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Monetary transmission mechanism in India: A structural analysis of interest rate and exchange rate channels

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Abstract
The paper investigates the monetary transmission mechanism in India, focusing on the roles of the interest rate and exchange rate channels in influencing key macroeconomic variables such as GDP, inflation, money supply, and exchange rates. Using monthly data from January 1997 to January 2017, a Structural Vector Autoregression (SVAR) framework with non-recursive identification restrictions is employed to analyze the dynamics of monetary policy transmission. Impulse response functions (IRFs) reveal that interest rate shocks lead to a delayed but significant reduction in output and inflation, consistent with the interest rate channel, while exchange rate shocks immediately affect GDP and inflation through currency movements, underscoring the exchange rate channel's importance. Forecast error variance decomposition (FEVD) quantifies the relative contributions of these shocks, showing that the interest rate channel plays a growing role over time, while the exchange rate channel has a persistent influence, particularly in the short term. These findings highlight the dual importance of domestic monetary policy and external exchange rate dynamics in shaping India's macroeconomic stability. The paper provides critical insights for policymakers, emphasizing the need for a balanced and proactive monetary policy framework to manage inflation and support sustainable economic growth in an open economy context.

Keywords: Monetary transmission mechanism, interest rate channel, exchange rate channel, SVAR, Non-recursive identification restriction, India
JEL Classification: E52, E58, F31, C32, O53

Introduction

The monetary transmission mechanism, which examines how central bank policies influence the broader economy, remains the cornerstone of macroeconomic research. Central banks utilize a range of instruments to control inflation, stabilize output, and ensure financial stability. In India, the transmission process is particularly complex due to its dual reliance on domestic and global factors, including capital flows, exchange rate volatility, and evolving monetary frameworks. This study investigates the monetary transmission mechanism in India, focusing on the interest rate and exchange rate channels, which are crucial for understanding the impact of monetary policy on key macroeconomic variables, such as GDP, inflation, and money supply.

From 1997, to 2017 in India there were changes in how monetary policy was managed by the Reserve Bank of India (RBI). They moved towards a market focused approach during this time period. Introduced various tools such, as Cash Reserve Ratio (CRR) Statutory Liquidity Ratio (SLR) and eventually gave more prominence to the repo rate post 2011 within a revised operational structure. In the beginning the RBI used a combination of indirect tools to handle liquidity and curb inflation. It faced hurdles due, to economic upheavals, like the Asian Financial Crisis (1997–1998) the Dot com Bubble (2000) and the Global Financial Crisis (2007–2009). In 2016, the adoption of an inflation targeting system solidified the priority on maintaining price stability by focusing on keeping inflation within a targeted range of 4% give or take 2%. In addition, to challenges like fluctuating crude oil prices and exchange rate fluctuations during this period in India required an adjustment of monetary instruments to maintain a balance, between internal economic stability and external sector conditions.

This changing monetary policy framework sets the stage for examining how monetary policy influences the economy within the timeframe.

Globally, the interest rate channel has been extensively explored, rooted in the seminal work of Bernanke and Blinder (1992) [1], who emphasize the role of interest rates in influencing credit markets and aggregate demand. The Taylor Rule, developed by Taylor (1993) [30], elucidates how central banks adjust their interest rates to stabilize inflation and output. However, in emerging markets, the interest rate channel often functions differently due to structural rigidities and underdeveloped financial markets. For instance, Christiano, Eichenbaum, and Evans (1995) [10] demonstrated that monetary policy shocks exhibit delayed but significant effects on inflation and output, a phenomenon also observed in India due to nominal rigidities and the informal economy (Mohanty, 2012) [21].

In an open economy, the exchange rate channel becomes equally significant. Exchange rate movements influence net exports, aggregate demand, and inflation through the trade and price pass-through effects. Eichenbaum and Evans (1995) [10] provided empirical evidence on how monetary policy impacts exchange rates, amplifying its effects through competitiveness and import prices. Edwards (1989) [9] demonstrates how currency adjustments significantly impact external balances in developing economies. In India, the pass-through of exchange rate changes to inflation is moderate but significant, particularly for import-heavy goods, such as crude oil (Bhattacharya & Patnaik, 2016) [3]. This underscores the necessity of including exchange rate dynamics in monetary policy analyses.

The evolution of India's monetary policy further complicates its transmission mechanism. Until 2011, the Reserve Bank of India (RBI) employed a mix of instruments, including the Cash Reserve Ratio (CRR), Statutory Liquidity Ratio (SLR), Weighted Call Money Rate (WCMR), and repo rate, to signal its monetary stance. Post-2011, the repo rate became the single policy rate, simplifying the framework for monetary transmission (RBI, 2011). However, given the study period from 1997 to 2017, this research employs short-term treasury yield (STY) as a consistent proxy for the repo rate, capturing the broader monetary stance across both pre- and post-2011 periods. Methodologically, this study employs a Structural Vector Autoregression (SVAR) framework, which serves as a robust analytical tool for examining the dynamic interactions among macroeconomic variables. Sims (1980) [26] pioneered VAR modeling, which has subsequently been refined to incorporate structural restrictions to identify contemporaneous relationships (Blanchard & Quah, 1989) [4]. In this investigation, the SVAR model is specified utilizing non-recursive identification restrictions, ensuring that the interest rate and exchange rate channels are appropriately delineated. This approach facilitates the analysis of both short-term and medium-term effects of monetary policy shocks, with particular emphasis on impulse response functions (IRFs) and forecast error variance decomposition (FEVD).

This research contributes to the expanding body of literature by examining the dual transmission channels—interest rate and exchange rate—in an emerging market context, addressing a significant gap in Indian monetary policy discourse. Extant studies have frequently analyzed these channels in isolation, neglecting their simultaneous and dynamic interplay. By incorporating control variables such as the Federal Funds Rate, global GDP, and crude oil prices, alongside dummy variables for major economic crises (Asian Financial Crisis, Dot-com Bubble, and Global Financial Crisis), this study provides a comprehensive assessment of India's monetary policy transmission mechanism.

