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Executive Summary:

<u>Problem Statement</u>

Supply chain systems, designed to produce and deliver goods efficiently, are essential for global trade and economies to thrive. In recent times, cost of living has surged, impacting supply chain stability and health. To provide insight into optimal planning and preparation for economic prosperity, this report delineates key economic metrics that affect supply chain stability and costs.

<u>Research Methods</u>

Cost of living data, economic development indicators, supply chain metrics, and household income and expenditure data were analyzed to provide insights.

Economic metrics for 218 countries were gathered from various datasets. The data was then cleaned and filtered. Correlation analyses were conducted by first replacing missing values with the mean of remaining values for a given country, and the data was then reduced to a historic mean 2009-2023 for each country. Significance was set to $p<0.05$ and only variables with a Pearson correlation coefficient > 0.7.

Time-series forecasting was utilized with the Auto ARIMA model to predict inflation trends as well as supply chain metrics across global regions. Historical inflation data was aggregated by region, averaging inflation rates across all countries within each region for each year. The dataset was cleaned to handle missing values, and annual inflation trends were converted into time-series data. The Auto ARIMA model was employed to determine the best-fitting parameters for each regional time series, enabling accurate inflation forecasting for a 3-year horizon.

<u>Recommendations</u>

Based on our analysis and insights, we propose various supply chain recommendations for businesses, policymakers and other relevant stakeholders. These include diversifying supply chain networks, increasing trade agreements between key nations, improving profit margins through non-price adjusting strategies, enacting strategic monetary policies, and investing in physical capital and R&D.

<u>Conclusions</u>

The complexity of supply chain dynamics demands several implementations in varying aspects. For instance, designing policies to influence the money supply and tax incentives, sourcing materials, enhancing international trade agreements, and accelerating investments in physical capital, specifically investment, particularly in analytical and predictive technology.

1. Overview

In recent years, the rising cost of living has significantly affected households, businesses, and economies worldwide. The COVID-19 pandemic exacerbated this strain by disrupting global trade systems through lockdowns, border closures, and supply chain shutdowns, leading to material shortages and escalating costs (Ayub, n.d). Although trade systems have largely rebounded, inflationary pressures, increased transportation costs, and persistent supply chain inefficiencies continue to drive up living expenses. As household expenses outpace income growth, consumer spending has weakened, creating ripple effects on supply chains, business profitability, and economic stability. Mitigating the rising costs in supply chains and the broader cost of living will require concerted efforts from business executives and policymakers. This report will outline strategies addressing the interconnected factors driving these challenges.

1.1: Impact of Rising Cost of Living on Supply Chain Stability and Cost

Closely interwoven with the stability of supply chains and their costs, rising living costs place inflationary pressures and increased costs surge through the production, transport, and distribution pipeline. Higher raw material, labour, and energy costs are forcing companies to alter their pricing approach, passing many of these costs on to consumers and thereby further reducing purchasing power and demand (McKinsey and Company, 2024). This, in turn, becomes a self-feeding circle; increased living costs contrast with the instability of supply chains. Businesses must make their supply chains resilient while being attentive to the customer's affordability issue (McKinsey and Company, 2024).

1.2: Regional and Economic Factors that Increase Supply Chain Costs

As explained, the increased cost of living has become a significant disruptor of supply chains due to increasing operation costs hence influencing businesses to manage their costs effectively. On the other hand, the cost of living cannot be considered in isolation; there are several external factors, especially economic and regional factors, which directly and indirectly impact the supply chain performance. Economic factors impact the overall financial condition of a particular country or region, such as inflation, interest rate, currency exchange rate, and labor

costs. Inflation increases the cost of raw materials, labour, energy, and transportation, which directly increases the supply chain cost. For instance, increased consumer prices pressure businesses to increase wages, which translates to increased costs for customers and eventually decreased demand due to affordability factors (Oner, 2010; McKinsey and Company, 2024). Similarly, currency fluctuations impact the price of imported and exported products as a weakened national currency elevates the cost of all imported products and raw materials, hence increasing supply chain costs (International Monetary Fund, 2010; OECD, 2023).

