**Research Report On:**

**To study the causality relationship between monetary policy and price stability in the Indian economy.**

**In partial fulfilment of the requirement for:**

|  |  |
| --- | --- |
| **Program** | Postgraduate in Diploma and Management (PGDM) |
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| **Academic Term** | 3rd |

**Table of Contents**

1. **Title of the Study**
2. **Abstract**
3. **Introduction**
4. **Literature Review**
5. **Data Profile**
6. **Methods, Models, and Empirical Analysis**
   * Data Preprocessing
   * Time Series Visualization
   * Stationarity Check (ADF Test)
   * Granger Causality Test
   * ARIMA Model for Inflation Forecasting
   * GARCH Model for Volatility Analysis
   * Wavelet Coherence Analysis
7. **Results & Discussion**
8. **Conclusion & Policy Implications**
9. **References**
10. **Appendices (if needed)**

**Title of the Study**

Does Monetary Policy Influence Price Stability in the Indian Economy?

**Abstract**

This study examines the causal relationship between the Reserve Bank of India (RBI) repo rate and inflation in India, focusing on price stability as a key economic objective. Using monthly data from 2004 to 2024, we employ Granger causality tests, ARIMA forecasting, GARCH models for volatility, and wavelet coherence analysis to assess the dynamic interactions between monetary policy and inflation. Our findings indicate weak short-term causality from the repo rate to inflation, while no reverse causality is observed. Additionally, the GARCH model confirms persistent inflation volatility, and wavelet coherence highlights time-dependent interactions. These insights suggest that while monetary policy influences inflation, it may not be the sole determinant, requiring complementary fiscal measures. Future research could integrate global economic variables and machine learning models to refine predictive accuracy.

**Introduction**

Monetary policy, primarily through the adjustment of the RBI repo rate, is a key tool for controlling inflation in India. The effectiveness of this tool in influencing price stability remains debated, with mixed empirical evidence. This study aims to determine whether RBI repo rate changes Granger cause inflation and assess the nature of their relationship over time. Existing research largely focuses on static models, overlooking volatility clustering and time-dependent interactions. We address this gap using advanced econometric techniques such as Granger causality tests, ARIMA forecasting, GARCH models for volatility, and wavelet coherence analysis to capture both short-term and long-term dependencies.

**Literature Review**

Previous studies, including Mishkin (1990) and Patra & Kapur (2010), have explored the link between interest rates and inflation. While some research suggests that repo rate changes directly affect inflation, others highlight that supply-side factors and global economic conditions play a significant role. However, few studies employ volatility modeling or time-frequency analysis. This study contributes by integrating Granger causality, GARCH models, and wavelet coherence analysis to provide a more comprehensive view of monetary policy effectiveness in India.

**Data Profile**

* **Timeframe:**
* 2004-2024 (Daily data)
* Descriptive

|  |  |  |
| --- | --- | --- |
| **Statistic** | **Monetary\_Policy** | **Price\_Stability** |
| Mean | 6.199432 | 5.283765 |
| Median | 6.5 | 4.88 |
| Standard Deviation | 1.1213238 | 5.658398 |
| Variance | 1.2573671 | 32.017471 |
| Minimum | 4 | -24.69 |
| Maximum | 8 | 60.5 |
| Skewness | -0.7179377 | 1.126745 |
| Kurtosis | 2.8938379 | 15.572674 |

* **Variables:**
  + **RBI Repo Rate** (monetary policy instrument)
  + **Consumer Price Index (CPI)** as a proxy for inflation
* **Sources:** RBI, Ministry of Statistics and Programme Implementation (MoSPI)
* **Data Transformations:**
  + First differencing for stationarity verification
  + Logarithmic transformation for volatility models
* **Visualizations:**
  + Time series plots of Repo Rate and CPI
  + ACF/PACF graphs to determine time series characteristics
  + Wavelet coherence heatmaps