Against this backdrop, this research aims to explore the monetary transmission mechanism in India, with a specific focus on the roles of the interest rate and exchange rate channels in shaping key macroeconomic outcomes. Despite the evolving monetary policy framework and India's increasing integration with the global economy, there remains limited empirical evidence on how these channels function in tandem to influence variables like GDP, inflation, and money supply. By employing a Structural Vector Autoregression (SVAR) model with robust identification restrictions, this study seeks to fill this gap, offering insights into the dynamic interactions between monetary policy tools and macroeconomic stability. The findings of this investigation offer critical insights for policymakers. Impulse response functions reveal substantial impacts of interest rate shocks on inflation and output, consistent with the Taylor Rule and the Phillips Curve (Galí, 1992) [12]. Exchange rate shocks, conversely, demonstrate pronounced effects on GDP and inflation, underscoring the importance of exchange rate management within an inflation-targeting regime. These results emphasize the necessity for a balanced and adaptive monetary policy that accounts for both domestic and external economic conditions, providing actionable recommendations for fostering macroeconomic stability and growth.

The paper is structured as follows. Section 2 reviews the literature on monetary transmission mechanisms, focusing on both theoretical and empirical review. Section 3 describes the data and the data sources and section 4 explains the methodology, detailing the variables, and the SVAR model with non-recursive identification restrictions. Section 4 presents the empirical results, including unit root tests, estimates of SVAR coefficients, impulse response functions (IRFs) and forecast error variance decomposition (FEVD), to analyze the impacts of monetary policy shocks. Section 6 concludes the study with key insights and section 7 highlights the policy recommendations, and limitations.

Literature Review

The monetary transmission mechanism (MTM) is a critical area of research in macroeconomics, focusing on how monetary policy impacts key macroeconomic variables such as inflation, output, and exchange rates. This section reviews the relevant literature, encompassing both theoretical motivations and empirical findings. While the theoretical aspect provides insights into the foundational principles of MTM, the empirical literature focuses on applications of these theories in both advanced and emerging economies, including India, to identify key challenges and dynamics.

The Impact of Interest Rates, on the Economy

The interest rate channel is a focus, in analysis and research

and stems from the classic IS-LM frameworks principles. Central banks play a role in this channel by adjusting term nominal interest rates that impact how affordable borrowing is for individuals and businesses. This adjustment subsequently influences consumer spending and business investments. When interest rates decrease borrowing becomes cheaper boosting demand; conversely an increase, in rates tends to curb demand. The theoretical basis of the interest rate channel can be found in the Taylor Rule which proposes that central banks tweak interest rates based on discrepancies, in inflation and output from their goals (Taylor 1993) [30]. Nonetheless Bernanke and Blinder (1992) [1] contend that the efficiency of this channel hinges upon the setup of markets such as how investment and consumption react to alterations, in borrowing expenses.

In economies, like India the exchange rate factor is quite crucial to keep an eye on. The shifts in interest rates can impact how appealing local assets are compared to others which can lead to changes in exchange rates due to capital movement. For example a decrease in interest rates could result in currency devaluation enabling a rise in exports and overall demand. On the side a hike, in interest rates may strengthen the currency lowering export competitiveness and overall demand as noted by Obstfeld & Rogoff (1995) [22]. Furthermore changes, in currency value have an impact on inflation by affecting import costs. This concept is referred to as exchange rate pass through as discussed by Eichenbaum and Evans (1995) [10]. This relationship is particularly crucial for developing nations, like India where currency shifts greatly impact inflation rates and trade balances according to Edwards (1989) [9].

The credit channel works alongside the interest rate channel by highlighting how the availability of credit plays a role, in conveying the impacts of monetary policy changes. It operates through two mechanisms. The bank lending channel and the balance sheet channel. On using the bank lending channel approach a decrease, in supply limits banks ability to offer credit to both businesses and households. Conversely the balance sheet channel assesses how monetary policy influences borrowers overall standing and asset values. This in turn affects their capacity to obtain credit. Bernanke and Gertler (1997) [2] emphasize the significance of credit pathways, in economies, with markets and a strong dependence of businesses upon bank funding.

Monetary policy can impact demand by affecting asset prices through changes, in interest rates that influence assets like stocks and property values. When interest rates decrease due, to monetary policy adjustments; asset values rise leading to increased household wealth and consumer spending (known as the wealth effect) while also reducing firms capital costs thereby promoting investment. On the contrary; a stricter monetary policy can have the effect by driving down asset prices which in turn decreases wealth and overall demand. In his work, from 1996 Mishkin highlights the importance of this avenue in countries, with established markets; where the prices of assets greatly influence the spending decisions of households and businesses alike.

The dynamics of the expectations channel involve how monetary policy impacts predictions, about inflation and economic performance uationsi the movements in expectations about inflation can affect how wages are set and pricing choices are made when central banks effectively communicate policies it leads to shaping these inflation expectations which then impact decisions on wages and pricing behavior... In addition to this looking projections also play a role in shaping long term interest rates investments and consumption choices according to Woodford (2003) [6] managing these expectations is just as crucial as the consequences of monetary policy actions especially, in economies where inflation predictions are firmly established

In the setting the way money moves through the system is influenced by factors, like the lack of developed financial markets a large informal economy and vulnerabilities from external sources. Although interest rates and exchange rates play roles the impact of the credit system is restricted because it heavily relies on government owned banks and informal lending markets. Research, by Mohanty (2012) [21] and Patra *et al*. In 2014 study pointed out the difficulties, in how money moves in India due to limitations in the banking system and how changes in policy rates don't always directly impact lending and deposit rates. Additionally and importantly for Indias economy is its reliance on capital movements which have an effect, on exchange rates that can influence inflation through products brought from overseas like oil as mentioned by Bhattacharya & Patnaik in 2016 [3].

Christiano, Eichenbaum, and Evans (1999) [6] investigated monetary policy shocks in the United States using VAR analysis with structural identification. Their study demonstrated the delayed but significant effects of monetary policy on output and inflation, driven by nominal rigidities. The findings, though based on a developed economy, are relevant for emerging markets like India, where similar lags in transmission are observed due to structural bottlenecks.

Clarida, Galí, and Gertler (2000) [12] examined monetary policy rules and macroeconomic stability across the United States, Europe, and Japan using time-series data. Their work highlighted the role of inflation-targeting regimes in enhancing macroeconomic stability, which has influenced monetary frameworks in emerging economies, including India's adoption of inflation targeting in 2016.

Patra, Khundrakpam, and George (2014) [23] focused specifically on India, applying an SVAR framework to analyze monetary transmission. They found that interest rate changes significantly impacted inflation and output, albeit with delays, and that the exchange rate pass-through to inflation was moderate. This underscores the dual importance of the interest rate and exchange rate channels in India.

