Colombian Departments' Exposure to Global Supply Chain Disruptions: Implications for Regional Inflation Differentials.

Hector Botello*

PhD candidate in economics

School of Economics, Washington State University, Pullman, USA;

Email: hector.botello@wsu.edu

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Global supply chain disruptions, exacerbated by the COVID-19 pandemic, have intensified inflation pressures across Colombia's regions, challenging the effectiveness of national monetary policy. This study employs System GMM and Difference GMM methodologies with a Supply Chain Exposure Index (SCEI) to examine how international supply chain shocks influence regional inflation dynamics. Findings reveal that departments with greater exposure to global trade experience higher inflation rates, and regional variations further impact the growth-inflation relationship. This study underscores the need for adaptive, regionally sensitive monetary policy to address inflation's heterogeneous impacts effectively, ensuring improved policy outcomes amid continued global disruptions.

Keywords: global supply chain disruptions; inflation; Colombia; regional disparities; monetary policy; System GMM; emerging markets

Subject classification codes: E31 (Price Level; Inflation; Deflation), E52 (Monetary Policy), O54 (Latin America; Caribbean)

Introduction

The COVID-19 pandemic has intensified global supply chain disruptions, causing widespread price increases and economic instability, particularly in emerging markets like Colombia. These disruptions have led to shortages and higher costs across various sectors, amplifying inflationary pressures and exposing vulnerabilities within globally integrated economies (Ali, 2023; Baral, 2021). Consequently, central banks now face complex challenges in balancing inflation control with the impacts of these sustained supply-side shocks (Bacsi, 2023; Khosrojerdi, 2023).

For Colombia, regional disparities further complicate the effects of global supply shocks on inflation. Differences in wage levels, labor informality, and industrial structures contribute to distinct inflationary dynamics across regions (Herrera, 2016; Arango, 2021; Bonet, 2007). As a result, while Valle del Cauca is highly sensitive to exchange rate fluctuations, other regions, like Bucaramanga and Cali, exhibit varying responses to monetary policy adjustments (Bermudez, 2021; Huertas, 2002). The pandemic has magnified these structural disparities, revealing the limitations of a uniform monetary policy approach in addressing regionally diverse inflationary pressures.

This study uses a dynamic panel approach to explore how global supply chain shocks drive regional inflation variations in Colombia and assesses the implications for inflation-targeting policy. Specifically, we apply System GMM and Difference GMM methodologies to capture the dynamic inflationary processes across regions while addressing endogeneity concerns. Additionally, we develop a Supply Chain Exposure Index (SCEI) and employ the Global Supply Chain Pressure Index (GSCPI) as an instrumental variable to quantify regional vulnerabilities to global shocks. This methodological framework provides a robust link between global disruptions and key financial indicators, including inflation and unemployment, enabling a more nuanced view of inflationary dynamics across Colombia's diverse economic landscape.

Using panel data from 21 Colombian states, we examine the relationship between supply chain exposure, economic growth, and inflation. This approach, complemented by traditional fixed-effects models, ensures the analysis captures both persistent structural factors and the dynamic inflationary impacts of global disruptions. Through this analysis, we aim to extend the literature on supply chain disruptions and

monetary policy in emerging markets, offering insights into the spatial dimensions of macroeconomic shocks. By highlighting the unique challenges faced by central banks in implementing uniform policies across regions, this study contributes to a broader understanding of inflation-targeting efficacy amid heterogeneous regional impacts.

The remainder of this paper is structured as follows: Section 2 reviews relevant literature on supply chain disruptions and inflation in emerging markets. Section 3 outlines the methodology, detailing the construction of the Supply Chain Exposure Index and the use of GSCPI in conjunction with System GMM and Difference GMM methods. Section 4 presents empirical findings, followed by a discussion in Section 5. Section 6 concludes with policy recommendations.

Literature review

Global supply chain disruptions have become a significant driver of inflation, especially in emerging markets. During the pandemic, widespread shortages and rising costs in global trade networks initiated inflationary pressures across multiple sectors (Ali, 2023; Baral, 2021). These disruptions have become more severe in emerging markets, where reliance on commodities and global production chains heightens vulnerability to supply-side shocks (Ndou, 2024; Aginta, 2022). In many developing countries, these shocks have driven inflation to critical levels, compounding other economic challenges, particularly amid ongoing geopolitical tensions (Hossain, 2022).

