Rotman Datathon 2025

Report on Analysing the Impact of Rising Cost of Living Relative to Economic Development and Supply Chain Dynamics

Team Name: T036

Sam Hossain

Zaheen Mahaey

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1. Introduction

The rising cost of living, driven by economic volatility, inflation, and global disruptions, has become a major challenge for households, businesses, and governments worldwide. It not only strains consumer spending but also directly impacts supply chain dynamics, increasing production, transportation, and labor costs. This report aims to explore the interplay between cost of living, economic development, and supply chain stability, while providing actionable strategies to mitigate these challenges.

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2. Analytical Objectives and Scope

The analysis is structured around three key questions:

1. **Impact on Supply Chains:** How does the rising cost of living influence supply chain stability and costs?
2. **Economic and Regional Drivers:** What economic and regional factors contribute to cost increases within supply chains?
3. **Strategic Adaptations:** How can organizations adapt their supply chain strategies to mitigate rising costs and maintain affordability?

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4. Methodology

The process started with merging the income group, region columns into the main data. Sourced two Human Development Index variables from United Nations Development Programme website and Producer Price Index (PPI) from World Bank Group and merged into the main data.

3.1 Analysis involved the following indices:

1. **Cost of Living Data:** Consumer Price Index (CPI), Cost of Living Index.
2. **Economic Development Indicators:** GDP per capita, Human Development Index (HDI), Gini Coefficient, Unemployment Rate.
3. **Supply Chain Metrics:** Producer Price Index (PPI), Logistics Performance Index (LPI), Freight Rate Indices.
4. **Household Metrics:** Average Household Income, Household Expenditure.

3.2 Analysis Steps:

1. **Data Cleaning:** Imputed missing values by Region, Income Group and Country-based time-series interpolation and KNN methods**.** Dropped 55 columns and 20+ countries for greater than 70% missing values.
2. **Correlation Analysis:** Identifying relationships between rising living costs, economic factors and supply chain variables.
3. **Multicollinearity Analysis:** Removing the features whose Variance Inflation factor (VIF) was greater than 10.
4. **Data Modeling:** Transformed the data into Multi-index and Long Format for Panel Data Analysis.
5. **Predictive Modelling:** Used regression and time-series models to predict shifts in supply chain costs. Two models fixed effects and random effects models were used for the analysis of data. Finally, Hausman test was carried out to validate the model selection.
6. **Insights generation:** Analyzed patterns across regions, income groups, countries and years(time data) to uncover disparities.

4. Key Findings

Aggregated Insights with Detailed Discussion:

The insights generated during the analysis of regions, income groups, and countries provide a holistic understanding of how fixed effects (interpreted here as drivers of inflationary or deflationary pressures) vary across geographic and economic contexts. Below is a detailed discussion of these insights and their implications.

4.1 Correlation Insights

- **Consumer Price Index (CPI):** Strongly correlated with rising Producer Price Index (PPI) and Freight Rate Indices, reflecting the downstream impact of living costs on supply chain costs.
- **Gini Coefficient and Unemployment Rate:** Regions with higher income inequality and unemployment showed greater supply chain disruptions, possibly due to weaker economic resilience.

4.2 Predictive Model (Fixed Effects) Insights (Appendix Figure 1)

- Identified key predictors of supply chain costs:
  - Freight Rate Indices (+0.63 impact per unit increase).
  - CPI (+0.37) and GDP per capita (-0.27, indicating wealthier economies manage supply chains better).
  - Predicted rising supply chain costs for inflationary regions unless infrastructure is improved.

- **Positive relationships**: Positive relationships with Producer Price Inflation (dependent variable) are observed for:
  a) **Energy price inflation:** This is expected because higher energy prices often contribute to higher overall inflation.
  b) **Imports growth:** This suggests that higher imports might influence supply-demand dynamics, impacting prices.
  c) **Broad money supply:** This suggests that increases in the money supply relative to GDP may contribute to higher inflationary pressures.
  d) Consumer price index (CPI, 2010 = 100)

: A slight positive relationship reflects that overall inflation levels in the economy impact producer prices.