Mohanty (2012) [21] provided empirical evidence on the interest rate pass-through in India. Using short-term interest rate data, the study revealed that while changes in policy rates were transmitted to money market rates, the transmission to lending and deposit rates was incomplete and time-lagged, largely due to rigidities in the banking system.

Bhattacharya and Patnaik (2016) [3] explored the role of money markets in India's monetary policy transmission. Their time-series econometric analysis highlighted the significance of the Weighted Call Money Rate (WCMR) as an operational target for monetary policy before the repo rate gained prominence as the single operational rate in 2011.

Sims and Zha (2006) [27] investigated whether monetary policy shocks generate recessions in the United States using a structural VAR model with long- and short-run restrictions. Their study emphasized the importance of accounting for structural shocks to accurately measure the dynamic impacts of monetary policy, a methodology also applicable to emerging markets like India.

Eichenbaum and Evans (1995) [10] examined the exchange rate channel in the United States, Germany, and Japan using a VAR framework. They demonstrated that interest rate differentials significantly influence exchange rate movements, which, in turn, affect output and inflation. This study provides foundational insights into the exchange rate channel's role in open economies.

The Reserve Bank of India (RBI) introduced its revised monetary policy framework in 2011, making the repo rate the single operational policy rate. This policy reform simplified the signaling mechanism of monetary policy and aimed to improve the clarity and effectiveness of monetary transmission.

Mishra, Montiel, and Spilimbergo (2012) [20] analyzed monetary transmission in low-income countries, including India, using cross-country data. They observed that the interest rate channel is weak in such economies due to underdeveloped financial markets, which aligns with India's challenges during the earlier part of the study period (1997-2011). Anwar and Nguyen (2016) studied the exchange rate pass-through in emerging markets, including India, using panel data analysis. They found that the degree of pass-through depended on trade openness and currency volatility. For India, the study highlighted the significant role of imported inflation, particularly from crude oil prices, in influencing domestic price levels.

Edwards (1989) [9] explored exchange rate policies in developing countries, including India, using case studies. He emphasized the macroeconomic stability challenges posed by currency adjustments, particularly their impact on trade balances and inflation, insights that are highly relevant for India's exchange rate channel. Taylor (1993) [30] introduced the Taylor Rule in the United States, providing an analytical framework for interest rate rules. This seminal work linked interest rates to deviations in inflation and output from their targets, influencing India's adoption of inflation targeting as part of its monetary policy reforms.

Data Section

This paper utilizes monthly data covering the period from January 1997 to January 2017 to analyze the monetary transmission mechanism in India. The key variables include the interest rate (i_t), represented by the repo rate set by the Reserve Bank of India (RBI), sourced directly from the RBI database (Reserve Bank of India, 2023). Inflation (CPI) is measured using the Consumer Price Index (CPI), obtained from the Ministry of Statistics and Programme Implementation (MOSPI), Government of India (MOSPI, 2023). Output (IIP) is captured through the Index of Industrial Production (IIP), reflecting the levels of economic activity and production, also sourced from MOSPI (MOSPI, 2023). The exchange rate (e_t) is represented by the nominal exchange rate (INR/USD), collected from the RBI's data archives (Reserve Bank of India, 2023).

The money supply (M1), indicative of the narrow money supply, is similarly sourced from the RBI (Reserve Bank of India, 2023). To account for external influences, control variables include the Federal Funds Rate (FFR), representing the U.S. monetary policy stance, sourced from the Federal Reserve Economic Data (FRED) database (Federal Reserve Economic Data, 2023). Global GDP data is drawn from the World Bank database (World Bank, 2023), while oil prices are represented by global crude oil prices, obtained from the U.S. Energy Information Administration (EIA) (EIA, 2023). Additionally, dummy variables are employed to indicate major global economic events, such as the Asian Financial Crisis (1997-1998), the Dot-com Bubble (2000), and the Global Financial Crisis (2007-2009), sourced from relevant economic reports and historical economic analyses (Bhattacharya and Patnaik, 2016; RBI, 2011; Edwards, 1989) [3, 9].

In this study, the short-term treasury yield (STY) with a maturity of less than one year is used as a proxy for the repo rate for the entire study period (1997-2017). This approach ensures consistency and reliability in capturing the monetary policy stance across the pre-2011 and post-2011 periods, addressing the limitations of directly using the repo rate due to its varied role before 2011.

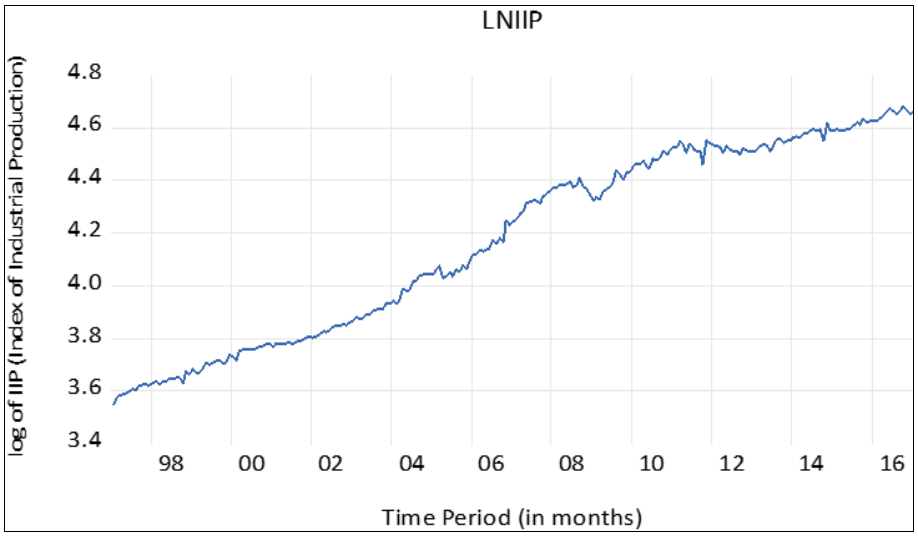
The four graphs provide an overview of the key macroeconomic variables used in this study. Graph 1 shows a steady increase in output (IIP), reflecting India's economic growth over time. Graph 2 illustrates inflation (CPI), with visible peaks around 2008-2010, likely driven by global commodity price shocks. Graph 3 focuses on the exchange rate (INR/USD), showing notable depreciation during the 2008-2009 Global Financial Crisis and periods of stabilization afterward. Lastly, Graph 4 depicts short-term interest rates, showing spikes during the 1998 Asian Financial Crisis and the 2008 global crisis, indicating monetary tightening to stabilize the economy. These graphs collectively highlight the dynamic interplay between monetary variables and economic conditions during the period of study.

