DETERMINANTS OF INFLATION EXPECTATIONS IN COLOMBIA: AN EMPIRICAL ANALYSIS

1. INTRODUCTION

Monetary policy is one of the clearest manifestations of the State's economic actions to ensure the traditional macroeconomic objectives of growth, stability, and development. Technically, monetary policy relies on five transmission mechanisms to achieve proposed objectives: interest rates, credit, and wealth (traditional channels), exchange rates, and inflation expectations. Specifically, the development of these transmission mechanisms depends on the regime adopted for conducting monetary policy: monetary strategy, exchange rate strategy, and inflation targeting strategy, each associated with its nominal anchor: monetary aggregates, exchange rates, and inflation expectations, respectively (Gómez, 2006).

One of the monetary policy channels especially relevant in inflation targeting schemes is inflation expectations, with its adoption as a monetary policy strategy since the end of the 20th century by countries such as New Zealand, England, and others. This strategy monitors inflation expectations to compare their dynamics with core and overall inflation based on a medium-term numerical target (usually a range) set by the monetary authority to steer actual inflation toward the agreed-upon path. Under this scheme, it is vital to monitor economic agents' inflation expectations, specifically companies, and households, to understand how they form expected price values and influence effective price setting.

Indeed, inflation expectations play a crucial role in inflation targeting schemes, where central banks monitor the dynamics of this variable, its anchorage with headline inflation, its response to changes in policy interest rate, and other variables. For this reason, researching determinants of inflation expectations and their heterogeneity contributes to understanding households and firms' economic choices and their reactions (Weber et al., 2022). Nevertheless, this variable is susceptible to changes depending on the occurrence of demand and supply shocks and changes in macro fundamentals and global outlook.

The primary drive behind this manuscript considers the determinants of inflation expectations in an emerging economy such as Colombia, with special emphasis on supply shocks that could affect it and seeking to understand how this variable is formed in a context of limited information, cognitive limitations, and heuristics on this variable, with little information for households as has been widely researched in developed countries (Kapoor and Kar, 2023). Furthermore, with the inflationary processes experienced worldwide since 2021, this phenomenon has gained significant prominence in understanding the potential reasons behind their detachment from inflation targets and how to seek their convergence once again. Identifying and analyzing the associated supply and demand shocks are of vital importance.

Recent literature has questioned the assumption of rational expectations, suggesting that individuals need to be fully informed due to cognitive limitations. Instead of maximizing the appropriation of available information, they use heuristics ('mental shortcuts') to guide their behavior and decision-making. Hence, there are limitations in economic agents' understanding of the economic environment, which constrains expectation formation in the context of monetary policy due to these limitations associated with agents' behavior and cognitive structure. As a result, macroeconomic analyses derived from classical and Keynesian theories (along with their 'Neo' and 'New' variants) have been questioned and complemented by the emergence of the field of behavioral economics.

Indeed, Angner and Loewenstein (2012) state that this field '(...) emerges in reaction to the notion that social and behavioral science should avoid reference to entities (such as cognitive and affective states) that cannot be directly observed.' (p. 643). Thus, it seeks to understand individuals' choice process and expectation formation, aiming to enhance economic theory's explanatory and predictive power by integrating psychology, neuroscience, and cognitive sciences. Specifically, behavioral macroeconomics has emerged to analyze relationships among economic agents from an aggregate perspective. Drawing from advancements in New Keynesian economics and behavioral economics, this field aims to explore the process of economic agents' expectation formation in scenarios of bounded rationality.

The research on behavioral macroeconomics has its foundations in the theory proposed by Keynes (1936), examining the subjective factors of propensity to consume, the analysis of determinants of liquidity preferences, and especially the influence of expectations in decision-making. Specifically, the introduction of the concept of 'animal spirits,' understood as those actions driven by emotion and not associated with a rational process of quantifying probabilities and benefits, was the seed for discussing the presence of expectations in scenarios of bounded rationality and a starting point to understand the instabilities of the economic cycle.

For this purpose, the second section investigates the determinants of inflation expectations in Colombia using the VAR-X model. Additionally, Given the latter finding, the third section employs a segmented regression to capture the incidence of global shipping container shortage in the context of the COVID-19 pandemic on inflation expectations for Chile, Colombia, and the United States. The empirical results reveal a stronger linear association between these variables, with a positive and significant coefficient for Chile and Colombia. Finally, the fourth section highlights the main findings, limitations and future research challenges.

2. DETERMINANTS OF INFLATION EXPECTATIONS IN COLOMBIA. A VAR-X ANALYSIS

The inflation expectations variable has been very important for monitoring inflation since the adoption of the inflation-targeting strategy in many developed and emerging countries (Jahan, 2012). Since the implementation of this strategy in 1990, New Zealand has stabilized inflation and output (Svensson, 2010). Specifically, this strategy uses inflation expectations as a nominal anchor to capture information about how households and firms form their price expectations and thus make the necessary adjustments to correct any deviations from the inflation rate target (Gómez, 2006). Indeed, proper monitoring of inflation expectations contributes to the accountability and effectiveness of monetary policy via trust building (Woodford, 2005).

In this way, different reasons exist for studying the inflation expectations phenomenon. As Galvis and Anzoátegui-Zapata (2019a, 2019b) mentioned, three groups of papers reflect the relevance of this topic in policy decision-making: a) inflation expectations role in monetary policy (Mankiw et al., 2003; De Mendonça, 2007; Montes et al., 2016; Coibion et al., 2020); b) the convergence between inflation expectations and inflation targeting, transparency, and accountability of monetary authority (Johnson, 2003; Levin et al., 2004; Gürkaynak et al., 2010); and c) the heterogeneity of survey-based inflation expectations amongst economic agents and inflation expectations formation process (Sims, 2003; Branch, 2004; Capistrán and Timmerman, 2009; Lahiri and Sheng, 2010; Dovern et al., 2012; Coibion and Gorodnichenko, 2015; Beckman and Czudaj, 2018; Coibion et al., 2022; Anzoátegui-Zapata and Galvis, 2020). From a different perspective, Kapoor and Kar (2023) point out that inflation expectations can be grouped within the subsequent research topics: heterogeneous inflation expectations and the new Keynesian Phillips curve, survey-based measures and information rigidity, monetary policy and authorities, forecasting, and transition to Euro.

Despite the importance we just mentioned, the literature on the determinants of inflation expectations in developing countries has not been extensively studied. In this way, Kapoor and Kar (2023) identify eight future research questions about inflation expectations, highlighting one of them: what benefits can a comprehensive research investigation on inflation expectations and perceptions offer from the standpoint of emerging economies? This question might be related to the fact that the appropriate anchoring process is slow given the learning process of economic agents about monetary policy goals and their instruments and the evolution of markets (Galvis and Anzoátegui-Zapata, 2019a). Likewise, these economies have a reputation of still building up the institution of central banks and, as such, the measurement of inflation expectations is a recent challenge since many of these countries have not been able to develop projects to collect data from household surveys (Galvis and Anzoátegui-Zapata, 2019b).

In this study, we analyze the case of an emerging economy, Colombia, to identify the determinants of its inflation expectations. Colombia implemented the inflation targeting strategy in 1999 under the authority of its central bank and has been working with it for approximately 24 years. According to our knowledge there are a few papers that have investigated inflation expectations and their determinants in Colombia and have consider it a key variable for monetary policy. In detail, the research on this phenomenon have focused on four main topics: estimation and determinants based on headline inflation, core inflation, interest rate, and weather shocks (Misas and Vásquez 2002, Vargas et al. 2009, González et al. 2010, Vargas-Herrera 2016, Romero and Saldarriaga 2023), measurement comparison (Arias et al. 2006), adaptive or rational expectations (Zárate et al. 2011, Huertas et al. 2015), and anchoring and disagreement (Gamba-Santamaría et al. 2016, Galvis and Anzoátegui-Zapata 2019[a],b, Anzoátegui-Zapata and Galvis-Ciro 2020).

To answer the question about the determinants of inflation expectations in Colombia, we proceed to combine the approaches of Ueda (2010), Vargas-Herrera (2016), and Ghosh et al. (2021), who use Vector Autoregression (VAR) models to study the determinants of inflation expectations associated with demand and supply shocks and the dynamic interaction between economic activity and monetary policy. Despite not having enough data availability, we were able to gather data for the period 2005:1 – 2022:4 for the following variables: the oil price, real exchange rate, headline inflation, output gap, policy interest rate, and inflation expectations. It is important to emphasize that we employ headline inflation regardless Deacon and Derry (1994) suggestion that headline inflation, rather than core inflation, might be affected by data collection time, absence of incentives against the projection of inflation, lack of weighting among participants of the survey, and short run focus economic agents.

The innovations of this manuscript are related with the inclusion of exogenous variables that are associated with supply shocks: the social protests, the supply chain pressure index, and the average temperature for the main cities. Here, we try to differentiate from other papers because the Ocean Niño Index (see Vargas-Herrera 2016 and Romero and Saldarriaga 2023) is very general and, as such, assumes that temperatures and climate conditions are the same throughout the different regions of Colombia. Additionally, considering that few papers have studied the determinants of inflation expectations in Latin America and the fact that previous research have focused on anchoring inflation expectations, comparison among its measures, and metrics for disagreement, this research gives an updated contribution about the factors that affect the formation of inflation expectations as a key variable for monetary policy.

