PROJECT-

Ques. 1- WHAT IS A VAR MODEL?

A VAR (Vector Autoregression) model is a statistical model used to capture the linear interdependencies among multiple time series data. It generalises the univariate autoregressive model to multivariate time series data, making it particularly useful in fields such as econometrics where multiple time series influence each other.

Ques. 2- WHY A VAR MODEL?

Advantages of Using VAR Models:

- **Multivariate Nature:** VAR models can analyse multiple time series simultaneously, making them ideal for systems where variables interact with each other.

- **Endogeneity:** All variables are considered endogenous, meaning they are explained by their own past values and those of other variables in the model.

- **Forecasting:** Highly effective for short-term forecasting of economic and financial time series.

Impulse Response Analysis: Useful for understanding how a shock to one variable affects others in the system.

- **Granger Causality:** Capable of testing for causal relationships between time series.

Ques. 3- HOW TO IMPLEMENT IT? With the help of data
Step-by-Step Implementation:

- **Data Collection:** Gather the time series data for the variables you are interested in. For instance, if analysing the relationship between GDP, inflation, and policy rate, collect historical data for these variables.

- **Data Preparation:**

Ensure the data is stationary. If it is not, apply differencing or other transformation methods to achieve stationarity.
Split the data into training and testing sets.

- **Model Selection:**

Determine the optimal lag length using criteria such as the Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC).

- **Model Estimation:**

Fit the VAR model to the training data. In Python, you can utilize the statsmodels library for this purpose**.**

Ques. 4-HOW POLICY RATE AFFECTS GDP AND INFLATION RATE?

Understanding the Impact of Policy Rate:
Policy Rate: The interest rate determined by the central bank (e.g., Federal Reserve, European Central Bank), which impacts other interest rates throughout the economy.

Transmission Mechanism:

- **Interest Rates:** Changes in the policy rate affect borrowing and lending rates, which in turn influence consumer spending and business investment.

- **Investment:** Increased interest rates make borrowing more costly, leading to a decrease in business investment spending.

- **Consumption:** Higher rates raise the cost of loans, reducing consumer spending on large purchases such as homes and cars.

- **Exchange Rate:** An increase in the policy rate can attract foreign investment, causing the currency to appreciate and potentially decreasing exports.
- **Inflation:** Elevated interest rates can dampen demand, thereby reducing inflationary pressures.
- **GDP:** Reduced investment and consumption lead to lower aggregate demand, which can slow GDP growth.

Effect of Industrial Production Index YoY on Consumer Price Index: YoY-

Code-(Python)

```
import pandas as pd
from statsmodels.tsa.api import VAR
import matplotlib.pyplot as plt

# Load the data from the Excel file
file_path = r'C:\Users\dell\Pictures\VAR model\VAR model data.xlsx'
data = pd.read_excel(file_path, skiprows=20)

# Display the first few rows to understand the structure
print(data.head(20))

# Extract relevant data rows (Modify these indices based on your data
structure)
industrial_production = data.iloc[18:, 1].reset_index(drop=True)
consumer_price_index = data.iloc[18:, 3].reset_index(drop=True)

# Create a DataFrame
df = pd.DataFrame({
    'Industrial_Production_YoY': industrial_production,
    'Consumer_Price_Index_YoY': consumer_price_index
})

# Convert to numeric values
df = df.apply(pd.to_numeric, errors='coerce')

# Drop NaN values
df = df.dropna()

# Display the prepared data
print(df.head())

# Fit a VAR model
model = VAR(df)
results = model.fit(maxlags=15, ic='aic')
```

```
# Print summary of results
print(results.summary())

# Plot the results
results.plot_forecast(10)
plt.show()
```

