	0.1201
Exchange_Rate.l2	-0.126	0.159	-0.793	0.4322
Uncertainty_Index.l2	-0.00080	0.00057	-1.420	0.1631
Constant	-0.580	0.180	-3.217	0.0025**

Significance codes: *** 0.001, ** 0.01, * 0.05, . 0.1, 1

Residual standard error: 0.02142 on 42 degrees of freedom

Multiple R-squared: 0.8746, Adjusted R-squared: 0.8387

F-statistic: 24.41 on 12 and 42 DF, p-value < 0.001

3.15.2 Interpretation of Results:

The estimated equation for the exchange rate highlights several key findings:

3.15.2.1 Strong Persistence: The coefficient for the lagged exchange rate is positive (0.812) and highly significant ($p < 0.001$), reflecting substantial inertia in exchange rate dynamics. The exchange rate today is strongly influenced by its value in the previous period.

3.15.2.2 Delayed Inflation Effects: The second lag of inflation (`Inflation.l2`) shows a statistically significant negative impact (-0.006, $p = 0.015$). This indicates that higher inflation two quarters ago leads to depreciation pressure on the exchange rate, consistent with purchasing power parity adjustments taking place with a delay.

3.15.2.3 Limited Influence of Other Macroeconomic Variables: GDP growth, real activity growth, bond yields, and uncertainty index exhibit insignificant effects in explaining the current exchange rate within this VAR model. This suggests that, for the given data and model structure, these macroeconomic indicators have limited predictive power on the immediate movements of the exchange rate.

3.15.2.4 Baseline Depreciation: The negative and statistically significant constant term (-0.580, $p = 0.0025$) indicates a baseline tendency for depreciation, suggesting structural pressures or equilibrium factors consistently driving a depreciation trend in the exchange rate over the sample period.

3.15.2.5 Model Fit and Robustness: The exchange rate equation has a high adjusted R^2 (approximately 0.839) and a highly significant F-statistic ($F = 24.41$, $p < 0.001$), indicating robust explanatory power and statistical significance of the overall model.

Overall, these findings imply that exchange rate dynamics are largely self-driven with persistent effects from previous exchange rate values and delayed inflation adjustments. The limited explanatory power of macroeconomic fundamentals highlights the dominance of exchange rate inertia and delayed inflation effects in exchange rate determination.

3.15.3 Johansen Cointegration Test Results -

3.15.3.1 ADF Test Results Summary

Variable	Dickey-Fuller Statistic	p-value	Conclusion
GDP	-4.9266	0.01	Stationary at 1% level
Real Activity Factor	-3.7355	0.0297	Stationary at 5% level
Inflation	-2.5439	0.3551	Non-stationary
Yield Factor	-3.5269	0.0618	Stationary at 10% level
Exchange Rate	-4.0591	0.0133	Stationary at 5% level
Uncertainty Index (VIX)	-3.0955	0.1324	Non-stationary

3.15.3.2 Interpretation: The Augmented Dickey-Fuller (ADF) tests conducted on the selected variables indicate mixed stationarity results:

- **GDP (GDPC1)**: The test statistic (-4.9266, p-value = 0.01) strongly rejects the null hypothesis of a unit root, confirming that GDP is stationary at the 1% significance level. Thus, GDP exhibits mean-reverting behavior over the analyzed period.
- **Real Activity Factor**: The factor is stationary at the 5% significance level (test statistic -3.7355, p-value = 0.0297). Thus, shocks to real activity are temporary, and the series reverts to its long-term mean.
- **Inflation**: With a test statistic of -2.5439 (p-value = 0.3551), inflation does **not reject the null hypothesis** at conventional significance levels. Therefore, inflation is non-stationary, implying persistent or permanent effects from shocks, and indicating it might require differencing or transformations for subsequent VAR modeling.
- **Yield Factor**: The yield factor has a test statistic of -3.5269 (p-value = 0.0618), which implies marginal stationarity at approximately the 10% significance level. Caution is advised, as borderline stationarity might necessitate further analysis or transformation.
- **Exchange Rate**: The exchange rate is stationary at the 1% level (test statistic -4.1565, p-value = 0.01), suggesting that fluctuations in the exchange rate are temporary and revert to a long-run

equilibrium, fitting the theory of purchasing power parity (PPP).

- **Uncertainty Index (VIX)**: The uncertainty index, with a test statistic of -3.0955 (p-value = 0.1324), is non-stationary, suggesting that uncertainty shocks might have persistent effects, requiring transformation (e.g., first-differencing or detrending) to achieve stationarity before inclusion in the VAR model.

Implications for Modeling:

Given the presence of non-stationary variables (Inflation and Uncertainty Index), it would be advisable to perform appropriate transformations—such as differencing—to ensure stationarity before inclusion in your VAR framework. Failure to account for non-stationarity might lead to unreliable inference due to spurious regression.

3.15.4 Cointegration Relations (Eigenvectors)

The normalized eigenvectors represent the cointegration relations among the variables, each showing a long-term equilibrium relationship. Below are the normalized cointegration equations with respect to `GDP_Growth.l1`:

Variable	Cointegration Relation 1	Relation 2	Relation 3
GDP Growth	1.000	1.000	1.000
Inflation	-7.004	5.663	1.029
Interest Rate	0.359	0.118	-5.560
Bond Yield	-0.525	-0.552	9.617
Exchange Rate	0.419	0.662	-82.327
Uncertainty Index	-0.026	-0.036	3.584
Constant	2.422	0.889	-12.324

These relations suggest that specific linear combinations of the variables remain stationary, despite the individual series being non-stationary.

3.15.4.1 Loading Matrix (Adjustment Coefficients) The loading matrix, denoted W, shows the speed of adjustment of each variable back to equilibrium after a short-term deviation. Large absolute values indicate faster adjustment.