As mentioned earlier, our VAR-X combines the contributions of Ueda (2010), Vargas-Herrera et al. (2009), and Ghosh et al. (2021). Following the technical notes of Hansen (2020), this VAR type uses alternative restrictions that do not rely exclusively on recursiveness. According to Stock and Watson (2001), an essential aspect of using VAR models for this research is associated with the fact that it can help to understand the relationships amongst endogenous variables considering the economic settings defined in the exogenous variables as critical aspects to understand shocks. Therefore, based on Sims (1980), Sims (1986), Enders (2015), and Stock and Watson (2001), the proposed VAR-X model can be represented as follows:

$$\mathrm{z_t} = \mathrm{A}(i)\sum_{i=0}^{p} \mathrm{z}_{\mathrm{t}-i} + \varphi \mathrm{x_t} + \varepsilon_{\mathrm{t}} \tag{1}$$

where z_t is a vector of k endogenous variables $z_1, \ldots, z_k$ (oil price, real exchange rate, interest rate, GDP gap, headline inflation, and inflation expectations); $A(i)$ is a lag operator matrix (with i lags); x_t is a vector of h exogenous variables $x_1, \ldots, x_h$ (Global Supply Chain Pressure Index, GSCPI, average temperature, social protests, and a dummy variable for the Covid-19); φ is a $k\ x\ h$ coefficient matrix; and ε_{t} is a vector of k white noise disturbances. Additionally, it is essential to mention that all variables included in z_t and x_t are stationary, and ε_{t} are white-noise disturbances, i.e., $\mathrm{E}(\varepsilon_{\mathrm{t}}) = 0$, $\mathrm{E}(\varepsilon_{\mathrm{t}}, \varepsilon_{\mathrm{t}}') = \Sigma$, $\mathrm{E}(\varepsilon_{\mathrm{t}}, \varepsilon_{\mathrm{s}}) = 0\ \forall\ \mathrm{t} \neq \mathrm{s}$. Specifically, we use a VAR-X model based on recursive short-run restrictions, following the intuition of Bernanke (1986), Blanchard and Watson (1986), and Lütkepohl et al. (2018). It is important to mention that we do not use a structural specification given that there is not a strong theory to understand inflation expectations and its determinants in emerging economies like Colombia.

Following Sims (1980), Sims (1986), Enders (2015), and Stock and Watson (2001), the interpretation of VAR results does not rest on the estimated contemporaneous and lagged coefficients of each variable, but on two critical elements of the moving average representation: the impulse-response functions (IRF) and the forecast error variance decomposition (FEVD). According to Hansen (2020), the IRF of a variable *a* concerning innovation *b* is the change in the time *t* projection of the a^{th} variable $z_{a,t+h}$ due to the b^{th} innovation e_{bt}. In this case, we use a generalized Impulse Function, based on Pesaran and Shin (1998), to estimate the IRF and avoid defining what order of these series is supposed to be.

On the other hand, the FEVD decomposes multistep forecast error variance by the component shock, indicating which shocks contribute the most to the variability of the endogenous variables in the system. Based on Ueda (2010) and Ghosh et al. (2021), we apply the following Cholesky decomposition ordering (starting with the least endogenous to the more endogenous variable) to obtain the FEVDs. First, we set first the Brent crude oil price as a reference, given the Colombian economic dependence in terms of production and export revenues. Second, the short-term interest rate, which is strongly linked to the policy interest rate. Third, the real exchange rate index, which is a key variable for a small open economy. Fourth, the GDP gap, which captures movements in output and economic activity around its trend. Fifth, lagged 1-period headline inflation, given that agents form heuristics with the closest information. And, finally, inflation expectations, obtained from a quarterly survey-based database.

Thus, the IRF and FEVD of our model allow us to evaluate the change and evolution throughout time of inflation expectations induced by shocks or innovations on the endogenous and exogenous variables and to compute the percentage of variability of the variance decomposition of inflation expectations that can be attributed to each shock (Galvis Ciro and Anzoátegui Zapata, 2019).

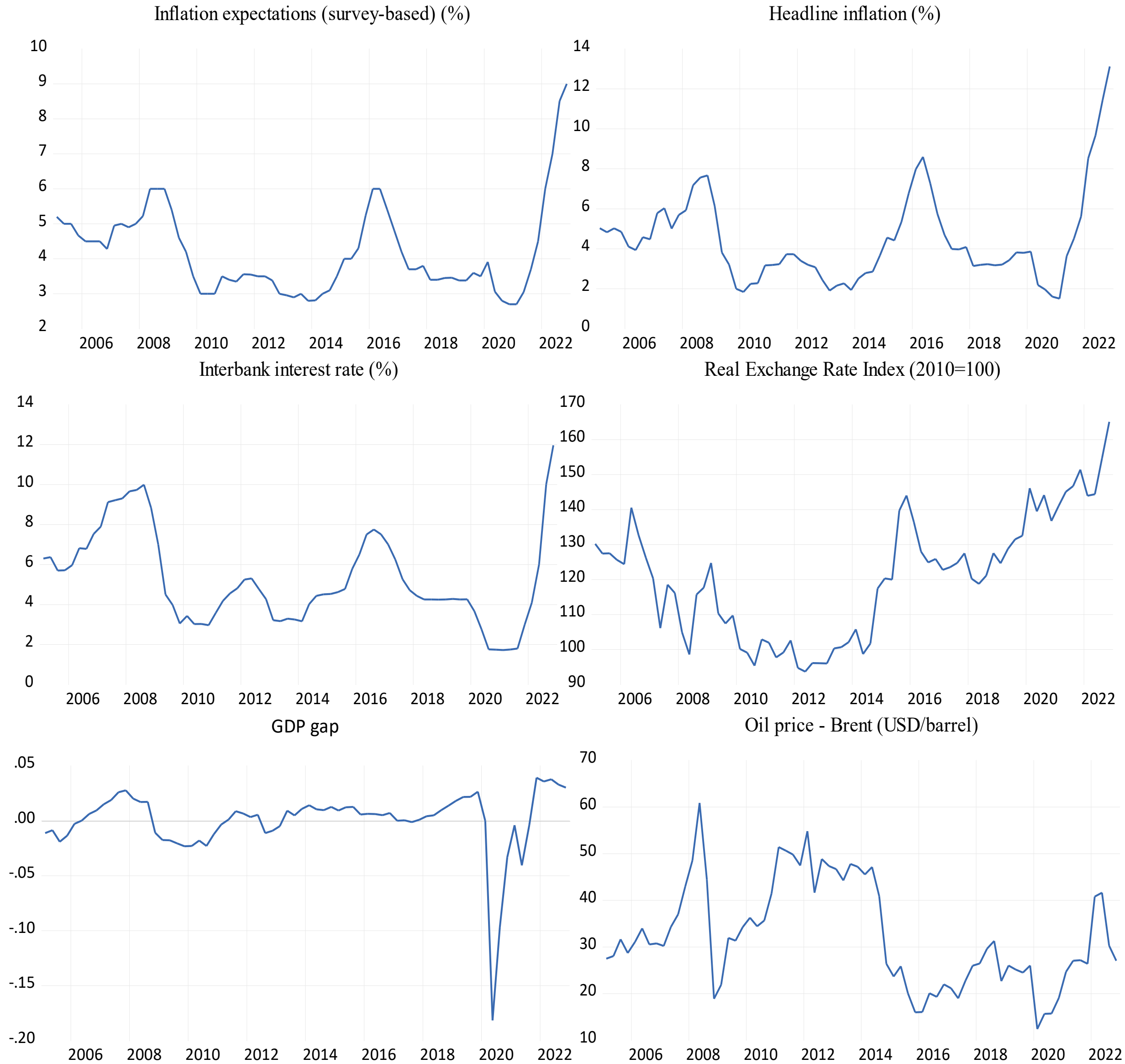
Compared to the papers that we use as references, we have the limitation of no having availability of reliable data based on a survey that follows inflation expectations to households. The data related to households' inflation expectations proposed by Fedesarrollo showed significant volatility. For this reason, following previous works, we have used quarterly survey-based data from the Colombian central bank for the 2005Q1-2022Q4 period, given data availability and stability. Table 1 summarizes the description of the variables with relevant papers that use these variables in their models. Similarly, Figure 1 shows their respective time series.