Results-

	Skewness	-0.02460632241994582	4.510773621898042	0.5752525529806357	0.7759413261067842	8.771364548730425
0	Kurtosis	-0.807611	56.811428	-0.996773	0.313443	116.924066
1	Coefficient Variation	0.363235	2.153520	0.590785	0.476987	0.540955
2	Min	33.435105	-53.246753	24.766448	0.000000	0.170000
3	Max	157.731959	133.518519	222.615203	19.672120	54.320000
4	Median	92.680412	4.387292	75.603979	6.276660	6.200000
5	Sum	34679.512393	1958.958520	39450.440141	2830.715496	1946.990000
6	Subtract	-124.296853	-186.765272	-197.848755	-19.672120	-54.150000
7	No. of Obs	397.000000	397.000000	400.000000	400.000000	301.000000
8	1991-01-01 00:00:00	38.199438	4.644682	24.889660	16.091935	0.000000
9	1991-02-01 00:00:00	37.758610	7.792836	24.889660	15.428546	0.000000
10	1991-03-01 00:00:00	46.795583	8.108108	24.766448	13.559333	0.000000
11	1991-04-01 00:00:00	33.689429	0.811771	24.889660	12.222223	0.000000
12	1991-05-01 00:00:00	33.553790	-1.981179	25.136095	12.087911	0.000000
13	1991-06-01 00:00:00	33.452060	-3.520782	25.752176	12.972984	0.000000
14	1991-07-01 00:00:00	34.638905	1.641791	26.368258	13.227530	0.000000
15	1991-08-01 00:00:00	33.435105	-1.498501	26.737904	14.210529	0.000000
16	1991-09-01 00:00:00	34.113302	1.004016	27.230768	15.706800	0.000000
17	1991-10-01 00:00:00	33.638564	1.121305	27.477203	14.358982	0.000000
18	1991-11-01 00:00:00	34.079392	-0.445765	27.723632	13.636367	0.000000
19	1991-12-01 00:00:00	37.606016	-0.180018	27.723632	13.065324	0.000000

	Industrial_Production_YoY	Consumer_Price_Index_YoY
0	34.079392	27.723632
1	37.606016	27.723632
2	39.725381	28.093279
3	39.131959	28.216496
4	45.473100	28.216496

Summary of Regression Results

Model:	VAR
Method:	OLS
Date:	Mon, 17, Jun, 2024
Time:	21:41:14

No. of Equations:	2.00000	BIC:	4.49073
Nobs:	375.000	HQIC:	4.09923
Log likelihood:	-1722.48	FPE:	46.6294
AIC:	3.84148	Det(Omega_mle):	39.7805

Results for equation Industrial_Production_YoY

	coefficient	std. error	t-stat	prob
const	3.060899	2.027782	1.509	0.131
L1.Industrial_Production_YoY	0.942191	0.054396	17.321	0.000
L1.Consumer_Price_Index_YoY	1.112959	0.744601	1.495	0.135
L2.Industrial_Production_YoY	-0.066600	0.073857	-0.902	0.367
L2.Consumer_Price_Index_YoY	0.183005	1.220341	0.150	0.881
L3.Industrial_Production_YoY	-0.084113	0.089176	-0.943	0.346
L3.Consumer_Price_Index_YoY	-1.151143	1.281323	-0.898	0.369
L4.Industrial_Production_YoY	-0.037217	0.085038	-0.438	0.662
L4.Consumer_Price_Index_YoY	-2.913147	1.296486	-2.247	0.025
L5.Industrial_Production_YoY	0.419121	0.085851	4.882	0.000
L5.Consumer_Price_Index_YoY	6.763805	1.297243	5.214	0.000
L6.Industrial_Production_YoY	-0.202319	0.087420	-2.314	0.021
L6.Consumer_Price_Index_YoY	-3.459561	1.337721	-2.586	0.010
L7.Industrial_Production_YoY	-0.149696	0.086205	-1.737	0.082
L7.Consumer_Price_Index_YoY	-3.818259	1.344013	-2.841	0.004
L8.Industrial_Production_YoY	0.250057	0.086408	2.894	0.004
L8.Consumer_Price_Index_YoY	4.657296	1.349310	3.452	0.001
L9.Industrial_Production_YoY	-0.181471	0.087232	-2.080	0.037
L9.Consumer_Price_Index_YoY	-2.671273	1.390974	-1.920	0.055
L10.Industrial_Production_YoY	-0.094987	0.087387	-1.087	0.277
L10.Consumer_Price_Index_YoY	1.010017	1.438348	0.702	0.483
L11.Industrial_Production_YoY	0.034147	0.085879	0.398	0.691
L11.Consumer_Price_Index_YoY	0.439833	1.448346	0.304	0.761
L12.Industrial_Production_YoY	0.548169	0.086934	6.306	0.000
L12.Consumer_Price_Index_YoY	1.346652	1.452566	0.927	0.354
L13.Industrial_Production_YoY	-0.633072	0.091712	-6.903	0.000
L13.Consumer_Price_Index_YoY	-5.205506	1.457349	-3.572	0.000