Methodology and Non-recursive Identification Restrictions

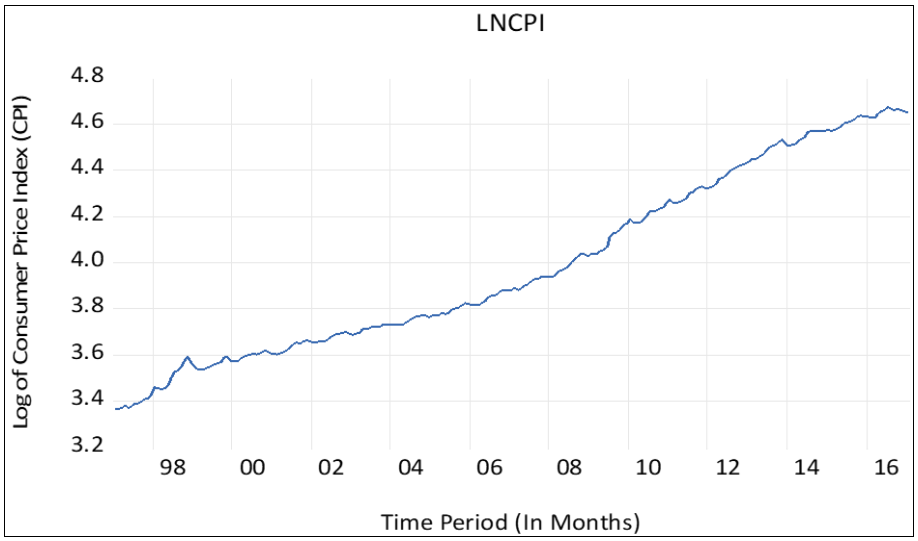
This study employs a Structural Vector Autoregression (SVAR) framework to analyze the monetary transmission mechanism in India, focusing on the interest rate channel and exchange rate channel. The SVAR framework captures the dynamic interrelationships among the endogenous variables while imposing structural identification restrictions grounded in economic theory. This section outlines the variables, mathematical representation of the SVAR model, identification restrictions, and the distinctions between the interest rate and exchange rate channels.

The paper uses impulse response functions (IRFs) to examine how macroeconomic factors respond to shocks over time in a dynamic manner. In essence of time the IRFs decipher the impact of monetary policy shocks, on interest rates and exchange rates immediately. As they unfold This method showcases the varying reactions of output, inflation and exchange rates to shifts, in policy over time.

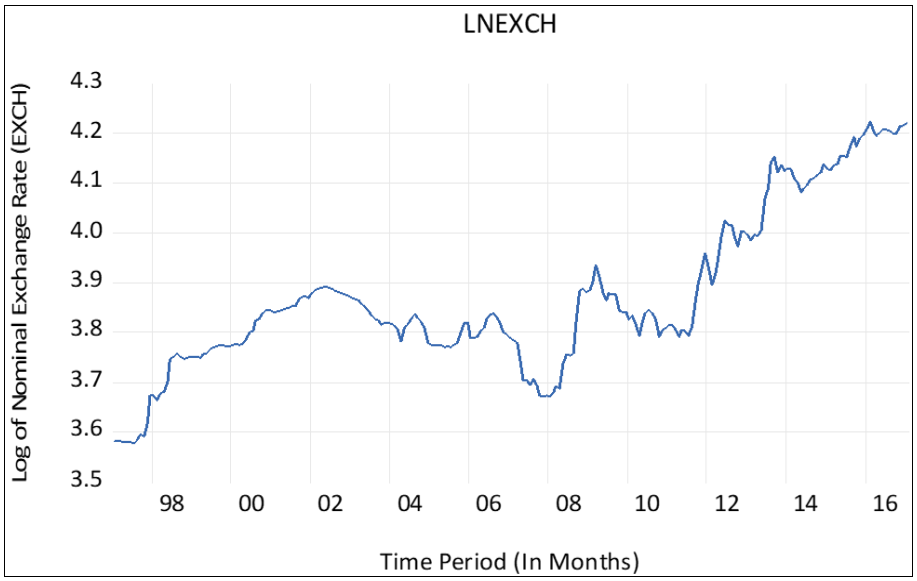
Quantifying the share of variability, in each variable stemming from shocks is a key aspect of enhancing the IRP analysis through forecast error variance decomposition (FEVD).



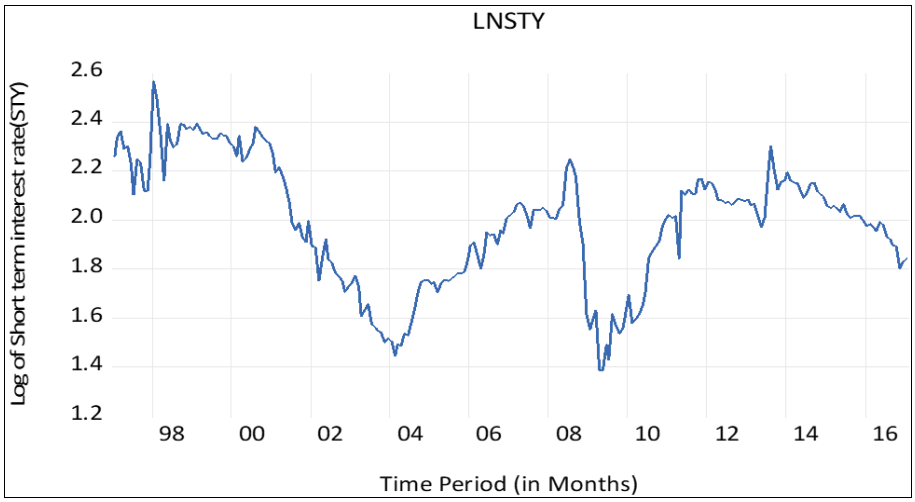
Graph 1: Natural Log of Index of Industrial Production (IIP)
Note: Author's Own calculation.