Table 1 *Endogenous Variables description*

Variable	Reference papers	Description
Inflation expectations		Data collected at the end of the year from the following economic sectors: manufacturing and mining industry, financial system, large chain stores, transportation and communications, academics and consultants, and labor unions spread throughout the four main cities of the country: Bogota, Medellin, Cali, and Barranquilla. *Source*: Banco de la República.
Oil price	Huang et al. (2016); Szyszko and Rutkowska (2019); Ueda (2010); Aastveit, Bjørnland, and Cross (2023)	Brent crude oil price (dollars per barrel). *Source*: US Energy Information Administration (EIA).
Interest rate	Clark and Davig (2011); Ellis et al. (2014); Huang et al. (2016); Melosi (2017); Pearce (1987); Shibamoto and Shizume (2014); Tillmann, (2007); Ueda (2010)	Interbank interest rate. *Source*: Banco de la República.
Real exchange rate	Ghosh et al. (2021)	Multilateral real exchange rate index, using the total weights and the CPI as a deflator (2010=100). *Source*: Banco de la República.
GDP gap	Clark and Davig (2011); Crowder et al. (1999); Shibamoto and Shizume (2014); Szyszko and Rutkowska (2019); Ueda (2010)	Hodrick-Prescott Filter applied on the quarterly, seasonally adjusted Gross Domestic Product (2015=100).

		Source: Departamento Administrativo Nacional de Estadística (DANE).
Headline inflation	Clark and Davig (2011); Shibamoto and Shizume (2014); Szyszko and Rutkowska (2019); Ueda (2010); Vargas-Herrera (2016)	Percent Change in Consumer Price Index (CPI) over the corresponding period of the previous year (dec 2018=100). *Source*: Banco de la República.

Figure 1 *Time series of endogenous variables*



Note: Quarterly data provided by Banco de la República (https://www.banrep.gov.co/es/estadisticas), DANE (https://www.dane.gov.co/index.php/estadisticas-por-tema/precios-y-costos/indice-de-precios-al-consumidor-ipc) and, U.S. Energy Information Administration (https://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm).

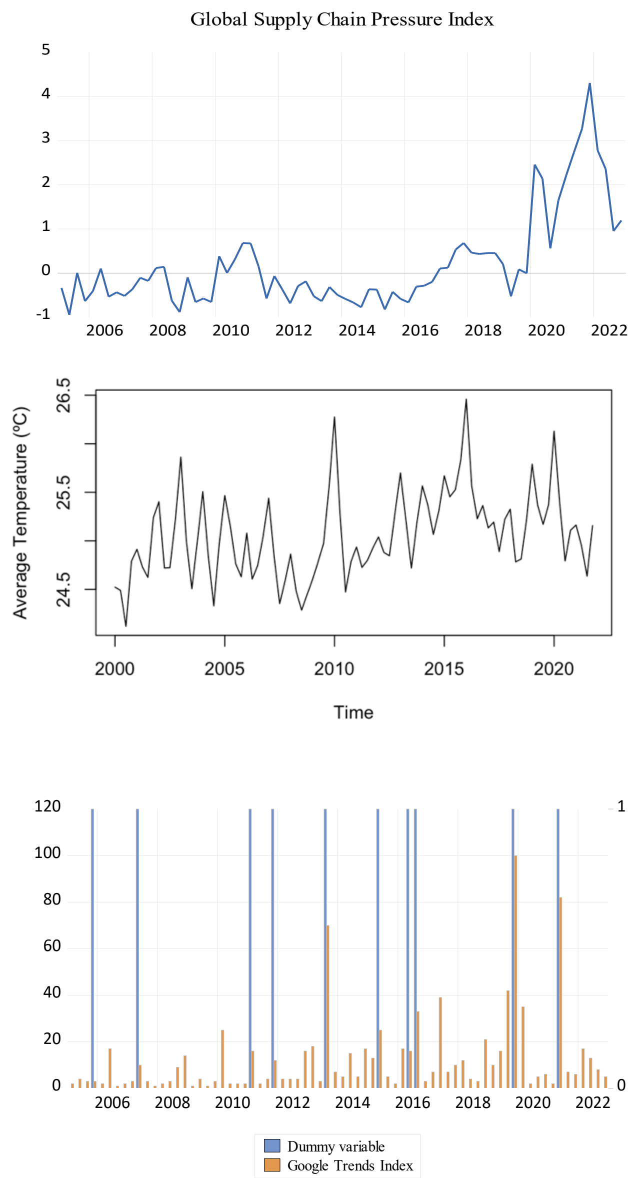
In addition, we employ three exogenous and a dummy variable for the more substantial decline in economic activity due to the Covid-19 pandemic in the second quarter of 2020. Table 2, summarize the description of the exogenous variables with relevant papers that use these variables in their models and show their respective time series, respectively.

Table 2 *Exogenous Variables description*

Variable	Reference papers	Description
Global Supply Chain Pressure Index (GSCPI)	Andriantomanga et al. (2022), Carrière-Swallow et al. (2023)	The GSCPI consolidates various widely used measures to offer a thorough overview of possible interruptions in the supply chain. It gauges global transportation expenses through the Baltic Dry Index (BDI) and the Harpex index, alongside airfreight cost indicators sourced from the U.S. Bureau of Labor Statistics. Additionally, it incorporates several supply chain factors extracted from Purchasing Managers' Index (PMI) surveys, specifically from manufacturing companies across seven closely linked economies: China, the euro area, Japan, South Korea, Taiwan, the United Kingdom, and the United States. *Source*: Federal Reserve Bank of New York.
Climate supply shock	Vargas-Herrera (2016), Meinerding et al. (2022), Romero and Saldarriaga (2023)	Average temperature in the four main cities of Colombia (Bogotá, Medellín, Cali, Barranquilla). Source: Institute of Hydrology, Meteorology and Environmental Studies (IDEAM).
Social protests		Google Trend Index based on the search words "protests" and "strikes" as a *proxy* for the effects that such protests have on the transportation and the provision of goods and services and the overall economic activity. To illustrate the usefulness of the proposed variable, Figure 2 shows the Google Trends index and a dummy variable that takes the value of 1, when these protests and strickes are mentioned in the news, and 0 otherwise. Note the association between the presence of

		each protest (dummy = 1) with the increase in the proposed index. *Source*: Google.

Figure 2 *Time series of exogenous variables*



Note: Quarterly data provided by IDEAM (http://www.ideam.gov.co/), Federal Reserve Bank of New York (https://www.newyorkfed.org/research/policy/gscpi#/overview), and Google Trends (https://trends.google.es/trends?geo=CO&hl=es).

Before we proceed to the estimation of our VAR-X model, we test the presence of unit roots in the series by using the Augmented Dickey-Fuller and the Phillips-Perron tests. Results for the natural logarithm of the series are shown in Table 3.

Table 3 *Unit root tests for endogenous and exogenous variables (series in levels)*

Variable	Spec.	Augmented Dickey-Fuller			Phillips-Perron		
		Lags	Test	P-value	Band	Test	P-value
Inflation expectations	T, C	1	-1.643912	0.7652	5	-0.693455	0.9695
Headline inflation	T, C	1	-1.336739	0.8704	5	-0.988401	0.9387
GDP gap	T, C	0	-4.222435	0.0069	4	-4.230041	0.0067
Interest rate	T, C	1	-2.471584	0.3410	5	-1.608773	0.7798
Real exchange rate	T, C	0	-1.910118	0.6389	5	-1.674525	0.7523
Oil price	T, C	0	-2.814296	0.1972	3	-2.853834	0.1837
GSCPI	T, C	0	-3.235399	0.0860	1	-3.191502	0.0944
Protests	T, C	0	-7.754241	0.0000	6	-7.830609	0.0000
Average temperature	T, C	2	-1.624668	0.7730	8	-3.558819	0.0408

Spec. = Specification, Trend (T), and constant (C), or neither a constant nor a trend (N) are included based on the Schwarz information criterion. The ADF, and PP tests were used with the Schwarz information criterion and Newey-West band, respectively.

As shown, the GDP Gap and Protests are I(0), while the rest of the series are non-stationary, or integrated of order 1, I(1). Excepting GDP gap and Protests, all series are I(1), we decided to estimate the model in first (log) differences. Additionally, using the Akaike Information Criterion, we identify and select a stable model with 6 lags (see Figure A1 and Table A2). Likewise, there is no evidence of autocorrelated residuals (See Table A3). At this point, it is important to highlight that although it may be counterintuitive to include oil prices as an endogenous variable, it improves the stability of the model. Furthermore, it ranks first in the Cholesky ordering as the least endogenous variable in the model, applying only for FEVD since, for model robustness purposes, we analyze the Generalized IRFs. However, it is important to annotate that we obtain similar results if we estimate the IRF based on a Cholesky ordering. Figure 3 below displays the IRFs of inflation expectations to different innovations with one generalized standard deviation. Table A4 summarizes the results of the VAR estimation.

According to the results, we find a significant and positive response of inflation expectations to interest rate shocks at quarters 3 and 4. Although this result seems counterintuitive at first glance, it makes sense if we recognize the presence of imperfect knowledge in the process of forming expectations. This asymmetry of information may affect the persistence of this variable and headline inflation, despite contractionary monetary policies, as suggested by Orphanides and Williams (2004). In this sense, this result highlights the non-formation of rational expectations of economic agents as behavioral macroeconomics emphasizes (De Grauwe and Ji, 2019). On the other hand, there is a significant and positive response of inflation expectations to real exchange rate shocks at quarters 2, 3, and 4. This results in a pass-through between the real exchange rate and the formation of inflation expectations, following the mechanisms explained in Ghosh et al. (2021). Finally, there is an inertial pattern when we analyze the response of inflation expectations to its own innovations, which corresponds with adaptive behavior during the first seven quarters.