Empirical research highlights the disproportionate impact of supply chain disruptions on inflation in import-reliant economies. Bacsi (2023) demonstrates that increased input costs from constrained supply chains particularly burden countries dependent on global imports. Similarly, Figueira (2024) emphasizes that inflationary

pressures in emerging economies are persistent, especially within globally integrated sectors (Aginta, 2022).

In Colombia, the structural composition of the economy has intensified inflationary pressures on imported inputs and commodities. Sectors like accommodation, food services, and construction have been especially vulnerable, with exchange rate volatility further exacerbating inflation (Bonet Moron, 2023). Regional inflation disparities in Colombia have deepened, notably in regions like Antioquia and Boyacá, which exhibit heightened sensitivity to economic changes due to specific structural characteristics.

The literature also highlights that supply chain constraints can lead to regional inflation differentials within countries. These disparities are influenced by local economic structures, sectoral composition, and integration into global supply chains (Chowdhury, 2021). Regions with higher dependency on tradable sectors or exports typically experience greater inflationary impacts from global shocks, whereas regions focused on non-tradable sectors often see more stable prices (Bonet, 2007). Studies indicate that inflationary pressures vary significantly based on a region's exposure to international markets and labor market composition (Herrera, 2016; Arango, 2021).

Regional inflation disparities in Colombia are shaped by differences in wage levels, labor informality, and industrial composition. Bonet (2004) finds that less-developed regions with limited industrial diversification show weaker responses to external shocks. In contrast, economically advanced regions like Valle del Cauca, with strong export ties, are more vulnerable to global supply chain disruptions and exchange rate fluctuations (Bermudez, 2021). These regional economic disparities pose

additional challenges for policymakers, as national inflation targets may not address the varied inflationary responses across regions.

Inflation targeting, widely adopted in emerging markets, aims to stabilize inflation within a specific range. Since the late 1990s, Colombia's inflation-targeting framework has effectively managed national inflation but struggles with regional heterogeneity. Research suggests that uniform monetary policies may be less effective across regions with different economic structures, where inflationary drivers vary (Duarte, 2017).

For instance, Ndou (2024) shows that in South Africa, inflation targeting faces limitations, with regions exposed to trade shocks experiencing more volatile inflation. This pattern aligns with Colombia's experience, where regions like Valle del Cauca, closely tied to global markets, encounter higher inflation volatility than more insulated regions (Ortiz, 2017; Huertas, 2002).

Finally, studies suggest that inflation targeting may be less effective in managing supply-side inflation than demand-driven inflation. Lin (2009) argues that supply-side inflation poses implementation challenges, particularly in countries like Colombia, where regional differences in inflationary processes weaken the policy's impact (Bermudez, 2021). Vidal (2021) notes that Colombia's inflation-targeting central bank may overlook regional inflation dynamics, particularly those tied to global supply chain disruptions. This evidence suggests that a more regionally adaptive monetary policy might better support welfare outcomes across Colombia's diverse economic landscape.

Theoretical Framework

This paper develops an integrated theoretical framework to analyze how supply chain disruptions generate regional inflation differentials and the implications for monetary policy effectiveness. The model extends the New Keynesian framework by incorporating regional heterogeneity in trade exposure and supply chain integration, showing how uniform national monetary policies may be suboptimal when faced with regional inflation disparities.

First, consider an economy consisting of two regions, indexed by $i \in \{1,2\}$, with differentiated exposure to global supply chains. Firms in each region produce using a combination of domestic and imported inputs, with regional integration into global trade captured by θ_i, the share of imported inputs in total production costs.

The total production cost for firms in region i is given by:

$$C_i = W_i(1 - \theta_i) + P_m(1 + SD_t)\theta_i \qquad (1)$$

where $W_{i,t}$ is the wage, P_m represents the initial price of imported inputs, SD_t is the supply chain disruption factor, and v is the elasticity of substitution.

