Revisiting Monetary Policy Transmission in India: A Data-Driven VAR–ICA Approach

From Coefficient-Restricted VARs to ICA-Identified Monetary Shocks

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Introduction

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- **Monetary policy** is one of the key tools used by central banks to influence inflation, output, and overall financial stability.
- Understanding how monetary policy decisions are transmitted through the economy — via interest rates, credit, and exchange rates — is crucial for designing effective policy responses.
- In emerging economies like **India**, the structure and strength of these transmission channels remain less predictable and more data-sensitive.
- This project explores the working of India's **monetary policy transmission mechanism**, analysing how policy actions influence macroeconomic variables such as growth, inflation, and financial rates.
- The objective is to provide a clear, data-driven understanding of how monetary policy shocks propagate across the economy.

Research Question

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- Despite extensive research, there remains limited consensus on:
  - How policy shocks propagate under a multi-instrument and evolving policy regime.
  - Whether conventional RVAR/SVAR models truly capture structural monetary shocks.

- **Central Research Question:**
  Can Independent Component Analysis (ICA), when integrated with a VAR framework, provide a more transparent and statistically grounded identification of monetary policy shocks in India?

- The study evaluates:
  - The dynamic impact of identified policy shocks on output, inflation, and exchange rate.
  - The relative strength of transmission channels using Impulse Response and FEVD analysis.

Literature Review

Literature Review (Foundations)

- **Joseph and Dash (2025):** Used coefficient-restricted VAR models to identify interest rate, credit, and exchange rate channels in India. *Limitation: required multiple model restrictions and strong identifying assumptions.*

- **Hyvärinen and Oja (2000):** Introduced *Independent Component Analysis (ICA)* as a data-driven method to separate statistically independent, non-Gaussian sources. *Relevance: Real macroeconomic variables are typically non-Gaussian, making ICA suitable for structural identification.*

- **Lanne and Luoto (2021):** Proposed a GMM estimation of non-Gaussian Structural VARs (SVARs). *Showed that identification is possible through higher-moment conditions rather than recursive or sign restrictions.*

Literature Review (Recent Extensions)

- **Lee et al. (2023):** Integrated ICA within a Structural VAR framework and developed a change-point detection approach. *Demonstrated ICA's robustness in identifying structural breaks and evolving macroeconomic relationships.*

- Together, these studies establish the empirical and statistical basis for this project:
  - ICA provides a transparent, fully data-driven identification of monetary policy shocks.
  - It eliminates arbitrary recursive restrictions and aligns with the non-Gaussian nature of macroeconomic data.

- **Contribution:** This project extends Joseph and Dash (2025) by combining a full VAR(1) framework with ICA-based identification to extract India's monetary policy shock directly from the data.

Data

Data Overview

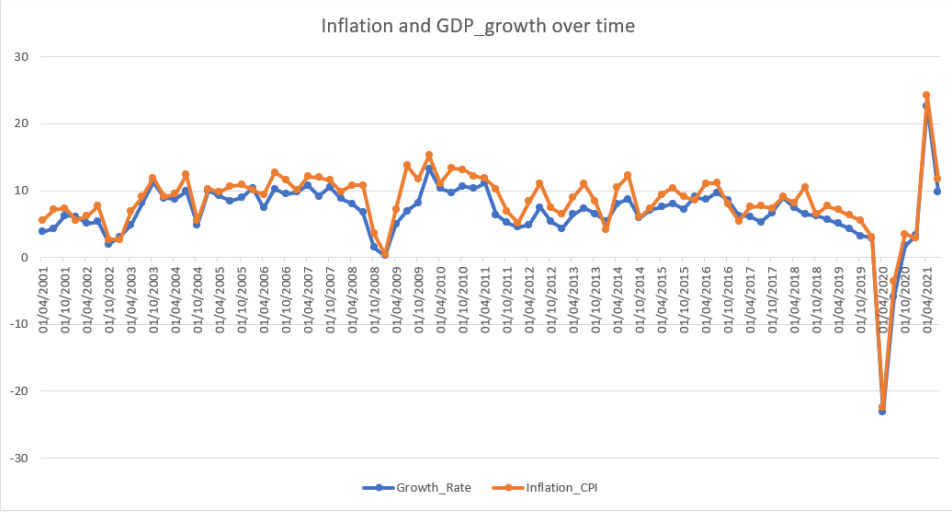
- The analysis uses **quarterly data** for India spanning **2001–02 Q1 to 2021–22 Q2**.
- The dataset is identical to that used in *Joseph and Dash (2025)* to ensure comparability.
- It includes six key **endogenous macro-financial variables:**
  1. Weighted Average Call Money Rate (**WACMR**) — policy rate proxy
  2. Year-on-Year GDP Growth (**Output**)
  3. Consumer Price Index (**Inflation**)
  4. Prime Lending Rate (**PLR**) — credit channel indicator
  5. 10-year Government Bond Yield (**GBYR**) — long-term interest rate
  6. Nominal Exchange Rate (**NER**) — INR per USD
- All variables are treated as **endogenous**; no exogenous controls (e.g., oil prices, Fed Funds Rate) are included to maintain a purely domestic framework.