Additionally, although the analysis of VAR models does not focus on the coefficients and their significance, it is important to highlight the fact that, concerning the proposed exogenous variables, only the coefficient associated with the dummy variable related with Covid-19 pandemic lockdown is significant. This could be related to the central bank's credibility in the inflation-targeting framework, leading to the effects of such supply shocks not strongly affecting inflation expectations (see Table A4). This complementary finding is consistent with the contributions of Galvis and Anzoátegui-Zapata (2019a,b) and Anzoátegui-Zapata and Galvis-Ciro (2020).

Figure 3 *Accumulated Impulse-Response Functions (Response variable: inflation expectations)*

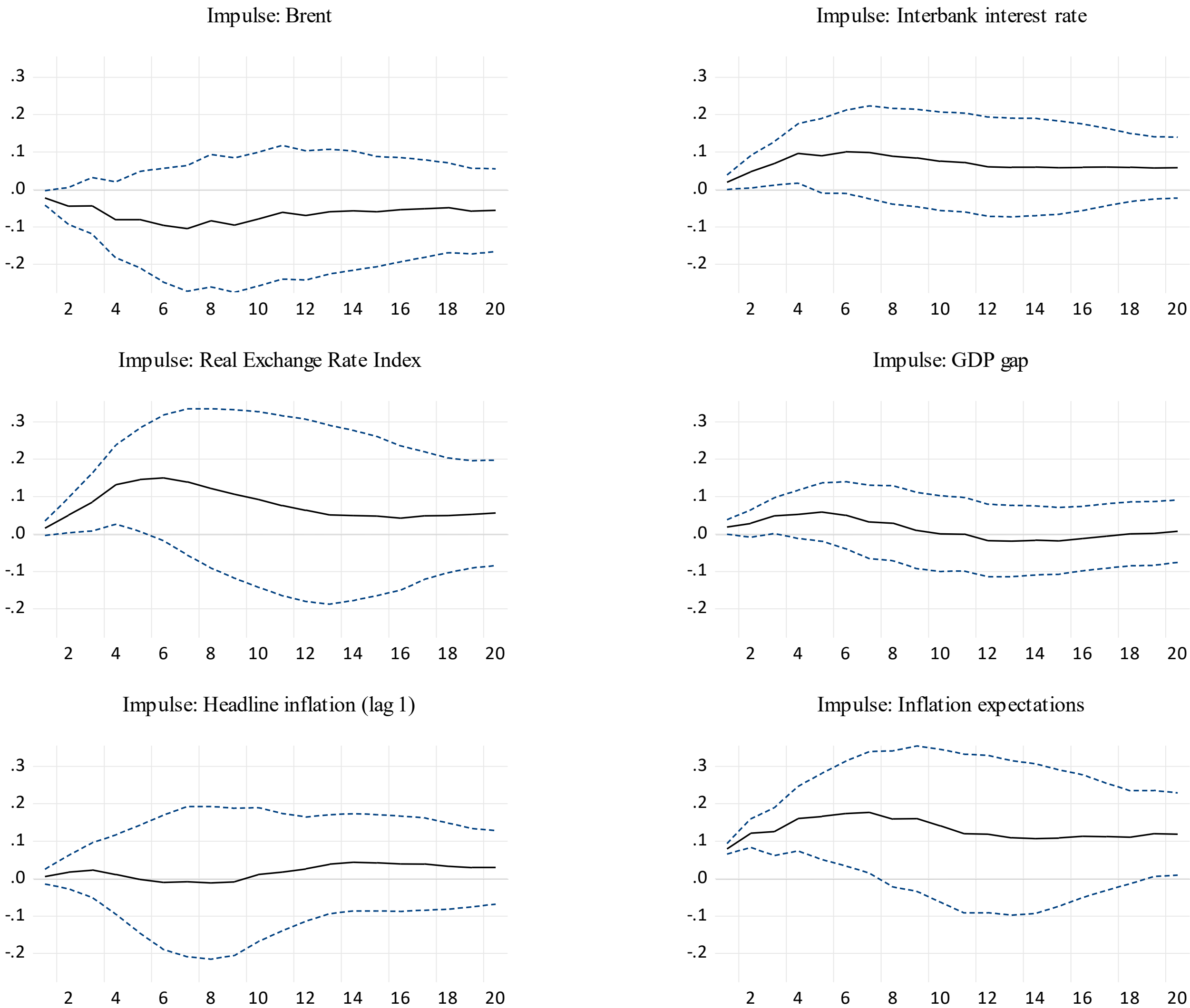
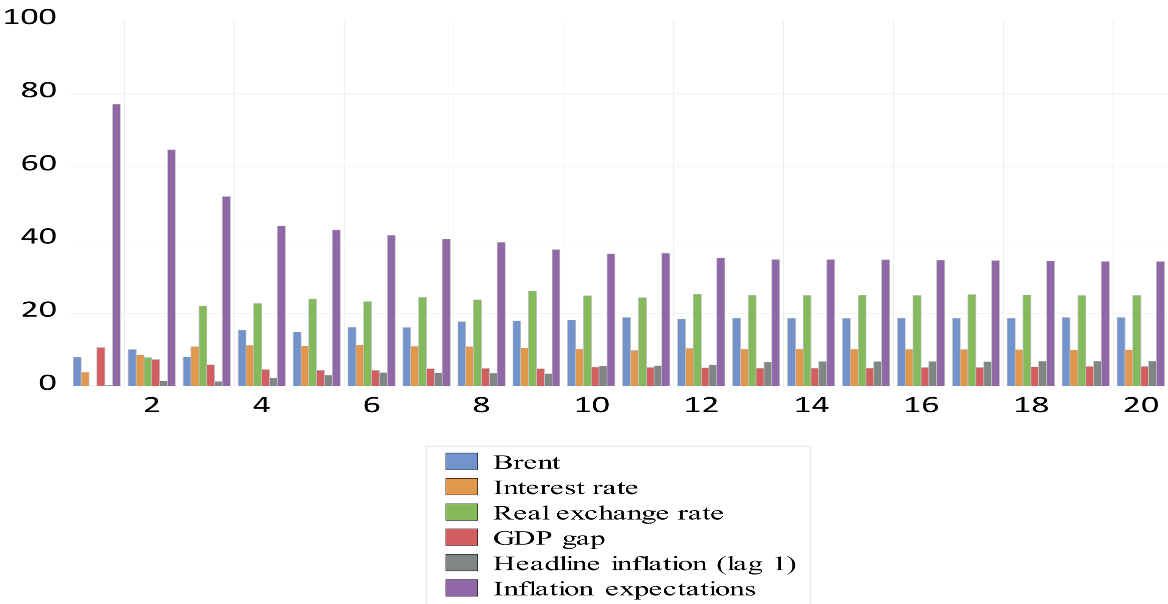


Figure 4 below shows the results of the variance decomposition. Inspection of the figure suggests that regardless there is a high percent inflation expectations variance due to itself, the percentage of the real exchange rate (24.87%) and oil price (18.80%) become relevant as sources of inflation expectations variability in the long run. That is, even though the percent inflation expectations variance decreases but is still high (33%), the real exchange rate and the oil price become very important once the weights have been stabilized over the time horizon. Additionally, there are minor percent from interest rate (9.93%), lagged headline inflation (6.85%), and GDP gap (5.43%) as sources of variability of inflation expectations. These results are coherent with the adaptive behavior of inflation expectations. Explicitly, given the scenario of imperfect knowledge suggested by Orphanides and Williams (2004), agents form their expectations based on variables that they observe and understand, i.e. the prices of goods and services, their share in household budgets, interest rates, gas and oil prices, and exchange rates.

Figure 4 *Variance Decomposition of Inflation Expectations*



Note: Percent inflation expectations variance due to included variables in the figure based on the selected horizon (20 periods).

Our previous results showed a significant and positive response of inflation expectations to interest rate shocks at 3 and 4 quarters, which seems a counterintuitive result at first glance. With the purpose of clarifying whether this pattern remains in the long term, that is whether there is evidence that these variables might be cointegrated or exhibit a long run equilibrium relationship where these tend to converge (Engle and Granger 1987, Johansen 1991), we estimate a vector error correction model (VECM) using the Johansen's (1991) methodology to test for cointegration and considering only the interest rate, the real exchange rate, and the inflation expectations.

Inflation expectations play an important role in an inflation targeting scheme. Specifically, this scheme allows monitoring how those approach the proposed target and how they change in the face of changes in total inflation and demand and supply shocks. Using a VAR-X model, we identify significant responses to inflation expectations for the first quarters. In detail, we detect a positive incidence of the interest rate on inflation expectations as a signal of imperfect understanding of economic events (imperfect knowledge) in the formation of expectations. Despite this positive relationship in the first quarters between the interest rate and inflation expectations, can be evidenced, associated with the transmission lags of monetary policy and its effect on inflation in a 9 to 12 months' time frame the VECM results show that the interest rate negatively affects inflation expectations in the long run. We do not observe significant results for the real exchange rate.