Let's now model the supply chain disruptions. Their affect the price of imported inputs, modeled as:

$$P_{m,i} = P_m \cdot (1 + SD_t) \qquad (2)$$

This leads to the following regional inflation equation, derived from the New Keynesian Phillips Curve (NKPC):

$$\pi_i = \beta E_t[\pi_{i,t+1}] + \kappa(\mu + \gamma_i SD_t) \qquad (3)$$

where γ_i captures the region's sensitivity to supply chain disruptions based on its trade exposure (θ_i). The regional inflation rate is directly related to the region's degree of trade integration, θ_i, and its exposure to global supply chain shocks:

$$\frac{\partial \pi_{i,t}}{\partial SD_t} = \kappa \gamma_i \theta_i \qquad (4)$$

Regions with higher θ_i will experience larger inflation responses to supply chain disruptions, leading to regional inflation disparities.

Materials and methods

Empirical Strategy and Econometric Approach

To examine the effects of global supply chain disruptions on inflation, we apply a dynamic panel model to manage potential endogeneity issues in critical variables, such as GDP growth and institutional quality index IQI. Addressing endogeneity is essential for consistent estimators, as ignoring it may lead to biased results (Wooldridge, 2010).

We use the System GMM estimator by Blundell and Bond (1998), which is well-suited for dynamic panels where endogeneity, autocorrelation, and heteroskedasticity may arise. System GMM combines first-difference and level equations with appropriate instruments to control for endogeneity.

Building on previous studies (Rogoff, 2003; Mishkin, 2007), we specify the following model:

$$\text{Inflation}_{it} = \alpha \text{Inflation}_{i,t-1} + \beta_1 \text{gdp_g}_{it} + \beta_2 \text{SCEI}_{it} + \beta_3 \text{IQI}_{it} + \gamma_t + \mu_i + \epsilon_{it}$$

where Inflation represents inflation in department i at time t, with lagged inflation capturing persistence. The growth rate of the Gross domestic product gdp_g represents economic performance, influencing inflation via demand and supply channels. The Supply Chain Exposure Index (SCEI) measures each department's exposure to global supply chain disruptions, while institutional quality IQI represents the effectiveness of institutions in inflation dynamics (Laeven & Valencia, 2008). Time effects γ control for common shocks, and department-specific effects μ account for unobserved heterogeneity.

Instrument Selection

To address endogeneity in GDP growth and lagged inflation, we proceed with two types of instruments:

- **GMM-type Instruments**: We use lagged levels and differences of endogenous variables, including lagged inflation and GDP growth, as instruments, we collapse option to prevent instrument proliferation and strengthen the Hansen test (Roodman, 2009).
- **External Instrument**: The Global Supply Chain Pressure Index (GSCPI) serves as an external instrument, representing international supply chain conditions, including shipping rates, delivery delays, and manufacturing backlogs (Benigno, 2022). GSCPI meets the relevance condition, as global supply chain disruptions can raise import prices, create input shortages, and increase domestic inflation (Auer, 2021). It is also exogenous to local conditions, as regional inflation or GDP in Colombia is unlikely to affect global supply chains.

Dynamic Panel Estimation

This model is used due to the presence of a lagged of inflation. which introduces endogeneity concerns. Traditional estimation methods, such as fixed or random effects models, may produce biased and inconsistent estimates in the presence of dynamic relationships (Nickell, 1981). The dynamic panel approach allows us to control unobserved heterogeneity and potential endogeneity by utilizing appropriate instruments, thereby providing more reliable and consistent parameter estimates (Arellano & Bond, 1991; Blundell & Bond, 1998). Additionally, these models can capture the inertia and adjustment processes inherent in economic variables like inflation, enhancing the model's ability to reflect real-world economic dynamics (Sarno & Taylor, 2002).

Therefore, the model starts with a System GMM estimator that combines equations in first differences and levels. The differenced equation eliminates the unobserved department-specific effect, denoted as μ_i, while the levels equation adds additional moment conditions to improve efficiency.