Regional factors are influences particular to specific locations where supply chain operations are concerned, including infrastructure quality, geopolitical stability, trade agreements, and natural resource availability. These factors determine how efficiently goods will be moved, warehoused, and distributed domestically and internationally. Poor infrastructure results in inefficiency, delay, and increased cost of transportation. This fact has been demonstrated in regions where either the road network is backward or the ports are congested, and supply chain costs are higher as a result of longer lead times (Ricadela, 2023; LeanDNA, 2024). Another common factor, and one that is somewhat prevalent in today's world, is that of conflict and trade embargoes, which serve to disrupt supply chains by limiting resource availability or transport routes. For example, trade restrictions by oil-exporting nations heighten fuel prices internationally, therefore increasing the cost of transport and supply chains accordingly (Oner, 2010; McKinsey and Company, 2024). Often linked to geopolitical strife is the imposition of tariffs and trade restrictions, which also raise the price of imported goods and thus, add to supply chain costs. Free trade agreements, however, work to lessen these barriers and promote supply chain operations at lower costs (Karanja, 2023; LeanDNA, 2024).

1.3: Supply Chain Costs Can Be Mitigated with Strategic Planning

Defining what economic and regional factors impact the supply chain identifies a venue through which firms and policymakers base long-term strategies in managing escalating costs. In understanding how supply chain costs are driven by inflation, energy prices, infrastructural quality, and geopolitical stability, decision-makers can apply strategic interventions like investment in resilient infrastructure, facilitation of trade agreements, or the utilization of energy-efficient technologies. Such strategies would have the effect of cutting down costs not only along

the supply chains but also ultimately impacting commodity prices to stabilize them and cushion consumers from an increasing cost of living. This way, addressing the root causes of supply chain inefficiencies creates a positive feedback loop, ultimately contributing to economic stability and enhancing consumer well-being.

2. Findings

2.1 Cost of Living and Supply Chains:

Various measures of supply chain cost and performance and cost of living metrics were chosen and correlated against one another to examine whether two variables are intertwined with each other. To efficiently examine these correlations, a correlation matrix of the chosen variables was calculated (Table 1; Figure 1). Variables with a Pearson correlation coefficient of $0.50 \geq R < 1$ were selected to examine any reasonable correlation.

Table *1: Pearson correlation coefficients for the correlation between two variables. P-values are denoted by an asterisk where *=p<0.05, **=p<0.01, and ***=p<0.001*