Additionally, we detect a pass-through effect regarding the positive response of inflation expectations to a real exchange rate shock and inflations expectations inertia to its own innovations. The inclusion of the exogenous variables contributes to the stability of the model specification, capturing supply shocks that have not been included before in the literature. These findings point to the relevance of examining the identified determinants in more depth from the perspective of behavioral macroeconomics, recognizing the bounded rationality of the agents.

Lastly, we need to emphasize that reliable data from household would be preferred to follow the trend in international research and thus make feasible comparisons. Given our finding that inflation expectations have a relevant weight of its variance decomposition, it is necessary to explore the perspective on how households form expectations from behavioral economics. We believe it is possible and feasible to carry out experiments to understand the expectation formation process at the individual level. With this approach, inflation expectations can be analyzed from a regional and local perspective, which will allow us to enhance our knowledge of its explanatory power in an inflation targeting strategy that sometimes has the weakness of not exploring the possible existence of regional disparities caused by monetary policy.

3. INFLATION EXPECTATIONS IN THE CONTEXTS OF COVID-19 AND GLOBAL SHIPPING CONTAINER SHORTAGES: A PRELIMINARY ANALYSIS

With the consolidation of an inflation targeting scheme worldwide, inflation expectations have gained relevance for macroeconomic analysis regarding its relationship with headline inflation and inflation targets (Gobbi, Mazzocchi and Tamborini 2019). Specifically, this monetary policy scheme evaluates the convergence of actual inflation against the proposed target, with inflation expectations being its nominal anchor which must be monitored to ascertain how far it is from that defined by the monetary authority. In this sense, understanding the process of formation of inflation expectations by households and firms is essential in contemporary economic policy. Thus, identifying determinants and shocks facilitates monetary policy decision-making.

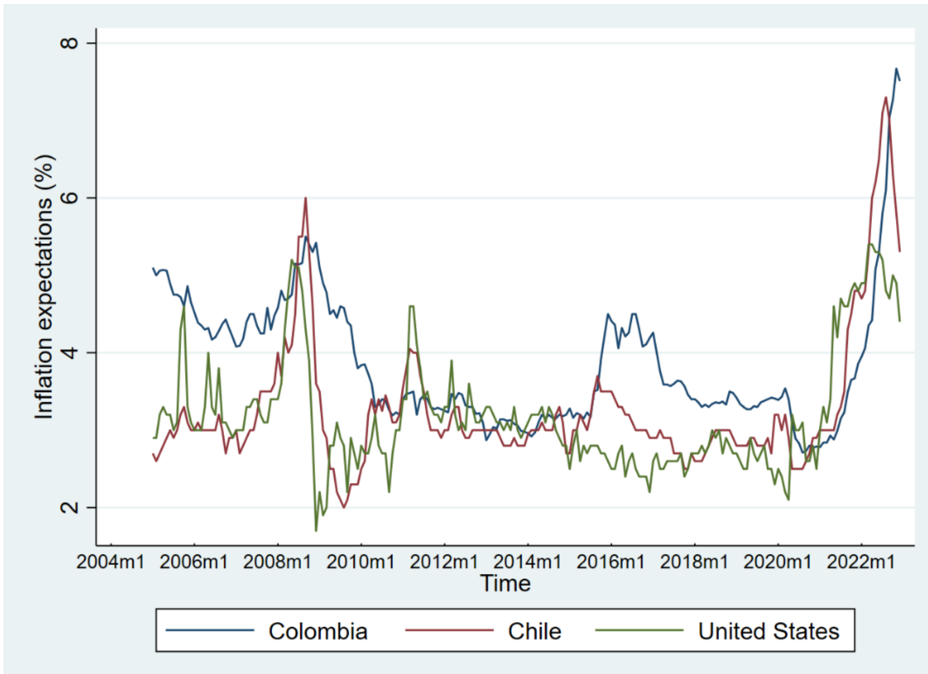
In studying the determinants of inflation expectations, there is a broad variety of works. Some channeled into supply and demand forces, while others have used multivariate time series models (see Kapoor and Kar (2023) for a comprehensive survey of the literature). In this sense, Ueda (2010) uses core inflation, the output gap, the interest rate, and inflation expectations as key endogenous variables, and oil prices and food inflation as exogenous variables. Recent works have opened the discussion to identifying the incidence of supply shocks on inflation expectations, in addition to the common determinants that depend on the settings of monetary policy in each country. The different supply shocks that have been studied range from oil prices (Ghosh et al., 2021), weather (Romero and Saldarriaga, 2023), macroeconomic policy uncertainty (Han et al., 2016), and financial market volatility (Stillwagon, 2018), among others.

In recent years, the emergence of two large shocks (the COVID-19 pandemic and the container crisis) called attention to broadening the identification of determinants of inflation expectations associated with supply shocks to create a broad view of monetary policy in the current times of uncertainty and volatility (Armantier et al., 2020; Apergis and Apergis, 2021; Ghosh et al., 2021; Andriantomanga et al. 2022; Carrière-Swallow et al.; 2023).

In detail, this section analyzes the incidence of COVID-19 through the global shipping container shortage on inflation expectations in two emerging countries, Colombia and Chile, and a developed country, the United States. The later country is used as a benchmark because it is one of the economies with great data availability and related studies on this phenomenon. The criteria used for comparison of these economies is the fact that they have the same monetary policy scheme: full inflation targeting (Cobham, 2021).

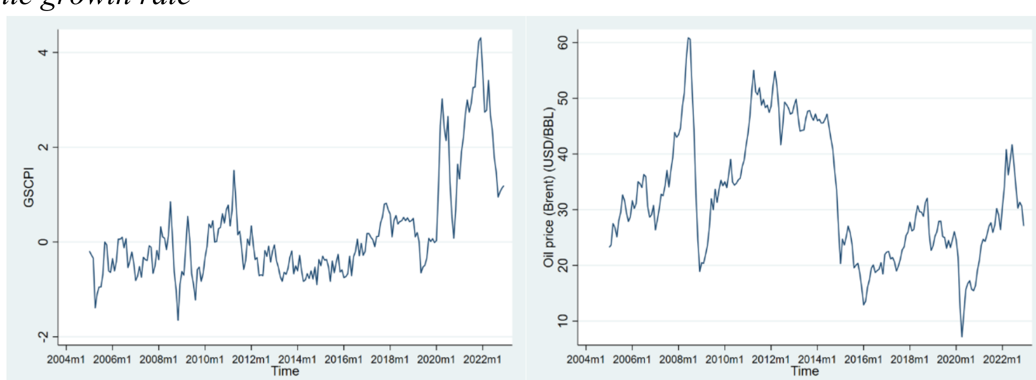
As Vargas-Herrera (2016) and Romero and Saldarriaga (2023) highlight, inflation expectations have suffered many oscillations associated with supply and demand shocks in Colombia since 2005 to 2022. In general, the volatility of this variable has been bigger in emerging countries such as Colombia and Chile compared to developed countries such as the United States. However, a clear upward pattern since 2020 is evident for the economies analyzed. This fact is associated with supply shocks such as GSCPI, oil price, and global financial volatility, measured by the CBOE Volatility Index, as well as demand shocks related to the economic growth of the United States. Figures 5 and 6 show the time series of inflation expectations for these countries (see Table A1 in the Appendix for a summary of the descriptive statistics).

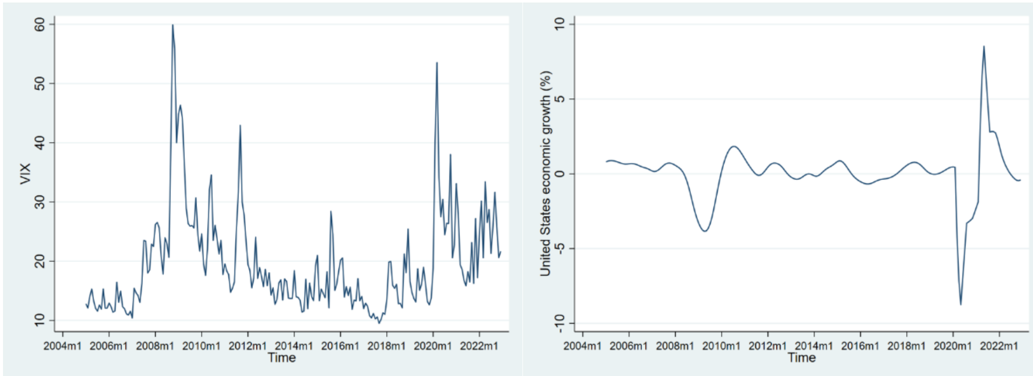
Figure 5 *Time series for inflation expectations for Colombia, Chile, and the United States*



Note: Monthly data provided by Banco de la República (https://www.banrep.gov.co/es/estadisticas), Banco Central de Chile (https://www.bcentral.cl/web/banco-central/areas/estadisticas) and, Federal Reserve Economic Data (https://fred.stlouisfed.org/).

Figure 6 *Time series of the independent variables: GSCPI, oil price, VIX, and United States economic growth rate*





Note: Monthly data provided by Federal Reserve Economic Data (https://fred.stlouisfed.org/).

