TOPIC: Analysis and Data Visualization of Food & Beverage Industry Trends: Insights into Consumer Preferences and Market Dynamics

Introduction

I am Sannidhya Das, currently pursuing an MSc in Data Science at St. Xavier's College, Kolkata, where I am in my second semester. As a data science enthusiast, I am passionate about exploring economic trends through data-driven insights.

This report presents an in-depth analysis of India's Food & Beverage Consumer Price Index (CPI) from January 2013 to January 2025. The objective of this study is to examine inflation trends, regional disparities, seasonal variations, and their impact on household expenses and purchasing power. By leveraging statistical methods and data visualization, I aim to provide a comprehensive understanding of how inflation has evolved over the years and its implications on the economy and consumers.

Through this analysis, I strive to bridge the gap between raw economic data and meaningful insights, reinforcing my expertise in data analytics, visualization, and economic trend forecasting.

Objective of this Report:

The objective of this study is to **analyze inflation trends in the Food & Beverages sector across Indian states** using statistical modeling, forecasting, clustering, and visualization techniques. The key objectives include:

1. **Rural vs Urban CPI Comparison:**

   o Identify **states where rural CPI is significantly higher than urban CPI**, highlighting possible supply chain inefficiencies, lack of subsidies, or transportation cost differences.

   o Analyze CPI fluctuations over time for urban and rural regions to assess inflation trends.

2. **State Performance Analysis & Visualization:**

   o **Identify top 5 states consistently overperforming All India CPI** using comparative analysis.

   o **Visualize inflation trends using time series plots, heatmaps, and bar charts** to uncover insights about CPI variations across states and time periods.

   o Assess the impact of key events like **COVID-19 and festive seasons on inflation** trends.

3. **Inflation Impact on Purchasing Power & Expenses:**

   o Measure how inflation has **reduced the purchasing power of ₹100** over time.

   o Analyze how inflation has affected **food expenses and cost-of-living indices**.

4. **CPI Trend Analysis & Forecasting:**

   o Use **ARIMA modeling** to forecast the **Consumer Price Index (CPI)** trends for the Food & Beverages sector in India.

   o Analyze historical CPI patterns and predict future inflation movements.

5. **State-Wise CPI Variability & Volatility:**

- o Measure **state-wise CPI stability** using **standard deviation and Augmented Dickey-Fuller (ADF) tests** to assess stationarity.
- o Identify high-volatility states where inflation control measures may be necessary.

6. **Clustering States Based on Inflation Trends:**

- o Implement **K-Means clustering** to group states into **high, medium, and low inflation zones**, helping policymakers focus on inflation hotspots.

Policy Implications & Recommendations :

- **Price Stabilization Measures**: Introduce policies to mitigate high CPI volatility in states with unstable inflation trends.
- **Rural-Urban Inflation Parity**: Address the CPI gap in rural and urban areas through better supply chain management and targeted subsidies.
- **Long-Term Economic Planning**: Use CPI trend analysis to design future monetary and fiscal policies for inflation control.

This study provides **data-driven insights into inflation trends, regional disparities, and economic impacts** to support **policymakers, economists, and businesses** in making informed decisions.

: Analysis For Food & Beverages Group :
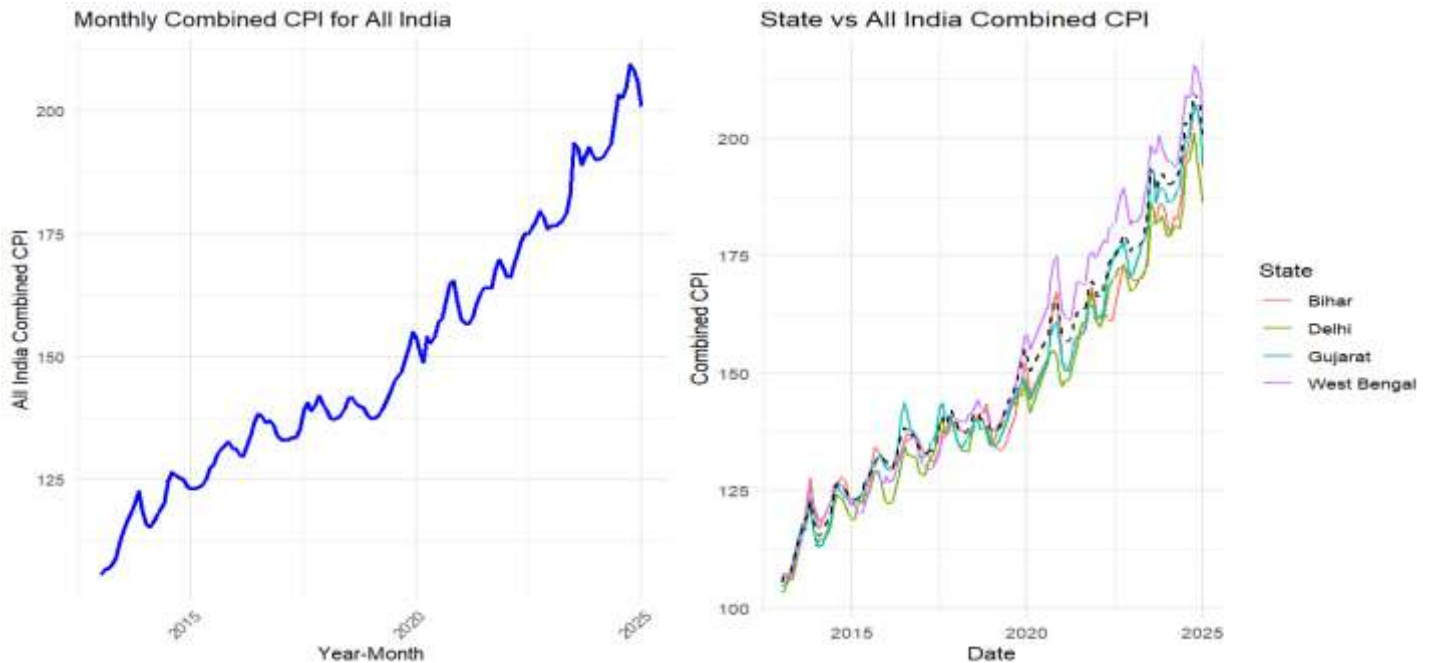
**First Graph: "Monthly Combined CPI for All India"**

- This graph shows the trend of the **All India Combined Consumer Price Index (CPI)** over time.

- The **CPI is increasing steadily**, indicating inflationary pressure.

- There are **seasonal fluctuations** (small ups and downs), but the overall trend is an **upward slope**.

- **Around 2020, the increase in CPI becomes steeper**, possibly due to external factors like the COVID-19 pandemic and its economic effects.

- The latest data points (2024-2025) show a **sharp rise**, indicating significant inflation in recent times.

Second Graph: "State vs All India Combined CPI"

- This graph **compares the CPI of selected states (Bihar, Delhi, Gujarat, West Bengal) with the All India Combined CPI**.

- The general **trend follows the All India CPI**, indicating that state-level inflation follows national patterns.

- **West Bengal (purple line) seems to have a higher CPI than other states in recent years**, meaning it has experienced more inflation than the national average.

- **Delhi, Gujarat, and Bihar have similar trends**, mostly staying close to the All India CPI (black dashed line).

- **Short-term deviations** suggest that some states temporarily overperform or underperform compared to the national CPI.

Key Insights

1. **Inflation is persistent and rising** – The general trend of increasing CPI shows that the cost of living is going up.

2. **State-wise variations exist** – Some states, like **West Bengal, have experienced higher inflation** compared to others.

3. **Possible external shocks** – The sharp rise post-2020 might be linked to economic disruptions like the **pandemic, supply chain issues, or government policies**.

4. **Policy Implications** – States with a **higher CPI than the national average** might need economic interventions to **control inflation and maintain affordability**.