Data Sources and Motivation for Selection

- **Sources:**
  - Reserve Bank of India (RBI)
  - FRED database

- **Why this period (2001–2022)?**
  - Captures major changes in India's **monetary policy regime**, including:
    - Transition to market-based interest rate system (early 2000s)
    - Global Financial Crisis (2008–09)
    - Shift to **Flexible Inflation Targeting** (2016 onwards)
  - Provides sufficient length and variation to analyse both pre- and post-inflation targeting transmission.
  - Ensures consistency with prior literature while extending the dataset to include recent policy cycles.

Data Visuals



Empirical Strategy

Empirical Strategy — Framework

- The analysis is divided into two stages:
  1. **Stage 1:** Estimate a reduced-form VAR to capture the joint dynamics among six endogenous variables:

$$y_t = c + A_1 y_{t-1} + u_t, \quad u_t \sim (0, \Sigma_u)$$

  2. **Stage 2:** Apply **Independent Component Analysis (ICA)** to the residuals u_t to recover statistically independent structural shocks:

$$u_t = B\varepsilon_t, \quad E[\varepsilon_t \varepsilon_t'] = I, \quad \varepsilon_t \text{ independent}$$

- This framework identifies structural monetary shocks directly from the data, without imposing recursive or sign restrictions.

Model Specification: VAR(1)

- The baseline model is a six-variable VAR(1):

$$y_t = c + A_1 y_{t-1} + u_t, \quad \text{with } y_t = \begin{bmatrix} \text{WACMR}_t \\ \text{GDP Growth}_t \\ \text{Inflation}_t \\ \text{PLR}_t \\ \text{NER}_t \\ \text{GBYR}_t \end{bmatrix}$$

- The optimal lag length ($p = 1$) is selected using the Bayesian Information Criterion (BIC):

$$\text{BIC}(p) = \ln |\Sigma_u(p)| + \frac{\ln(T)}{T} k^2 p$$

- Each variable is endogenous; u_t captures contemporaneous interactions among the macro-financial indicators.

Independent Component Analysis (ICA)

- Conventional SVAR identification assumes recursive ordering:

$$A_0 u_t = \varepsilon_t, \quad \Sigma_u = A_0^{-1}(A_0^{-1})'$$

  which requires restrictive zero restrictions on A_0.

- ICA relaxes this by assuming **statistical independence** and **non-Gaussianity** of the structural shocks:

$$u_t = B\varepsilon_t, \quad \varepsilon_t \text{ mutually independent, } E[\varepsilon_t \varepsilon_t'] = I$$

- The ICA algorithm (FastICA) finds an unmixing matrix $W = B^{-1}$ that maximises non-Gaussianity (via kurtosis or negentropy):

Identification of Structural Shocks

- The ICA decomposition yields:

$$\hat{u}_t = \hat{B}\hat{\varepsilon}_t, \quad \text{with } \hat{B} = W^{-1}$$

  where each column of $\hat{B}$ represents the contemporaneous impact of one structural shock.