L14.Industrial_Production_YoY	0.161690	0.097369	1.661	0.097
L14.Consumer_Price_Index_YoY	5.955031	1.422505	4.186	0.000
L15.Industrial_Production_YoY	0.056413	0.086077	0.655	0.512
L15.Consumer_Price_Index_YoY	-2.251512	0.856855	-2.628	0.009

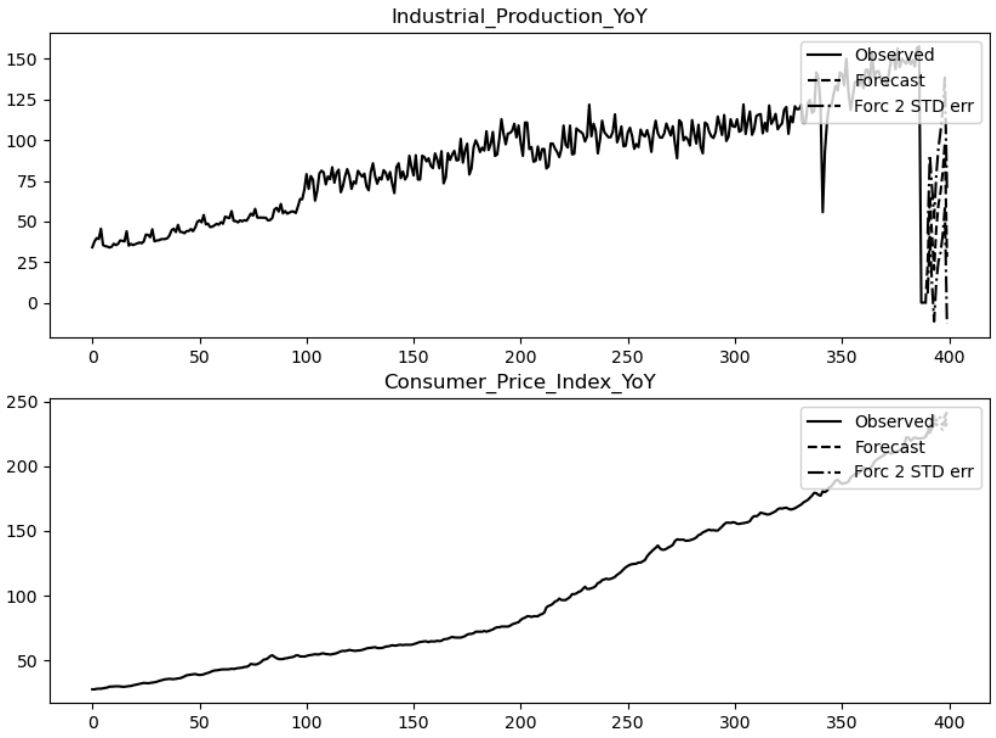
Results for equation Consumer_Price_Index_YoY

	coefficient	std. error	t-stat	prob
const	-0.100773	0.145866	-0.691	0.490
L1.Industrial_Production_YoY	0.007894	0.003913	2.017	0.044
L1.Consumer_Price_Index_YoY	1.274647	0.053562	23.798	0.000
L2.Industrial_Production_YoY	-0.003194	0.005313	-0.601	0.548
L2.Consumer_Price_Index_YoY	-0.525309	0.087784	-5.984	0.000
L3.Industrial_Production_YoY	-0.017978	0.006415	-2.803	0.005
L3.Consumer_Price_Index_YoY	0.284957	0.092170	3.092	0.002
L4.Industrial_Production_YoY	0.017017	0.006117	2.782	0.005
L4.Consumer_Price_Index_YoY	-0.029762	0.093261	-0.319	0.750
L5.Industrial_Production_YoY	-0.014485	0.006176	-2.346	0.019
L5.Consumer_Price_Index_YoY	-0.098719	0.093315	-1.058	0.290
L6.Industrial_Production_YoY	0.002452	0.006288	0.390	0.697
L6.Consumer_Price_Index_YoY	0.129696	0.096227	1.348	0.178
L7.Industrial_Production_YoY	0.006182	0.006201	0.997	0.319
L7.Consumer_Price_Index_YoY	-0.270436	0.096680	-2.797	0.005
L8.Industrial_Production_YoY	0.010240	0.006216	1.647	0.099
L8.Consumer_Price_Index_YoY	0.260550	0.097061	2.684	0.007
L9.Industrial_Production_YoY	-0.001716	0.006275	-0.274	0.784
L9.Consumer_Price_Index_YoY	0.015553	0.100058	0.155	0.876
L10.Industrial_Production_YoY	-0.001463	0.006286	-0.233	0.816
L10.Consumer_Price_Index_YoY	0.077169	0.103466	0.746	0.456
L11.Industrial_Production_YoY	-0.018046	0.006178	-2.921	0.003
L11.Consumer_Price_Index_YoY	-0.077456	0.104185	-0.743	0.457
L12.Industrial_Production_YoY	0.004244	0.006253	0.679	0.497
L12.Consumer_Price_Index_YoY	0.156232	0.104488	1.495	0.135
L13.Industrial_Production_YoY	-0.000405	0.006597	-0.061	0.951
L13.Consumer_Price_Index_YoY	-0.070405	0.104832	-0.672	0.502
L14.Industrial_Production_YoY	-0.003954	0.007004	-0.564	0.572
L14.Consumer_Price_Index_YoY	-0.082636	0.102326	-0.808	0.419
L15.Industrial_Production_YoY	0.018323	0.006192	2.959	0.003
L15.Consumer_Price_Index_YoY	-0.043942	0.061637	-0.713	0.476