The difference equation is:

$$\Delta\text{Inflation}_{it} = \alpha\Delta\pi_{i,t-1} + \beta_1\Delta\text{gdp_g}_{it} + \beta_2\Delta\text{SCEI}_{it} + \beta_3\Delta\text{IQI}_{it} + \Delta\gamma_t + \Delta\epsilon_{it}$$

The levels equation is:

$$\text{Inflation}_{it} = \alpha\text{Inflation}_{i,t-1} + \beta_1\text{gdp_g}_{it} + \beta_2\text{SCEI}_{it} + \beta_3\text{IQI}_{it} + \gamma_t + \mu_i + \epsilon_{it}$$

Using appropriate instruments in both equations ensures consistent parameter estimates. We employ robust standard errors for the one- and two-step System GMM estimators to improve accuracy (Kripfganz, 2019). To assess robustness, we estimate

separate System GMM models for Colombia's main regions—the Andean, Caribbean, and Pacific regions—and re-estimate the model for the post-pandemic period, where supply chain disruptions may have amplified regional disparities.

Data

Our analysis uses panel data from 21 Colombian departments from 2016 to 2023. Antioquia, Atlántico, Bolívar, Boyacá, Caldas, Caquetá, Cauca, Cesar, Córdoba, Huila, La Guajira, Magdalena, Meta, Nariño, Norte de Santander, Quindío, Risaralda, Santander, Sucre, Tolima, and Valle del Cauca. The main data sources include the Colombian National Administrative Department of Statistics (DANE) and the Central Bank of Colombia. This study employs a rich dataset covering Colombian departments over the period from 2016 to 2023. Appendixes 1 and 2 detail the construction of the SCEI and IQI respectively. the global Supply Chain Pressure Index (GSCPI) was taken from the FRED information system provided by the federal reserve. All monetary values are adjusted for inflation and expressed in constant prices using the national CPI to ensure comparability over time.

5. Results

Our analysis employs both one-step and two-step System GMM estimations to assess the impact of GDP growth, supply chain exposure, and institutional quality on regional inflation dynamics in Colombia. The findings are summarized in Table 1

Table 1: Comparison of System GMM and Difference GMM Estimation Results

Variable	Sys GMM (1-Step)	Sys GMM (2-Step)	Diff GMM (1-Step)	Diff GMM (2-Step)

Constant	0.077***	0.0778***	-	-
	(12.95)	(12.18)		
Gdp growth	0.183***	0.186***	0.141***	0.163***
	(4.06)	(3.91)	(3.50)	(4.39)
SCEI	0.058***	0.057***	0.118*	0.131**
	(5.39)	(4.77)	(2.38)	(2.71)
IQI	-0.0357*	-0.037	-0.043	-0.090**
	(-2.02)	(-1.95)	(-1.26)	(-3.12)
Observations	165	165	117	117
Groups	21	21	21	21
Instruments	22	8	5	5
AR(1) p-value	0.006	0.232	0.006	0.006
AR(2) p-value	0.193	0.746	0.173	0.173
Hansen J p-value	0.115	0.115	0.033	0.033
Wald chi2	40.56	40.56	30.75	30.75
Prob > chi2	0.000	0.000	0.000	0.000

Note: Standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01. System GMM includes the levels equation, while Difference GMM uses only differenced variables. AR(1) and AR(2) are Arellano-Bond tests for serial correlation. Hansen J and Sargan tests assess instrument validity.

The results underscore the significance of the Supply Chain Exposure Index (SCEI) in influencing inflation across Colombian departments. In the System GMM models, SCEI consistently shows a positive and significant effect on inflation, with a coefficient of 0.0568 in the one-step and 0.131 in the two-step Difference GMM model (both significant at $p<0.05p < 0.05p<0.05$). These results suggest that departments more vulnerable to global supply chain disruptions experience higher inflation rates, indicating the substantial role that global economic conditions play in local price stability.

GDP growth also demonstrates a robust positive relationship with inflation, with coefficients of 0.183 in the one-step System GMM model and 0.163 in the two-step Difference GMM model. These results imply that a one percentage point increase in GDP growth is associated with an increase of approximately 0.16-0.18 percentage points in inflation. This positive association aligns with the expected growth-inflation tradeoff commonly observed in developing economies, where strong economic growth often contributes to rising price levels.