- **Negative relationships**: Negative relationships with Producer Price Inflation (dependent variable) are observed for:
  a) **Real effective exchange rate:** A stronger currency could reduce the cost of imported goods, reducing inflationary pressures.
  b) **Real interest rate (%):** This is consistent with economic theory, where higher interest rates may reduce consumption and investment, leading to lower inflation.
  c) **Population growth (annual %):** This could be because population growth may lead to more labour supply and increased economic activity, potentially reducing inflationary pressure.

4.3 Regional-Level Fixed Effects on Producer Price Inflation (Appendix Figure 2)

Insights and Trends:

- **Regions with Negative Fixed Effects (Deflationary Trends):**
  a) **North America** stands out as the region with the most negative fixed effect, suggesting exceptional control over inflationary pressures. This could be attributed to:
     - Advanced logistics and supply chain networks.
     - High resource accessibility and efficient energy management.
     - Resilience to external shocks due to robust economic policies.
  b) **East Asia & Pacific and Europe & Central Asia** exhibit moderate deflationary pressures, likely due to:
     - Strong trade balances and export-driven economies.
     - Advanced manufacturing bases and technological leadership in supply chain systems.
- **Regions with Positive Fixed Effects (Inflationary Trends):**
  a) **Sub-Saharan Africa** emerges as the region with the most significant inflationary pressures. Key factors include:
     - High dependence on imported goods due to underdeveloped local industries.
     - Energy price volatility and weak transportation infrastructure.
     - Persistent supply chain vulnerabilities exacerbated by geopolitical and economic instability.
  b) **South Asia and Latin America & Caribbean** exhibit moderate inflationary trends, potentially driven by:
     - Rapidly growing populations and urbanization leading to increased demand.
     - Reliance on imports for energy and raw materials.
     - Labor cost pressures in expanding economies.

c) **Middle East & North Africa** reflects a slight positive effect, likely due to oil price fluctuations, uneven economic diversification, and regional conflicts.

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4.4 Income Group-Level Fixed Effects on Producer Price Inflation (Appendix Figure 3)

Insights and Trends:

- **Low Income Groups:** Exhibit the highest fixed effects (8.91 on average), highlighting significant inflationary pressures due to:
    - Underdeveloped infrastructure and supply chain systems.
    - Heavy reliance on imports for essential goods and energy.
    - Higher vulnerability to external shocks like global energy crises.
- **High Income Groups:** Exhibit the lowest fixed effects (3.52 on average), indicating robust control over inflation due to:
    - Advanced logistics systems and localized production.
    - Diversified economies with lower dependence on imports.
    - Greater fiscal capacity to cushion against economic pressures.
- **Middle-Income Groups:**
    - **Lower Middle Income:** Moderate inflationary pressures (6.36 on average), reflecting their transitional stage of development.
    - **Upper Middle Income:** Slightly lower inflation (5.68 on average) due to greater economic diversification and industrial development.

4.5 Country-Level Fixed Effects on Producer Price Inflation (Appendix Figure 4a, 4b & 4c)

Insights and Trends:

- **Top 10 Countries with Positive Fixed Effects (High Inflationary Pressures):**
    - **Madagascar (16.1)** and **Argentina (14.1):** Extreme inflationary pressures are due to:
        - Economic instability and

- volatile exchange rates.
- High dependence on imports for essential goods.
- Poor infrastructure leading to supply chain inefficiencies.

Other countries with high inflation include **Azerbaijan, Brazil, Angola, Uzbekistan, Ukraine, Tajikistan, Iran, and Turkiye.**

- **Bottom 10 Countries with Negative Fixed Effects (Deflationary Trends):**
  - **United States (-12.9):** Exemplary supply chain resilience due to:
    - Advanced logistics and diversified production.
    - Strong fiscal policies mitigating inflationary pressures.

Other countries with significant deflationary trends include **Hong Kong SAR (-10.6), Japan (-8.8), and United Kingdom (-8.0).**

Countries like **Belarus, Lithuania, Montenegro, Netherlands, Lebanon, and Palau** also exhibit strong cost control.

4.6 Yearly Insights (Appendix Figure 5a & 5b)

- **Yearly Insights for Income Groups:**
  - **High Income Groups:** Show consistent control over inflation across all years.
  - **Low Income Groups:** Show spikes in inflation during global crises (e.g., energy price surges).

- **Yearly Insights for Regions:**
  - **North America:** Displays steady negative fixed effects year-over-year.
  - **Sub-Saharan Africa:** Shows frequent and sharp spikes in inflation, often during economic turmoil.
  - **South Asia:** Experiences moderate but steady inflationary pressures.