- To identify the **monetary policy shock**, each independent component (IC_1–IC_6) is correlated with lagged macro variables:

$$\text{corr}(IC_j, y_{t-1})$$

- The component with the strongest contemporaneous loading on the policy rate (WACMR) — IC_6 — is identified as the **Monetary Policy Shock**.

- The sign of IC_6 is normalised so that a positive shock represents a *policy tightening*.

Dynamic Analysis: IRF and FEVD

Impulse Response Function (IRF):

$$\text{IRF}(h) = \Psi_h b_{MP}, \quad \Psi_h = A_1^h, \quad b_{MP} = \text{column of } \hat{B} \text{ for IC}_6$$

Traces the h-period effect of a one-unit monetary policy shock on all variables.

Forecast Error Variance Decomposition (FEVD):

$$\text{FEVD}_i^{MP}(H) = \frac{\sum_{h=0}^{H} (e_i' \Psi_h b_{MP})^2}{\sum_{k=1}^{6} \sum_{h=0}^{H} (e_i' \Psi_h b_k)^2}$$

Measures how much of variable i's forecast variance is explained by the monetary policy shock.

Together: IRFs capture the *direction and timing*, while FEVDs quantify the *importance* of monetary shocks across channels.

Results & Discussion

VAR Lag Selection

Table 1: VAR Order Selection Criteria

Lag (p)	AIC	BIC	FPE	HQIC
0	8.089	8.271	3260.0	8.162
1	**0.2161**	**1.485**	**1.245**	**0.7241**
2	0.4339	2.791	1.573	1.377
3	1.029	4.474	2.972	2.408
4	0.5399	5.072	1.975	2.354

Interpretation:

All four information criteria — AIC, BIC, FPE, and HQIC — reach their minimum at **lag order 1 (p = 1)**, indicating that a parsimonious **VAR(1)** specification sufficiently captures the short-run dynamics among the six endogenous variables without overfitting.

Full VAR(1) Estimation

Model: Six-variable VAR(1) estimated using quarterly data (2001–02 Q1 to 2021–22 Q2). Variables: WACMR, GDP Growth, Inflation, PLR, GBYR, NER.

Key Highlights:

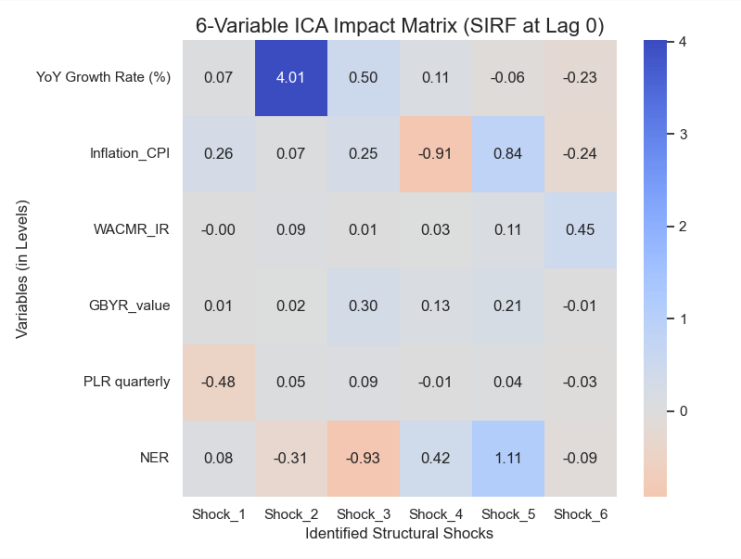
- **Strong persistence** in financial rates — WACMR (0.90***), GBYR (0.83***), PLR (0.80***), NER (1.01***).
- **GDP Growth:** Positive own-lag (0.42***); appreciation (–0.14**) slightly lowers growth.
- **Inflation:** Weak short-run response to financial variables.
- **GBYR & PLR:** Both negatively affected by exchange rate (–0.02**), showing easing under rupee strength.
- **NER:** Highly autoregressive, limited macro feedbacks.