Correlation matrix of residuals

	Industrial_Production_YoY	Consumer_Price_Index_YoY
Industrial_Production_YoY	1.000000	-0.126760
Consumer_Price_Index_YoY	-0.126760	1.000000

Figure-



Interpretation-

The two plots show the Year-over-Year (YoY) changes in Industrial Production and the Consumer Price Index (CPI) along with their forecasts. Here is the interpretation for each plot:

Top Plot: Industrial Production YoY

1. ***Observed Data:***
    - *The solid black line represents the observed values of the Industrial Production YoY.*
    - *The observed values show a generally increasing trend over the time period with some fluctuations.*
2. ***Forecast:***
    - *The dashed line represents the forecasted values for Industrial Production YoY.*
    - *The forecast indicates that the Industrial Production is expected to remain relatively stable in the short term, with some degree of variability.*
3. ***Forecast Error Bands:***
    - *The dotted lines represent the forecast error bands, specifically the 2-standard deviation (2 STD) error bands.*
    - *These bands show the range within which the actual values are expected to fall with a high degree of confidence.*

- *The error bands widen in the forecast period, indicating increasing uncertainty as the forecast horizon extends.*

Bottom Plot: Consumer Price Index (CPI) YoY

1. ***Observed Data:***
   - *The solid black line represents the observed values of the Consumer Price Index YoY.*
   - *The observed CPI values show a consistent upward trend over the time period.*
2. ***Forecast:***
   - *The dashed line represents the forecasted values for the CPI YoY.*
   - *The forecast indicates a continuation of the increasing trend, although the rate of increase appears to be steady.*
3. ***Forecast Error Bands:***
   - *The dotted lines represent the forecast error bands, specifically the 2-standard deviation (2 STD) error bands.*
   - *Similar to the top plot, these bands show the range within which the actual values are expected to fall with high confidence.*
   - *The error bands widen over the forecast period, indicating increasing uncertainty as time progresses.*

General Interpretation:

- ***Trend Analysis:***
  - *Both the Industrial Production and CPI show upward trends in their observed data.*
  - *The forecasted values suggest that these trends are expected to continue, although the Industrial Production shows more variability compared to the CPI.*
- ***Uncertainty:***
  - *The widening of the forecast error bands in both plots indicates that the uncertainty of the forecasts increases as the forecast horizon extends.*
  - *This is a common characteristic in time series forecasting, where long-term predictions tend to be less certain than short-term ones.*
- ***Economic Implications:***
  - *An increasing trend in Industrial Production indicates growing economic activity and potential expansion in the industrial sector.*
  - *A rising CPI suggests increasing inflation, which can impact purchasing power and economic policy decisions.*

Overall, these plots provide valuable insights into the future expectations of industrial production and inflation, highlighting both the anticipated trends and the uncertainty associated with these forecasts.