5. Strategic Recommendations

5.1 For Policymakers:

- **Support Infrastructure Development**: Focus on improving transportation networks and warehousing facilities, especially in regions like Sub-Saharan Africa and South Asia.
- **Promote Regional Cooperation**: Encourage trade agreements that reduce dependency on imports and stabilize costs.
- **Targeted Fiscal Policies**: Subsidize critical supply chain components, such as fuel and energy, to reduce inflationary pressures.

5.2 For Businesses:

- **Digital Transformation**: Invest in AI-driven supply chain management systems to improve efficiency and reduce costs.
- **Diversify Supply Chains**: Shift from over-reliance on single regions for production to minimize disruptions.
- **Focus on Sustainability**: Adopt renewable energy sources to lower energy price volatility.

5.3 For Deflationary Regions:

- Policymakers in North America, East Asia, and Europe should continue investing in technological innovation and infrastructure upgrades to sustain supply chain efficiencies.
- Focus on supporting global supply chain networks and sharing best practices with inflationary regions.

5.4 For Inflationary Regions:

- Sub-Saharan Africa needs targeted interventions, such as:
    - Development of local industries to reduce import dependency.
    - Investment in renewable energy to mitigate energy cost volatility.
    - Enhancements in transportation infrastructure to lower logistics costs.
- South Asia and Latin America should:
    - Increase domestic production capacities for essential goods.

- Address labor market inefficiencies to manage wage-driven inflation.
- Strengthen trade agreements to stabilize import costs.

5.5 For Low Income Groups:

- Build local production hubs to reduce import reliance.
- Improve infrastructure (e.g., roads, ports, and warehouses) to enhance supply chain efficiency.
- Encourage foreign investment in renewable energy and manufacturing.

5.6 For Middle Income Groups:

- Enhance workforce productivity through education and skill development.
- Promote public-private partnerships to improve infrastructure and reduce logistics costs.

5.7 For High Income Groups:

- Serve as role models for supply chain efficiency and cost control strategies.
- Leverage global partnerships to support lower-income regions in stabilizing inflation.

5.8 For Countries

- **High Inflation Countries:**
    - Focus on macroeconomic stabilization policies, reducing dependency on imports.
    - Invest in renewable energy and domestic manufacturing.
- **Low Inflation Countries:**
    - Use their position to provide technical and financial assistance to inflationary regions.
    - Promote global best practices in supply chain management.

6. Conclusion: This analysis highlights the interconnected nature of economic development, cost of living, and supply chain dynamics. High-income countries and deflationary regions showcase strong supply chain resilience, while inflationary pressures in low-income countries underscore the urgent need for infrastructure development and policy interventions. By leveraging data-driven insights and fostering global collaboration, stakeholders can ensure more stable and equitable supply chain systems in the face of rising costs.

Appendix

Figure 1

Panel OLS Regression (fixed effect) model output

PanelOLS Estimation Summary

Dep. Variable:	Producer price inflation, annual	R-squared:	0.7536
Estimator:	PanelOLS	R-squared (Between):	0.4675
No. Observations:	2805	R-squared (Within):	0.7536
Date:	Thu, Jan 16 2025	R-squared (Overall):	0.6983
Time:	17:03:36	Log-likelihood	-8789.8
Cov. Estimator:	Unadjusted		
		F-statistic:	239.57
Entities:	187	P-value	0.0000
Avg Obs:	15.000	Distribution:	F(33,2585)
Min Obs:	15.000		
Max Obs:	15.000	F-statistic (robust):	239.57
		P-value	0.0000
Time periods:	15	Distribution:	F(33,2585)
Avg Obs:	187.00		
Min Obs:	187.00		
Max Obs:	187.00		