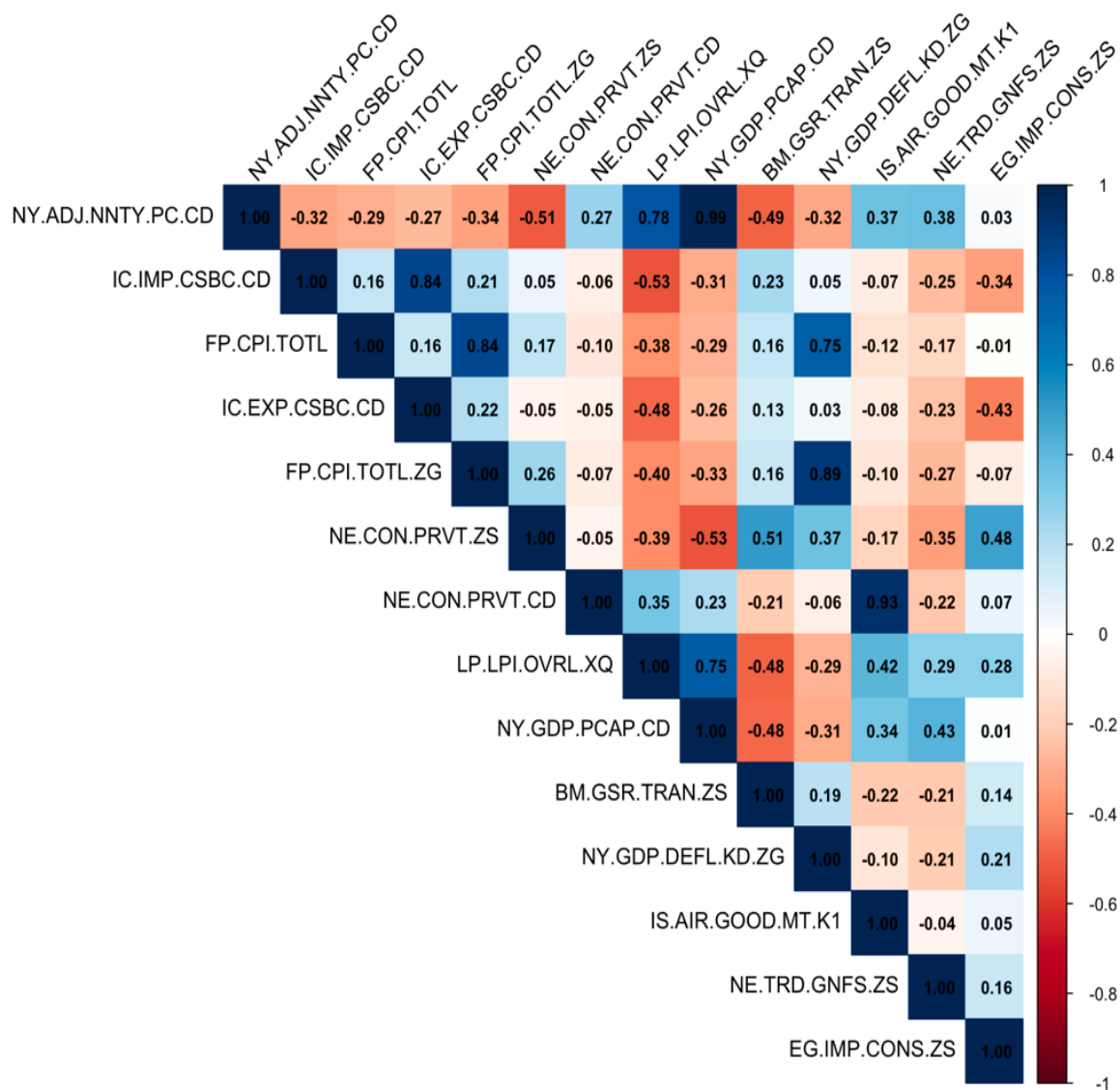| Variable 1	Variable 2	Correlation	P-Value
NY.ADJ.NNTY.PC.CD	NY.GDP.PCAP.CD	0.9892	***
NY.GDP.PCAP.CD	NY.ADJ.NNTY.PC.CD	0.9892	***
IS.AIR.GOOD.MT.K1	NE.CON.PRVT.CD	0.9311	***
NE.CON.PRVT.CD	IS.AIR.GOOD.MT.K1	0.9311	***
FP.CPI.TOTL.ZG	NY.GDP.DEFL.KD.ZG	0.8944	***
NY.GDP.DEFL.KD.ZG	FP.CPI.TOTL.ZG	0.8944	***
IC.EXP.CSBC.CD	IC.IMP.CSBC.CD	0.8439	***
IC.IMP.CSBC.CD	IC.EXP.CSBC.CD	0.8439	***
FP.CPI.TOTL	FP.CPI.TOTL.ZG	0.8351	***
FP.CPI.TOTL.ZG	FP.CPI.TOTL	0.8351	***
LP.LPI.OVRL.XQ	NY.ADJ.NNTY.PC.CD	0.7816	***
NY.ADJ.NNTY.PC.CD	LP.LPI.OVRL.XQ	0.7816	***
LP.LPI.OVRL.XQ	NY.GDP.PCAP.CD	0.7527	***
NY.GDP.PCAP.CD	LP.LPI.OVRL.XQ	0.7527	***
FP.CPI.TOTL	NY.GDP.DEFL.KD.ZG	0.7490	***
NY.GDP.DEFL.KD.ZG	FP.CPI.TOTL	0.7490	***
NE.CON.PRVT.ZS	NY.GDP.PCAP.CD	-0.5297	***
NY.GDP.PCAP.CD	NE.CON.PRVT.ZS	-0.5297	***
IC.IMP.CSBC.CD	LP.LPI.OVRL.XQ	-0.5269	***
LP.LPI.OVRL.XQ	IC.IMP.CSBC.CD	-0.5269	***
NE.CON.PRVT.ZS	NY.ADJ.NNTY.PC.CD	-0.5086	***
NY.ADJ.NNTY.PC.CD	NE.CON.PRVT.ZS	-0.5086	***
BM.GSR.TRAN.ZS	NE.CON.PRVT.ZS	0.5074	***
NE.CON.PRVT.ZS	BM.GSR.TRAN.ZS	0.5074	***