Even though different publications have been released on the relationship between Covid-19 and inflation expectations (Armantier et al., 2020; Gautier et al., 2020; Apergis and Apergis, 2021; Riggi et al., 2021; Coleman and Nautz, 2022; Detmers et al., 2022), to the best of the authors' knowledge, the relationship between container shortage and inflation expectations has been little studied. Indeed, only a few works analyze the relationship between inflation and container shortages, such as Andriantomanga et al. (2022). This research studies the incidence of supply chain disruptions on different measures of inflation (headline, food, and tradable) and their implications on monetary policy in Sub-Saharan Africa. Alternatively, Carrière-Swallow et al. (2023) study the impact of global shipping costs on domestic prices for 30 developed and 16 emerging countries. However, the last-mentioned paper analyzes the incidence of shipping costs over inflation expectations as an indirect effect, not finding a highly statistically significant response until 12 months after the shock.

In this way, this section examines the relationship between inflation expectations and global supply chain pressures in the context of the COVID-19 pandemic through the container shortage that affected the world between 2020 and 2021. The authors propose a segmented regression based on Generalized Least Squares (GLS), considering the presence of autocorrelation in the data, to identify the positive trend in the context of the pandemic and container shortage as an explanation for de-anchoring inflation expectations compared to the inflation target since the middle of 2021. It is important to mention that segmented regression is a valuable tool when dealing with data that has clear breakpoints with varying relationships between variables across different segments, as the pandemic restrictions interrupt activity. Indeed, this technique improves model fitting, captures heterogeneity of the data, and provides more interpretable models in terms of changes of relation between variables at different breakpoints (Cruz et al., 2019; Cruz et al., 2022).

According to the optimal lag and threshold identified in the segmented regression, based on the lowest estimated value of the Sum of Squared Errors (SSE), a marked positive trend is found among the mentioned variables, especially for Chile and Colombia, showing the incidence of a supply shock associated with the container crisis on inflation expectations.

The Interrupted Time Series (ITS) design, often employed in public health, is a quasi-experimental approach for assessing the effects of interventions or exposures. Within an ITS design, data is gathered at several time intervals before and after an interruption, such as an intervention or exposure. The data is modelled during pre-interruption to estimate the underlying long-term trend. Segmented linear regression models are frequently applied to ITS data through various estimation techniques; pioneering papers came from Quandt (1958) and Thistlethwaite and Campbell (1960). Additionally, the method proposed by Cruz et al. (2019) and Cruz et al. (2022) provides an estimate of the time change of the regression coefficients. This time change may be different from the onset of the shock because there could be a time lag between the shock and the impact on the association between variables.

The proposed GLS approach, detailed below, considers the presence of autocorrelation in the time series data. A GLS-based segmented regression will allows capturing the incidence of the COVID-19 pandemic through the container shortage in 2020 over inflation expectations. To reach the established goal, the authors suppose there is a supply shock and employ the Global Supply Chain Pressure Index (GSCPI) measured by the Federal Reserve Bank of New York on the inflation expectations (survey-based) of three countries: Chile, Colombia, and the U.S. for the period 2005:1-2022:12 (measurement carried out by the country's central banks). As control variables, the authors include the oil price (Brent reference), the VIX as a common measure of global volatility, and the economic growth rate of the United States (measured by the annual variation of Normalized Leading Indicator OECD based on Gross Domestic Product), given its participation in international trade (Ghosh et al., 2021; Stillwagon, 2018).

Let $\Lambda = \{l_1, l_2, \ldots, l_M\}$ be a set of candidate lags and $\mathrm{T} = \{\tau_1, \tau_2, \ldots, \tau_N\}$ be a set of candidate thresholds. For a pair of candidate lag and threshold, say, $(l, \tau) \in \Lambda \times \mathrm{T}$, the piecewise regression model is obtained as follows:

$$Y(t_i) = X(t_i) + \varepsilon_i \quad (1)$$

where,

$$X(t_i) = \begin{cases} \beta_0^0 + \beta_1^0 X_1(t_i - l) + \beta_2^0 X_2(t_i - l) + \beta_3^0 X_3(t_i - l) + \beta_4^0 X_4(t_i - l), \ X(t_i) < \tau \\ \beta_0^1 + \beta_1^1 X_1(t_i - l) + \beta_2^1 X_2(t_i - l) + \beta_3^1 X_3(t_i - l) + \beta_4^1 X_4(t_i - l), \ X(t_i) \geq \tau \end{cases}$$

(2)

where Y denotes the survey-based inflation expectations, X_1 is the GSCPI, X_2 is the oil price (Brent reference), X_3 is the economic growth of the United States, and X_4 is the volatility index. Assuming a first order autocorrelation in the error term, i.e., the error in time *t* is influenced by only the previous one: $\varepsilon_t = \phi \varepsilon_{t-1} + w_t$, where ϕ is the magnitude of autocorrelation ($|\phi| < 1$), and w_t represents a normally distributed white noise ($w_t \sim N(0, \sigma_w^2)$). The method used to estimate the variance for white noise ($\hat{\sigma}_w^2$) involves computing the squared differences between the residuals and their mean. Subsequently, the sum of these squared differences is calculated over the time span of the residuals, subtracting one from the total count. Subsequently, the full covariance matrix with non-zero off-diagonal elements is estimated for capturing the presence of autocorrelation:

$$\Sigma = \hat{\sigma}_w^2 \begin{pmatrix} 1 & \hat{\phi} & \hat{\phi}^2 & \dots & \hat{\phi}^{n-1} \\ \hat{\phi} & 1 & \hat{\phi} & \dots & \hat{\phi}^{n-2} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \hat{\phi}^{n-1} & \dots & \hat{\phi}^2 & \hat{\phi} & 1 \end{pmatrix} \quad (3)$$

and the GLS coefficients estimate, $\hat{\beta}_{GLS} = (X'\Sigma^{-1}X)^{-1}(X'\Sigma^{-1}Y)$, denoted these by:

$$\widehat{\beta_0^0} = \widehat{\beta_0^0}(\tau,l), \widehat{\beta_1^0} = \widehat{\beta_1^0}(\tau,l), \widehat{\beta_2^0} = \widehat{\beta_2^0}(\tau,l), \widehat{\beta_3^0} = \widehat{\beta_3^0}(\tau,l), \widehat{\beta_4^0} = \widehat{\beta_4^0}(\tau,l)$$
$$\widehat{\beta_0^1} = \widehat{\beta_0^1}(\tau,l), \widehat{\beta_1^1} = \widehat{\beta_1^1}(\tau,l), \widehat{\beta_2^1} = \widehat{\beta_2^1}(\tau,l), \widehat{\beta_3^1} = \widehat{\beta_3^1}(\tau,l), \widehat{\beta_4^1} = \widehat{\beta_4^1}(\tau,l) \quad (4)$$

Finally, the Sum of Squares Error (SSE) ($SSE(\tau,l)$) is obtained as:

$$SSE(\tau,l)_{X(t_i)<\tau} = \sum_{X(t_i)<\tau} \left[Y(t_i) - \left(+ \widehat{\beta_1^0} X_1(t_i - l) + \widehat{\beta_2^0} X_2(t_i - l) + \widehat{\beta_3^0} X_3(t_i - l) + \widehat{\beta_4^0} X_4(t_i - l) \right) \right]^2 \quad (5)$$

$$SSE(\tau,l)_{X(t_i)\geq\tau} = \sum_{X(t_i)\geq\tau} \left[Y(t_i) - \left(\widehat{\beta_0^1} + \widehat{\beta_1^1} X_1(t_i - l) + \widehat{\beta_2^1} X_2(t_i - l) + \widehat{\beta_3^1} X_3(t_i - l) + \widehat{\beta_4^1} X_4(t_i - l) \right) \right]^2 \quad (6)$$

$$SSE(\tau,l) = SSE(\tau,l)_{X(t_i)<\tau} + SSE(\tau,l)_{X(t_i)\geq\tau} \quad (7)$$

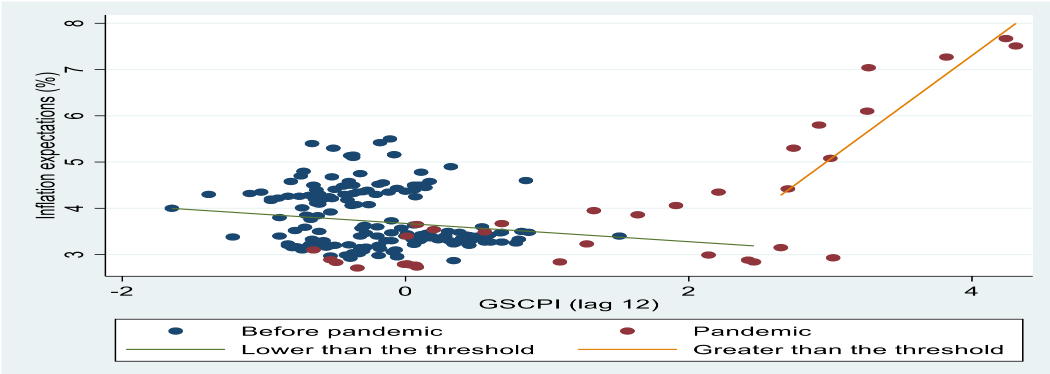
Hence, the optimal threshold $\hat{\tau}$ and $\hat{l}$ are given by:

$$(\hat{\tau},\hat{l}) = argmin\, SSE(\tau,l)\ \forall\ (\tau,l) \in \Lambda \times \mathrm{T} \quad (8)$$