Figure 2

Region level fixed effects

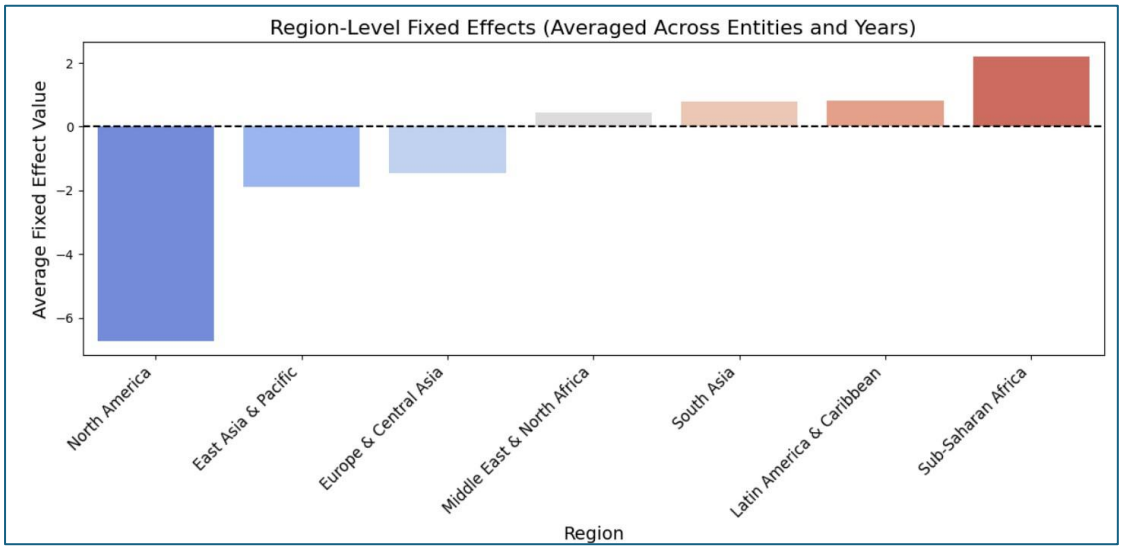

Figure 3

Income group-level fixed effects on Producer Price Inflation

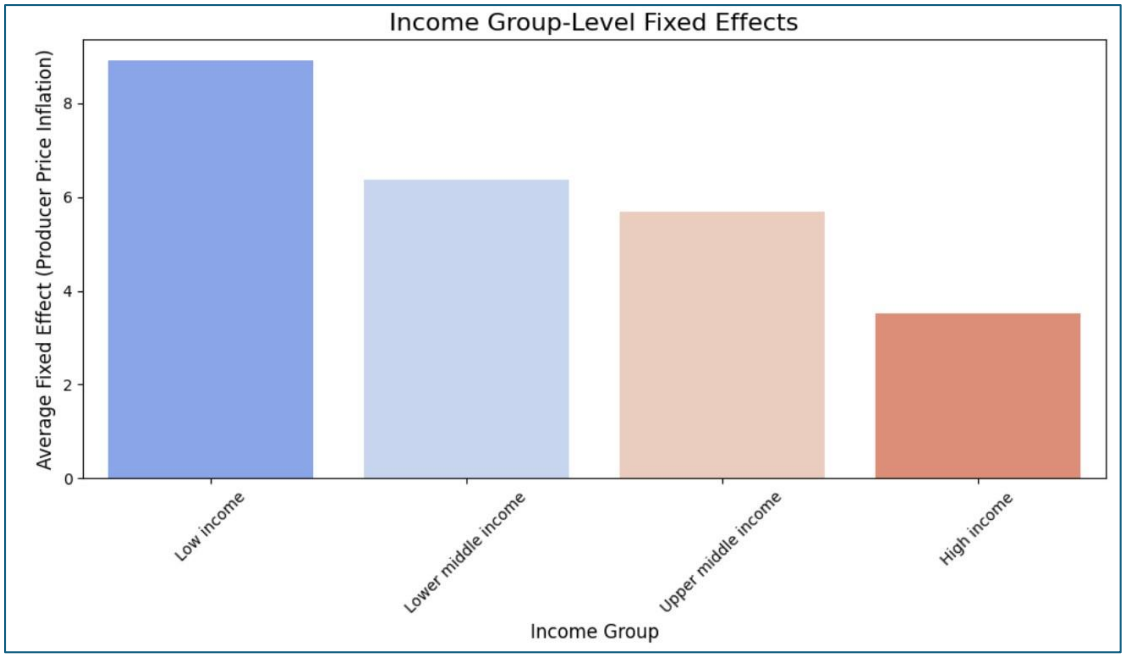

Figure 4a