Top 5 States Overperforming All India CPI (Year-wise)
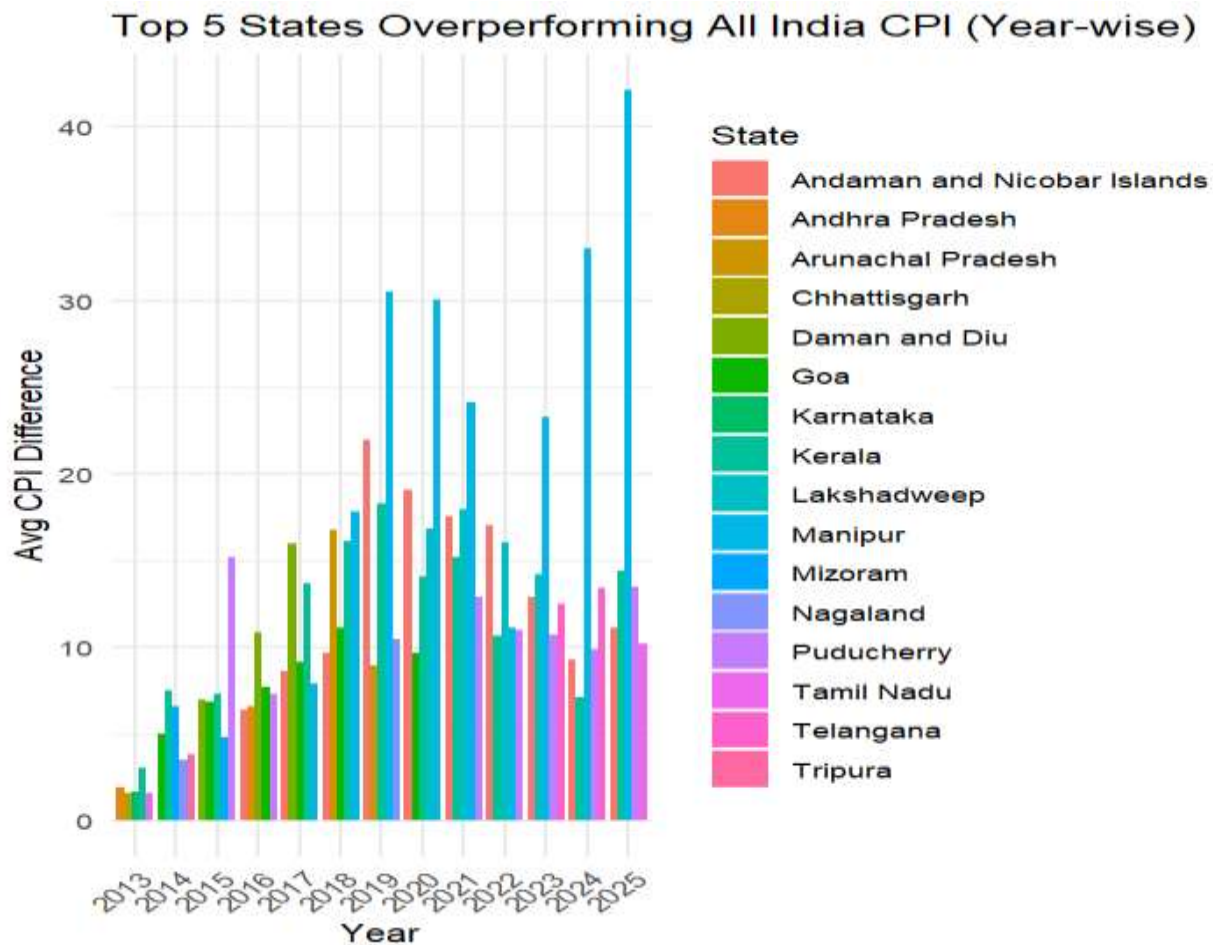
Third Graph: Top 5 States Overperforming All India CPI (Year-wise)

1. Consistently Overperforming States:

- Andaman & Nicobar appears almost every year.
- Goa & Daman & Diu consistently overperformed until 2018.
- Mizoram emerged as a top performer after 2016, with increasing CPI differences over time.

2. Dynamic Inflation Trends: The top 5 overperforming states change yearly, indicating regional economic shifts rather than a single dominant state.

3. Rising Inflationary Pressure: The height of bars increases over time, suggesting widening CPI gaps between overperforming states and the national average.

4. Possible Causes:

- Supply chain disruptions in isolated regions.
- Economic growth & local policies driving inflation in specific states.
- Sector-specific factors, such as tourism, impacting CPI trends.

5. Policy Implications:

- Targeted interventions (price controls, subsidies, economic diversification) may be needed.
- Infrastructure and supply chain improvements could help stabilize inflation in frequently overperforming states.
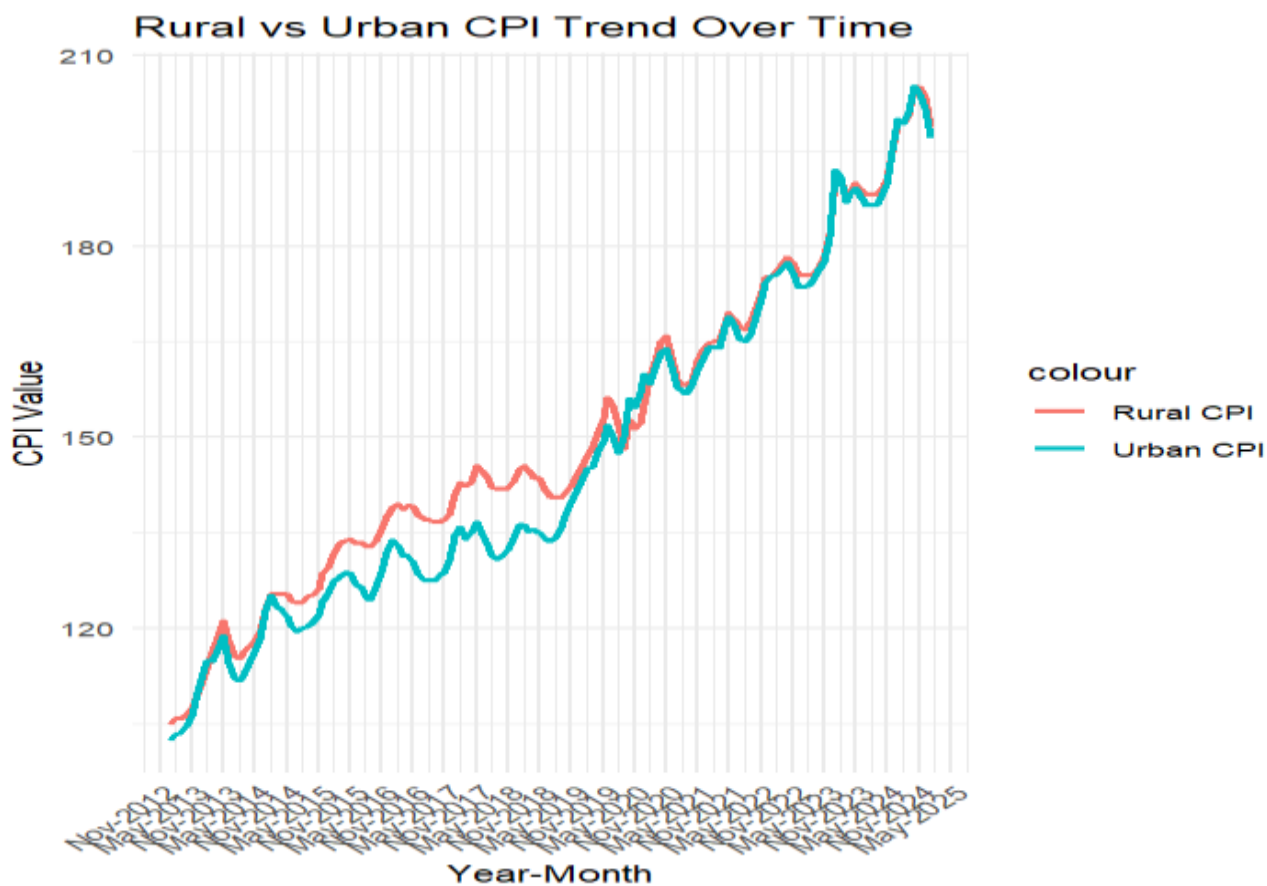
Fourth Graph: Rural vs Urban CPI Trend Over Time

1. Before 2020: Rural CPI was consistently higher than Urban CPI, indicating stronger inflation in rural areas due to higher food prices, supply chain inefficiencies, and limited access to alternatives.

