Forecasting Core Inflation in India

A Four-Step Approach

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INTRODUCTION

What is Core Inflation?

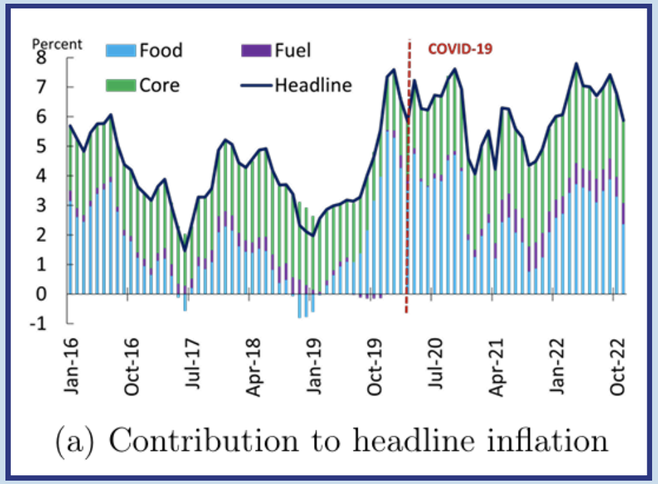
- Core Inflation refers to the long-term trend in prices, excluding volatile components like food and fuel.
- It is a key metric for assessing inflationary pressures due to its stability and focus on demand-side factors.

Inflation Targeting in India

- Core inflation has averaged around 55% of headline inflation in India since 2016.
- Flexible Inflation Targeting (FIT) adopted by the Reserve Bank of India (RBI) aims to manage inflation more effectively.

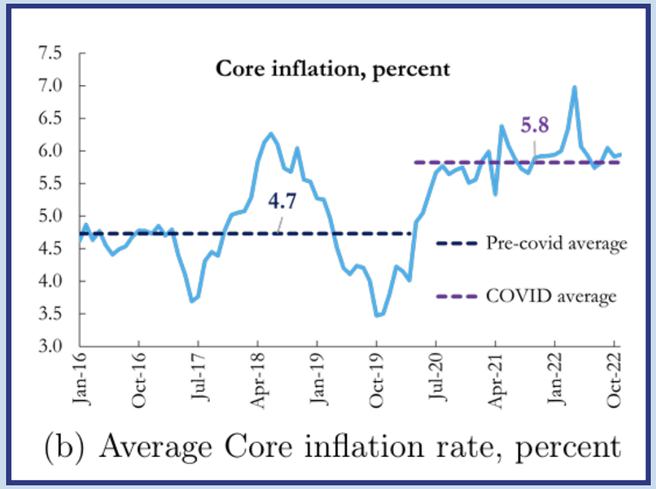
Focus on Core Inflation

- Core inflation (excluding volatile components like food and fuel) forms approximately 47% of headline inflation in India.
- Core inflation serves as a proxy for demand-driven inflation.



(a) Contribution to headline inflation

- Despite headline CPI being the nominal anchor, core inflation significantly influences headline dynamics.



(b) Average Core inflation rate, percent

- Core inflation has seen a rise from a pre-COVID average of 4.7% to 5.8% during COVID.

Source: *Rishabh Choudhary & Chetan Ghate & Md Arbaj Meman, 2023. "Forecasting Core Inflation in India: A Four-Step Approach," IEG Working Papers 461, Institute of Economic Growth*

MOTIVATION

- **Major Role in Inflation Dynamics:** Core inflation, contributing around 55% to headline inflation, offers a stable, demand-driven measure vital for policy targeting.
- **Supports RBI's Inflation-Targeting Framework:** Since 2016, the RBI's flexible inflation-targeting relies on accurate forecasts to manage inflation expectations and ensure economic stability.
- **Responsiveness to Demand Shifts:** Core inflation's sensitivity to structural changes (e.g., during COVID-19) makes it a crucial indicator for underlying economic conditions.
- **Focus on Demand-side Pressures:** By excluding volatile components like food and fuel prices, core inflation provides a stable measure that reflects underlying demand-driven inflation, crucial for policy targeting.
- **Improving Accuracy with Disaggregated Inflation Forecasts :** Traditional inflation models may struggle to capture real-time demand-side pressures, but disaggregating inflation forecasts allows for a more detailed analysis of individual components, improving accuracy.

OBJECTIVES

MAIN OBJECTIVE:

- **To develop an accurate forecasting method for core inflation in India** through a comprehensive four-step approach that includes high-frequency data and demand index construction.