Residual Correlation Matrix

Table 2: Correlation Matrix of Residuals from VAR(1) Model

	GDP Growth	Inflation	WACMR	GBYR	PLR	NER
GDP Growth	1.000	0.061	0.133	0.149	0.104	-0.275
Inflation	0.061	1.000	-0.059	0.276	-0.077	0.167
WACMR	0.133	-0.059	1.000	0.151	-0.011	0.080
GBYR	0.149	0.276	0.151	1.000	0.147	0.010
PLR	0.104	-0.077	-0.011	0.147	1.000	-0.127
NER	-0.275	0.167	0.080	0.010	-0.127	1.000

ICA Results — Heatmap

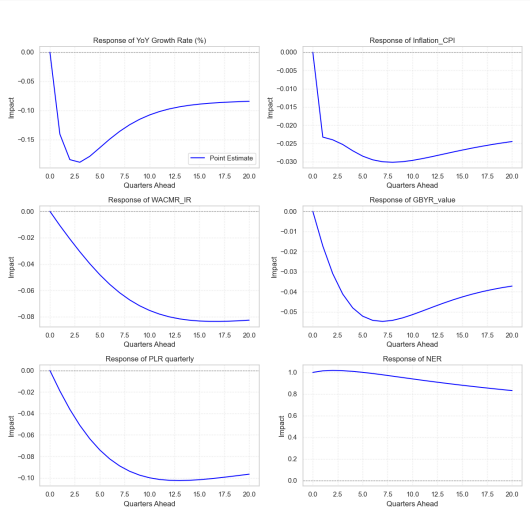


ICA results(contd)

Key Points:

- ICA successfully separated six independent shocks (**Shock 1–Shock 6**).
- **Shock 6** identified as the **Monetary Policy Shock** — strongest contemporaneous effect on **WACMR** ($+0.45$).
- Sign normalised: positive shock $\Rightarrow$ policy tightening.
- **Immediate effects (Lag 0):**
  - WACMR $\uparrow$ $+0.45$ — tightening identified.
  - GDP Growth $\downarrow$ –0.23; Inflation $\downarrow$ –0.24.
  - NER $\downarrow$ –0.09 $\rightarrow$ Rupee appreciation.
  - GBYR, PLR show negligible short-run changes.
- **Interpretation:** Consistent with theory — tightening reduces output & inflation, strengthens currency. No "exchange rate puzzle"; credit channel weak in short run.

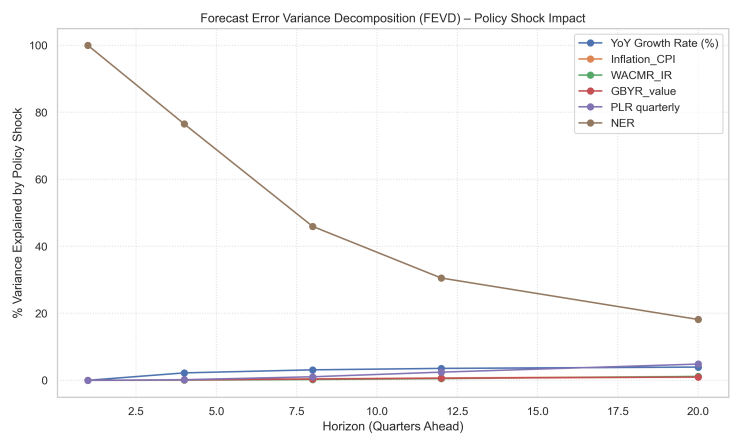
IRF Results


Response of YoY Growth Rate (%)
Response of Inflation_CPI
Response of WACMR_IR
Response of GBYR_value
Response of PLR quarterly
Response of NER
Impact
Quarters Ahead
Point Estimate

IRF: Interpretation

- **GDP Growth:** Contracts immediately (–0.15%), bottoms out by Q3; recovers after Q8 and stabilises by Q20.
- **Inflation (CPI):** Declines gradually (–0.03 by Q5–Q8) — delayed but clear disinflationary response.
- **WACMR:** Rises persistently, peaking at +1.16 by Q15–Q20 — gradual policy tightening.
- **GBYR (10-year yield):** Slight short-run dip, rises to +0.96 by Q20 — slow bond adjustment.
- **PLR (lending rate):** Strong, persistent rise (+4.85 by Q20) — clear credit pass-through.
- **NER (exchange rate):** Sharp appreciation (from 100 $\rightarrow$ 18 by Q20) — dominant exchange-rate channel.