Institutional quality appears to have a moderating effect on inflation, especially in the Difference GMM models. The coefficient is negative and statistically significant in the Difference GMM model (-0.091, $p<0.05p < 0.05p<0.05$), suggesting that improvements in institutional quality may help stabilize inflation. This finding aligns with the hypothesis that higher-quality institutions facilitate better economic governance, potentially reducing inflationary pressures by improving policy implementation and reducing uncertainties.

Diagnostic and Model Robustness Tests

Model diagnostics support the validity of our empirical strategy. The Arellano-Bond AR(1) test indicates expected first-order serial correlation, while the AR(2) test confirms no second-order serial correlation, essential for consistency. The Hansen JJJ-test p-values suggest that the instruments used are valid, with no significant over-identification issues across most specifications. The instrument count remains conservative to avoid proliferation, particularly in the System GMM models where only 22 instruments were used.

Robustness Checks: Regional Heterogeneity

To explore regional heterogeneity, we estimate separate models for the Andean, Caribbean, and Pacific regions. Results showed in table 2 reveal notable regional differences in how supply chain exposure and GDP growth affect inflation. For instance, the Caribbean region shows the highest SCEI coefficient (0.065, $p<0.01p < 0.01p<0.01$), suggesting that supply chain disruptions exert a stronger inflationary impact here compared to the Andean (0.038) and Pacific (0.040) regions. Similarly, GDP growth's effect on inflation is most pronounced in the Andean region (0.426,

p<0.01p < 0.01p<0.01) and least in the Caribbean region (0.116, p<0.05p < 0.05p<0.05), reflecting regional differences in economic structure and policy sensitivity.

Table 2: System GMM Estimation Results by Region: Dependent variable inflacion

Variable	**Andean**	**Caribbean**	**Pacific**
Constant	0.0727***	0.0765***	0.0747***
	(0.0057)	(0.0081)	(0.0034)
Gdp growth	0.4256***	0.1157***	0.3982***
	(0.0547)	(0.0323)	(0.0803)
SCEI	0.0383***	0.0651***	0.0399***
	(0.0102)	(0.0210)	(0.0031)
IQI	-0.0176*	-0.0251	0.0272
	(0.0102)	(0.0234)	(0.0198)
Observations	71	55	23
Groups	9	7	3
AR(1)	0.005	0.036	0.090
AR(2)	0.035	0.405	0.375
Hansen J	0.962	0.996	0.968

Note: Standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01. AR(1) and AR(2) are Arellano Bond tests for first and second-order serial correlation. Hansen J and Sargan tests assess instrument validity.

The results suggest that regional inflation responses to global disruptions and growth rates vary, likely due to distinct economic characteristics. Institutional quality shows marginal significance in the Andean region, supporting its role in inflation stabilization in some contexts, although it remains insignificant in the Caribbean and Pacific.

Post-Pandemic Period Analysis

To assess the robustness of our results over time, we estimate models using post-pandemic data (2020 and beyond). Table 3 presents these findings. The coefficients on GDP growth (0.210) and SCEI (0.085) are positive and significant, indicating that both

economic growth and global disruptions continued to drive inflation in the post-pandemic period. Institutional quality remains a significant stabilizer, with a coefficient of -0.080 in the two-step model, highlighting the importance of governance in moderating inflation during periods of economic recovery.

Table 3: System GMM Estimation Results for Post-Pandemic Periods

Variable	**Two step**	**One step**
Gdp growth	0.2103***	0.2198***
	(0.0733)	(0.0595)
SCEI	0.0845***	0.0755**
	(0.0275)	(0.0307)
IQI	-0.0804**	-0.1172***
	(0.0389)	(0.0404)
Constant	0.0807***	0.0791***
	(0.0105)	(0.0108)
Observations	84	63
Number of groups	21	21
Number of instruments	17	14
AR(1) test (p-value)	0.048	0.986
AR(2) test (p-value)	0.109	0.070
Hansen J test (p-value)	0.150	0.155

Note: Robust standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01. The dependent variable is inflation. Both specifications include year effects. The models use collapsed instruments for GDP growth and treat it as endogenous. The GPSC term is treated as strictly exogenous.