Figure 1: Correlation matrix of various supply chain and cost of living variables. Values in the squares represent the Pearson correlation values. Diagonals correlating identical variables are coloured black. The bottom half of the correlation matrix has been omitted to remove for ease of analysis.

[IC.IMP.CSBC.CD] = Cost to import, border compliance (US$)
[FP.CPI.TOTL] = Consumer price index (2010 = 100)
[IC.EXP.CSBC.CD] = Cost to export, border compliance (US$)
[FP.CPI.TOTL.ZG] = Inflation, consumer prices (annual %)
[NE.CON.PRVT.ZS] = Households and NPISHs final consumption expenditure (% of GDP)
[NE.CON.PRVT.CD] = Households and NPISHs Final consumption expenditure (current US$)
[LP.LPI.OVRL.XQ] = Logistics performance index: Overall

[NY.GDP.PCAP.CD] = GDP per capita (current US$)
[BM.GSR.TRAN.ZS] = Transport services (% of service imports, BoP)
[NY.GDP.DEFL.KD.ZG] = Inflation, GDP deflator (annual %)
[IS.AIR.GOOD.MT.K1] = Air transport, freight (million ton-km)
[NE.TRD.GNFS.ZS] = Trade (% of GDP)
[EG.IMP.CONS.ZS] = Energy imports, net (% of energy use)

Among the analyzed variables, Logistic Performance Index (LP.LPI.OVRL.XQ) and GDP Per Capita (NY.GDP.PCAP.CD), exhibited a high correlation coefficient of R = 0.75; p<0.001, indicating that the higher the logistics performance, the higher the economic output per capita. This suggests that highly efficient supply chains are a driver of economic development. Such an interrelation of both variables is further underlined at the national level, as the Logistics Performance Index and Adjusted Net National Income Per Capita (NY.ADJ.NNTY.PC.CD) also exhibited a high correlation coefficient of R = 0.78; p<0.001. Together, these findings highlight how effective logistics systems—such as improved customs processes, robust infrastructure, and enhanced tracking capabilities—can facilitate trade, reduce costs, and boost supply chain efficiency. In turn, higher income levels may enable further investments in logistics infrastructure, creating a positive feedback loop where economic growth and logistics performance mutually reinforce each other.

Likewise, Inflation, FP.CPI.TOTL.ZG, and Consumer Price Index, CPI, FP.CPI.TOTL were strongly positively correlated, R = 0.84; p < 0.001, indicating that there is indeed a direct relationship between increased inflation and increased consumer prices. This connection highlights the significant impact inflation has on living costs, as escalating prices for essential goods and services erode household purchasing power and economic stability. Furthermore, the interconnected nature of inflationary pressures and cost-of-living metrics is evident, with CPI serving both as a reflection of inflation. Such findings must galvanize action against inflation to stabilize living costs, as perpetual and intense inflation will only add to the economic burden of households while prolonging and extending disturbances throughout supply chains via increased material, labor, and logistic costs. Swift yet calculated policy changes are imperative to correcting aberrant economic climates, be it over-stimulated or under-stimulated, prior to their intensification.