SUB-OBJECTIVE:

- **Compare Aggregate vs. Disaggregated Forecasting:** Evaluate whether predicting individual core inflation components and aggregating them provides better accuracy than forecasting core inflation as a single measure across different forecast periods.

- **Use a Demand Index Based on High-Frequency Data:** Create a demand index from indicators like industrial production and credit data to capture real-time demand conditions, enhancing short-term forecasting, especially in volatile economic periods.

RESEARCH METHODS

4 STEP APPROACH

1 IDENTIFYING & CONSTRUCTING COVARIATES

Construction of **Demand Index** from high-frequency indicators.

2 MODEL FITTING & FORECASTING

Disaggregated forecasting using **MARSS** models for each component of core inflation.

3 CONSTRUCTING AGGREGATE INDEX

Forecasting aggregate inflation by applying predicted growth rates to index values.

4 FORECASTING Y-O-Y INFLATION RATE

Forecasting the year-on-year inflation growth rate.

Selected High-Frequency Indicators used for constructing Demand Index:

IIP Index (Index of Industrial Production):

- Measures the output of various sectors such as mining, manufacturing, and electricity.
- Serves as an overall economic health indicator, directly influencing demand projections.

Gems, Jewelry & Gold Imports:

- Reflects luxury spending and consumer confidence.
- High import levels indicate a rise in consumer wealth and investment in assets.

Petroleum Consumption:

- Represents the energy demand of the economy, correlated with industrial activity and transportation needs.
- Higher petroleum consumption reflects robust economic activity and higher demand in various sectors.

Two-Wheeler Motor Vehicle Sales:

- Relevant to assessing rural and semi-urban demand as two-wheelers are predominantly used in these areas.
- Acts as a proxy for broader consumer demand, especially in lower and middle-income segments.

Passenger Vehicle Sales:

- Indicative of consumer spending patterns and household purchasing power.
- An increase in vehicle sales generally reflects higher disposable income and consumer confidence.

Crude Steel Production:

- A core component of industrial demand and infrastructure growth.
- Higher steel production signals increased activity in manufacturing and construction, which are demand-sensitive sectors.

Bank Credit for Non-Food Sectors:

- Represents credit extended to various industrial and service sectors excluding food.
- A rise in non-food credit indicates increased investment and consumer demand, reflecting economic expansion.

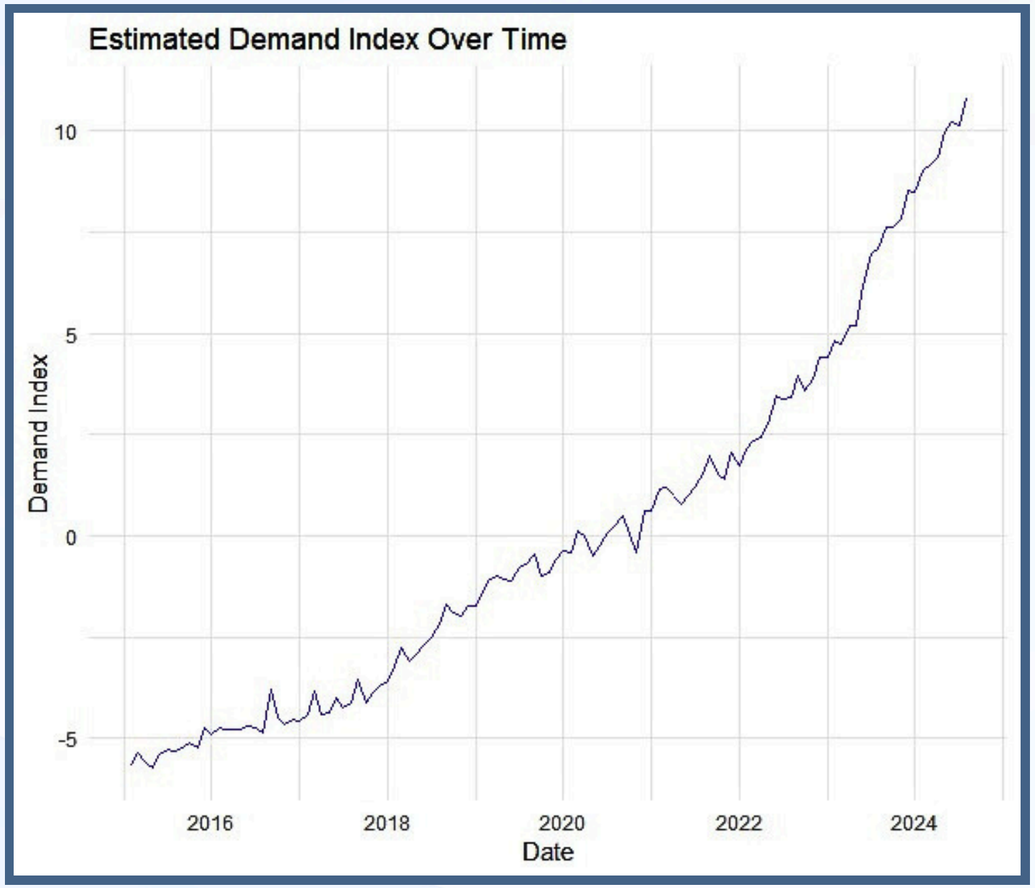
Construction of Demand Index from high-frequency indicators.