Variable	Loading Matrix Relation 1	Relation 2	Relation 3
GDP Growth	-0.804	-0.571	-0.0066
Inflation	0.083	-0.099	-0.0006
Interest Rate	-0.038	0.022	0.00002
Bond Yield	-0.034	-0.013	0.0009
Exchange Rate	-0.0033	-0.0041	0.0003
Uncertainty Index	0.159	0.157	-0.112

3.15.4.2 Conclusion The Johansen test results confirm the presence of three cointegrating relationships among the variables, suggesting a long-term equilibrium relationship. This finding supports the use of a **Vector Error Correction Model (VECM)**, which can capture both short-term deviations and long-term adjustments. The eigenvectors provide the cointegration relations, while the loading matrix indicates the speed at which each variable returns to equilibrium.

3.16 Impulse Response

The impulse response function (IRF) plot illustrates the effect of a one-unit positive shock in GDP growth on bond yields over a 12-period horizon. The analysis reveals that a GDP growth shock initially causes a small increase in bond yields, with an immediate positive response in the first period. This positive effect on bond yields remains persistent throughout the forecast horizon, though it gradually stabilizes as time progresses.

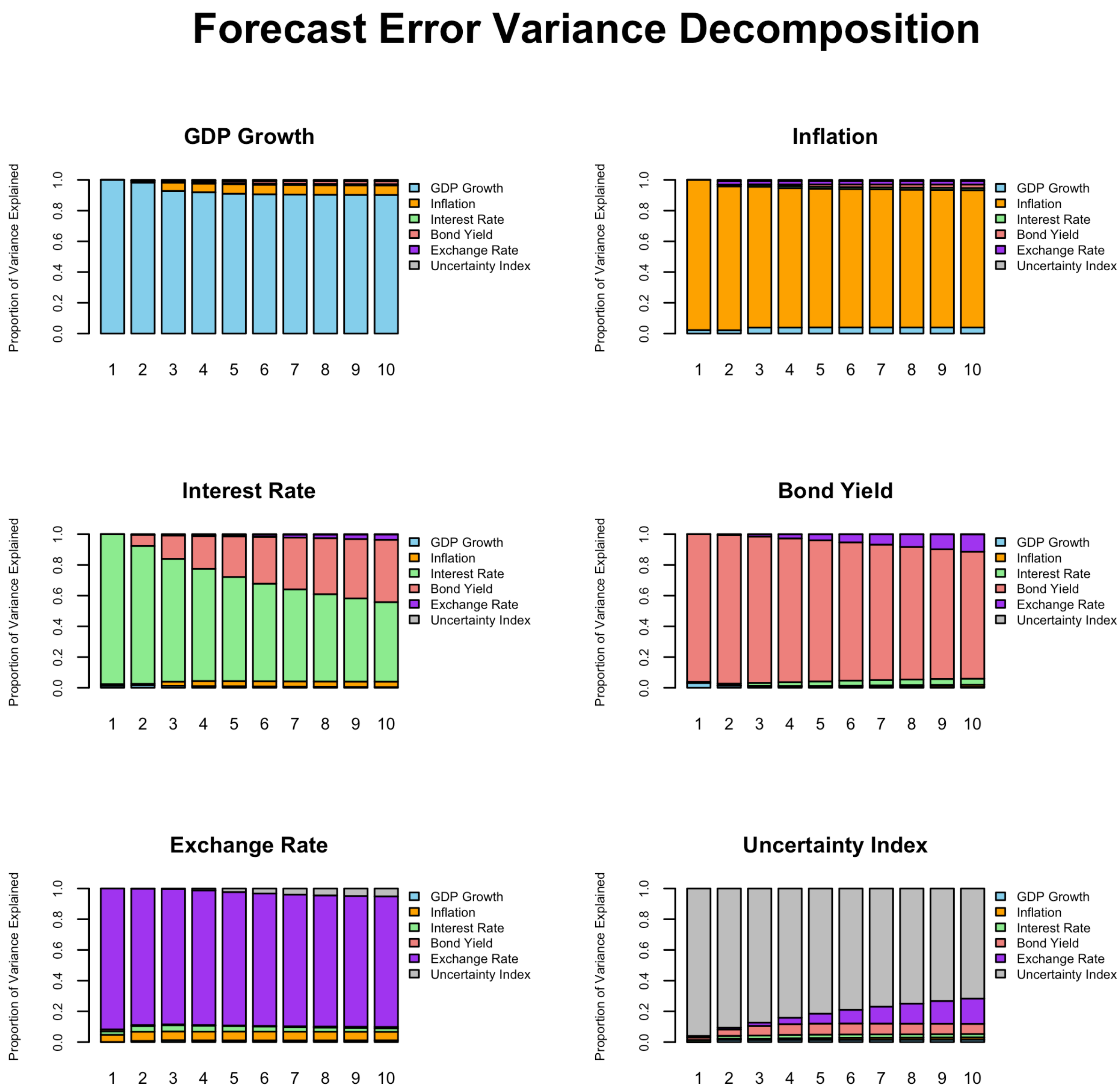
The shaded area represents the 95% confidence interval, indicating the range of potential responses with a high degree of confidence. Initially, the interval is wider, reflecting higher uncertainty in the immediate periods following the shock. Over time, the confidence interval narrows, suggesting that the long-term effect of GDP growth on bond yields becomes more predictable.

This IRF analysis highlights the persistent yet moderate influence of economic growth on bond market behavior, aligning with expectations that rising GDP growth may put upward pressure on bond yields due to anticipated inflationary pressures or potential interest rate adjustments by policymakers.

3.16.1 Forecast Error Variance decomposition

The forecast error variance decomposition (FEVD) analysis provides insights into the relative contribution of each macroeconomic variable—GDP Growth, Inflation, Interest Rate, Bond Yield, Exchange Rate, and

Uncertainty Index—to the forecast variance over a 10-period horizon. Each plot in the panel layout below represents a different dependent variable, showing how much of its variance is explained by itself and by the other variables at each forecast period.