Country-level fixed effects on Producer Price Inflation

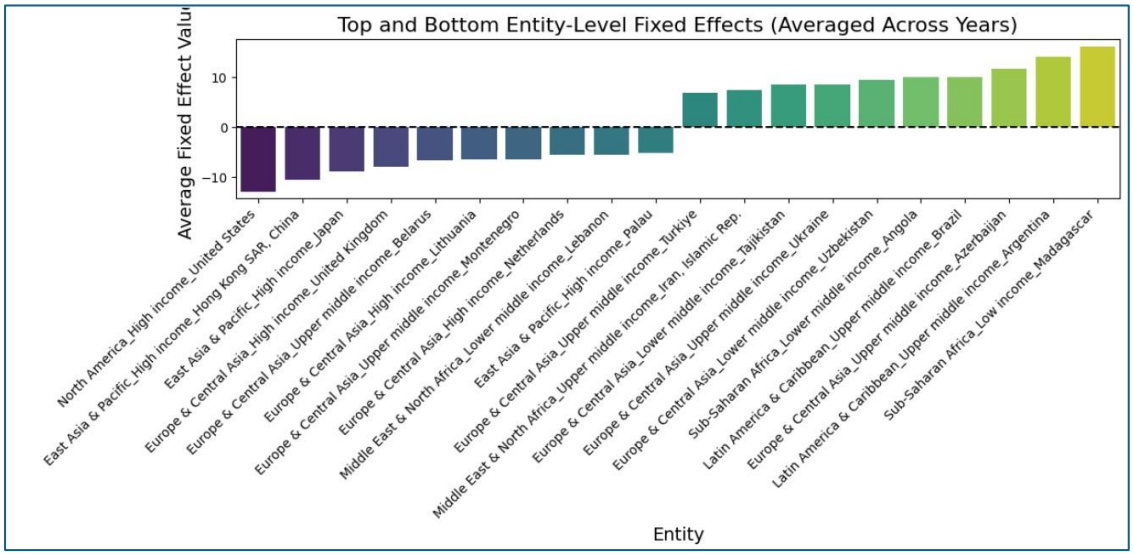

Figure 4b

Country-level (top 10) fixed effects on Producer Price Inflation

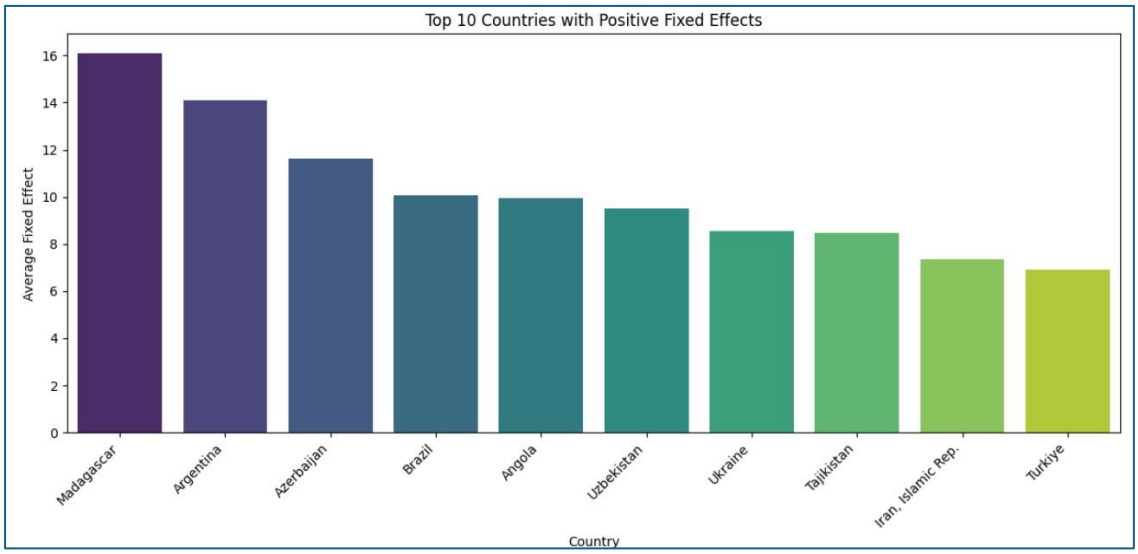

Figure 4c