Effect of Industrial Production Index YoY on Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg-

Code-

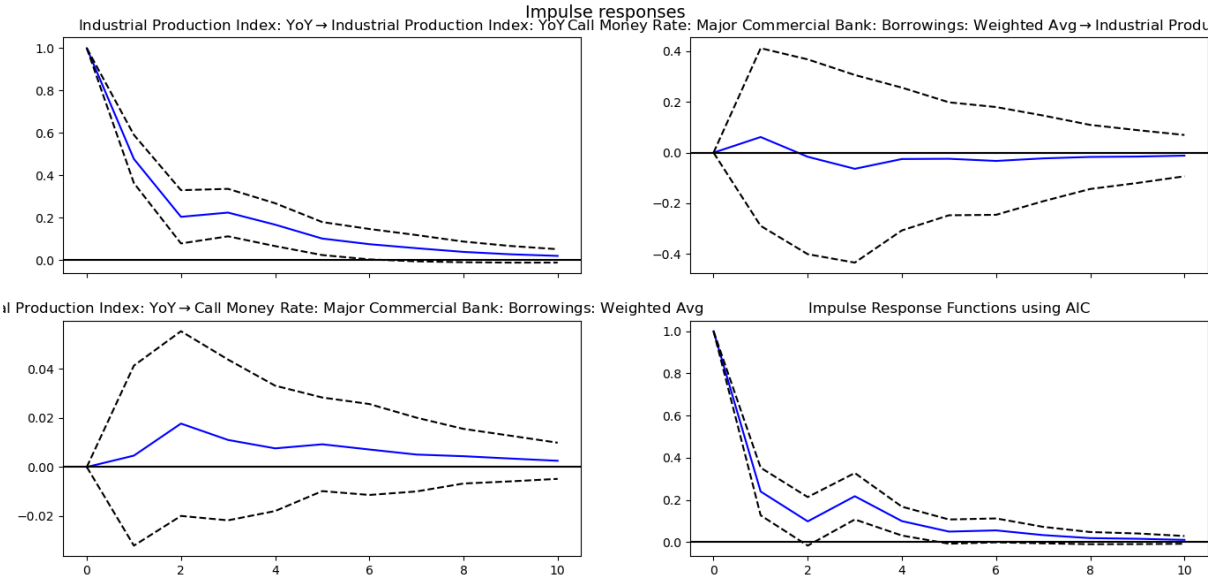
```
import pandas as pd
from statsmodels.tsa.api import VAR

# Load the dataset
file_path = r'C:\Users\dell\Pictures\VAR model\VAR model data.xlsx'
data = pd.read_excel(file_path, sheet_name='Final data')

# Convert the date column to datetime format and set it as the index
data['Date'] = pd.to_datetime(data['Date'])
data.set_index('Date', inplace=True)

# Select the relevant columns for the VAR model
variables = ['Industrial Production Index: YoY', 'Call Money Rate:
Major Commercial Bank: Borrowings: Weighted Avg']
df = data[variables].dropna()

# Fit the VAR model and select the optimal lag length using AIC
model_aic = VAR(df)
results_aic = model_aic.fit(maxlags=15, ic='aic')

# Print the summary of the results for the AIC model
print("Results using AIC:")
print(results_aic.summary())

# Extract and print the coefficients for the Call Money Rate equation
print("\nResults for equation Call Money Rate: Major Commercial Bank:
Borrowings: Weighted Avg")
print(results_aic.coefs_exog)

# Plot the impulse response functions for the AIC model
irf_aic = results_aic.irf(10)
irf_aic.plot(orth=False, impulse='Call Money Rate: Major Commercial
Bank: Borrowings: Weighted Avg')
plt.title('Impulse Response Functions for Call Money Rate')
plt.show()
```

```
# Plot the forecast error variance decomposition for the AIC model
fevd_aic = results_aic.fevd(10)
fevd_aic.plot()
plt.title('Forecast Error Variance Decomposition for Call Money Rate')
plt.show()
```