What is Demand Index

The demand index is calculated as a latent variable in a model with observable high-frequency indicators, like vehicle sales, industrial production, etc.

- The steady growth, with notable **acceleration** in recent years, suggests that **demand-driven inflationary pressures** could be significant in the near future.
- This index is a powerful tool in identifying trends that influence inflation forecasts.

The sustained growth in demand, as shown by the index, is likely to contribute to **increased inflationary pressures** in the near future.



Disaggregated & Aggregated forecasting using EM model.

- **Reasons for using EM Algorithm :** (EM) algorithm is an iterative statistical technique used to find the maximum likelihood estimates of parameters in models that depend on unobserved (latent) variables.

- **Weight :** Using the weights of high-frequency indicators more than volatile ones .This improves the stability and reliability of forecasting models. High-frequency indicators provide a consistent, real-time view of economic trends, helping capture sustained demand and supply dynamics

```
weights <- c(0.3, 0.2, 0.2, 0.1, 0.05, 0.05, 0.1)
Z_matrix <- matrix(weights, nrow = 7, ncol = 1)
```

The weights of volatile components i.e., **Crude Steel Production** and **Petroleum Consumption** are less as compared to other components

Why do we use State-Space Model?

- It captures unobserved component
- Handling Complex Dynamic Processes
- Flexibility with Irregular Patterns and Structural Changes
- Modelling Seasonality and Trend Separately
- Enhanced Forecasting Accuracy with Multivariate Modeling

The state-space model used in our analysis can be represented as follows:

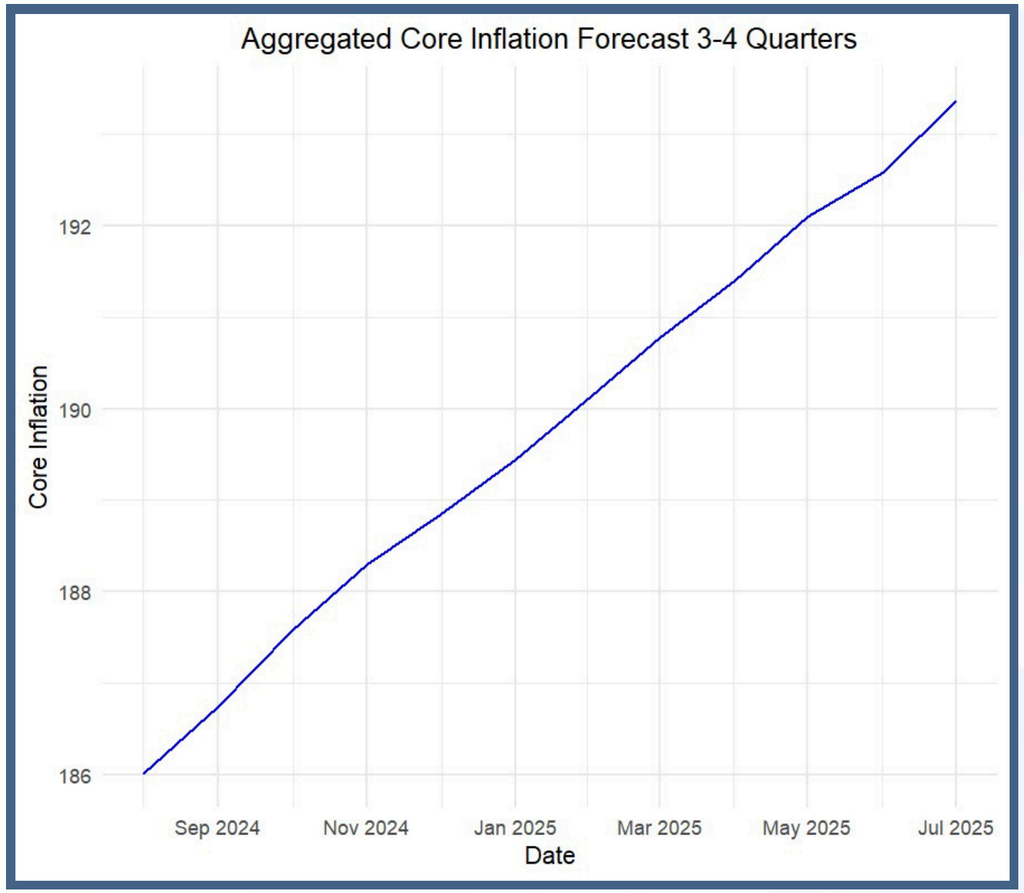
$$\mathbf{Y}_t = \mathbf{A}\mathbf{X}_t$$