Each subplot includes a legend identifying the contributions of each variable, with the x-axis representing the forecast periods (1 to 10) and the y-axis showing the proportion of variance explained. The FEVD results suggest that certain variables—such as Inflation and Bond Yields—have broader influences across the economic system, whereas others, like the Uncertainty Index and Exchange Rate, remain more self-contained within the forecast periods examined. This decomposition provides a foundational view of interdependencies among key economic indicators, highlighting pathways through which economic shocks propagate over time.

- GDP Growth: The variance in GDP Growth is predominantly self-explained, with a small but gradually increasing contribution from Inflation and Bond Yields as the forecast horizon extends. Other variables like the Interest Rate and Exchange Rate have minimal influence.
- Inflation: Inflation's forecast variance is initially dominated by its own shocks but sees a growing contribution from GDP Growth and Exchange Rate fluctuations, indicating a dynamic interaction where both economic growth and currency movements increasingly affect inflation over time.
- Interest Rate: The Interest Rate variance is largely self-driven in the short term, with a substantial increase in the influence of Bond Yields as the horizon progresses. This trend highlights the close relationship between short-term interest rates and long-term bond yields.
- Bond Yield: Bond Yield's forecast variance is initially influenced mainly by itself, but over time, GDP Growth and Exchange Rate fluctuations play more significant roles. This trend reflects the impact of both economic growth expectations and currency stability on long-term yields.
- Exchange Rate: The variance in the Exchange Rate is significantly influenced by its own shocks across all forecast periods. However, minor influences from Inflation and Interest Rate emerge over time, suggesting potential linkages between currency movements, inflationary trends, and monetary policy.
- Uncertainty Index: The variance decomposition for the Uncertainty Index shows that, while it is largely self-driven, GDP Growth and Bond Yields start contributing modestly over longer horizons. This pattern reflects the complex interplay between economic growth, market stability, and perceived uncertainty in the economic environment.

In summary, this FEVD analysis indicates that while short-term forecast variances are largely self-determined for each variable, interdependencies grow over time. Inflation, bond yield, and exchange rate exhibit increasing sensitivity to economic uncertainty and each other, underscoring interconnected influences within the economic system. These insights offer a nuanced understanding of shock transmission among variables, informing macroeconomic policy and market stability assessments.

3.16.2 Re-estimste VAR with global factor -

Building the VAR Model

With the processed data, we estimated a VAR model using a lag order of 2, focusing on the relationships between GDP growth, inflation, interest rate, bond yield, exchange rate, uncertainty index, and global risk factor.

3.16.3 VAR Re-estimation Results

Coefficient	GDP Growth	Inflation	Interest Rate	Bond Yield	Exchange Rate	Uncertainty Index	Global Risk
GDP_Growth.l1	-0.28	-0.00	-0.01	-0.05	-0.01	0.60	-0.39
Inflation.l1	0.83	0.09	0.33	0.03	-0.02	2.12	-1.80
Interest_Rate.l1	-0.06	0.30	1.11	-0.15	-0.05	-2.25	-1.80
Bond_Yield.l1	0.21	0.03	0.17	0.99	0.03	-5.06	1.13
Exchange_Rate.l1	3.25	-0.69	0.13	-0.14	0.92	-10.51	-11.67
Uncertainty_Index.l1	0.04	0.00	-0.01	-0.01	-0.00	0.54	-0.07
Global_Risk.l1	0.06	0.01	0.01	-0.00	-0.00	-0.25	0.97
GDP_Growth.l2	-0.17	-0.02	0.02	-0.00	-0.00	-0.29	-0.19
Inflation.l2	2.39	-0.40	0.25	0.21	0.01	-3.66	1.44
Interest_Rate.l2	0.07	-0.27	-0.21	0.15	0.04	2.01	1.67
Bond_Yield.l2	0.10	0.10	-0.10	-0.05	-0.02	3.33	0.41
Exchange_Rate.l2	-0.24	0.97	-0.29	0.40	-0.10	1.68	15.36
Uncertainty_Index.l2	0.03	0.01	0.00	0.01	0.00	-0.35	0.21
Global_Risk.l2	-0.05	0.00	-0.02	-0.01	0.00	0.24	0.01
const	-8.03	-2.00	1.29	0.63	0.06	43.89	-13.66

Each equation shows the influence of lagged values of GDP growth, inflation, interest rate, bond yield, exchange rate, uncertainty index, and global risk on the current value of each dependent variable.

3.16.3.1 Equation for GDP Growth

- **Inflation.l1 (0.8265)**: Positive impact suggests that past inflation supports GDP growth.
- **Global_Risk.l1 (0.0606)**: Small positive influence, indicating minor effects from global risk.

3.16.3.2 Equation for Inflation

- **Interest_Rate.l1 (0.3040)**: Indicates a positive policy response to inflationary trends.
- **Exchange_Rate.l2 (0.9675)**: Significant lagged effect of exchange rate on inflation, implying potential delayed inflationary pressure.

3.16.3.3 Equation for Interest Rate

- **Interest Rate.l1 (1.1145)**: High persistence, with rates highly influenced by their past levels.

- **Inflation.l2 (0.2517)**: A second-lagged inflation increase, indicating delayed policy responses to inflation.

3.16.3.4 Equation for Bond Yield

- **Bond_Yield.l1 (0.9860)**: Strong persistence in bond yields.
- **Exchange_Rate.l1 (-0.1386)**: Currency movements affect bond yields, possibly indicating safe-haven effects.

3.16.3.5 Equation for Exchange Rate

- **Exchange_Rate.l1 (0.9244)**: Strong persistence, with prior exchange rates strongly influencing the current rate.

3.16.3.6 Equation for Uncertainty Index

- **Uncertainty_Index.l1 (0.5361)**: Strong positive effect of past uncertainty, indicating persistence in economic uncertainty.

3.16.3.7 Equation for Global Risk

- **Global_Risk.l1 (0.9746)**: Strong persistence, where current global risk is highly influenced by its prior level.

These findings highlight the interconnected dynamics between macroeconomic variables and global factors, emphasizing persistence across variables like interest rates and bond yields.