FEVD


Forecast Error Variance Decomposition (FEVD) – Policy Shock Impact
% Variance Explained by Policy Shock
Horizon (Quarters Ahead)
YoY Growth Rate (%)
Inflation_CPI
WACMR_IR
GBYR_value
PLR quarterly
NER
0
20
40
60
80
100
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0

FEVD - Interpretations

- **WACMR (policy rate):** $\approx 100\%$ in the short run $\rightarrow \approx 45\%$ by 20Q.
- **GDP Growth:** $\approx 3.95\%$ at 20Q $\Rightarrow$ modest medium-run role.
- **Inflation (CPI):** $\approx 1.13\%$ at 20Q $\Rightarrow$ limited influence on price variance.
- **PLR (lending rate):** rises to $\approx 4.85\%$ at 20Q $\Rightarrow$ gradual but small credit-channel contribution.
- **GBYR (10Y yield):** low throughout (well below 2%) $\Rightarrow$ mild pass-through to long rates.
- **NER (exchange rate):** 100% at 1Q $\downarrow \approx 18\%$ at 20Q; *treat with caution* (possible non-stationarity/sensitivity).

Takeaway: Policy shock $\Rightarrow$ dominant for **WACMR**; **modest** for growth, inflation, and credit; **weak** for long-term yields.

Limitations

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- Uses quarterly data (2001–2022) — limited sample; higher-frequency data could show finer policy effects.
- Excludes global factors like oil prices and U.S. Fed rate — may miss external spillovers.
- ICA assumes independent and non-Gaussian shocks — complete independence is unlikely in real data.
- Exchange rate (NER) shows strong persistence — may cause minor bias in long-run results.
- VAR(1) assumes stable relationships — may not fully capture post-2016 policy regime changes.
- Focused on interest rate, credit, and exchange rate channels — omits asset-price and expectations channels.

Conclusion

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- Proposed a unified **VAR(1)–ICA** framework for analysing India's monetary policy transmission.
- ICA offers a **data-driven identification** of structural shocks without recursive restrictions.
- **IC6** identified as the monetary policy shock with strongest effect on WACMR.
- Monetary tightening raises short-term rates, lowers growth and inflation, and strengthens the rupee.
- FEVD shows policy shock drives WACMR; modest effect on growth and inflation.
- Transmission mainly via **interest-rate and exchange-rate** channels; weak credit response.
- ICA-based VAR provides a **transparent, statistically robust** view of policy dynamics.

References

References

1. Al-Mashat, R. (2003). *Monetary policy transmission in India: Selected issues and statistical appendix.* IMF Country Report, 3, 261.
2. Aleem, A. (2010). Transmission mechanism of monetary policy in India. *Journal of Asian Economics, 21*(2), 186–197.
3. Bhoi, B. K., Mitra, A. K., Singh, J. B., & Sivaramakrishnan, G. (2017). Effectiveness of alternative channels of monetary policy transmission: Some evidence for India. *Macroeconomics and Finance in Emerging Market Economies, 10*(1), 19–38.
4. Joseph, J. P., & Dash, S. K. (2025). Monetary policy transmission in India — a coefficient-restricted VAR approach. *Applied Economics,* 1–21.
5. Hyvärinen, A., & Oja, E. (2000). Independent component analysis: Algorithms and applications. *Neural Networks, 13*(4–5), 411–430.
6. Lanne, M., & Luoto, J. (2021). GMM estimation of non-Gaussian structural vector autoregression. *Journal of Business & Economic Statistics, 39*(1), 69–81.
7. Lee, S., Lee, S., & Maekawa, K. (2023). Change point test for structural vector autoregressive model via independent component analysis. *Journal of Statistical Computation and Simulation, 93*(5), 687–707.