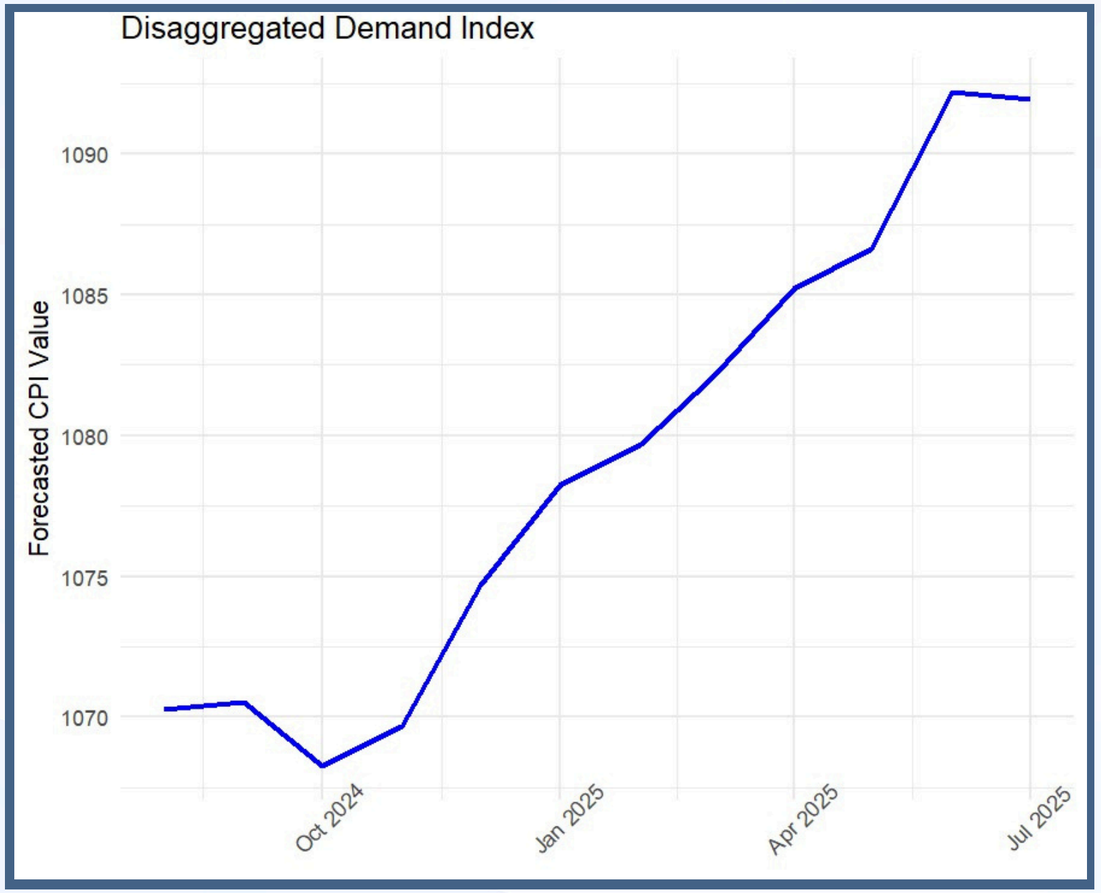
$$\mathbf{X}_t = \mathbf{B}\mathbf{X}_{t-1} + \mathbf{E}_t$$