**Methods, Models, and Empirical Analysis**

1. **Data Preprocessing**
   * Extracts date, repo rate, and inflation (CPI)
   * Converts into monthly time series
   * Handles missing values and ensures stationarity
2. **Time Series Visualization**
   * Time series plots for Repo Rate & CPI
   * Observes long-term trends & cyclical fluctuations
3. **Stationarity Check (ADF Test)**
   * Augmented Dickey-Fuller (ADF) test applied to both variables
   * If non-stationary, first differencing is applied
   * Confirms stationarity using ACF & PACF plots
4. **Granger Causality Test**
   * Tests if changes in Repo Rate predict Inflation (CPI)
   * Uses grangertest() with optimal lag selection (VARselect())
   * Results:
     + Repo Rate → Inflation (p = 0.0892): Weak causality
     + Inflation → Repo Rate (p = 0.2723): No causality
5. **ARIMA Model for Inflation Forecasting**
   * Uses auto.arima() to find best-fitting ARIMA model
   * Forecasts inflation trends for future periods
   * Observes cyclical fluctuations with moderate accuracy
6. **GARCH Model for Volatility Analysis**
   * Uses rugarch::ugarchspec() to estimate GARCH(1,1) model
   * Confirms high volatility persistence in inflation (α+β ≈ 0.9752)
   * Identifies inflation shocks and clustering effects
7. **Wavelet Coherence Analysis**
   * Uses analyze.coherency() to examine time-frequency relationships
   * Identifies short-term coherence (16–32 month period) stronger than long-term trend
   * Suggests time-varying influence of monetary policy on inflation

**Results & Discussion**

**Augmented Dickey-Fuller Test:**

* **Dickey-Fuller Test Statistic = -0.82585**
  + This value is **not sufficiently negative** to reject the null hypothesis.
* **Lag order = 15**
  + The test used 15 lags to remove autocorrelation effects.
* **p-value = 0.9593**
  + The **high p-value (> 0.05)** suggests that the null hypothesis **cannot be rejected**.
* **Null Hypothesis (H₀):** The series has a **unit root (non-stationary)**.
* **Alternative Hypothesis (H₁):** The series is **stationary**.

**Granger Causality Results:**

* **Model 1 (Full Model):** Includes lags of **both monetary policy and inflation**.
* **Model 2 (Restricted Model):** Includes **only lags of monetary policy** (without inflation).
* **Null Hypothesis (H₀):** **Inflation does not Granger cause monetary policy.**
* **Alternative Hypothesis (H₁):** **Inflation Granger causes monetary policy.**
* **F-statistic = 0.8531**, **p-value = 0.4262**
* The **high p-value (> 0.05)** means we **fail to reject the null hypothesis**.

**ARIMA Forecasting:**

#### **Model Parameters**

* **AR(1) = 0.4452**:
  + The first-order autoregressive term suggests that past inflation values influence future values with a moderate effect.
* **MA(1) = -1.4123, MA(2) = 0.4210**:
  + The first and second moving average terms capture short-term fluctuations in inflation, with **MA(1) being strongly negative**.
* **Drift = -0.0006**:
  + Indicates a slight **downward trend** in the inflation series over time.

#### **Model Fit & Evaluation**

* **sigma² = 30.33**:
  + Measures the variance of the model's residuals, indicating the level of uncertainty.
* **Log-Likelihood = -11546.55**:
  + Used for model comparison; higher (less negative) is better.
* **AIC (23103.1) & BIC (23134.18)**:
  + Lower values indicate a better model fit, but should be compared with alternative models.

#### **Forecasting Performance (Error Measures)**

* **RMSE (5.5034)**:
  + Average error in predicting inflation, with lower values being better.
* **MAE (3.2281)**:
  + Measures the average absolute error, showing moderate accuracy.
* **MAPE (∞)**:
  + Indicates an issue, possibly due to near-zero inflation values in the dataset.
* **ACF1 (-0.0011)**:
  + Shows negligible autocorrelation in residuals, indicating **uncorrelated prediction errors** (a good sign).

**GARCH Volatility:**

### **Model Overview**

The model used is **GARCH(1,1) with ARFIMA(1,0,1)**, which:

* **Captures volatility clustering** in inflation over time.
* **Accounts for both short-term shocks and long-term volatility persistence**.
* **Uses a normal distribution** for error terms.

#### **Conclusion from α + β**

* **α (0.01203) + β (0.98334) ≈ 0.9954**
* Since this sum is **very close to 1**, it indicates that inflation volatility is **highly persistent**, meaning:
  + **Inflation shocks take a long time to die out.**
  + **Periods of high inflation remain high for extended periods.**
  + **RBI's monetary policy may have a delayed effect on stabilizing inflation.**

**Model Evaluation & Diagnostics**

#### **Akaike Information Criterion (AIC) = 6.2222, BIC = 6.2323**

* These values help compare models. **Lower values indicate a better fit**, meaning the model balances complexity and accuracy.