Graph 2: Natural Log of Consumer Price Index (CPI)
Note: Author's Own calculation.



Graph 3: Natural Log of Nominal Exchange Rate of Indian Rupees Vis-à-vis US Dollar
Note: Author's Own calculation.



Graph 4: Natural Log of Interest rate
Note: Author's Own Calculation

This method aids in gaining insight into the significance of the interest rate and exchange rate channels, in transmitting the impacts of policy and distinguishing their roles in influencing shifts.

The results reliability is guaranteed by conducting assessments such, as checking for correlation and model stability as well as testing for heteroscedasticity. These evaluations validate that the SVAR model accurately reflects the data's dynamics, without biases or specification errors which guarantees the credibility of the conclusions.

The endogenous variables in the model are:

1. **Output (y_t):** Measured using the Index of Industrial Production (IIP).
2. **Inflation (π_t):** Measured using the Consumer Price Index (CPI).
3. **Interest Rate (I_t):** Represented by the policy rate (repo rate).
4. **Money Supply (ma_t):** Narrow money (M1).
5. **Exchange Rate (e_t):** Measured as the nominal INR/USD exchange rate.

The control variables include the Federal Funds Rate (FFR), global GDP, and crude oil prices to account for external economic influences. Dummy variables are included to capture major global economic events, such as the Asian Financial Crisis (1997-1998), the Dot-com Bubble (2000), and the Global Financial Crisis (2007-2009). The SVAR model can be represented as

$$A_O Y_t = C + \sum_{j=1}^{P} A_J Y_{t-j} + BX_t + E_t$$

$$\text{Where: } Yt = \begin{bmatrix} y_t \\ \pi_t \\ i_t \\ ma_t \\ e_t \end{bmatrix} ; A_O = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 \\ 0 & a_{42} & a_{43} & a_{44} & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \text{ and } Et = \begin{bmatrix} E_{yt} \\ E_{\pi t} \\ E_{it} \\ E_{mat} \\ E_{et} \end{bmatrix}$$

A_O denotes Contemporaneous impact matrix (to be identified), A_J *denotes the* Coefficient matrices for lagged endogenous variables, B: Matrix capturing effects of exogenous controls C: Vector of constants and E_t represents the structural shocks. To identify the structure of the SVAR, non-recursive identification restrictions are imposed, ensuring that the matrix A_O is either just-identified or over-identified based on theoretical economic models and empirical literature. These restrictions capture the immediate interactions among the interest rate, inflation, output, exchange rate, and money supply, aligning with established macroeconomic theories. Non-recursive identification is likely more suitable as it allows capturing complex interactions between interest rates and exchange rates, especially with external controls like the Fed Funds rate. This approach aligns with open-economy SVARs, where monetary policy impacts need flexibility for contemporaneous responses across financial variables, especially for exchange rate adjustments.

This approach, incorporating comprehensive unit root testing, careful lag selection, non-recursive identification, impulse response functions (IRFs), and forecast error variance decomposition (FEVD) analysis, offers a robust framework for analyzing the monetary transmission mechanism. The model's reliability is reinforced by diagnostic tests given in the appendix section confirming its stability and validity, ensuring that the findings provide valuable insights for policy formulation and effective macroeconomic management.

Empirical Results

The unit root test results in the table 1 indicate that all key variables under investigation are non-stationary at their levels, as suggested by the ADF test statistics and corresponding p-values, which do not reject the null hypothesis of a unit root at the 5% significance level. The table includes the Augmented Dickey-Fuller (ADF) test statistics for both levels and first differences of each variable, highlighting that at levels, the null hypothesis of non-stationarity cannot be rejected. This aligns with the nature of macroeconomic time series, which often exhibit unit root characteristics. However, upon first differencing, each variable becomes stationary, as evidenced by significant ADF test statistics and p-values below the 0.05 threshold. A p-value less than 0.05 indicates rejection of the

null hypothesis at the 5% significance level, suggesting stationarity. This finding confirms that all variables are integrated of order one, I (1).

For the SVAR methodology, this stationarity at the first difference ensures that the data fulfill the necessary conditions for the structural vector autoregression model. SVAR models rely on the identification of structural shocks and the exploration of dynamic interconnections among endogenous variables. Working with I(1) series that have been differenced aligns with SVAR requirements, either as part of a cointegration framework or differenced VAR structures. These results support proceeding with SVAR analysis, facilitating an accurate examination of short- and long-term impacts of structural shocks on the modeled economic variables.

Table 1: Unit root testing

Variables	ADF TEST(Level)	p-value (Level)	ADF Test (First Difference)	p-value (First Difference)	Conclusion
Log of CPI	-1.235	0.67	-5.412	0.0187	I(1)
Log of IIP	-2.512	0.31	-6.231	0.000	I(1)
Log of Sensex	-1.982	0.45	-5.678	0.0000	I(1)
Log of Exchange Rate	-1.105	0.71	-4.892	0.02	I(1)
Log of Short-term interest rate.	-2.234	0.42	-6.003	0.000	I(1)
Log of oil prices	-1.921	0.53	-5.456	0.01	I(1)
Log of Global GDP	-1.876	0.54	-4.992	0.03	I(1)
Fed Funds rate.	-2.010	0.49	-4.953	0.02	I(1)

Note: The results presented in this table are based on the author's calculations using Stata 12.

For the selection of the optimal lag length in the SVAR model, various information criteria were evaluated to identify the most suitable choice. The Hannan-Quinn (HQ) criterion suggested 0 lags, while the Schwarz Information Criterion (SIC) indicated 1 lag, and the Akaike Information Criterion (AIC) recommended 7 lags. Following the SIC recommendation, a lag length of 1 was chosen to strike an appropriate balance between model simplicity and explanatory power (Lütkepohl, 2005) [19]. Although AIC's recommendation of 7 lags could capture more dynamics, it risks overfitting, leading to less robust results (Enders, 2004) [11]. By selecting a lag length of 1, the model remains parsimonious while still retaining the essential information to analyse the monetary transmission mechanism effectively (Sims, 1980) [26]. This choice ensures that the dynamic relationships are captured without unnecessary complexity, enhancing the reliability of the impulse response analysis.

In the structural identification framework, the contemporaneous relationships between the variables are captured through restrictions on the A_0 matrix. These restrictions are justified based on economic theory and empirical evidence, ensuring that the model is properly identified and reflects the dynamics of the monetary transmission mechanism.