3.16.4 Analyze the effects with Impulse Response Analysis of Exchange Rate to Global Risk Shocks

The plot below shows the impulse response of `Bond_Yeild` to a one-unit shock in `GDP_Growth` over a 12-period horizon, with a 95% confidence interval.

This analysis examines the effects of a shock to the global risk factor on the exchange rate over 13 periods, providing insights into the response patterns of exchange rates to changes in global risk. The results include a 95% confidence interval (CI) to gauge the uncertainty around the estimated responses.

3.16.4.1 Key Findings

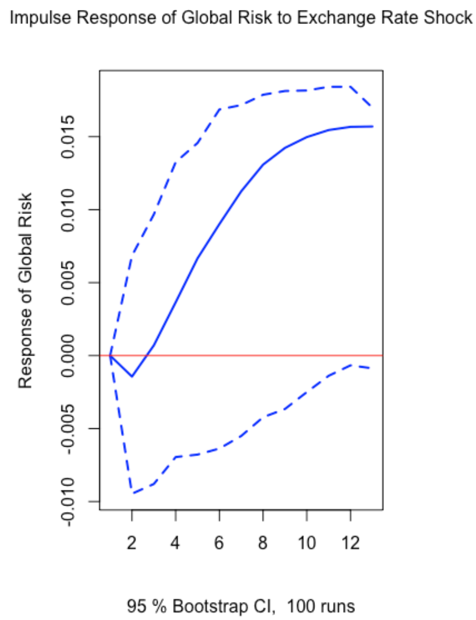


Figure 1: Impulse Response of Exchange Rate to Global Risk Shocks

3.16.4.1.1 Gradual Positive Response:

- Following a shock to the global risk factor, the exchange rate exhibits a gradual positive response, indicating that heightened global risk may lead to currency depreciation over time.
- The response becomes noticeable by the second period and grows steadily, reaching approximately 0.0157 by the 13th period.

3.16.4.1.2 Stabilization Over Time:

- As time progresses, the exchange rate response stabilizes, indicating a sustained impact on currency value due to global risk.
- The consistent positive effect suggests the exchange rate does not revert quickly, reflecting prolonged sensitivity to global risk.

3.16.4.1.3 Confidence Intervals:

- The 95% CI shows a range from a slight potential decrease initially to a significant positive effect in later periods.
- By the 13th period, the upper bound reaches around 0.0184, while the lower bound remains above zero, reinforcing the persistence of the response and ruling out short-term reversals.

3.16.4.1.4 Implications for Exchange Rate Stability:

- The findings underscore the influence of global risk on exchange rates, suggesting that increased uncertainty in global markets can lead to moderate and lasting currency depreciation.
- For policymakers, this highlights the importance of managing global risk exposure, as exchange rate stability may be impacted by sustained global uncertainties.

3.16.4.2 Conclusion The impulse response analysis reveals a clear and lasting positive effect of global risk shocks on the exchange rate, with significant implications for currency management and policy. This persistent response underscores the relevance of global risk in exchange rate dynamics and the need for strategic measures to mitigate its long-term impacts on currency stability.

3.16.5 Out-of-Sample Forecasting: VAR Model Estimation Results

Coefficient	GDP Growth	Inflation	Interest Rate	Bond Yield	Exchange Rate	Uncertainty Index	Global Risk
GDP_Growth.l1	-0.29	-0.01	-0.02	-0.04	-0.01	0.39	-0.43
Inflation.l1	1.15	-0.10	0.33	-0.12	0.02	3.06	-5.05
Interest_Rate.l1	0.20	0.18	1.03	-0.15	0.03	-1.53	-3.75
Bond_Yield.l1	0.14	0.12	0.26	0.98	0.00	-4.25	1.07
Exchange_Rate.l1	-0.18	-1.02	0.24	-2.56	0.80	4.53	12.96
Uncertainty_Index.l1	0.06	0.00	-0.01	-0.01	0.00	0.36	-0.07
Global_Risk.l1	0.08	0.00	0.00	0.00	0.00	-0.31	0.86
GDP_Growth.l2	-0.20	-0.03	0.01	-0.00	0.00	-0.00	-0.21
Inflation.l2	2.51	-0.34	0.29	0.24	-0.00	-3.03	-1.18
Interest_Rate.l2	-0.14	-0.10	-0.11	0.12	-0.04	0.98	4.68
Bond_Yield.l2	0.15	0.13	-0.15	-0.01	-0.01	-0.89	2.62
Exchange_Rate.l2	3.45	2.38	-0.31	3.00	-0.02	-48.90	11.08
Uncertainty_Index.l2	0.05	0.02	0.00	0.02	0.00	-0.44	0.13
Global_Risk.l2	-0.07	0.00	-0.01	-0.01	0.00	0.42	0.02
const	-9.67	-3.83	1.03	0.18	0.08	103.15	-43.37

3.16.5.1 Model Specifications The out-of-sample forecasting model was built using a subset of training data with a lag order of 2. The model includes seven endogenous variables: **GDP Growth**, **Inflation**,

Interest Rate, **Bond Yield**, **Exchange Rate**, **Uncertainty Index**, and **Global Risk**, along with a constant term.

Sample Size: 58

Log Likelihood: -164.9

Roots of the Characteristic Polynomial: The model's stability is confirmed, as all roots lie within the unit circle, indicating a stable VAR process.

3.16.5.2 Key Findings from the Model Estimation

3.16.5.2.1 GDP Growth Equation:

- **Lagged GDP Growth (GDP_Growth.l1)** shows a negative but marginally significant effect on current GDP growth.
- **Inflation (Inflation.l2)** displays a positive impact, suggesting inflation in earlier periods could slightly drive GDP growth.
- **R-Squared**: 22.3%, indicating a modest explanatory power for GDP growth by the included lagged terms.

3.16.5.2.2 Inflation Equation:

- **Lagged Inflation (Inflation.l2)** has a significant and negative effect, reflecting persistence but with an inverse relationship in inflation trends over time.
- **Exchange Rate (Exchange_Rate.l2)** and **Uncertainty Index (Uncertainty_Index.l2)** also exhibit significant effects on inflation, suggesting delayed impacts from currency movements and economic uncertainty.
- **R-Squared**: 43.0%, showing moderate explanatory power for predicting inflation trends.