#### **Ljung-Box Test on Standardized Residuals (p-value > 0.05 at Lag[1])**

* **No significant autocorrelation in residuals**, meaning **GARCH properly captures volatility**.

#### **ARCH LM Test (p-values > 0.05 for most lags except Lag[7])**

* **No remaining ARCH effect**, meaning **the model successfully accounts for volatility clustering**.

#### **Nyblom Stability Test (Joint Statistic = 1.84, Critical Value = 1.68 at 5% level)**

* Indicates **some mild instability in the model parameters** (particularly **MA(1)**), suggesting inflation dynamics may shift over time.

#### **Sign Bias Test (p < 0.01 for all terms)**

* **Strong sign bias detected**, meaning **inflation responds asymmetrically to positive vs. negative shocks**.
* **RBI rate hikes and cuts may have different effects on inflation volatility**.

**Policy & Economic Implications**

** Inflation volatility is highly persistent → RBI's repo rate adjustments may not have an immediate stabilizing effect.**

** Short-term inflation shocks are small but significant → Policy should be forward-looking rather than reactive.**

** Asymmetric inflation response → Rate hikes may control inflation better than rate cuts boost economic growth.**

** Wavelet analysis shows time-varying impact → The repo rate’s influence on inflation is stronger in certain periods than others.**

**Wavelet Coherence:**

* Moderate short-term coherence (16-32 months), suggesting time-dependent interactions

**Linear Regression Analysis: Monetary Policy and Price Stability**

To further examine the relationship between monetary policy (RBI Repo Rate) and inflation (price stability), a simple linear regression was conducted using the formula:

**price\_stability ~ monetary\_policy**

**Key Regression Output:**

* Coefficient of monetary\_policy: **-0.481** (p < 0.01)
* Constant (Intercept): **8.263**
* R² = **0.009**, Adjusted R² = **0.009**
* F-statistic = **33.82** (df = 1, 3695), p < 0.01
* Observations = **3697**

**Interpretation:**

* The negative coefficient implies that an increase in repo rate is associated with a slight decrease in price stability (i.e., inflation), consistent with theoretical expectations.
* However, the very low R² suggests that repo rate explains **less than 1% of the variation** in inflation, highlighting a weak linear relationship.
* The statistical significance is likely driven by the large sample size rather than strong predictive power.
* The scatter plot (Figure 1) shows a flat linear fit with high dispersion, reinforcing the conclusion of limited explanatory strength.

**Conclusion & Policy Implications**

* Short-term impact: The RBI repo rate has some influence on inflation but is not the sole determinant
* Long-term impact: No strong long-term causality between repo rate and inflation
* Policy Implications:
  + RBI should not rely solely on repo rate adjustments to control inflation
  + Fiscal policies & global factors should be incorporated into inflation management
* Future Research:
  + Incorporate global economic variables (e.g., commodity prices, exchange rates)
  + Apply machine learning models to improve inflation prediction accuracy

**References**

* Mishkin, F. S. (1990). Interest rates and inflation. *National Bureau of Economic Research.*
* Patra, M. D., & Kapur, M. (2010). A monetary policy model without money for India. *RBI Occasional Papers.*
* RBI (2024). Macroeconomic Indicators. *Reserve Bank of India.*
* MoSPI (2024). Inflation Data. *Ministry of Statistics and Programme Implementation.*

**Appendices**

**R Codes**

**# Install required packages**

**install.packages(c("readxl", "tseries", "vars", "forecast", "rugarch", "lmtest", "ggplot2", "gridExtra","moments","stargazer","WaveletComp"))**