Overall, these findings suggest that while GDP growth and global disruptions are key inflation drivers, institutional quality offers a stabilizing influence, particularly in times of heightened economic uncertainty. Robustness checks across regions and time periods affirm the model's consistency, underscoring the need for adaptive policy responses to manage inflation effectively in diverse regional contexts.

Discussion

This study provides evidence that regional exposure to global supply chain disruptions, coupled with local economic growth and institutional quality, shapes inflation dynamics across Colombia. These findings underscore the importance of recognizing regional economic diversity within Colombia's monetary policy framework, given that a uniform policy may overlook critical inflationary drivers in more vulnerable regions.

The results show that Colombian departments more integrated into global trade experience higher inflation rates when exposed to supply chain shocks, aligning with the theoretical expectation that trade-intensive regions are more inflation-sensitive to external disruptions. This is consistent with previous research on the inflationary impact of global supply constraints in emerging economies (Bacsi, 2023; Figueira, 2024).

Regional analysis also reveals heterogeneity in inflation responses. The Caribbean region shows a pronounced sensitivity to supply chain exposure, likely due to its reliance on trade sectors. This pattern aligns with Bonet (2004), who found that economic diversification in Colombia reduces inflation volatility, which we observe more prominently in the Andean region. Additionally, the positive relationship between GDP growth and inflation confirms the theoretical inflation-growth tradeoff, with more intense effects in regions like the Andean and Pacific, where growth is constrained by supply bottlenecks (Kilian, 2009).

Institutional quality emerges as a stabilizing factor, especially in regions with stronger governance frameworks. These results suggest that effective institutions contribute to inflation stability by strengthening policy implementation and reducing economic uncertainties. This finding aligns with Laeven and Valencia (2008), who

highlight the role of institutional quality in mitigating inflationary pressures in emerging markets.

These findings suggest several important considerations for Colombia's monetary policy framework:

1. **Adaptive Inflation Targeting**: The central bank could improve inflation control by adopting an adaptive inflation-targeting framework that considers regional economic conditions. Incorporating indicators such as the Supply Chain Exposure Index (SCEI) into policy deliberations could enable more responsive adjustments to localized inflation drivers, particularly in regions like the Caribbean, which are disproportionately impacted by global shocks.

2. **Strengthening Local Institutions**: Given the stabilizing effect of institutional quality, strengthening governance frameworks in regions with lower institutional performance could help curb inflationary pressures. Policymakers might focus on improving local regulatory environments and enhancing transparency to support effective inflation control in regions where governance gaps are more pronounced.

3. **Addressing Regional Disparities to Reduce Socioeconomic Inequality**: Persistent inflation in trade-dependent regions could exacerbate regional economic disparities, reducing real income and increasing social inequality. Ignoring regional inflation differentials may elevate social costs and strain economic stability, particularly in areas most vulnerable to global disruptions.

This study is subject to several limitations. The analysis relies on available regional data, which may not fully capture informal economic activity or sector-specific

factors influencing inflation in Colombia. Future research could benefit from more granular data on regional economic structures and a broader set of inflation determinants, including exchange rates and sector-specific dynamics. Additionally, exploring the potential for adaptive monetary policies tailored to regional conditions could offer further insights into managing inflation in Colombia's economically diverse regions and similar emerging markets.

Declaration of interest statement

None

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Appendix 1: Construction of the Supply Chain Exposure Index (SCEI)

To quantify each department's exposure to global supply chain disruptions, we construct a **Supply Chain Exposure Index (SCEI)** incorporating several key dimensions. The SCEI is based on four primary variables:

Herfindahl-Hirschman Index of Import Concentration: Measures the concentration of imports for each department, indicating the level of diversification in import sources. A higher index suggests reliance on fewer sources, increasing vulnerability to supply chain disruptions.

Primary Road Network per 100,000 Inhabitants: Represents infrastructure development, reflecting the accessibility and connectivity of regions. Limited infrastructure can exacerbate the impact of global supply chain disruptions on local economies.

Imports-to-GDP Ratio: Calculates the proportion of imports relative to GDP, indicating the degree of economic dependence on imported goods. A higher ratio implies greater exposure to external supply shocks.