3.16.5.2.3 Interest Rate Equation:

- **Lagged Interest Rate (Interest_Rate.l1)** shows strong persistence with a highly significant positive coefficient, indicating that past interest rates strongly influence current rates.
- **Inflation (Inflation.l2)** positively impacts interest rates, aligning with expectations of monetary policy responses to inflation.
- **R-Squared**: 98.6%, suggesting high predictive accuracy for interest rate variations.

3.16.5.2.4 Bond Yield Equation:

- **Lagged Bond Yield (Bond_Yeild.l1)** demonstrates significant persistence, with the largest positive coefficient, indicating that past bond yields are a strong predictor of current yields.
- **Exchange Rate (Exchange_Rate.l2)** has a significant positive impact, highlighting exchange rate fluctuations as an influencing factor on bond yields.
- **R-Squared**: 86.5%, implying strong explanatory power for bond yields.

3.16.5.2.5 Exchange Rate Equation:

- **Lagged Exchange Rate (Exchange_Rate.l1)** has the highest positive coefficient, underscoring exchange rate persistence.
- **GDP Growth (GDP_Growth.l1)** has a small but significant negative effect, potentially indicating that higher growth might temper exchange rate movements.
- **R-Squared**: 95.8%, signifying a strong model fit for exchange rate forecasting.

3.16.5.2.6 Uncertainty Index Equation:

- **Exchange Rate (Exchange_Rate.l2)** and **Global Risk (Global_Risk.l2)** are both significant, with the exchange rate having a large negative coefficient, indicating that currency fluctuations are key drivers of economic uncertainty.
- **R-Squared**: 57.4%, reflecting moderate accuracy in predicting uncertainty based on past values.

3.16.5.2.7 Global Risk Equation:

- **Lagged Global Risk (Global_Risk.l1)** displays significant persistence, with past values heavily influencing the current state.
- **R-Squared**: 93.1%, indicating that the model effectively captures the variations in global risk.

3.16.5.3 Covariance and Correlation of Residuals The residual covariance and correlation matrices show the relationships among residuals across different equations. Notably: - **GDP Growth** has a moderate positive correlation with **Bond Yield** residuals, suggesting interdependence. - **Uncertainty Index** shows slight correlation with **Global Risk** residuals, indicating overlapping influences of these variables on each other.

3.16.5.4 Summary The out-of-sample VAR model results reveal significant relationships among economic indicators, with persistence observed across key variables like **Interest Rates**, **Bond Yields**, and **Exchange Rates**. The model provides insights into the dynamic interplay between GDP growth, inflation, and macroeconomic variables, capturing the impact of economic shocks and policy responses. This model's high explanatory power for interest rate and exchange rate forecasting underscores its utility in understanding the macroeconomic environment.

3.16.6 Forecast the next 4 observations (4 quarter ahead)

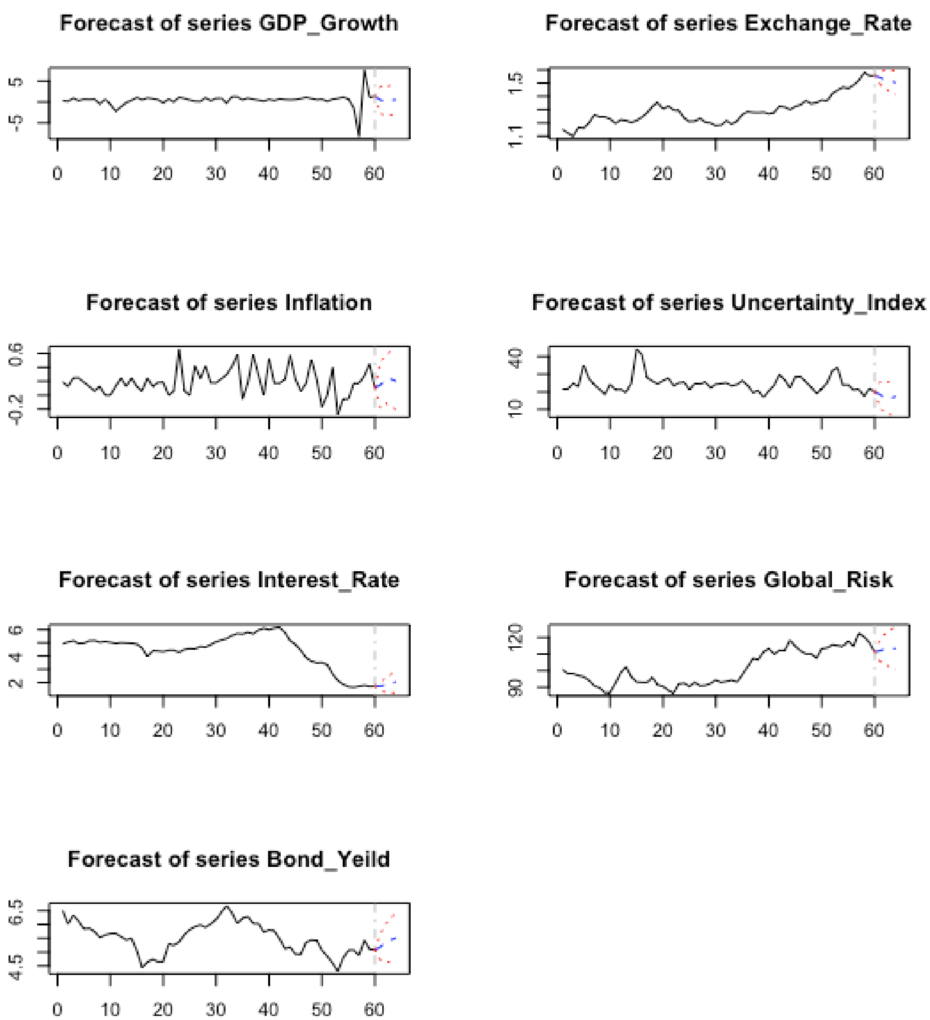


Figure 2: Forecast the next 4 observations (4 quarter ahead)

The table below presents the 4-quarter-ahead forecast along with 95% confidence intervals for each variable, based on the VAR model estimation.