**# Load required libraries**

**library(readxl)**

**library(tseries)**

**library(vars)**

**library(forecast)**

**library(rugarch)**

**library(lmtest)**

**library(ggplot2)**

**library(gridExtra)**

**library(moments)**

**library(stargazer)**

**library(WaveletComp)**

**# Load the dataset**

**file\_path <- "C:/Users/ASUS/Downloads/AMAN FE.xlsx" # Ensure correct file path**

**df <- read\_excel(file\_path, sheet = 1)**

**# Check dataset structure**

**str(df)**

**colnames(df) # Display column names**

**# Identify and format Date column**

**date\_col <- grep("date|Date|DATE", colnames(df), value = TRUE)**

**if (length(date\_col) == 1) {**

**df$Date <- as.Date(df[[date\_col]], tryFormats = c("%Y-%m-%d", "%d-%m-%Y", "%m/%d/%Y"))**

**} else {**

**stop("No valid Date column found. Check column names.")**

**}**

**# Ensure sorted data by Date**

**df <- df[order(df$Date), ]**

**# Identify monetary policy and price stability columns**

**mp\_col <- grep("Interest|Policy|Rate", colnames(df), value = TRUE, ignore.case = TRUE)**

**ps\_col <- grep("Inflation|Price|CPI", colnames(df), value = TRUE, ignore.case = TRUE)**

**if (length(mp\_col) == 1 && length(ps\_col) == 1) {**

**monetary\_policy <- as.numeric(df[[mp\_col]])**

**price\_stability <- as.numeric(df[[ps\_col]])**

**} else {**

**stop("Could not detect monetary policy or price stability columns. Check column names.")**

**}**

**# Remove missing values**

**df <- df[!is.na(monetary\_policy) & !is.na(price\_stability), ]**

**# Descriptive Statistics**

**summary\_stats <- data.frame(**

**Statistic = c("Mean", "Median", "Standard Deviation", "Variance", "Minimum", "Maximum", "Range", "Skewness", "Kurtosis"),**

**Monetary\_Policy = c(mean(monetary\_policy), median(monetary\_policy), sd(monetary\_policy), var(monetary\_policy), min(monetary\_policy), max(monetary\_policy), max(monetary\_policy) - min(monetary\_policy), skewness(monetary\_policy), kurtosis(monetary\_policy)),**

**Price\_Stability = c(mean(price\_stability), median(price\_stability), sd(price\_stability), var(price\_stability), min(price\_stability), max(price\_stability), max(price\_stability) - min(price\_stability), skewness(price\_stability), kurtosis(price\_stability))**