2. After 2020: The gap between Rural and Urban CPI narrowed, suggesting better infrastructure, pandemic-induced economic shifts, and policy interventions stabilizing rural prices.

  Key Insights:

- **Structural Changes**: Rural and urban inflation trends converging indicate evolving market dynamics.

- **Policy Impact:** Government interventions and rural development programs may have contributed to CPI stabilization.

- **Future Monitoring**: Any renewed rise in rural CPI could signal inflationary pressures needing targeted policy responses.

These are the top 5 states which has higher rural CPI than urban. which indicates Arunachal Pradesh, Manipur, Andaman & Nicobar Islands, Daman & Diu, and Lakshadweep have higher Rural CPI, indicating possible supply chain issues, lack of subsidies, or increased transportation costs in rural areas.

	State	Avg_Rural_CPI	Avg_Urban_CPI	Diff
1	Arunachal Pradesh	152.1736	0.0000	152.17357
2	Manipur	186.0598	165.5742	20.48557
3	Andaman and Nicobar Islands	171.0202	156.7177	14.30242
4	Daman and Diu	146.4226	134.1048	12.31786
5	Lakshadweep	160.9370	148.6858	12.25118

Distribution of Rural CPI Across States
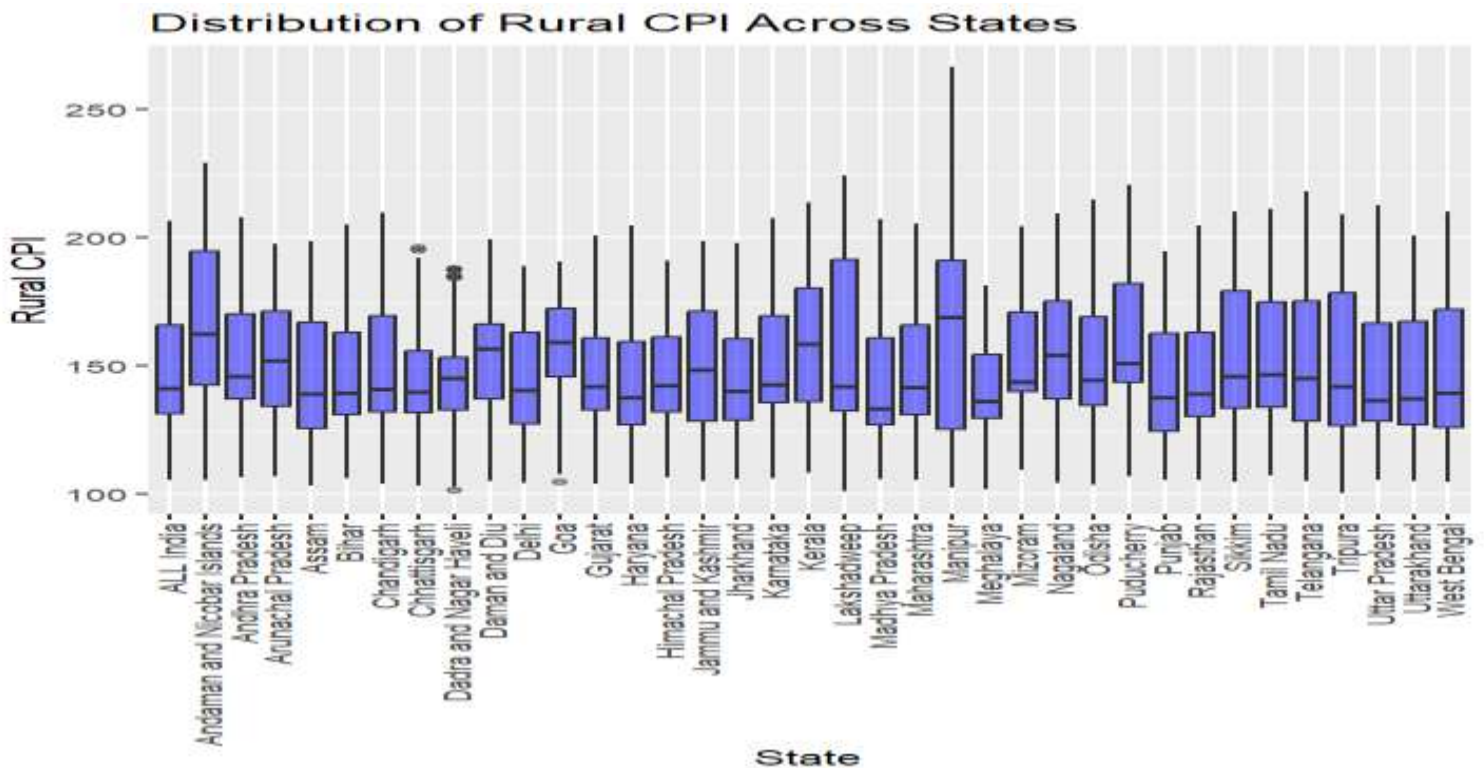
**Fifth Graph: Distribution of Rural CPI Across States**

- The outliers in Dadra & Nagar Haveli, Chhattisgarh, and Goa suggest some price shocks in Rural CPI, but we cannot conclude high overall variability without further analysis.

- **Median Rural CPI fluctuates significantly**, indicating **diverse inflation patterns** due to supply chain issues, economic disparity, and state policies.