Finally, Imports of Goods and Services as a Percentage of GDP (NE.TRD.GNFS.ZS) and Household Final Consumption Expenditure (NE.CON.PRVT.CD) resulted in a moderate correlation (R = 0.51; p<0.001), indicating that higher household spending, to some extent, aligns with increased import activity relative to GDP. This suggests that growing consumer demand often drives reliance on imported goods, particularly in economies where domestic

production cannot fully meet consumption needs. We presume that, in recent years, Imports of Goods and Services as a Percentage of GDP and Household Final Consumption Expenditure have exhibited a moderate correlation, as supply chain disruptions have left countries more dependent on their domestic goods, as opposed to imported foreign goods.

2.2 Regional and Economic Factors
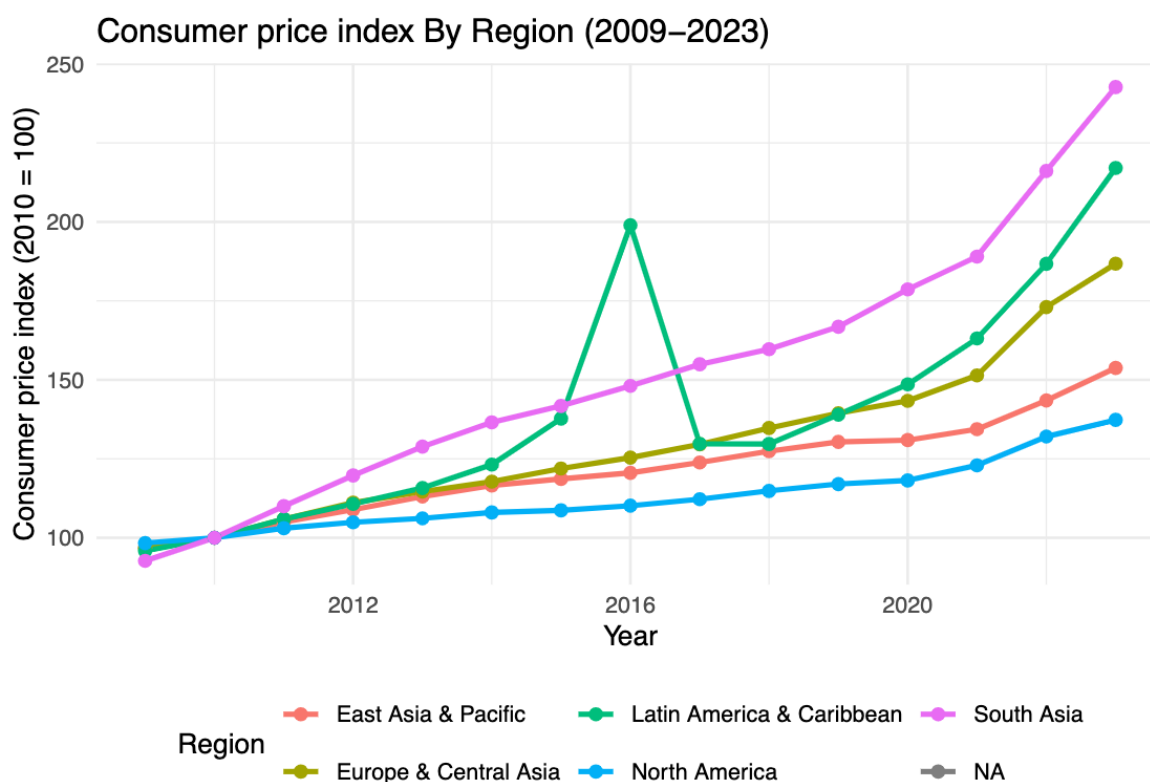
Despite the perception of increasing inflation as a worldwide phenomenon in equal amounts, Figure 2 underscores notable variations across different regions regarding the pace at which the costs of living have escalated over time. From 2016 onwards, the CPI rose most sharply in South Asia, which saw a steep surge above all other regions by 2023, indicating the sustained inflationary pressures driven by economic instability and supply chain disruption, allied with rising demand for goods and services in these growing economies. Developing regions like Latin America and the Caribbean show an upward rise of the CPI, mostly after 2016, indicating a prevalence of inflation that is usually attached to the fluctuating exchange rate,