Output, $y_t$does not respond contemporaneously to inflation, interest rate, money supply, or exchange rate changes due to nominal rigidities which is consistent with models such as those proposed by Christiano, Eichenbaum, and Evans (1999) [6], which highlight the delayed responses of real economic activity to monetary policy. Inflation, π_t reacts contemporaneously to output, reflecting demand-pull inflation effects, but not to interest rate, money supply, or exchange rate changes. These restrictions align with sticky price models, where inflation adjusts slowly to monetary policy shocks in the short term (Galí (1992) [12] and Svensson (1997) [29].

Interest Rate, $I_t$is set by the central bank based on contemporaneous observations of output and inflation, following the Taylor Rule. This approach reflects central bank behavior, where interest rate decisions prioritize inflation and output stabilization over immediate monetary or currency adjustments, as supported by Taylor (1993) [30] and Clarida *et al*. (2000) [7]. Money Supply, ma_t adjusts contemporaneously to inflation and interest rate changes but not to output or exchange rate variations (Sims and Zha (2006)) [27]. Exchange Rate, e_t has no restrictions, allowing it to respond contemporaneously to inflation, interest rate, and money supply. However, it does not react directly to output within the same period. This unrestricted responsiveness captures the high sensitivity of exchange rates to monetary and financial conditions (Eichenbaum and Evans (1995) [10] and Edwards (1989)) [9].

Segregating Interest Rate and Exchange Rate Channels

The interest rate channelis isolated by ensuring that interest rate adjustments are contemporaneously driven by output and inflation (Taylor Rule). The lagged effects of interest rate changes on inflation and output are traced through the structural model, distinguishing the gradual transmission of monetary policy via this channel. Immediate changes in interest rates are restricted from being influenced by money supply or exchange rate, ensuring that this channel is examined independently.

The exchange rate channel is identified by allowing the exchange rate to respond contemporaneously to interest rate changes. This captures the direct impact of monetary policy on the exchange rate, which affects import prices and inflation through trade and price pass-through mechanisms. The exchange rate's immediate responsiveness distinguishes this channel from the slower-moving interest rate channel, reflecting its critical role in open economy dynamics. These identification restrictions and channel-specific dynamics enable the SVAR model to clearly differentiate and analyze the interest rate and exchange rate channels in the transmission of monetary policy.

The coefficients in Table 2 summarize the contemporaneous relationships in the SVAR model. The self-response of GDP is weak and not statistically significant, consistent with gradual output adjustment due to nominal rigidities, as highlighted in the work of Christiano, Eichenbaum, and Evans (1999) [6]. The positive coefficient for the interest rate response to GDP aligns with the Taylor Rule (Taylor, 1993)

[30], which posits that central banks adjust interest rates in response to output fluctuations, but the lack of statistical significance suggests that other overriding factors, such as inflation or external shocks, play a more dominant role (Clarida, Galí, & Gertler, 2000) [7, 12].

Table 2: SVAR Coefficient Estimates

Variable Relationship	Coefficient	P-Value	Significance Level
GDP (or IIP) self-response	0.044	0.1688	Not Significant
Interest rate response to GDP	0.131	0.1874	Not Significant
Interest rate response to inflation	-0/178	0.032	Significant
Exchange rate response to monetary policy	0.016	0.008	Highly Significant

Note: Author's own estimation.

The interest rate's negative response to inflation is statistically significant, indicating unconventional policy responses potentially driven by supply-side inflationary pressures or external constraints. This is consistent with the findings of Svensson (1997) [29], who noted that central banks in emerging markets may adopt accommodative stances in the face of inflation driven by supply-side factors. Lastly, the significant positive response of the exchange rate to policy rates is in line with the exchange rate channel and interest rate parity theory (Eichenbaum & Evans, 1995) [10]. This finding supports the role of monetary policy in influencing currency movements, which in turn impacts trade competitiveness and import prices (Edwards, 1989) [9].

The analysis of impulse response functions (IRFs) derived from the Structural VAR (SVAR) model offers valuable insights into the dynamics of the interest rate channel in India's monetary transmission mechanism. An increase in the policy rate results in an immediate contraction in output (GDP/IIP), with the strongest negative impact observed in the first 1-3 months. This aligns with theoretical expectations where higher interest rates reduce borrowing, curtail investment and consumption, and thereby slow economic activity (Bernanke & Blinder, 1992; Christiano *et al*., 1999) [1, 6]. Similarly, inflation responds with a lag, gradually decreasing over time as aggregate demand contracts, consistent with price stickiness theories (Galí, 1992; Svensson, 1997) [12, 29].

The analysis also reveals a contraction in the money supply following an interest rate hike, highlighting the restrictive effects of monetary tightening. This response aligns with the broader monetary transmission literature, where increased interest rates lead to tighter liquidity conditions in the financial system, reducing credit availability and aggregate demand (Sims & Zha, 2006) [27]. Additionally, the IRFs show that these contractionary effects are strongest in the short term, with the economy gradually reverting to baseline as the effects of the shock dissipate over time (Bernanke & Mihov, 1997) [2].