Distribution of Urban CPI Across States
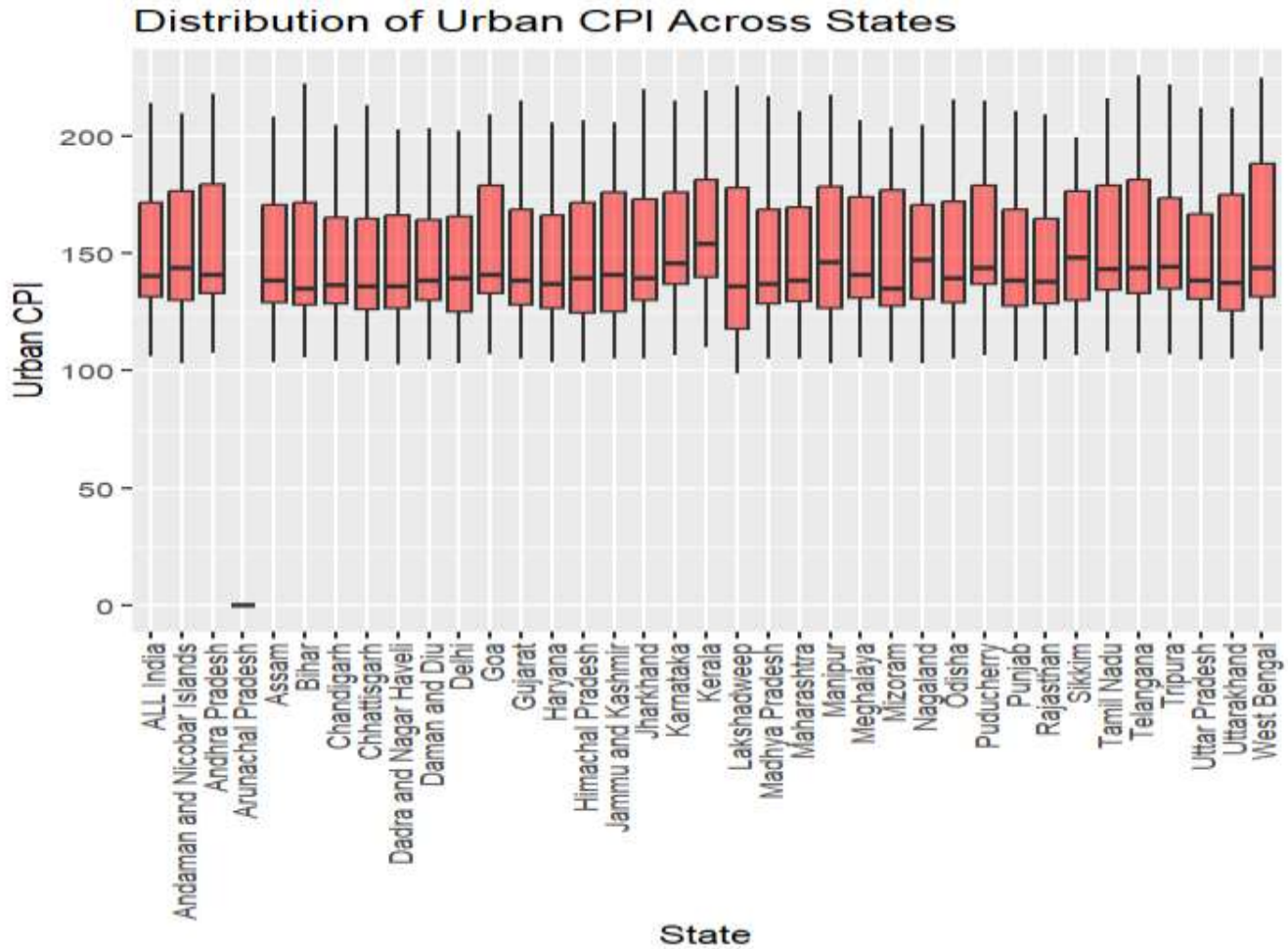
Sixth Graph: Distribution of Urban CPI Across States

- Urban CPI remains stable, with minimal variation across states, suggesting better price control mechanisms in cities.
- No outliers in Urban CPI, implying more uniform inflation trends across urban areas.
- Arunachal Pradesh lacks Urban CPI data, likely due to a negligible urban population.

States with Highest CPI Volatility
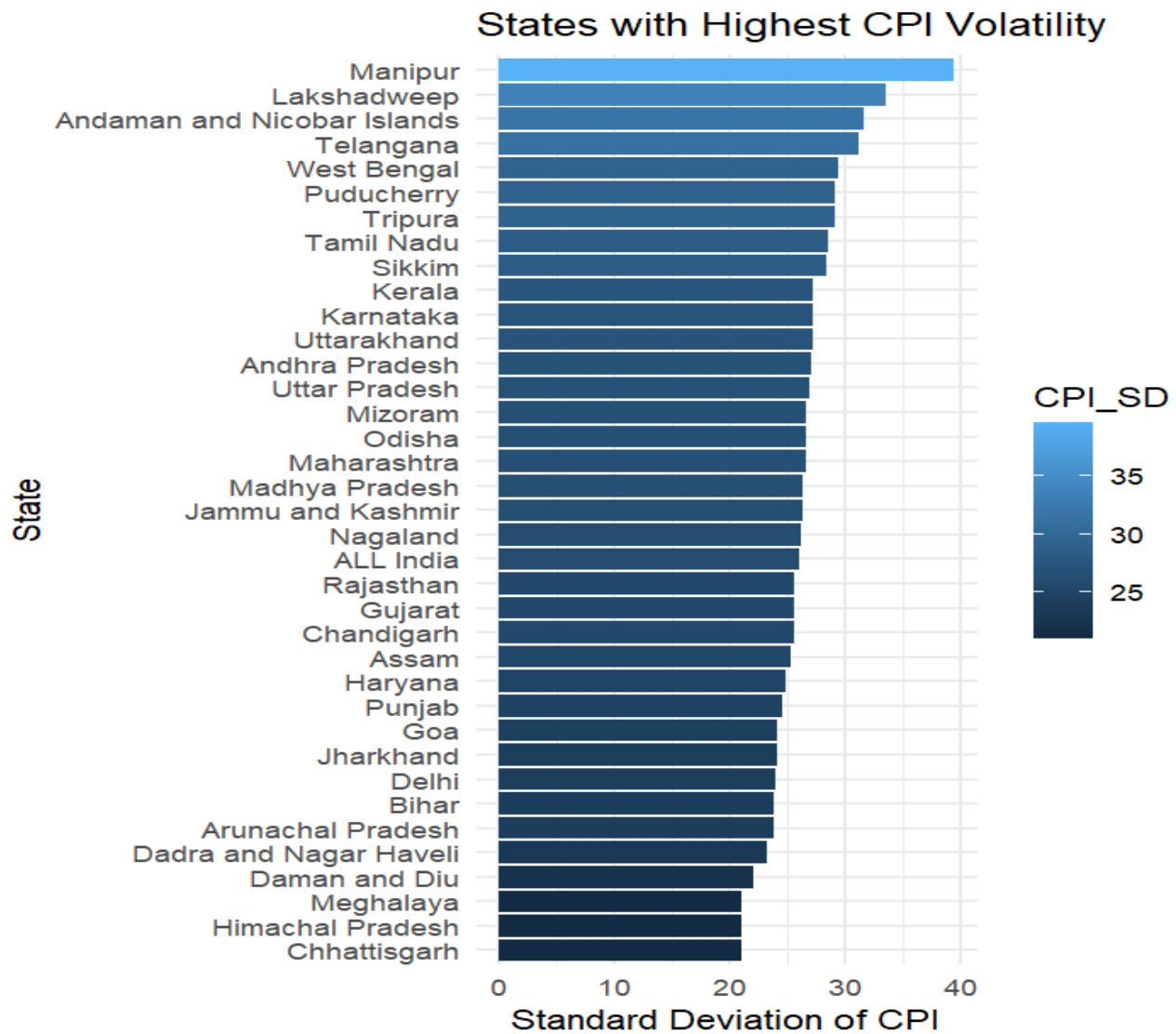
Seventh Graph: States with Highest CPI Volatility

1. **High Volatility States (Manipur, Lakshadweep, Andaman, Telangana, West Bengal)**

- Frequent CPI fluctuations indicate price instability and possible market disruptions.

2. **Low Volatility States (Dadra & Nagar Haveli, Daman & Diu, Meghalaya, Himachal Pradesh, Chhattisgarh)**

- More stable inflation trends, suggesting consistent price control and fewer economic shocks.

3. **Implications:**

- High volatility states may require targeted economic policies to stabilize inflation.

- Low volatility states could indicate efficient inflation management or slow economic changes.

- Further analysis can uncover specific causes of fluctuations in high-variability regions.