import dependence, and political factors affecting regional economies. A prominent player in South Asia, India held interest rates constant at a historical low of 4%, for nearly two years, which elevated economic output gap (Bhat & Ganguly, 2023). Similarly, in North America, Canada maintained an immensely low policy rate of 0.25% for nearly two years, from 2020 to 2022, resulting in a significant increase in economic output gap (Benchetrit, 2024). Lower interest rates, by increasing money supply into the economy and lowering borrowing costs, has been linked to both increased investment and consumer spending (Ma & Wang, 2019). In turn, inclined spending, attributed to lower lending rates, results in greater GDP and inflation, making goods and services—including those that supply chains rely on—more expensive.

By contrast, North America and Europe & Central Asia show more stable and moderate increases in the respective levels of CPI over the same period, reflecting less inflation and stronger economies. This steadier trend could be due to stronger monetary policies, greater productive capabilities, and resilient supply chains. East Asia & Pacific demonstrates a moderate but regular increase in the CPI, reflecting balanced inflationary trends across developing and developed economies in the region.

2.3 Supply Chain Stability Prediction

To predict supply chain stability for the next 3 years from 2023, we decided not to go ahead with the Prophet time series model. This is because we didn't have access to any seasonal data and the Prophet model works best with seasonal data. Furthermore, with the Prophet model, there would not be any trends beyond yearly increases to observe. Therefore, we decided to use the ARIMA time series model to forecast inflation, air transport (freight), and transport services by region.
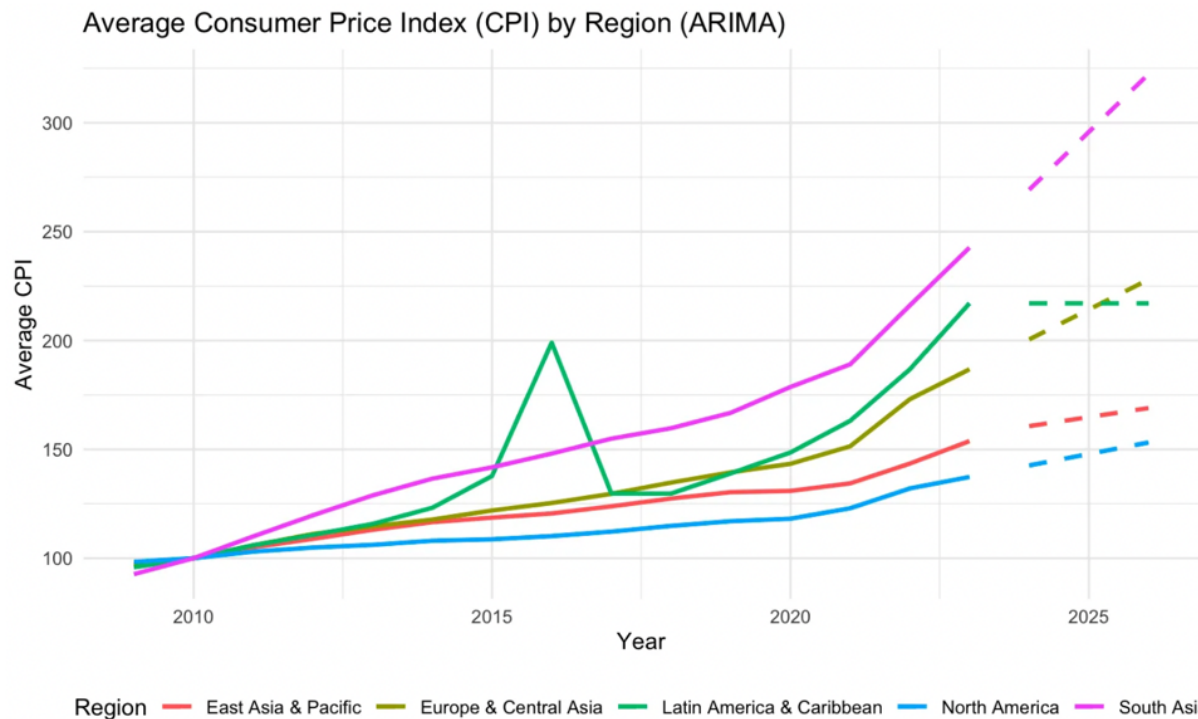
Figure 3: Consumer Price Index (CPI) by Region (2009–2026): South Asia, Europe & Central Asia, and Latin America & Caribbean are expected to achieve the highest CPI growth. Whereas the rate of CPI growth for North America and East Asia & Pacific region is expected to decrease.
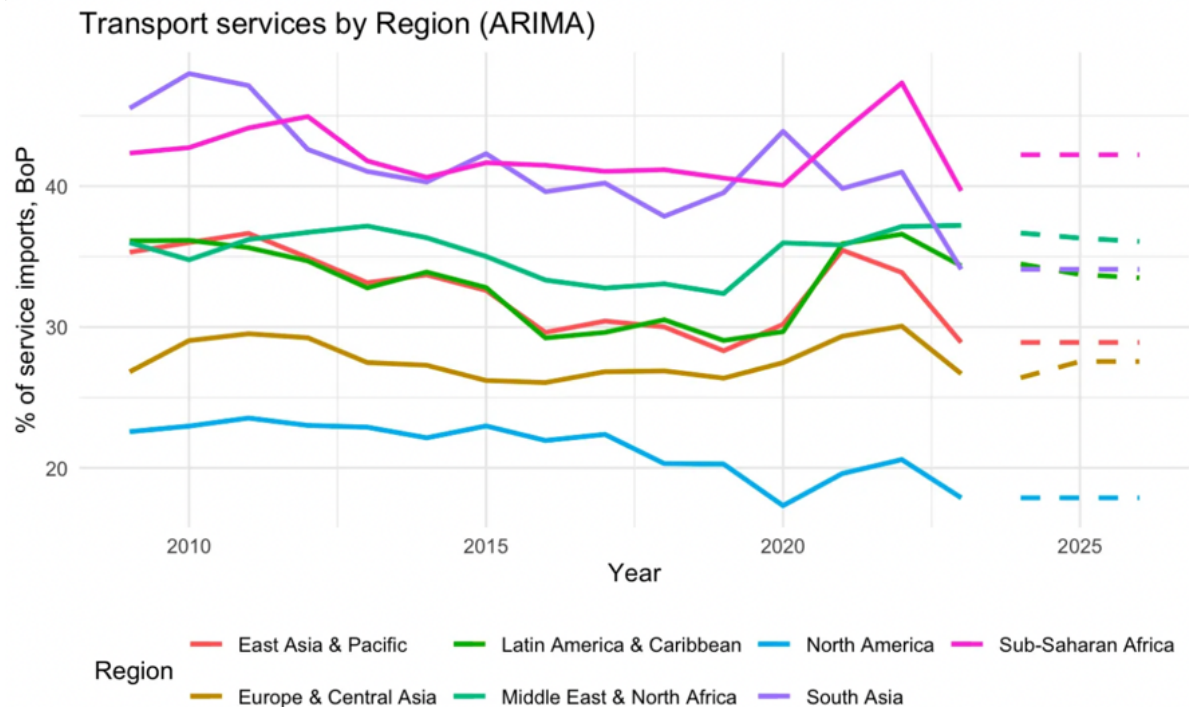