Cost per Kilogram to Transport Goods to Customs Port: Reflects the transportation costs associated with moving goods to ports, impacting trade efficiency. Higher costs can increase susceptibility to global supply chain issues.

To integrate these indicators into a single composite index, we standardize each variable using z-scores and then compute the average of the standardized values. This method ensures that each variable contributes equally to the index, regardless of their

original scales (Nijboer, 2015). Mathematically, the SCEI for department *i* at time *t* is calculated as:

$$\text{SCEI}_{it} = \frac{1}{4}\sum_{k=1}^{4}\left(\frac{X_{kit} - \overline{X_k}}{\sigma_{X_k}}\right)$$

where:

- X_{kit} is the value of variable *k* for department *i* at time *t*.
- X_k and σ_{X_k} are the mean and standard deviation of variable *k*, respectively.

The resulting SCEI provides a comprehensive measure of each department's exposure to global supply chain disruptions. Departments with higher values are considered more vulnerable to external supply chain shocks, which can influence regional inflation through increased import prices and supply shortages.

Appendix 2: Construction of the Institutional Quality Index (IQI)

This section details the methodology employed to construct the Institutional Quality Index (IQI), used as a proxy for institutional quality in the transmission of monetary policy across departments and over time.

The IQI is based on variables that capture various aspects of institutional quality. The institutional dimension encompasses key indicators addressing effectiveness, legal requirements, administrative capacity, and management. It focuses on management of regional royalties, fiscal autonomy, local revenue collection capacity, savings capacity, Open Government Index, transparency in handling royalties, homicide rate, kidnapping rate, extortion rate, number of judges per 100,000 inhabitants, judicial efficiency, judges' productivity, and alternative justice mechanism efficiency.

These variables provide a comprehensive measure of institutional quality by covering administrative performance, fiscal management, transparency, and security and justice.

Data Preparation

Before constructing the index, data undergo several preprocessing steps. Variables where higher values indicate worse institutional quality (e.g., crime rates) are reverse-coded so that higher values consistently represent better institutional quality. The reverse-coded variables include the kidnapping rate, homicide rate, and extortion rate.

To ensure comparability among variables with different scales and units, each variable is standardized within each year. The standardization is performed using the z-score transformation:

$$Z_{ijt} = \frac{X_{ijt} - \mu_{jt}}{\sigma_{jt}}$$

where:

Z_{ijt} is the standardized value of variable *j* for department *i* in year *t*.

X_{ijt} is the original value.

μ_{jt} and σ_{jt} are the mean and standard deviation of variable *j* in year *t*, respectively.

Index Construction

The IQI is constructed using Principal Component Analysis (PCA) for each year. PCA reduces the dimensionality of the dataset by transforming the original variables into a new set of uncorrelated variables (principal components) that capture the maximum variance. For each year *t*, we perform PCA on the set of standardized variables:

$$\boldsymbol{Z_t} = [Z_{1t}, Z_{2t}, \ldots, Z_{nt}]$$

The PCA solves the eigenvalue problem:

$$\boldsymbol{C_t e_k} = \lambda_k \boldsymbol{e_k}$$

where:

$\boldsymbol{C_t}$ is the covariance matrix of $\boldsymbol{Z_t}$

λ_k is the *k*-th largest eigenvalue.

$\boldsymbol{e_k}$ is the corresponding eigenvector.

We select the first principal component (PC1) as the Institutional Quality Index for year *t*, as it captures the largest amount of variance in the data:

$$\text{IQI}_{it} = \boldsymbol{e_{1t}^{\top} Z_{it}}$$

where:

$e1$ is the eigenvector corresponding to the largest eigenvalue λ_{1t}.

$\boldsymbol{Z_{it}}$ is the vector of standardized variables for department *i* in year *t*.

The resulting IQI provides a composite score for each department and year, where higher values indicate better institutional quality. The data for the variables used in constructing the IQI were obtained from the Colombian National Administrative Department of Statistics (DANE). The department codes correspond to the official codes used by DANE, ensuring consistency and accuracy in data matching. While the IQI provides a comprehensive measure of institutional quality, it is subject to the limitations inherent in the available data and the chosen methodology. Future research could incorporate additional variables or alternative methodologies to further refine the index.