Rural vs Urban CPI Difference by State
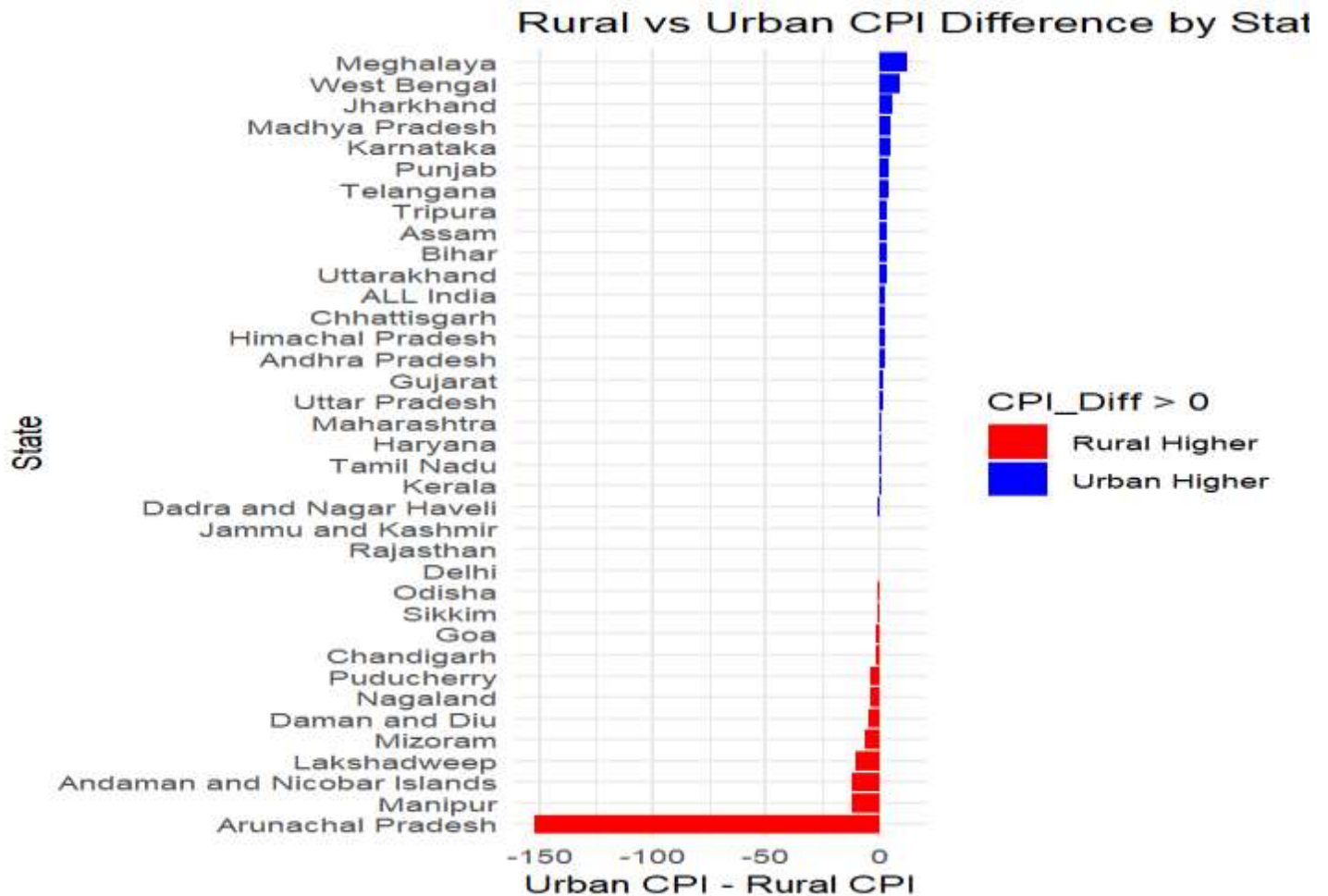
Eighth Graph: Rural vs Urban CPI Difference by State

- Urban CPI is significantly higher in Meghalaya, West Bengal, Jharkhand, Madhya Pradesh, and Karnataka, indicating a higher cost of living in urban areas due to housing, services, and demand.
- Rural CPI is higher in Arunachal Pradesh, Manipur, Andaman & Nicobar, and Lakshadweep, possibly due to supply chain inefficiencies or higher transportation costs.
- **Policy Implications:** Urban inflation control is needed in some states, while rural price stabilization is crucial in others.
- **Potential Trends:** Reverse urbanization could occur if rural costs continue rising beyond urban areas.

CPI Heatmap Across States and Year
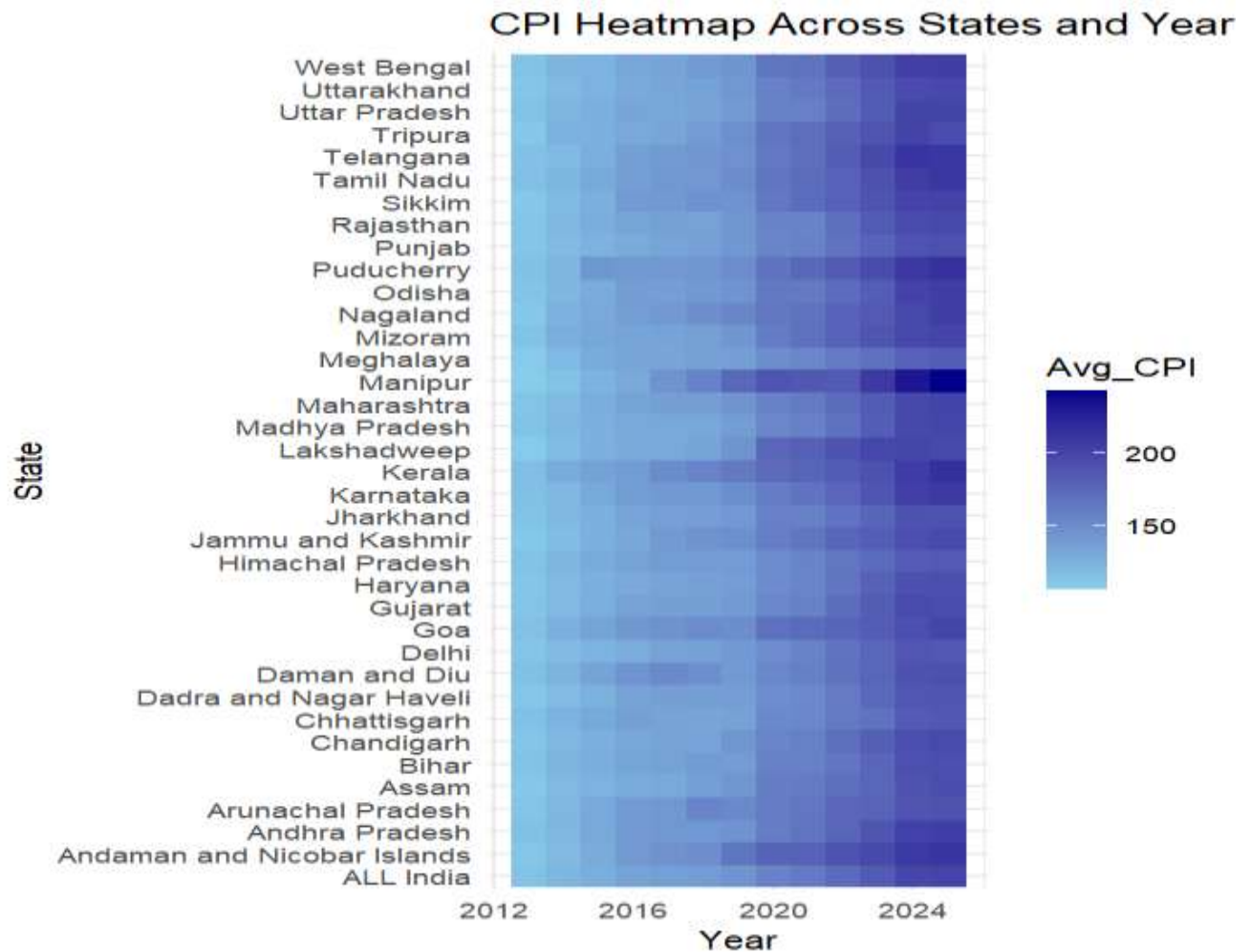
Ninth Graph: CPI Heatmap Across States and Years

- **Regional Inflation Variations:** Some states consistently show high CPI, indicating sustained inflationary pressure, while others remain stable.
- **Yearly Trends:** Increasing CPI over time in most states suggests rising inflation, while some states may show stabilization.
- **State-Specific Insights:** Persistent high-CPI states require inflation control measures, while fluctuating states indicate economic instability.
- **Policy Implications:** Helps identify states needing targeted interventions like subsidies, supply chain improvements, or price control policies.