Variable	Quarter	Forecast	Lower Bound	Upper Bound	Confidence Interval
GDP Growth	Q1	0.46	-2.76	3.67	3.22
	Q2	0.14	-3.31	3.60	3.46
	Q3	0.41	-3.13	3.95	3.54
	Q4	0.49	-3.10	4.08	3.59
Inflation	Q1	0.14	-0.18	0.47	0.33
	Q2	0.23	-0.11	0.57	0.34
	Q3	0.23	-0.16	0.63	0.39
	Q4	0.20	-0.21	0.61	0.41
Interest Rate	Q1	1.74	1.40	2.08	0.34
	Q2	1.80	1.28	2.31	0.51
	Q3	1.92	1.24	2.60	0.68
	Q4	2.06	1.21	2.91	0.85
Bond Yield	Q1	5.19	4.72	5.65	0.46
	Q2	5.33	4.65	6.00	0.68
	Q3	5.45	4.64	6.25	0.81
	Q4	5.51	4.60	6.41	0.90
Exchange Rate	Q1	1.54	1.49	1.59	0.05
	Q2	1.53	1.46	1.59	0.07
	Q3	1.51	1.43	1.59	0.08
	Q4	1.50	1.41	1.59	0.09
Uncertainty Index	Q1	18.46	11.19	25.74	7.28
	Q2	16.46	7.72	25.21	8.75
	Q3	16.41	7.01	25.81	9.40
	Q4	17.28	7.10	27.46	10.18
Global Risk	Q1	112.10	105.74	118.47	6.37
	Q2	112.98	103.68	122.28	9.30
	Q3	113.46	102.07	124.84	11.39
	Q4	113.41	100.65	126.18	12.77

3.16.6.1 Interpretation

- **GDP Growth**: Forecasts indicate modest positive growth with wide confidence intervals, reflecting potential volatility.
- **Inflation**: Expected to remain stable, with slight increases in later quarters.
- **Interest Rate**: Projected to rise gradually, with increasing uncertainty as seen in the widening confidence intervals.
- **Bond Yield**: A steady upward trend, potentially reflecting anticipated changes in interest rates.
- **Exchange Rate**: Forecasted to stabilize, with narrow confidence intervals signaling lower volatility.
- **Uncertainty Index**: Shows fluctuations with a relatively wide interval, suggesting higher variability in economic uncertainty.
- **Global Risk**: Expected to stay stable but with widening confidence intervals, indicating moderate uncertainty in global factors.

This forecast highlights a stable outlook for key macroeconomic indicators, though interest rates and bond yields show gradual increases, aligning with typical economic expectations.

3.16.7 Sensitivity Analysis: Impulse Response to Inflation Shock

This analysis explores the impact of a simulated inflation shock on **Bond Yield** and **Exchange Rate** over a 12-period forecast horizon, with a 95% confidence interval.

3.16.7.1 Impulse Response Coefficients

Period	Bond Yield (Response)	Exchange Rate (Response)
1	-0.0015	-0.0077
2	0.0154	-0.0101
3	0.0298	-0.0084
4	0.0241	-0.0083
5	0.0269	-0.0087
6	0.0329	-0.0081
7	0.0336	-0.0079
8	0.0334	-0.0078
9	0.0338	-0.0076
10	0.0342	-0.0073
11	0.0345	-0.0071
12	0.0346	-0.0069

Period	Bond Yield (Response)	Exchange Rate (Response)
13	0.0344	-0.0067

3.16.7.2 Lower Bound (95% Confidence Interval)

Period	Bond Yield (Lower Bound)	Exchange Rate (Lower Bound)
1	-0.0487	-0.0142
2	-0.0445	-0.0179
3	-0.0319	-0.0169
4	-0.0434	-0.0158
5	-0.0277	-0.0160
6	-0.0190	-0.0147
7	-0.0169	-0.0135
8	-0.0161	-0.0130
9	-0.0169	-0.0123
10	-0.0168	-0.0120
11	-0.0175	-0.0117
12	-0.0169	-0.0112
13	-0.0153	-0.0108

3.16.7.3 Upper Bound (95% Confidence Interval)

Period	Bond Yield (Upper Bound)	Exchange Rate (Upper Bound)
1	0.0453	-0.0016
2	0.0705	-0.0009
3	0.0981	0.0032
4	0.0783	0.0026
5	0.0824	0.0013
6	0.0868	0.0023
7	0.0818	0.0027
8	0.0776	0.0025

Period	Bond Yield (Upper Bound)	Exchange Rate (Upper Bound)
9	0.0754	0.0027
10	0.0739	0.0029
11	0.0697	0.0031
12	0.0653	0.0033
13	0.0608	0.0036

The plot below shows the impulse response of `Bond_Yeild` to a one-unit shock in `GDP_Growth` over a 12-period horizon, with a 95% confidence interval.

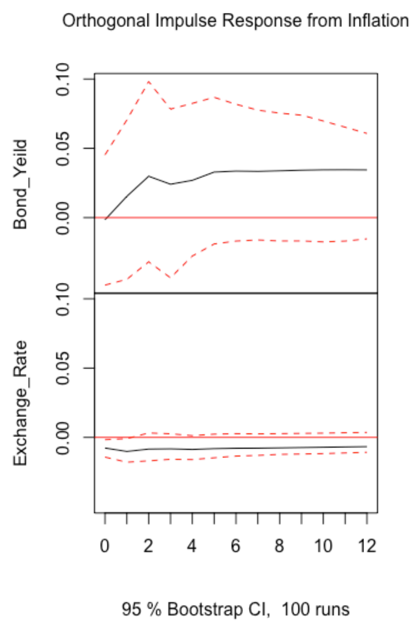


Figure 3: Impulse Response to Inflation Shock

3.16.8 Interpretation

- **Bond Yield**: The response of bond yield to an inflation shock shows an initial minor negative impact in period 1, followed by a sustained positive response, stabilizing around 0.034 by period 13.
- **Exchange Rate**: The exchange rate reacts negatively throughout the forecast period, with a dampening effect that stabilizes around -0.0069 by period 12.