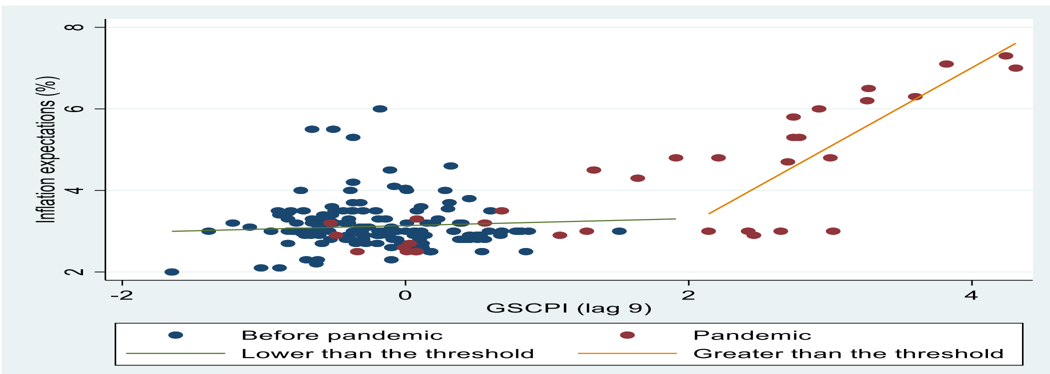
Finally, the corresponding LSE of $\beta_0^0, \beta_1^0, \beta_2^0, \beta_3^0, \beta_4^0 \beta_0^1, \beta_1^1, \beta_2^1, \beta_3^1, \beta_4^1$ are $\widehat{\beta_0^0}(\hat{\tau},\hat{l})$, $\widehat{\beta_1^0}(\hat{\tau},\hat{l})$, $\widehat{\beta_2^0}(\hat{\tau},\hat{l})$, $\widehat{\beta_3^0}(\hat{\tau},\hat{l})$, $\widehat{\beta_4^0}(\hat{\tau},\hat{l})$, $\widehat{\beta_0^1}(\hat{\tau},\hat{l})$, $\widehat{\beta_1^1}(\hat{\tau},\hat{l})$, $\widehat{\beta_2^1}(\hat{\tau},\hat{l})$, , $\widehat{\beta_3^1}(\hat{\tau},\hat{l})$,, $\widehat{\beta_4^1}(\hat{\tau},\hat{l})$

According to the optimal lag and threshold identified in the segmented regression, based on the lowest estimated value of SSE, the authors make scatterplots that capture the relation between inflation expectations and GSCPI before and during the pandemic, fitting the segmented regression based on the identified change point. The proposed thresholds are associated with change points of the GSCPI in the first six quarters of the pandemic (2020-2022) with different combinations of lags from one to 12, expecting delayed effects over a one-year window. Based on these criteria, a marked positive trend is found among the mentioned variables, especially for Chile and Colombia, showing the incidence of a supply shock associated with the container crisis on inflation expectations. Figure 6 summarizes the scatterplots and the segmented regressions for Chile, Colombia, and the United States.

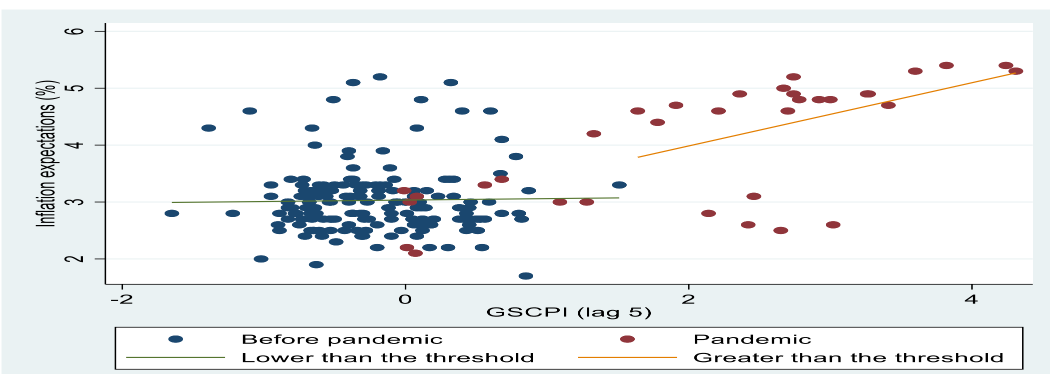
Figure 1 *Scatterplots and fittest linear regression for the country based on OLS*
Colombia



Chile



United States



Note: The sample period is 2005-2022 (monthly). Since observations are mixed to carry out the segmented regression, data is not time indexed.

For Colombia and Chile, the authors identify a positive and significant coefficient for GSCPI after the threshold, capturing the positive incidence of this supply shock on inflation expectations with the possibility of generating a positive cumulative causation process when there are strong increases in this variable, with lagged effects at three and four quarters for Chile and Colombia, respectively. Besides, this coefficient is larger in Chile than Colombia, related to the fact that the economic openness is greater in Chile than Colombia, as captured by the trade-to-GDP ratio, which was 75.02% in Chile compared to 48.62% in Colombia for 2022 (data obtained from the World Bank).

Albagli et al. (2022) identify that firms utilize fluctuations in the costs of inputs they observe in their dealings with suppliers, known as supply chain inflation, to adjust their expectations regarding overall inflation, even when these changes are not immediately connected. Moreover, they find that firms respond to these expectations by adjusting their prices accordingly, with a full pass-through effect. In addition, the threshold in Colombia (2020m7) is located before that of Chile (2021m2) as a sign of an earlier impact of this variable on the nominal anchor of the inflation targeting scheme. However, results are not significant for the United States (lag 5, threshold located in 2021m4) and for any country before the identified thresholds. The GLS segmented regression results are summarized in Table 4.

Table 4 *GLS estimations for Colombia, Chile, and the United States*

Estimations	**Chile**	**Colombia**	**United States**
Optimal Lag	9	12	5
Optimal Threshold	2021m2	2020m7	2021m4
SSE before Threshold	52.8453	78.3991	35.7208
SSE after Threshold	5.4413	1.0485	1.7382
Coefficients before Threshold	$\widehat{\beta_0^0} = 2.3632 \pm 0.2615$ $\widehat{\beta_1^0} = 0.0517 \pm 0.0546$ $\widehat{\beta_2^0} = 0.0201 \pm 0.0063$ $\widehat{\beta_3^0} = -0.0019 \pm 0.0197$ $\widehat{\beta_4^0} = 0.0087 \pm 0.0036$	$\widehat{\beta_0^0} = 3.8133 \pm 0.2008$ $\widehat{\beta_1^0} = 0.0239 \pm 0.0283$ $\widehat{\beta_2^0} = -0.0016 \pm 0.0036$ $\widehat{\beta_3^0} = -0.0183 \pm 0.0131$ $\widehat{\beta_4^0} = 0.0020 \pm 0.0018$	$\widehat{\beta_0^0} = 1.6908 \pm 0.3031$ $\widehat{\beta_1^0} = -0.0657 \pm 0.0884$ $\widehat{\beta_2^0} = 0.0394 \pm 0.0077$ $\widehat{\beta_3^0} = -0.0035 \pm 0.0389$ $\widehat{\beta_4^0} = 0.0027 \pm 0.0058$
Coefficients after Threshold	$\widehat{\beta_0^1} = -1.3893 \pm 1.9519$ $\widehat{\beta_1^1} = 1.4258 \pm 0.5675$ $\widehat{\beta_2^1} = 0.1251 \pm 0.0486$ $\widehat{\beta_3^1} = -0.1042 \pm 0.1532$ $\widehat{\beta_4^1} = 0.0635 \pm 0.0665$	$\widehat{\beta_0^1} = 5.8644 \pm 6.5237$ $\widehat{\beta_1^1} = 0.9057 \pm 0.8737$ $\widehat{\beta_2^1} = -0.0704 \pm 0.0888$ $\widehat{\beta_3^1} = -0.5878 \pm 0.2498$ $\widehat{\beta_4^1} = -0.0125 \pm 0.0594$	$\widehat{\beta_0^1} = 1.8731 \pm 0.6842$ $\widehat{\beta_1^1} = -0.0482 \pm 0.2125$ $\widehat{\beta_2^1} = 0.0918 \pm 0.0228$ $\widehat{\beta_3^1} = 0.1119 \pm 0.0460$ $\widehat{\beta_4^1} = 0.0008 \pm 0.0155$

Note: Sample period is 2005-2022 (monthly). Proposed confidence interval: $\hat{\beta} \pm 2\sqrt{\widehat{\sigma_{\hat{\beta}}^2}}$.