Year-over-Year CPI Inflation Rate
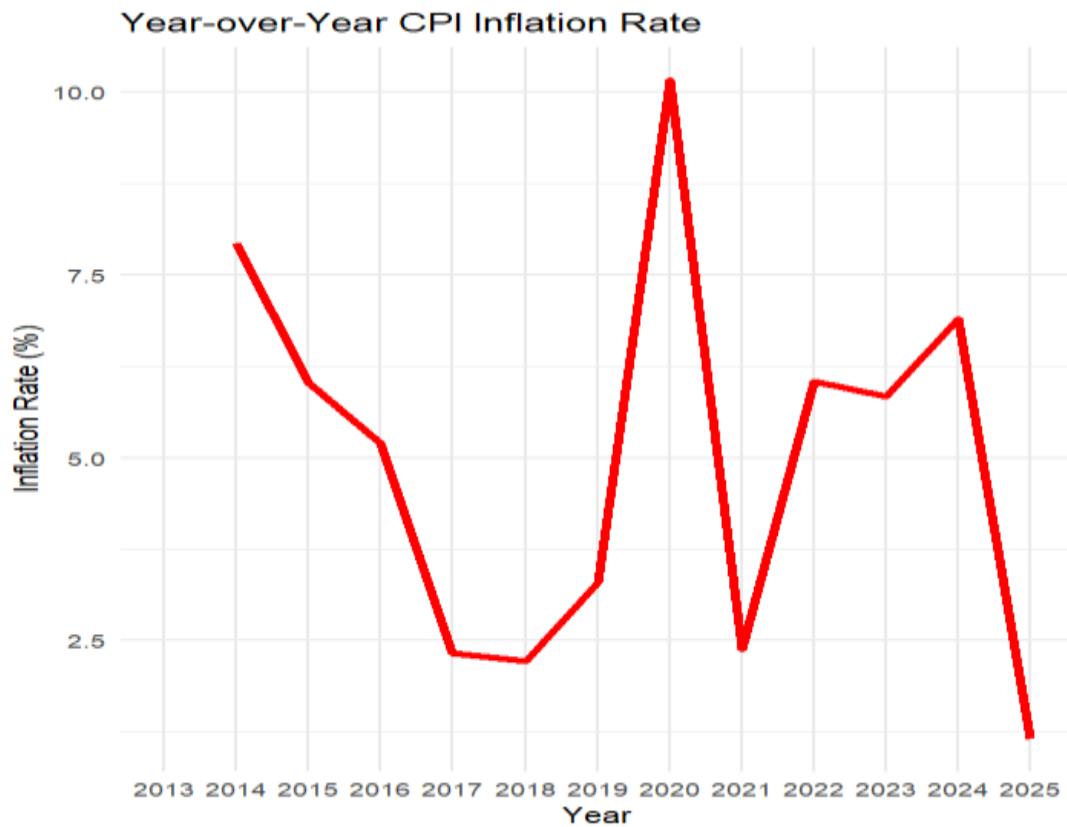
Tenth Graph: Year-over-Year CPI Inflation Rate

1. **2014-2018:** Inflation steadily declined, indicating price stability due to strong policies and economic control.

2. **2019:** Inflation started rising again, suggesting demand growth and possible supply constraints.

3. **2020 (Peak Inflation):** The highest inflation spike, likely due to COVID-19 disruptions, supply chain breakdowns, and fiscal stimulus.

4. **2021:** Sharp decline as supply chains recovered and inflation control measures took effect.

5. **2022-2024:** Fluctuations in inflation, possibly due to commodity price hikes or geopolitical factors.

6. **2025 (All-Time Low):** Inflation at its lowest, suggesting either successful policies or a cooling economy.

Overall: The CPI trend reflects economic cycles influenced by policies, global events, and supply-demand shifts. Policymakers must ensure stable inflation to balance economic growth and purchasing power.

Now to get more understanding from the data, I formed some questions and based on those questions tried to provide solution.

1. **What is the overall CPI inflation trend over the past 5 years?**

CPI Inflation Trend (Last 5 Years)
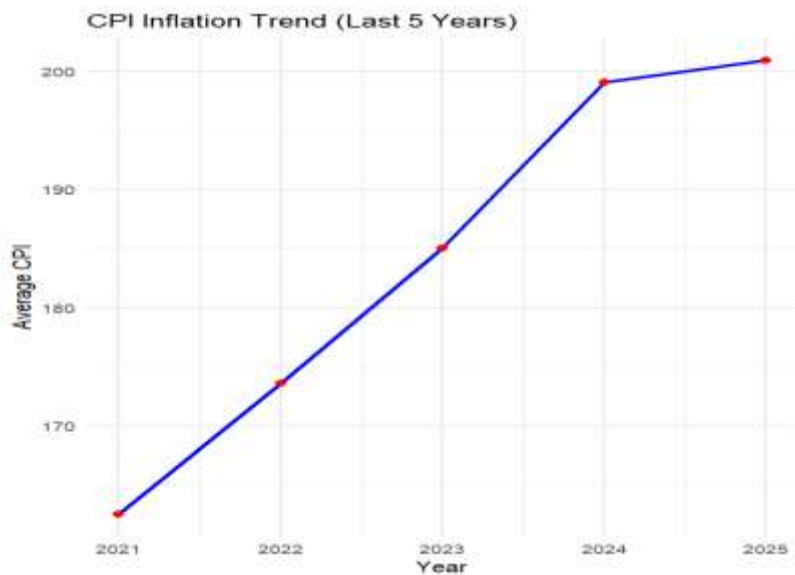
	Year	Avg_CPI
1	2021	162.5000
2	2022	173.5750
3	2023	185.0083
4	2024	199.0917
5	2025	200.9000

2. How did inflation fluctuate during the COVID-19 pandemic?

CPI During COVID-19 (2019-2021)
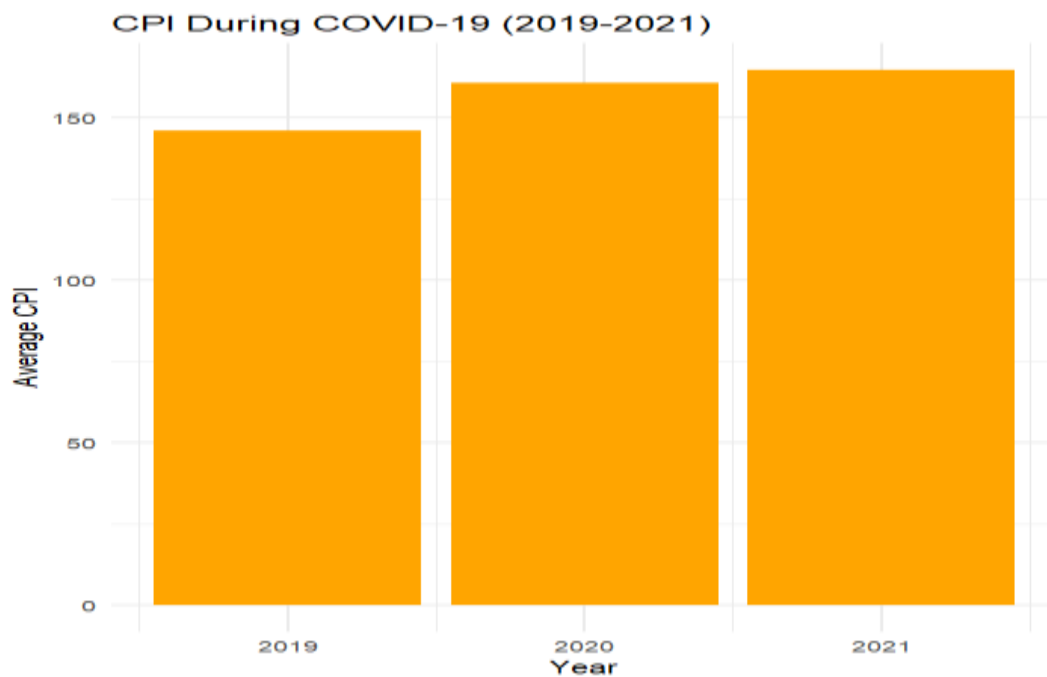
3. How does inflation fluctuate during festive seasons?