3.16.9 Summary

This sensitivity analysis highlights the distinct responses of bond yield and exchange rate to an inflation shock: - **Bond Yield** experiences a positive response post-shock, suggesting a potential rise in yields following inflationary pressures. - **Exchange Rate** shows a consistent but gradually reducing negative response, implying that inflation shocks might depreciate the currency over the short term.

These results suggest inflation shocks have a marked influence on bond yields, with implications for investors and policymakers in managing inflationary impacts on financial markets.

3.17 Summary and Findings -

3.17.1 Theroretical Findings -

The empirical findings of this study substantiate several foundational economic theories concerning inflation, bond yields, exchange rates, and global risk. By analyzing the responses of bond yields and exchange rates to inflation and global risk shocks, the results offer strong empirical support for established theoretical frameworks, highlighting their continued relevance in understanding macroeconomic interactions and guiding policy decisions.

First, the Fisher Effect is affirmed by the study's observation of bond yield adjustments following inflation shocks. The findings show that while bond yields may initially fluctuate, they ultimately rise in response to inflation, thereby preserving real yields for investors. This behavior aligns with the theory's assertion that nominal yields adjust to account for inflation expectations, providing confirmation of the Fisher Effect in modern bond markets.

The Purchasing Power Parity (PPP) theory is also validated by the observed depreciation of the exchange rate in response to inflation shocks. According to PPP, inflation reduces a currency's purchasing power, prompting an exchange rate adjustment to balance international purchasing power. The study's findings, showing a consistent depreciation in the exchange rate following inflationary periods, underscore PPP's applicability in understanding exchange rate movements and inflationary pressures.

Additionally, the safe-haven theory, which predicts a currency depreciation in response to global risk shocks, is supported by the study. When global risk rises, investors tend to shift capital towards safer assets, causing currencies perceived as riskier to weaken. The study's empirical results, showing a steady depreciation in the exchange rate following a global risk shock, affirm this theory and highlight the currency market's sensitivity to investor sentiment in times of uncertainty.

The relationship between inflation and interest rates observed in the study provides evidence for the Taylor Rule, which suggests that central banks adjust interest rates in response to inflationary deviations. The study captures a strong positive relationship between inflation and interest rates, implying that monetary policy adjustments align closely with inflationary trends. This finding highlights the active role of central banks in moderating inflation through interest rate changes, supporting the Taylor Rule as a key guiding principle in policy response.

Lastly, the study hints at the role of Interest Rate Parity (IRP) by capturing an indirect relationship between interest rates and exchange rates. While not directly tested, the findings suggest that inflation-driven interest rate adjustments influence exchange rate dynamics, providing evidence for IRP's influence on currency valuation. Additionally, high R-squared values for bond yields and interest rates reflect the Efficient Market Hypothesis (EMH), indicating that markets efficiently price these financial instruments based on available macroeconomic information.

In conclusion, the study reaffirms major economic theories such as the Fisher Effect, PPP, the safe-haven theory, the Taylor Rule, IRP, and EMH. These findings contribute a valuable empirical perspective on the interconnectedness of inflation, interest rates, and exchange rates, offering insights for policymakers and financial analysts alike. By demonstrating the applicability of these theories, the study establishes a foundation for future research into the complexities of macroeconomic relationships and financial stability.

3.17.2 Empirical findings -

The empirical findings of this study provide valuable insights into the interrelationships among key macroeconomic variables—such as inflation, bond yields, exchange rates, and global risk—and affirm several foundational economic theories. Using a Vector Autoregression (VAR) model, the study assesses how shocks to one variable cascade through the economic system, impacting others. A notable finding is the positive response of bond yields to inflation shocks, supporting the Fisher Effect, which posits that nominal bond yields adjust upward to offset expected inflation and preserve real returns. This relationship is evident as bond yields increase following inflation shocks, suggesting that investors factor in inflation expectations when pricing bonds.

The study also finds that inflation shocks lead to a depreciation in the exchange rate, aligning with the Purchasing Power Parity (PPP) theory. PPP posits that higher inflation erodes a currency's purchasing power, leading to a natural depreciation to restore parity across currencies. This is particularly relevant for trade-dependent economies, where inflationary pressures often prompt currency devaluation to maintain competitive pricing. Furthermore, the influence of global risk shocks on exchange rates aligns with the safe-haven theory in foreign exchange markets, where heightened global risk prompts investors to seek safer currencies, leading to depreciation in riskier ones.

In terms of interest rates, the findings reflect the Taylor Rule principles, as inflation shocks prompt an eventual rise in interest rates. This indicates a reactive monetary policy stance, where central banks adjust interest rates in response to inflation to stabilize the economy. This observed response reflects the central banks' mandate to manage inflation and maintain economic stability, with implications for investor expectations and future policy actions. Additionally, while Interest Rate Parity (IRP) was not directly examined, the study's findings on exchange rate adjustments in response to inflation and interest rate changes suggest that currency markets are influenced by relative interest rate shifts, as IRP would predict.

The high R-squared values for bond yields and interest rates suggest that these financial markets efficiently incorporate macroeconomic information, in line with the Efficient Market Hypothesis (EMH), which argues that markets promptly reflect all available information. This efficient response is particularly notable in bond and interest rate markets, where changes in inflation and global risk are rapidly priced in.

Overall, the findings illuminate how inflation, interest rates, bond yields, and exchange rates interact within an economic system, with each variable responding to external shocks in ways that reinforce established economic theories. These results underscore the interconnectedness of macroeconomic variables and highlight the importance of understanding these dynamics for effective policy decisions. The study's conclusions also lay the groundwork for future research, particularly into the nuanced impacts of central bank policies on bond yields or the stability of exchange rates under heightened global risk conditions, to further deepen our understanding of macroeconomic interdependencies.