Results-

```
Results using AIC:
  Summary of Regression Results
==================================
Model:                         VAR
Method:                        OLS
Date:           Tue, 18, Jun, 2024
Time:                     00:50:38
----------------------------------------------------------------------
No. of Equations:         2.00000    BIC:                    7.29124
Nobs:                     298.000    HQIC:                   7.18708
Log likelihood:          -1892.20    FPE:                    1233.45
AIC:                      7.11756    Det(Omega_mle):         1177.48
----------------------------------------------------------------------
Results for equation Industrial Production Index: YoY
=================================================================================================================================
                                                                coefficient       std. error           t-stat            prob
---------------------------------------------------------------------------------------------------------------------------------
const                                                             2.213830         1.686113            1.313           0.189
L1.Industrial Production Index: YoY                               0.476877         0.058070            8.212           0.000
L1.Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg   0.061693         0.178907            0.345           0.730
L2.Industrial Production Index: YoY                              -0.024089         0.064417           -0.374           0.708
L2.Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg  -0.060487         0.183811           -0.329           0.742
L3.Industrial Production Index: YoY                               0.137152         0.058167            2.358           0.018
L3.Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg  -0.046024         0.178553           -0.258           0.797
=================================================================================================================================

Results for equation Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg
=================================================================================================================================
                                                                coefficient       std. error           t-stat            prob
---------------------------------------------------------------------------------------------------------------------------------
const                                                             3.373379         0.543062            6.212           0.000
L1.Industrial Production Index: YoY                               0.004638         0.018703            0.248           0.804
L1.Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg   0.239687         0.057622            4.160           0.000
L2.Industrial Production Index: YoY                               0.014369         0.020747            0.693           0.488
L2.Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg   0.040467         0.059202            0.684           0.494
L3.Industrial Production Index: YoY                              -0.001204         0.018734           -0.064           0.949
L3.Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg   0.183232         0.057508            3.186           0.001
=================================================================================================================================

Correlation matrix of residuals
                                                        Industrial Production Index: YoY  Call Money Rate: Major Commercial Bank:
 Borrowings: Weighted Avg
Industrial Production Index: YoY                                                1.000000
                0.015021
Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg                0.015021
                1.000000



Results for equation Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg
[[2.2138297 ]
 [3.37337929]]
```


Figure-



Interpretation-

The figure shows a set of Impulse Response Functions (IRFs) for a VAR model. The IRFs illustrate how a shock to one variable impacts other variables in the system over time. Each plot includes a blue line representing the impulse response and dashed lines representing the confidence intervals (typically 2-standard deviations) around the response.

Top Left Plot

- ***Title: "Industrial Production Index: YoY → Industrial Production Index: YoY"***
- ***Interpretation:***
    - *This plot shows the response of the Industrial Production Index (YoY) to its own shock.*
    - *The response starts at 1 (indicating a unit shock), decreases sharply, and then gradually stabilizes around zero.*
    - *The confidence intervals widen initially but narrow over time, indicating decreasing uncertainty as the effect of the shock diminishes.*

Top Right Plot

- ***Title: "Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg → Industrial Production Index: YoY"***
- ***Interpretation:***
    - *This plot shows the response of the Industrial Production Index (YoY) to a shock in the Call Money Rate for major commercial banks.*
    - *The response is initially negative, indicating that an increase in the Call Money Rate leads to a decrease in industrial production.*
    - *Over time, the response stabilizes around a slightly negative value.*
    - *The confidence intervals show that the effect is statistically significant in the short term but becomes less certain over time.*

Bottom Left Plot

- ***Title: "Production Index: YoY → Call Money Rate: Major Commercial Bank: Borrowings: Weighted Avg"***
- ***Interpretation:***
    - *This plot shows the response of the Call Money Rate to a shock in the Industrial Production Index (YoY).*
    - *The response is initially positive, indicating that an increase in industrial production leads to an increase in the Call Money Rate.*
    - *The response fluctuates around zero before stabilizing.*
    - *The confidence intervals indicate significant short-term effects but greater uncertainty in the longer term.*

Bottom Right Plot

- ***Title: "Impulse Response Functions using AIC"***

- ***Interpretation:***
    - *This plot appears to summarize multiple IRFs or may focus on another specific relationship within the VAR model, chosen using the Akaike Information Criterion (AIC).*
    - *The response starts positive and decreases over time, indicating an initial increase in the dependent variable following the shock.*
    - *The confidence intervals again indicate a high level of initial uncertainty that decreases over time.*

General Observations

- ***Impulse Response:*** *The blue lines show the magnitude and direction of the response of a variable to a shock in another variable.*

- ***Confidence Intervals:*** *The dashed lines represent the uncertainty around the impulse response. Narrower intervals indicate more confidence in the response, while wider intervals indicate less confidence.*

- ***Shock Effects:*** *Initial impacts are typically stronger and diminish over time, demonstrating the transient nature of shocks in time series data.*

These plots provide insights into the dynamic relationships between industrial production and the call money rate, showing how shocks in one variable affect the others over time.