Inflation tends to rise during festive seasons, with **November** generally experiencing the highest price levels among the three months. This suggests that food & beverage expenses during festivities are increasing over time, impacting consumers' purchasing power.

CPI During Festive Seasons

Month
- December (red)
- November (green)
- October (blue)

[Bar chart showing CPI values from 2013 to 2024, with three bars (December, November, October) per year. CPI rises from about 120 in 2013 to about 205 in 2024. Y-axis labeled "CPI" ranging 0 to 200, X-axis labeled "Year".]
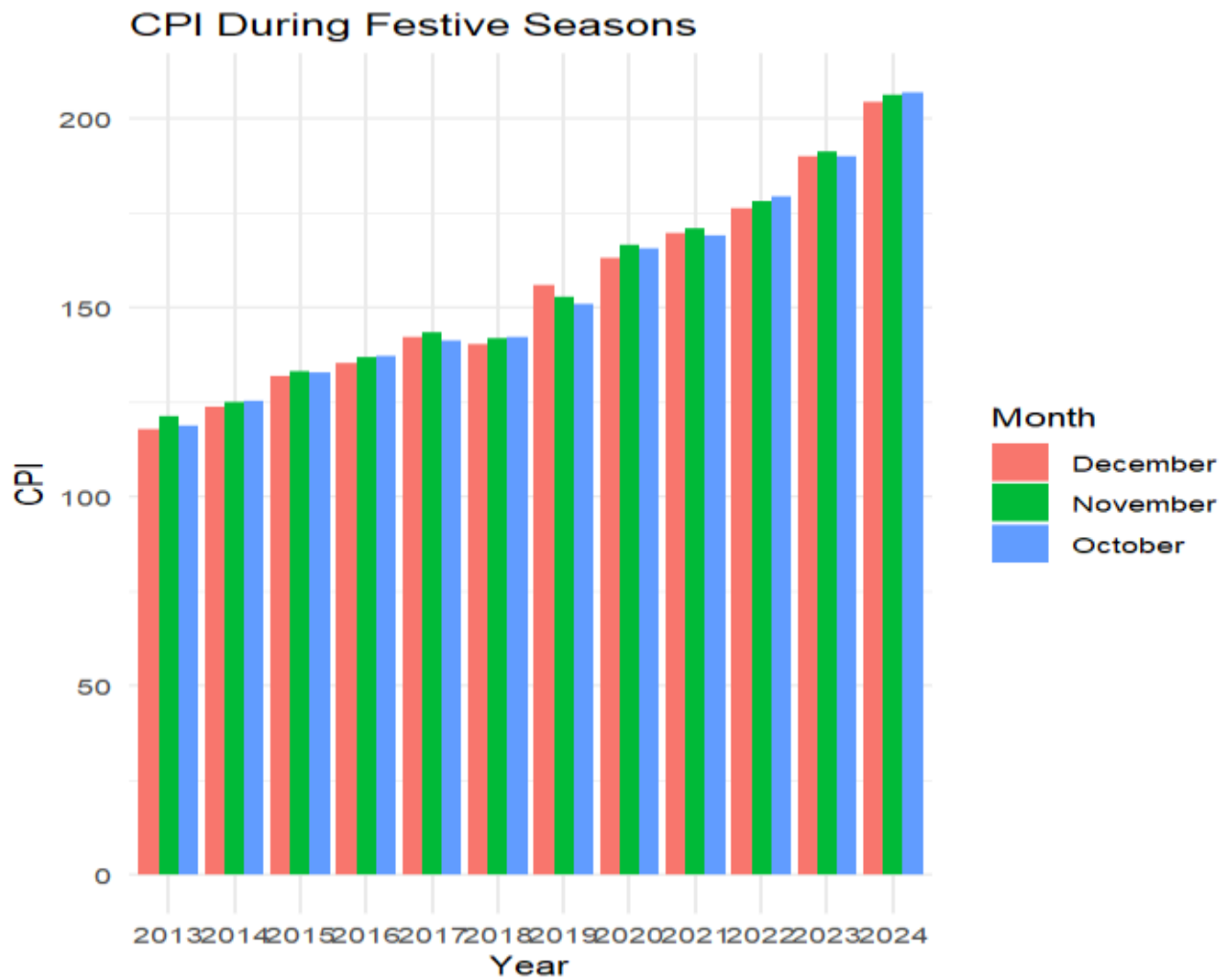
4. **How much has inflation reduced the purchasing power of ₹100?**

	Year	Purchasing_Power
1	2013	0.8914311
2	2014	0.8259438
3	2015	0.7789763
4	2016	0.7405084
5	2017	0.7236581
6	2018	0.7079530
7	2019	0.6853814
8	2020	0.6221823
9	2021	0.6076778
10	2022	0.5730325
11	2023	0.5414199
12	2024	0.5064722
13	2025	0.5006884

Due to inflation, ₹100 in **2013** will be worth only **₹50.07 in 2025** in terms of purchasing power. This means prices have nearly **doubled**, reducing the value of money significantly over time.

5. How much has inflation increased food expenses?

	Year	Avg_CPI	Cost_Index
1	2013	112.2081	100.0000
2	2014	121.0791	107.9058
3	2015	128.3541	114.3893
4	2016	135.0268	120.3360
5	2017	138.1523	123.1215
6	2018	141.1966	125.8346
7	2019	145.8574	129.9883
8	2020	160.5443	143.0773
9	2021	164.5052	146.6072
10	2022	174.4849	155.5012
11	2023	184.7079	164.6119
12	2024	197.4887	176.0022
13	2025	199.7568	178.0235

In 2025, the Cost Index is 178, meaning that household expenses have increased by 78% since 2013. Due to inflation, the **cost of living in 2025 is 1.78 times higher** than in 2013. If a household spent ₹10,000 on goods and services in 2013, they would need **₹17,800 in 2025** to afford the same lifestyle.

Insights from performing Statistical Analysis:

1. **Observations From Chi-Square Test on Inflation Trends:**
   By performing the Chi-Square test, we got p-value is very small, we reject the null hypothesis, meaning that inflation trends are not independent of state. In other words, the pattern of inflation (whether it increases or decreases) varies significantly across different states. **This suggests that economic factors, policies, or regional differences may influence inflation differently in each state.**

2. **Insights From CPI Trend Forecasting (ARIMA Model):**

- The **forecasted CPI plot** provides insights into expected inflation movements. If the forecast shows an **upward trend**, it indicates that inflation is likely to rise further. Conversely, if the trend stabilizes or declines, it suggests potential price stability or deflationary tendencies.

- This analysis helps in predicting future inflation rates, assisting policymakers, businesses, and consumers in making informed financial and economic decisions.