Figure 4: Transport Services by Region (2009–2026): The percentage of service imports representing transport services is portrayed to be quite volatile over the given time period. The Sub-Saharan, Middle East & North African, and South Asian region is expected to achieve the highest growth in the next 3 years. While Latin America & Caribbean and North American regions are expected to have the lowest rate of growth.
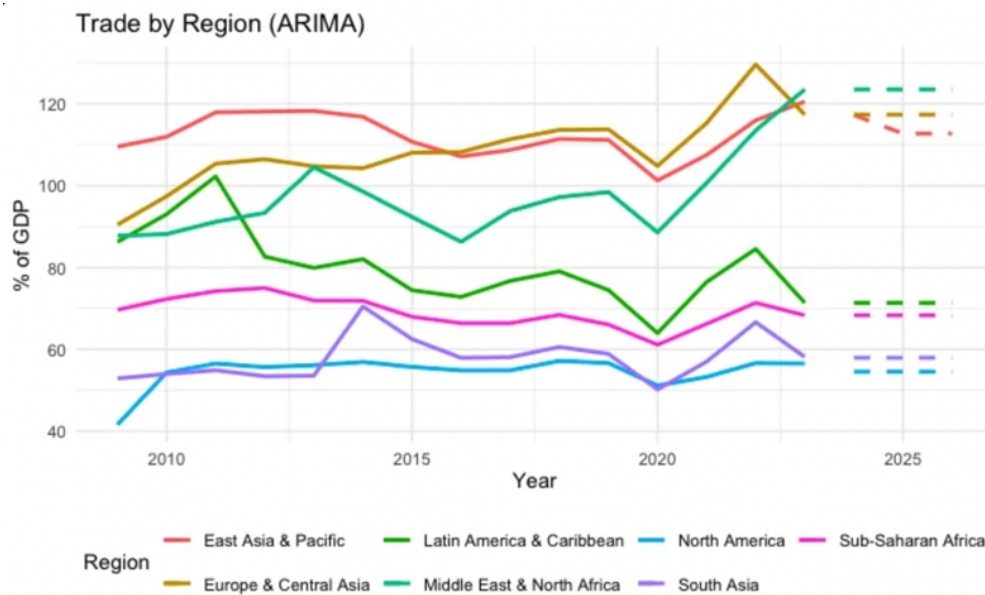
Figure 5: Trade by Region (2009–2026): The percentage of GDP representing trade shows the Middle East & North Africa, Europe & Central Asia, and the Sub-Sahara African region is expected to achieve the highest growth in the next 3 years. However, the Sub-Saharan African region is forecasted to experience a reduction in its trade. Lastly, the remaining regions are expected to have no growth or decline in the next 3 years.

3. Recommendations

Supply chains are multi-faceted systems with incredible nuance. For optimal solutions regarding efficient supply chain practices, we bring forth several recommendations in varying areas including the sourcing of materials, monetary policy, international trade agreements, tax incentives, and physical capital investment particularly in analytical and predictive technology.

3.1 Diversify Supply Chain Networks

Diversifying supply chain networks, by establishing multiple sources of procurement, reducing dependencies, and making supply chains less susceptible to significant inefficiency, should any single supplier fail to provide materials.

3.2 Establish International Trade Agreements

During periods of elevated strain on supply chain processes, increased trade agreements between nations can ameliorate customs efficiency, resulting in the swift distribution of goods to economies. Uniform protocols regarding the processing of goods, among members of such agreements, would ensure a standardized practice that could enhance processing speeds. Furthermore, the reduction of tariffs reduces the financial strains of foreign producers, allowing a higher quantity of goods to be sold and thus at a lower price.

3.3 Proactive Monetary Policy Action

Monetary policy is paramount in ensuring healthy economic conditions and thus supply chain stability. There must be proactive monitoring of inflation and CPI and appropriate changes made to monetary policy rates, to prevent aberrant output gaps that can overheat or under-stimulate economies. Policymakers must ensure low interest rates are not prolonged to the extent that they were post-pandemic, which imposed overbearing pressures on the economy and thus supply chains.

Tax incentives, including lower borrowing costs for particular investments that encourage the development of efficient supply chains, can further augment supply chains and reduce susceptibility to inefficiencies.

3.4 Investment in Physical Capital and R&D

Invest in advanced logistics technologies like real-time tracking and demand forecasting tools to enhance supply chain efficiency by reducing operational costs and improving decision-making accuracy.

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