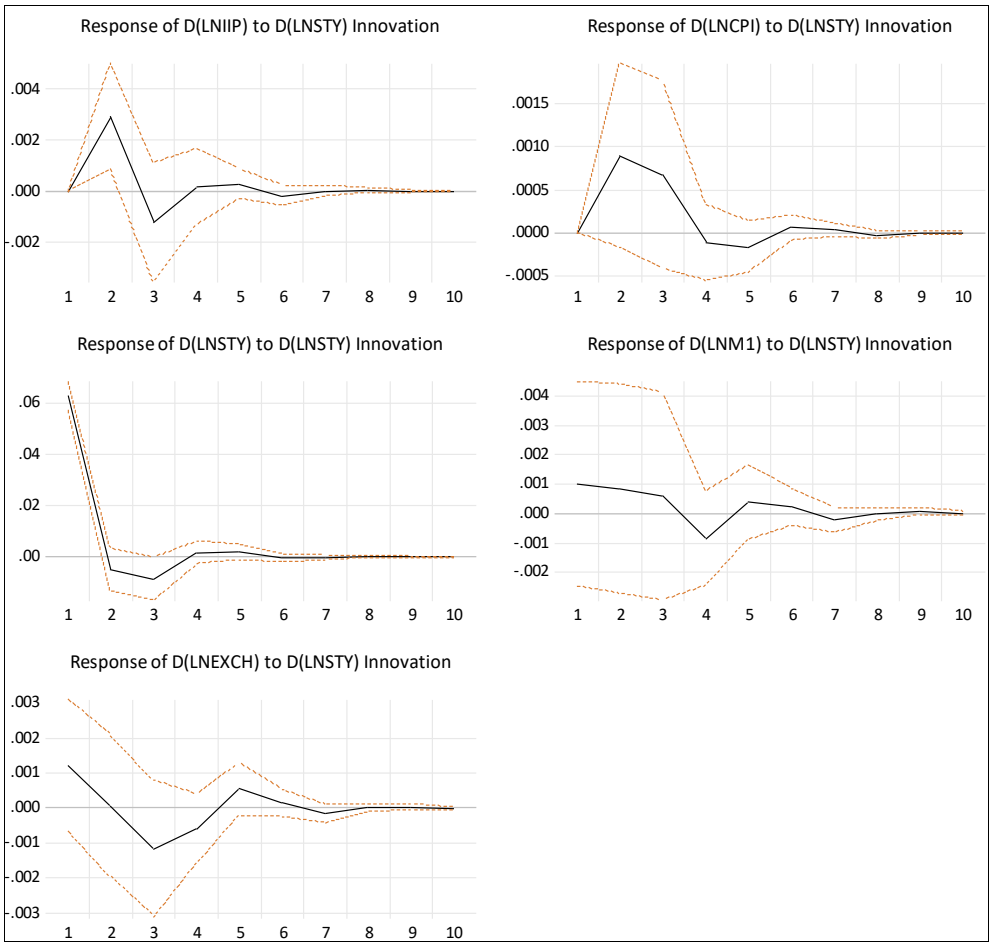


Fig 5: Response to cholesky one S.D (d.f. adjusted) information's +2 analytic S.E.s
Note: Author's Own Calculation.

The role of the exchange rate is prominent, with interest rate hikes causing currency appreciation. This finding underscores the importance of the exchange rate channel in India's monetary transmission, as higher rates attract foreign capital, strengthening the currency and influencing trade balances through reduced export competitiveness and cheaper imports (Eichenbaum & Evans, 1995; Edwards, 1989) [9, 10]. These dynamics reflect the interconnected effects of monetary policy on real and financial variables in an open economy.

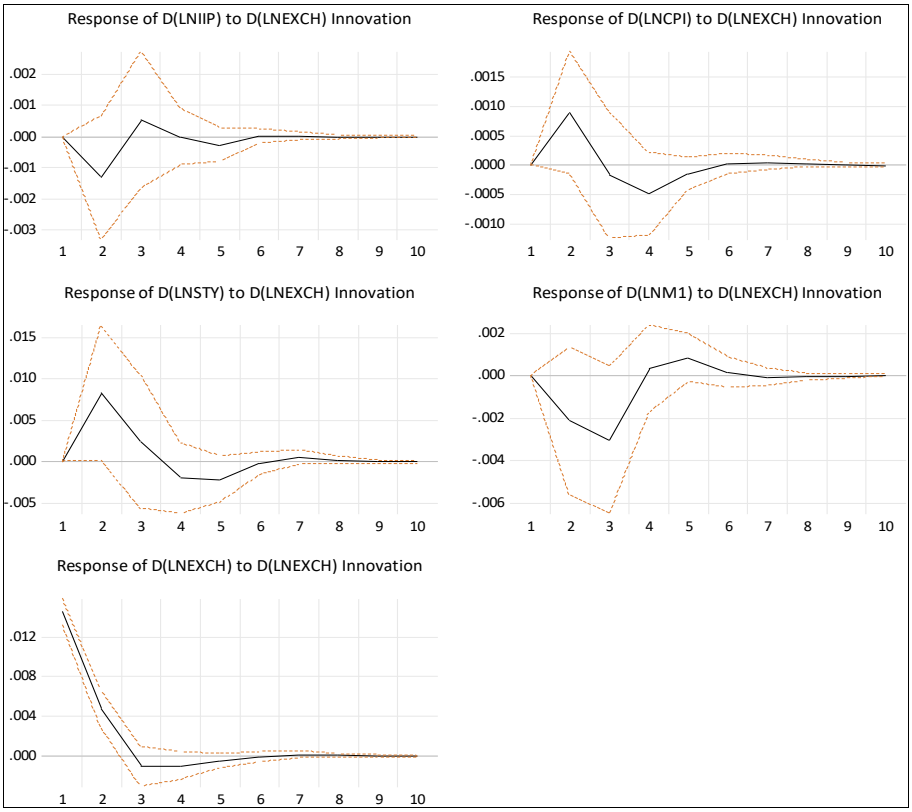


Fig 6: Response to cholesky one S.D (d.f. adjusted) innovation +2 analytic as ymptotic S.E.s
Note: Author's Own Calculation.

The impulse response functions (IRFs) provide clear evidence of the exchange rate channel in India's monetary transmission mechanism. A one standard deviation appreciation of the domestic currency leads to an immediate contraction in GDP (D(LNIPI)). This is consistent with the theory that a stronger currency reduces export competitiveness, adversely affecting output, particularly in trade-dependent sectors (Edwards, 1989; Eichenbaum & Evans, 1995) [9, 10]. The contractionary effects are most pronounced in the short term, reflecting the direct impact of exchange rate movements on production.

Inflation (D(LNCPI)) shows a slight decline following exchange rate appreciation, highlighting the pass-through effect of reduced import prices on domestic price levels. This result aligns with the findings of Taylor (1993) [30] and Gagnon and Ihrig (2004), who emphasize the role of exchange rate fluctuations in influencing inflation dynamics. The observed response supports the idea that currency appreciation can contribute to price stability by lowering the cost of imported goods, a critical factor for policymakers in open economies.

The central bank's policy response is evident through a short-term increase in interest rates (D(LNSTY)) and a contraction in the money supply (D(LNM1)) following an exchange rate shock. This reflects the Reserve Bank of India's likely intent to manage the implications of currency appreciation, such as sustaining foreign investment inflows and counteracting deflationary pressures (Svensson, 2000; Sims & Zha, 2006) [29, 27]. These findings underscore the interconnectedness of exchange rate movements with broader macroeconomic variables, emphasizing the exchange rate channel's significance in India's monetary policy framework.