Forecasts from ARIMA(0,1,3)(0,1,1)[12]
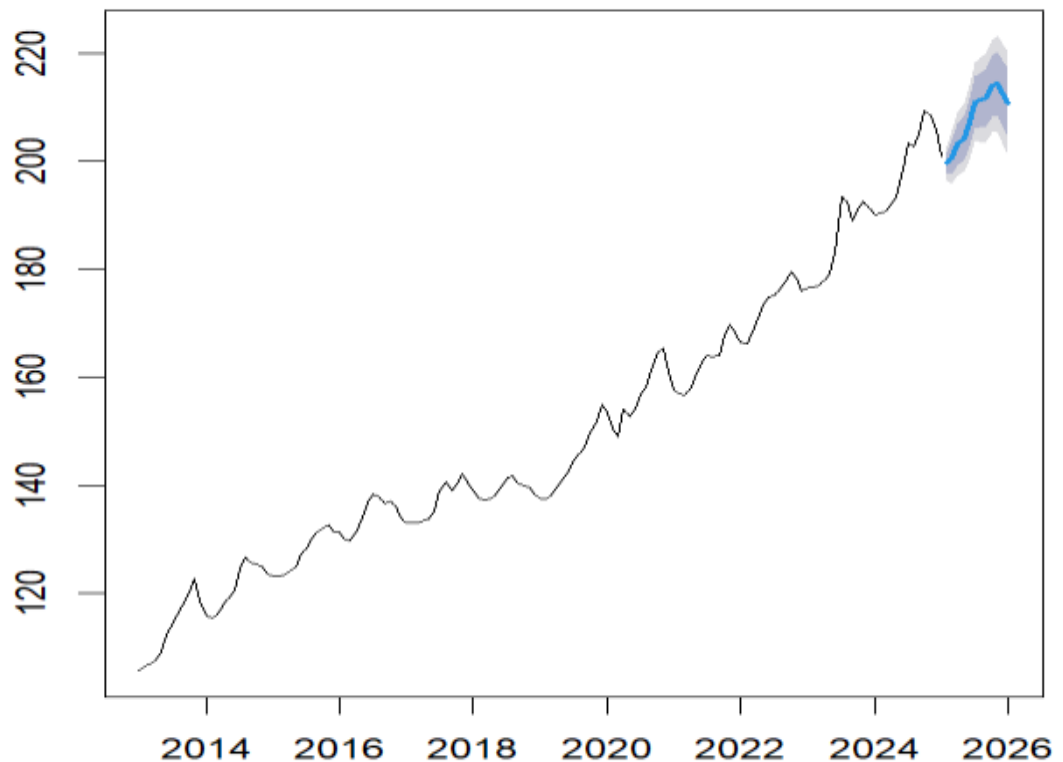
Insights:

1. **Projected CPI Growth:**
   - The **Consumer Price Index (CPI) for the Food & Beverages sector** in India is expected to **rise steadily** from **199.58 in Feb 2025 to 210.65 in Jan 2026**, indicating an **inflationary trend**.
2. **Short-Term vs. Long-Term Stability:**
   - The confidence intervals (**Lo 80 - Hi 80, Lo 95 - Hi 95**) widen over time, suggesting **increased uncertainty in long-term predictions**. This highlights the potential for **greater volatility in food prices**.
3. **Seasonal Effects:**
   - Some months (e.g., **Jun 2025 & Oct 2025**) show **larger CPI increases**, possibly due to **seasonal demand, supply chain constraints, or agricultural cycles**.
4. **Policy Implications:**
   - **Government interventions** such as **buffer stock management, import/export regulations, and agricultural subsidies** may help **stabilize food prices**.

- o **Monetary policy adjustments (interest rate changes)** may be needed to **control food inflation impacts on the broader economy**.
5. **Forecasting Adjustments:**
   - o Since the **Augmented Dickey-Fuller (ADF) test showed non-stationarity**, policymakers should **use differenced data for better forecasting models**.
   This forecast underscores the need for **proactive inflation control measures** to **ensure food price stability and affordability** in India.

3. CPI Stability Analysis:

A. CPI Volatility Across States (Standard Deviation Analysis):

By calculating the standard deviation of the Combined CPI for each state, we identified states with the most volatile inflation over time.

- **States with high CPI volatility (e.g., Manipur, Lakshadweep, Andaman, Telangana, West Bengal) experience frequent price fluctuations.**
- High volatility suggests economic instability, possibly due to supply chain disruptions, seasonal effects, or inconsistent government interventions.
- Low volatility states have more stable inflation rates, making them less susceptible to price shocks.

B. CPI Stationarity Test (ADF Test):

The Augmented Dickey-Fuller (ADF) Test was performed to check whether CPI follows a stationary process or if it exhibits a trend over time.
- By performing the test we got CPI values are affected by **long-term economic factors** rather than short-term fluctuations.
- To make the data stationary for forecasting models, **differencing (ΔCPI = CPI_t - CPI_(t-1))** is required.

Government Policy Implications for the Food & Beverages Industry :

1. Inflation Control for High Volatility States

- Implement price stabilization measures such as food subsidies, minimum support prices (MSP), and buffer stock reserves to mitigate extreme price fluctuations.

- Strengthen agricultural supply chains by improving storage facilities, transportation networks, and cold chains to reduce post-harvest losses and stabilize food prices.

- Enhance regional food policies to ensure uniform inflation control, especially in states with high volatility (e.g., Manipur, Lakshadweep, Andaman, Telangana, West Bengal).

2. Monetary and Fiscal Policies Based on Food & Beverages CPI Trends

- Since CPI for the Food & Beverages industry follows a trend, interest rate policies should account for seasonal agricultural patterns and global commodity price movements.

- The government should monitor food inflation expectations and ensure that minimum wages, food security schemes (like PDS), and nutrition-based welfare programs keep pace with price trends.

- Encourage investment in food processing and storage technologies to minimize inflationary pressures from supply chain inefficiencies.

3. Differencing CPI for Effective Forecasting in the Food & Beverages Industry

- Economic models should incorporate differencing techniques before making policy decisions related to food inflation control.

- Non-stationary Food & Beverages CPI data suggests that inflation-targeting policies must consider long-term agricultural productivity, climate change effects, and trade policies rather than focusing only on short-term fluctuations.

- The government should use predictive analytics to anticipate food price shocks and take proactive policy measures to ensure stable food prices and affordability.

4. <u>**Observations from Clustering Analysis: Identifying Similar States Based on CPI Trends :**</u>

The K-Means clustering technique was applied to group Indian states based on their average Consumer Price Index (CPI) for the Food & Beverages industry. This helps in identifying states with similar inflationary patterns, enabling targeted economic and policy interventions.
The clustering analysis categorized states into **three groups** based on their inflation levels:

1. **High Inflation States**
   - **States:** Andaman & Nicobar, Kerala, Manipur, Puducherry
   - These states experience persistently **high food inflation**, possibly due to **higher transportation costs, limited local production, and supply chain inefficiencies**.
2. **Medium Inflation States**
   - **States:** Andhra Pradesh, Arunachal Pradesh, Daman and Diu, Goa, Jammu and Kashmir, Karnataka, Lakshadweep, Mizoram, Nagaland, Odisha, Sikkim, Tamil Nadu, Telangana, Tripura, West Bengal
   - Inflation is moderate but **fluctuates based on seasonal factors and policy interventions**.
3. **Low Inflation States**

- o **States:** Assam, Bihar, Chandigarh, Chhattisgarh, Dadra and Nagar Haveli, Delhi, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Madhya Pradesh, Maharashtra, Meghalaya, Punjab, Rajasthan, Uttar Pradesh, Uttarakhand
- o These states exhibit **relatively stable food prices**, likely due to **strong agricultural output, efficient supply chains, or government price controls**.

Policy Implications :

- **For High-Inflation States:**
  - o Implement **targeted price stabilization policies**, such as subsidies and stock reserves for essential food items.
  - o Improve **transportation and storage infrastructure** to reduce supply chain disruptions.
- **For Medium-Inflation States:**
  - o Strengthen **market linkages** to reduce seasonal price fluctuations.
  - o Promote **food processing and preservation industries** to ensure steady supply and pricing.
- **For Low-Inflation States:**
  - o **Monitor price stability** to prevent sudden spikes.
  - o Encourage **exports and trade of surplus food items** to boost economic growth.

By leveraging **clustering insights**, policymakers can **tailor inflation control strategies** to different state groups, ensuring a **more balanced and effective approach** to food price stability.

Clustering States Based on CPI Trenc