In matrix notation, this can be written as:

$$\begin{bmatrix} Y_{1t} \\ Y_{2t} \\ \vdots \\ Y_{Kt} \\ \pi_t^{core} \end{bmatrix}_{(K+1)\times 1} = \begin{bmatrix} \lambda_1 & 0 & 1 & 0 & \dots & 0 & 0 \\ \lambda_2 & 0 & 0 & 1 & \dots & 0 & 0 \\ \vdots & \dots & & & & & \\ \lambda_K & 0 & \dots & 0 & 1 & 0 & 0 \\ \beta_1 & \beta_2 & 0 & \dots & 0 & 1 & 1 \end{bmatrix} * \begin{bmatrix} X_t \\ X_{t-1} \\ \epsilon_1^Y \\ \epsilon_2^Y \\ \vdots \\ \epsilon_K^Y \\ \pi_t^{trend} \\ \epsilon_t^\pi \end{bmatrix}_{(K+4)\times 1}$$

Forecasting year-on-year inflation growth rate.





DATA SOURCES

- **High-Frequency Indicators** are selected metrics that provide timely insights into economic activities.
- For this study, these indicators are chosen to capture various facets of demand across sectors in the Indian economy, with data available monthly from January 2015 to August 2024.
- This extended time frame allows us to capture a comprehensive view of inflation dynamics and study any potential changes over the years.
- These indicators allow real-time monitoring of economic trends and are crucial for accurately forecasting core inflation.

Selected High-Frequency Indicators for Demand Index:

- IIP Index
- Gems, Jewel & Gold Import
- Petroleum Consumption
- Two Wheeler Motor Vehicle Sale
- Passenger Vehicle Sale
- Crude Steel Production
- Bank Credit for Non-Food Sectors

DATA SOURCES

CPI Sectors for Disaggregated Forecasting

- To forecast inflation accurately, we analyze Consumer Price Index (CPI) sectors separately to capture sector-specific price trends:

  - **Clothing and Footwear:** Sensitive to consumer demand, seasonal trends.
  - **Food and Beverages:** High weight in CPI, fluctuates with supply and seasonality.
  - **Fuel and Light:** Volatile, influenced by global energy prices and policy changes.
  - **Housing:** Reflects long-term trends, including real estate and rental demand.
  - **Miscellaneous:** Encompasses healthcare, education, transport, and other services.
  - **Pan, Tobacco, and Intoxicants:** Includes regulated goods; affected by taxes and consumer trends.

EMPIRICAL FINDINGS

Short-term forecasting is more accurate using **disaggregated** components

Disaggregated forecasting demonstrates stronger short-term predictive accuracy, with lower RMSE values compared to aggregated methods.

Long-term forecasting is more accurate using **aggregate** components.

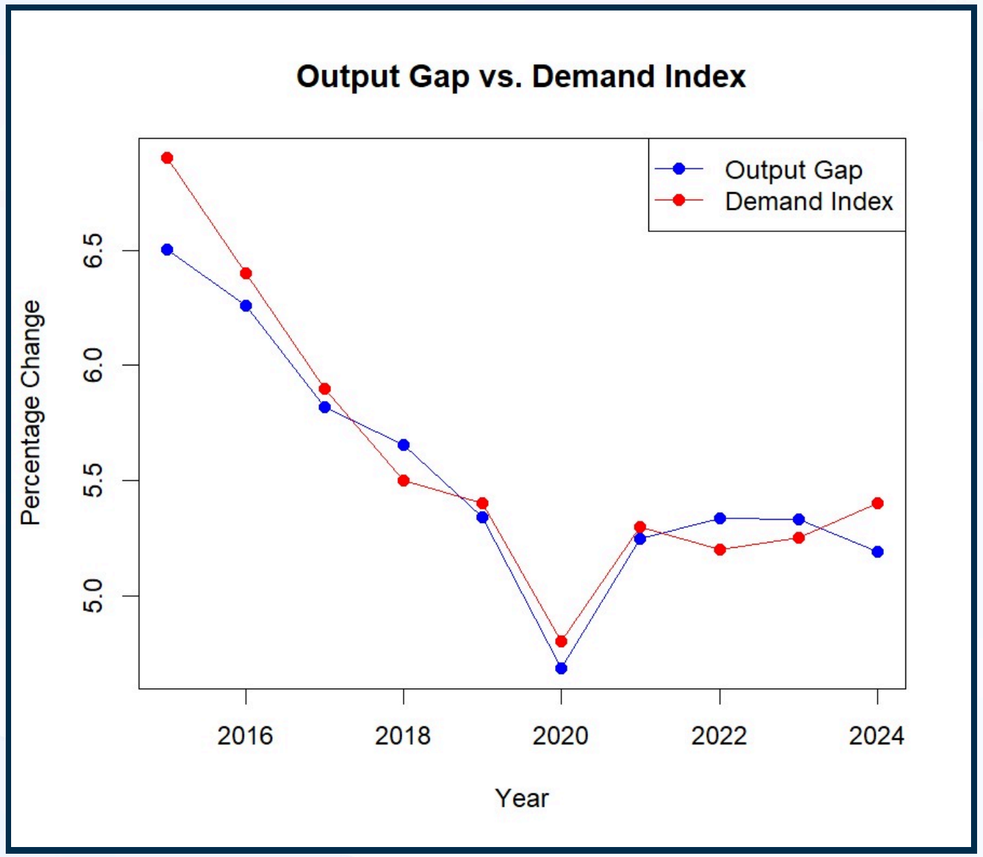
Aggregate forecasting achieves lower relative Root Mean Squared Error (RMSE) values, reflecting improved accuracy in capturing longer-term trends.