**)**

**print(summary\_stats)**

**# Convert to time series**

**start\_year <- as.numeric(format(min(df$Date), "%Y"))**

**monetary\_policy\_ts <- ts(monetary\_policy, start = c(start\_year, 1), frequency = 12)**

**price\_stability\_ts <- ts(price\_stability, start = c(start\_year, 1), frequency = 12)**

**# Step 2: Plot Time Series**

**p1 <- ggplot(df, aes(x = Date, y = monetary\_policy)) +**

**geom\_line(color = "blue") +**

**ggtitle("Monetary Policy Time Series") +**

**xlab("Year") + ylab("Interest Rate / Policy Rate") + theme\_minimal()**

**p2 <- ggplot(df, aes(x = Date, y = price\_stability)) +**

**geom\_line(color = "red") +**

**ggtitle("Price Stability Time Series") +**

**xlab("Year") + ylab("Inflation / CPI") + theme\_minimal()**

**grid.arrange(p1, p2, ncol = 1)**

**# Step 3: Check for Stationarity (ADF Test)**

**adf\_test\_mp <- adf.test(monetary\_policy\_ts)**

**adf\_test\_ps <- adf.test(price\_stability\_ts)**

**print(adf\_test\_mp) # Print ADF test results**

**print(adf\_test\_ps)**

**# Step 4: Plot ADF & ACF Results**

**par(mfrow = c(2,2)) # Arrange 2x2 plots**

**acf(monetary\_policy\_ts, main = "ACF: Monetary Policy (Before Differencing)")**

**acf(price\_stability\_ts, main = "ACF: Price Stability (Before Differencing)")**

**pacf(monetary\_policy\_ts, main = "PACF: Monetary Policy (Before Differencing)")**

**pacf(price\_stability\_ts, main = "PACF: Price Stability (Before Differencing)")**

**# If non-stationary, take first differences**

**if (adf\_test\_mp$p.value > 0.05) {**

**d\_monetary\_policy <- diff(monetary\_policy\_ts)**

**adf\_test\_dmp <- adf.test(d\_monetary\_policy)**

**print(adf\_test\_dmp)**

**} else {**

**d\_monetary\_policy <- monetary\_policy\_ts**

**}**

**if (adf\_test\_ps$p.value > 0.05) {**

**d\_price\_stability <- diff(price\_stability\_ts)**

**adf\_test\_dps <- adf.test(d\_price\_stability)**

**print(adf\_test\_dps)**

**} else {**

**d\_price\_stability <- price\_stability\_ts**

**}**

**# Step 5: Plot ACF & PACF for Differenced Series**

**par(mfrow = c(2,2))**

**acf(d\_monetary\_policy, main = "ACF: Differenced Monetary Policy")**

**acf(d\_price\_stability, main = "ACF: Differenced Price Stability")**

**pacf(d\_monetary\_policy, main = "PACF: Differenced Monetary Policy")**

**pacf(d\_price\_stability, main = "PACF: Differenced Price Stability")**

**# Fix for length mismatch**

**min\_length <- min(length(d\_monetary\_policy), length(d\_price\_stability))**

**d\_monetary\_policy <- d\_monetary\_policy[1:min\_length]**

**d\_price\_stability <- d\_price\_stability[1:min\_length]**

**# Step 6: Granger Causality Test**

**data\_diff <- data.frame(d\_monetary\_policy, d\_price\_stability)**

**VARselect(data\_diff, lag.max = 10, type = "const") # Select optimal lag**

**var\_model <- VAR(data\_diff, p = 2, type = "const") # Update lag based on VARselect()**

**summary(var\_model)**

**grangertest(d\_price\_stability ~ d\_monetary\_policy, order = 2, data = data\_diff)**

**grangertest(d\_monetary\_policy ~ d\_price\_stability, order = 2, data = data\_diff)**

**# Step 7: ARIMA Model**

**arima\_model <- auto.arima(d\_price\_stability) # Identify best ARIMA model**

**summary(arima\_model)**

**# Forecasting**

**arima\_forecast <- forecast(arima\_model, h = 20)**

**plot(arima\_forecast, main = "ARIMA Forecast for Price Stability")**

**# Step 8: GARCH Model for Volatility**

**garch\_spec <- ugarchspec(variance.model = list(model = "sGARCH", garchOrder = c(1,1)),**

**mean.model = list(armaOrder = c(1,1)),**

**distribution.model = "norm")**

**garch\_fit <- ugarchfit(spec = garch\_spec, data = d\_price\_stability)**

**print(garch\_fit)**

**# Plot GARCH Model (only volatility)**

**plot(fit, which = 3)**

**# Granger Causality Test**

**var\_model <- VAR(cbind(monetary\_policy, price\_stability), p = 2, type = "const")**

**granger\_test <- causality(var\_model, cause = "monetary\_policy")**

**print(granger\_test)**

**# Volatility Calculation**

**df$Volatility <- c(NA, diff(log(price\_stability)))**

**df\_volatility <- df[-1, c("Date", "Volatility")]**

**# Plot Volatility**

**plot(df\_volatility$Date, df\_volatility$Volatility, type = "l", col = "purple", main = "Volatility of Price Stability", xlab = "Date", ylab = "Volatility")**

**print(p5)**

**# Wavelet Analysis**

**wavelet\_data <- data.frame(time = df$Date, monetary\_policy = monetary\_policy, price\_stability = price\_stability)**

**wavelet\_result <- analyze.coherency(wavelet\_data,**

**my.pair = c("monetary\_policy", "price\_stability"),**

**loess.span = 0,**

**dt = 1,**

**dj = 1/20,**

**lowerPeriod = 2,**

**upperPeriod = 64,**

**make.pval = TRUE,**

**n.sim = 100)**

**# Corrected plot function for wavelet analysis**

**wc.image(wavelet\_result, main = "Wavelet Coherence: Monetary Policy vs Price Stability")**

**# Regression Analysis**

**regression\_model <- lm(price\_stability ~ monetary\_policy, data = df)**

**summary(regression\_model)**

**# Plot Regression**

**reg\_plot <- ggplot(df, aes(x = monetary\_policy, y = price\_stability)) +**

**geom\_point(color = "blue") +**

**geom\_smooth(method = "lm", color = "red") +**

**ggtitle("Regression: Monetary Policy vs Price Stability") +**

**xlab("Monetary Policy") +**

**ylab("Price Stability") +**

**theme\_minimal()**

**print(reg\_plot)**

**# Regression Table**

**stargazer(regression\_model, type = "text")**

**Visuals**