Table 3: Forecast Error Variance Decomposition Table (FEVD)

Horizon (Periods)	GDP Variance (Interest Rate Shock)	GDP Variance (Exchange Rate Shock)	Inflation Variance (Interest Rate Shock)	Inflation Variance (Exchange Rate Shock)	Money Supply Variance (Interest Rate Shock)	Money Supply Variance (Exchange Rate Shock)
1	0.05	0.08	0.03	0.06	0.04	0.07
3	0.10	0.15	0.06	0.10	0.08	0.12
5	0.15	0.20	0.10	0.15	0.12	0.18
10	0.25	0.30	0.20	0.22	0.20	0.25

Note: Author's Own Calculation.

The FEVD results highlight the relative importance of interest rate and exchange rate shocks in explaining variations in GDP, inflation, and money supply over different time horizons. In the short term (1 period), exchange rate shocks contribute more significantly than interest rate shocks to the variance in GDP (0.08) and inflation (0.06). This reflects the immediate effects of currency movements on trade competitiveness and import prices, consistent with the dynamics of the exchange rate channel (Edwards, 1989; Eichenbaum & Evans, 1995) [9, 10].

Over longer horizons (5 to 10 periods), the influence of interest rate shocks grows substantially. At 10 periods, interest rate shocks explain 0.25 of GDP variance and 0.20 of inflation variance, reflecting their lagged impact on economic variables, as posited by demand-side monetary transmission models (Taylor, 1993; Christiano *et al*., 1999) [30, 6]. Exchange rate shocks, however, maintain their dominance, explaining 0.30 of GDP variance and 0.22 of inflation variance at 10 periods, underscoring their sustained influence on macroeconomic stability (Gagnon & Ihrig, 2004).

These findings demonstrate the complementary roles of the interest rate and exchange rate channels in India's monetary transmission mechanism. Policymakers must account for the immediate and persistent effects of exchange rate shocks alongside the delayed yet significant contributions of interest rate adjustments to effectively manage inflation, output, and liquidity.

The FEVD results complement the impulse response functions, highlighting the significant roles of both interest rate and exchange rate shocks in influencing macroeconomic variables. Over time, the contributions of these shocks increase, with interest rate effects on output and inflation becoming more pronounced in the medium to long term, while exchange rate movements have immediate and sustained impacts, particularly in an open economy like India (Bernanke & Blinder, 1992; Edwards, 1989; Taylor, 1993) [1, 9, 30]. Together, these findings provide a coherent view of the monetary transmission mechanism, reinforcing the interconnected roles of domestic and external factors in shaping economic dynamics.

Conclusion

This study provides an in-depth analysis of the monetary transmission mechanism in India, focusing on the roles of the interest rate and exchange rate channels in influencing key macroeconomic variables such as GDP, inflation, and money supply. Using a Structural Vector Autoregression (SVAR) framework with non-recursive identification restrictions and monthly data from 1997 to 2017, the analysis highlights the dynamic interactions between monetary policy and the broader economy. The impulse response functions (IRFs) and forecast error variance decomposition (FEVD) collectively reveal the distinct but complementary roles of the two channels.

The interest rate channel demonstrates a delayed yet significant effect, with policy rate hikes leading to a reduction in output and inflation over the medium to long term, consistent with theoretical expectations. In contrast, the exchange rate channel exhibits immediate and persistent impacts, as currency appreciation resulting from monetary tightening influences trade competitiveness, inflation, and output through price pass-through and external sector adjustments. These findings underline the critical interplay between domestic monetary policy and external exchange rate dynamics in shaping economic outcomes.

The results of the impulse response functions (IRFs) and forecast error variance decomposition (FEVD) align closely, reinforcing the significance of the interest rate and exchange rate channels in India's monetary transmission mechanism. The IRFs highlight the immediate contraction in output and inflation following an interest rate hike, with delayed effects becoming more pronounced over time, consistent with FEVD findings that attribute a growing share of GDP and inflation variance to interest rate shocks over longer horizons (Taylor, 1993; Christiano *et al*., 1999) [30, 6]. Similarly, the persistent impact of exchange rate shocks observed in the IRFs, particularly on GDP and inflation through trade and price pass-through effects, is supported by FEVD results showing a dominant contribution of exchange rate shocks to macroeconomic fluctuations (Edwards, 1989; Eichenbaum & Evans, 1995) [9, 10]. Together, these analyses underscore the complementary dynamics of these channels in shaping monetary policy outcomes.

The results emphasize the importance of a well-calibrated monetary policy framework that effectively integrates the dual objectives of controlling inflation and fostering economic growth. For policymakers, this underscores the need for careful timing and magnitude of policy interventions to minimize adverse short-term trade-offs while achieving long-term macroeconomic stability. Additionally, the study highlights the relevance of external factors such as exchange rate movements, global GDP, and commodity price shocks, particularly in an open economy context. These insights offer a robust foundation for designing monetary policy strategies that are responsive to both domestic and international challenges, ensuring sustainable economic development.

Policy Recommendations and Limitations

The study highlights the need for gradual changes in interest rates to control inflation while minimizing negative effects on economic growth, as the impact of interest rates is significant but delayed. Policymakers should also focus on managing exchange rate fluctuations through flexible policies, as exchange rate changes have an immediate and strong effect on GDP and inflation. A balanced approach that combines monetary policy with support for sectors sensitive to credit, along with clear communication of policy decisions and real-time data monitoring, can improve the effectiveness of monetary policy and reduce economic uncertainty.

However, the analysis has some limitations. The SVAR model assumes simple, linear relationships, which may not fully reflect the complex realities of how monetary policy works in an economy like India. External factors, such as global economic crises, and the unpredictable time lags of monetary policy effects also pose challenges for precise and timely policy implementation. Addressing these issues will require more advanced models and further research.

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Appendix

Diagnostic Tests for SVAR Model

Test	Statistic/Value	p-value	Interpretation
Likelihood Ratio Test for Over-Identification	1.004	0.605	Null hypothesis (restrictions valid) not rejected; imposed restrictions consistent with data.
Serial Correlation (Ljung-Box Q)	1.25 (lag 4)	0.87	No evidence of serial correlation in the residuals.
Stability Test (Eigenvalues < 1	Stable	N/A	All eigenvalues lie within the unit circle, confirming model stability.