Country-level (bottom 10) fixed effects on Producer Price Inflation

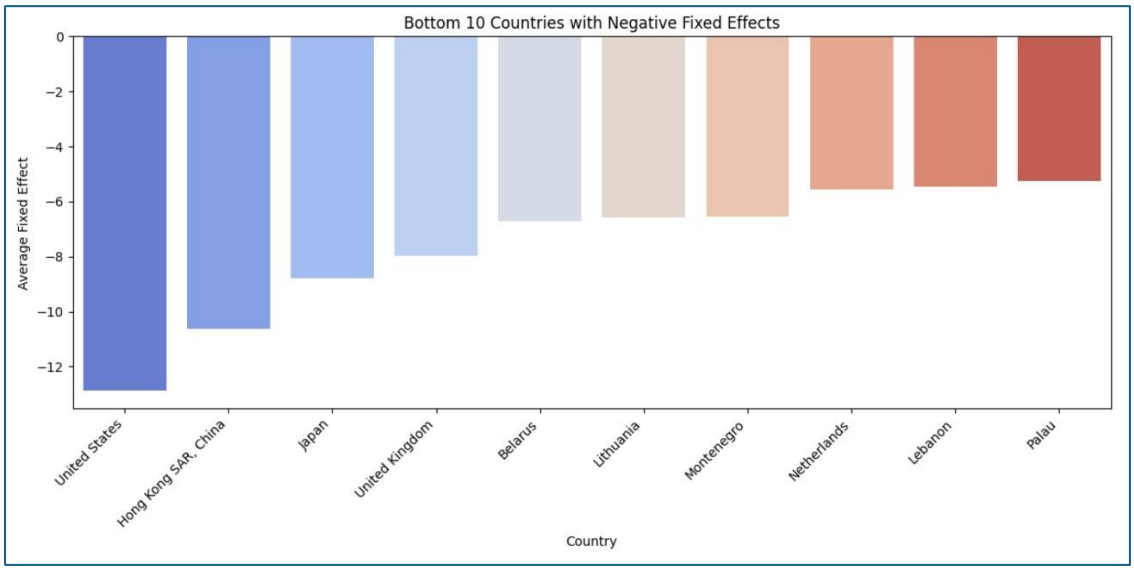

Figure 5a

Yearly Insights for income groups

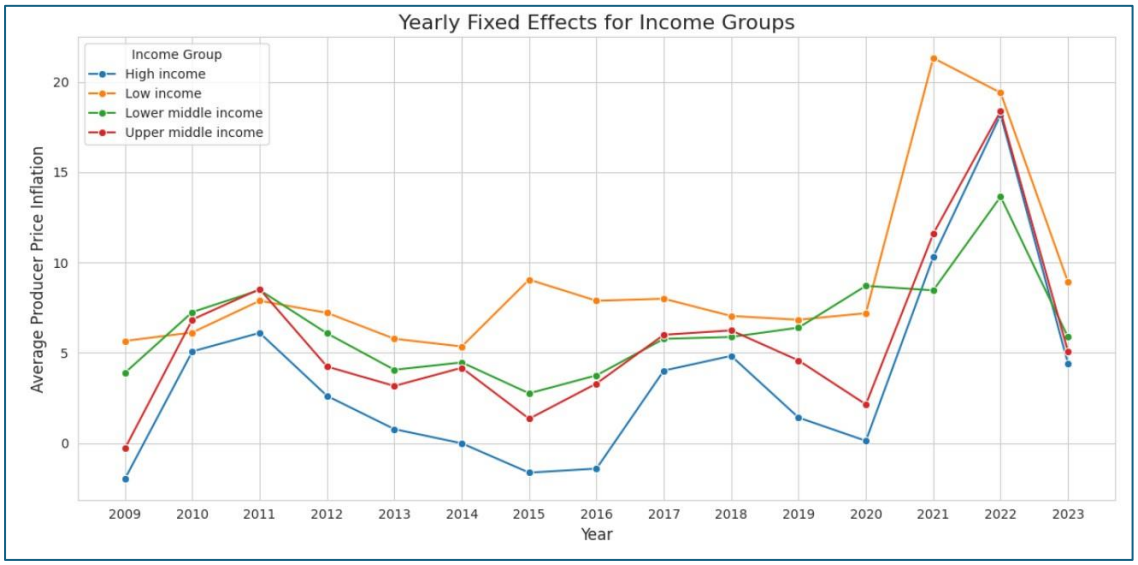

Figure 5b

Yearly Insights for regions