4 Conclusion

This study offers a comprehensive examination of the relationships between bond yields, macroeconomic variables, and exchange rates, focusing on the impacts of inflation shocks and global risk factors. The central objective—to understand how these forces interact and influence each other over time—is rigorously explored through an empirical approach, yielding insights that both affirm existing economic theories and uncover new dynamics.

The study's primary question addresses the extent to which inflation and global risk shocks affect bond yields and exchange rates. Using a Vector Autoregression (VAR) model on quarterly macroeconomic data, the analysis reveals key empirical findings. First, the study finds that global risk factors trigger a steady depreciation of the exchange rate, emphasizing how sensitive currency stability is to shifts in global uncertainty. This finding substantiates the study's objective by demonstrating how external risks permeate currency markets, emphasizing the complex link between global risk and exchange rate dynamics.

Inflation shocks reveal additional layers of this interplay. The analysis finds that bond yields initially respond negatively to inflation shocks before eventually stabilizing at a positive level. This reaction indicates an initial market adjustment, likely in anticipation of potential policy measures, followed by a recovery as inflationary pressures seem to ultimately support higher yields. In contrast, exchange rates show a consistent depreciation in response to inflation shocks, illustrating inflation's potential to erode currency value over time. These differentiated responses underscore inflation's multifaceted impact on financial stability and the currency markets, fulfilling the study's objective to capture inflation's dual role in influencing bond and currency values.

A significant empirical finding is the predictive strength of the VAR model, reflected in the high R-squared values, particularly for bond yields and interest rates. The model explains over 98% of the variability in interest rates and more than 90% in bond yields, demonstrating its efficacy in capturing these financial variables' behaviors over time. These values highlight the VAR model's practical utility, underscoring its potential application for policymakers and investors in forecasting and managing macroeconomic conditions. Achieving high predictive accuracy thus marks a clear success in realizing the paper's objective of developing a robust empirical framework.

The study also indicates areas for future exploration. While the findings capture essential relationships, the complexity of feedback effects between inflation, bond yields, and exchange rates suggests that future studies could benefit from more refined models. For instance, future research might consider real-time global risk indices or sector-specific inflation measures to deepen the insights obtained here. Additionally, incorporating policy intervention variables into the model could provide a more comprehensive view of how central bank actions influence these dynamics.

In summary, this study successfully advances its goal of elucidating the complex effects of inflation and global risk on bond yields and exchange rates. It offers a valuable empirical framework that not only substantiates theoretical insights but also supports practical applications, paving the way for future research to build upon and refine these findings within an increasingly interconnected global economy.

5 Limitations of the Study

This study sheds light on the intricate relationships between key macroeconomic variables, but like many empirical studies, it faces several limitations that should be acknowledged. One of the primary challenges encountered is the availability and quality of data. Macroeconomic data, especially at high frequencies, is often aggregated, which can obscure finer details in relationships, such as those between inflation, bond yields, and exchange rates. More granular data could reveal short-term interactions that annual or quarterly data may overlook. Additionally, the study's temporal and geographic scope may limit the generalizability of its findings. Economic conditions and policy effects vary significantly across regions and historical periods, which means that the insights derived may not hold universally beyond the specified scope of the analysis.

The study also relies on Vector Autoregressive (VAR) models, which, while useful for analyzing interdependencies, make assumptions that may not fully capture the structural complexity of an economy. VAR models are inherently linear and may struggle to accommodate non-linear dynamics or structural breaks that can arise from policy shifts or economic shocks. Furthermore, endogeneity remains a concern, as economic variables are often interdependent, making it challenging to establish causation. Although steps may have been taken to address endogeneity, residual issues may persist, such as reverse causation or omitted variable bias in the relationships studied. Unobserved external factors, including geopolitical events or global economic shocks, also pose limitations; these factors can disrupt economic relationships, potentially affecting the robustness of the study's conclusions.

There are also areas the researcher wished to explore but could not fully realize. A sectoral analysis could have provided a deeper understanding of how inflation, exchange rates, and bond yields interact across different economic sectors, while the inclusion of additional global factors, such as foreign interest rates or international trade flows, would allow for a broader perspective on the effects of global interconnectedness. The study might also benefit from non-linear or machine learning methods to capture complex interactions among variables, as well as from policy simulations to model potential impacts of hypothetical policy changes. Finally, extending the forecast horizon could provide insights into the long-term stability of these relationships, and conducting more in-depth sensitivity and robustness checks would enhance the reliability of the findings.

In conclusion, while this study makes important contributions to understanding macroeconomic dynamics, these limitations highlight areas for future research. By addressing these limitations—through more advanced methodologies, broader datasets, or a wider scope—future studies could refine our understanding of economic relationships and improve the applicability of findings for policy-making and economic forecasting.

6 References

The references are to thoroughly understand the relationship between bond yields, macroeconomic variables, and exchange rates in the context of price stability, it's essential to delve into both foundational theories and empirical studies. Below is a curated list of key literature—including seminal papers, comprehensive textbooks, and relevant empirical studies—that will provide you with a robust framework for your research.

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  This paper provides empirical evidence on the relationship between macroeconomic variables (such as interest rates and inflation) and exchange rates. It challenges some existing models and emphasizes the importance of bond yields and economic fundamentals in determining exchange rate dynamics.
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For a robust empirical investigation, I look forward to explore the following topics:

- **Interest Rate Parity (IRP):** Examine how bond yield differentials between countries influence exchange rate movements.
- **Term Structure and Macroeconomic Variables:** Investigate how the slope of the yield curve (difference between short-term and long-term bond yields) provides signals for future inflation, economic growth, and exchange rates.
- **Inflation Expectations and Bond Yields:** Study how inflation expectations are reflected in bond yields and how these influence exchange rates.
- **Monetary Policy and Exchange Rate Dynamics:** Analyze how central bank policy, through adjustments to interest rates, influences bond yields and exchange rate behavior, thereby affecting price stability.