	Model	X1.quarter	X2.quarter	X3.quarter	X4.quarter	X5.quarter	X6.quarter	X7.quarter	X8.quarter
1	ARIMA	1.00	1.00	1.00	1.00	1.000	1.00	1.00	1.0
2	ARIMA Aggregate	1.05	1.10	1.15	0.92	0.925	0.82	0.85	0.7
3	ARIMA Disaggregate	0.90	0.85	0.80	0.95	1.000	1.10	1.20	1.3

EMPIRICAL FINDINGS

Correlation with Output Gap:

- The demand index closely correlates with the output gap, indicating it captures similar demand pressures as traditional output gap measures.
- This strong correlation validates the demand index as an effective, real-time proxy for the output gap, making it useful for timely economic analysis where traditional output gap data may lag.
- Incorporating this demand index into the forecasting model improves the accuracy of predictions by capturing the underlying demand-side factors that influence inflation.



LIMITATIONS

- **Data limitations:** Data given to us is given through a lag which can impact real time data forecasting , it could also have measurement errors and noise due to rapid collection method which can induce bias, high frequency indicator are also sensitive to economic shocks thus impacting forecasting.
- **Sensitivity to initial assumption and prior:** The robustness of the derived demand index (using the Bayesian approach) to different assumptions on priors is crucial. The results can be seen by the relative RMSE.In particular, altering the priors for the loading factor and the demand index coefficient (by replacing the Normal priors with Beta priors) leads to slight improvements in accuracy, reflected in the decreased relative RMSE values
- **Effect of covid:** COVID-19 introduced unprecedented volatility into high-frequency indicators This highlights model might need recalibration for unprecedented economic condition.

CONCLUSION

- **Short-Term Forecasting** :The Results indicate that when it comes to short-term forecasting, employing an approach that involves separately forecasting the core CPI components and then aggregating them leads to improved forecasting efficacy
- **Long-Term Forecasting** : for long-term forecasting, directly forecasting aggregate core inflation provides a more accurate representation of overall inflation behavior, considering the collective impact of core CPI components.
- **Demand Index** :
  - The demand index provides valuable information regarding overall economic activity, which is crucial for understanding inflation dynamics.
  - Incorporating this demand index into the forecasting model improves the accuracy of predictions by capturing the underlying demand-side factors that influence inflation
- **Disaggregate approach :** By employing an appropriate specification, this approach outperforms other forecasting methods. The accurate specification of the model enables a better understanding of the unique characteristics and relationships within each component, leading to more accurate predictions

RESOURCES

Code for Demand Index & Forecasting Core Inflation:

https://github.com/Tan-Hub01/Forecasting_Core_Inflation

Data for CPI Sectors:

https://drive.google.com/drive/folders/19IpEqT_6PT3w9m1NJxjI0U0nILC57AJ3?usp=drive_link

Data for High Frequency Indicators:

https://drive.google.com/drive/folders/1nH6Mr81For6FSpEetT8ntjJrs4rvJu-V?usp=drive_link

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Thank You!