The previous results are coherent with the findings of Andriantomanga et al. (2022), which focused on the implication of global supply chain disruptions on inflation and monetary policy for different African economies. Now, suppose that their intuition on the inflation expectations phenomenon is adopted. In this case, that the incidence of GSCPI is significant in emerging countries such as Colombia and Chile makes sense, compared to a developed economy as the United States, given the fact that central banks of the first type of countries have lower efficiency and infrastructure by monitoring global supply chains and adjusting the monetary policy stance before disruptions have fully passed into all inflation components. Additionally, these results are linked with Carrière-Swallow et al. (2023), who propose that in countries with a lower proportion of imports in their domestic consumption, as well as those following inflation targeting schemes and having anchored inflation expectations, impacts are less pronounced, as evidenced for the case of the United States.

After the optimal threshold for Chile and Colombia, the segmented GLS regressions capture a positive and significant relationship between inflation expectations and the GSCPI. Additionally, the impact of global supply chain disruption in Colombia is earlier than in Chile, with a more significant lag effect for this economy. However, no significant relationship is evident for the United States.

These results highlight the adaptive behavior of inflation expectations in response to shocks, in this case, supply shocks, with various capabilities in terms of lags as a fundamental insight into the agents constrained rationality. In addition, it is evident that in emerging economies such as Chile and Colombia, a supply shock such as the one analyzed in the global supply chain can generate a positive cumulative causation process on inflation expectations, thus increasing the possibility of de-anchoring. Future research should address the presence of time lags and extend the model to include other types of shocks.

4. CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH

Years ago, research related to inflation expectations was unremarkable in scenarios of controlled inflation anchored to the proposed target ranges in developed and emerging countries. However, the Covid-19 pandemic, along with supply shocks such as the container crisis, the increase in oil prices, and recent conflicts, triggered a rise in inflation rates around the world from mid-2021 onwards. This surge has led to a reconsideration of mainstream monetary policy, especially the effectiveness of its instruments in terms of concrete outcomes regarding price stability. Particularly, the disanchoring of inflation expectations from the proposed target ranges has raised questions about the determinants of this phenomenon to understand the forces that could lead to their convergence once again.

In this sense, recent efforts to understand the phenomenon of inflation expectations through surveys, especially targeting households, have allowed for a greater capture of variability in this area, moving beyond the traditional hypothesis of rational expectations in the face of limited rationality in decision-making and price formation. Thus, behavioral macroeconomics aims to shed light on identifying other determinants stemming from the understanding of individuals with limited education and information when forming their expectations.

Additionally, considering that a large part of the available literature is focused on developed countries due to data availability, the opportunity to analyze this phenomenon in an emerging country like Colombia opens the possibility of proposing different determinants from the traditional ones suggested by monetary policy. These determinants are closely linked to inflation, understanding the presence of supply shocks that contribute to its disanchoring from the target inflation and draw attention to the urgency of expanding the measurement of inflation expectations among households.

To summarize the main contributions of this research, its findings are condensed into three relevant conclusions. First, we make an exhaustive characterization of the existing literature on inflation and inflation expectations in Latin American countries and specifically in Colombia, allowing for the identification of key determinants. Indeed, inflation expectations emerged as a highly impactful factor within the economic landscape. Over recent years, their significance in macroeconomic research has intensified, evident in their substantial role within economic dynamics as revealed by econometric models. Despite becoming a pivotal aspect in countries' policymaking, these expectations serve as an indicator of public perception regarding central bank operations, crucial in maintaining economic stability.

Second, this research precises the identification of determinants of inflation expectations in Colombia, considering both traditional variables proposed by the literature and exogenous variables associated with supply shocks. In detail, employing a VAR-X model, we unveil noteworthy reactions of inflation expectations, particularly in the initial quarters. Specifically, we observe a favorable impact of the interest rate on inflation expectations, indicating an imperfect comprehension of economic events (limited understanding) in shaping these expectations. Despite this positive correlation during the early quarters between the interest rate and inflation expectations, as associated with the time lags in transmitting monetary policy and its influence on inflation over a span of 9 to 12 months, the VECM outcomes reveal a negative long-term effect of the interest rate on inflation expectations. Furthermore, we identify a pass-through effect, notably the positive reaction of inflation expectations to a shock in the real exchange rate, along with inertia in inflation expectations regarding its own changes.

Third, the incorporation of exogenous variables bolsters the stability of the model's specification, capturing supply shocks previously unaccounted for in the literature. These discoveries underscore the importance of delving deeper into the identified determinants through the lens of behavioral macroeconomics, acknowledging the bounded rationality of economic agents. Hence, this manuscript contributes to understanding how endogenous and exogenous factors influence inflation expectations, providing a comprehensive view of their dynamics in developing economies. Specifically, detailed evaluation of the impact of supply shocks, such as the recent container crisis, contributes to understand the impact of this shock on inflation expectations in emerging economies like Colombia and Chile, compared to the United States as a contrasting country.

These findings underscore how inflation expectations adapt in reaction to shocks, specifically supply shocks, exhibiting diverse response times, which serves as a crucial indication of the limited rationality among economic agents. Moreover, it's apparent that in emerging economies like Chile and Colombia, a supply shock like the one examined within the global supply chain can initiate a positive cumulative effect on inflation expectations, potentially leading to a greater likelihood of disanchoring.

Once the main conclusions are established, it's vital to highlight the main limitation of this work related to the absence of a consolidated household inflation expectations survey by the central bank, as seen in developed countries like the United States, Japan, New Zealand, among others, impacts the results, limiting the understanding of only a portion of the phenomenon related to supply. Therefore, efforts to expand measurements to this economic agent become a pending challenge to enhance the study options of this phenomenon. Furthermore, the possibility of conducting experiments supported by behavioral economics and neuroeconomics would enhance the depth of the findings obtained, considering that all the work was done using secondary sources of information.

Finally, based on the path taken in this research exercise, five future lines of investigation are identified. Firstly, there is the possibility of evaluating the presence of spillover effects in emerging economies such as the Pacific Alliance members related to common supply shocks like sharp increases in oil prices, supply chain pressures, or climate-related shocks. Secondly, given the limitation of information regarding household inflation expectations, attention is drawn to the possibility of constructing synthetic indicators from social media information or newspaper articles using natural language processing techniques. Thirdly, since inflation expectations serve as the nominal anchor in the inflation targeting framework, there is an interest in comparing the determinants of this phenomenon in different monetary schemes, such as those focused on exchange rates as seen in Asian Countries in the Middle East.

Fourthly, expanding the segmented regression analysis in contexts of supply shocks and inflation expectations for countries with different characteristics, such as Eastern Europe or East Asia. Fifthly, exploring behavioral economics techniques to evaluate how the assertiveness of central bank communications and increased financial literacy could act as protective mechanisms for anchoring inflation expectations to proposed targets. Particularly, in the current context, it has become evident that traditional postulates and techniques offer only a partial understanding of the determinants of inflation expectations. The disanchoring of these expectations and their variability, especially concerning households, maintains the premise that we continue to face a "black box" scenario. Limited rationality intersects with cognitive biases, emotions, perceptions, and constraints in education and information, highlighting the need for broader exploration within this realm.

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Appendix

Figure A1 *AR Roots Graph*

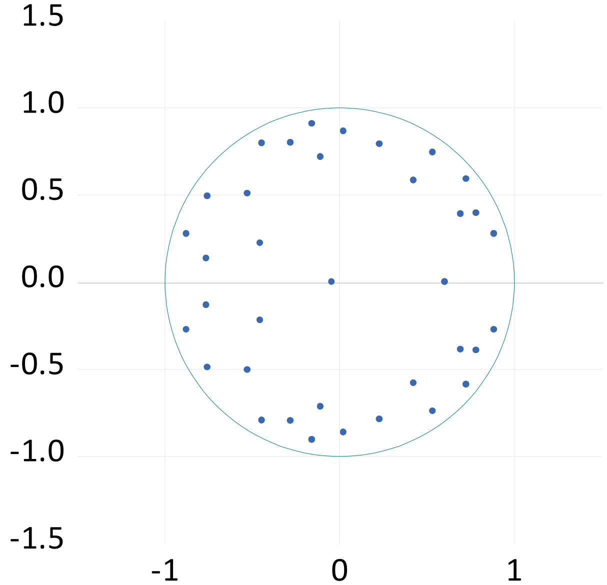
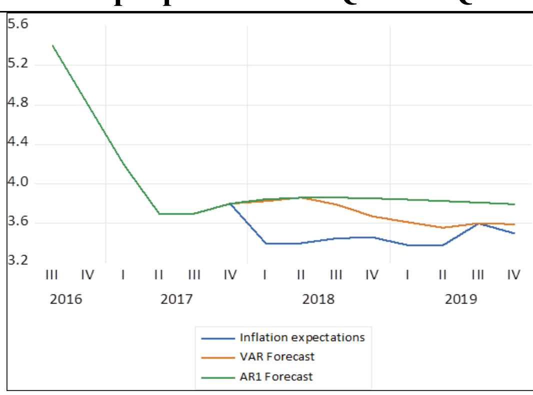
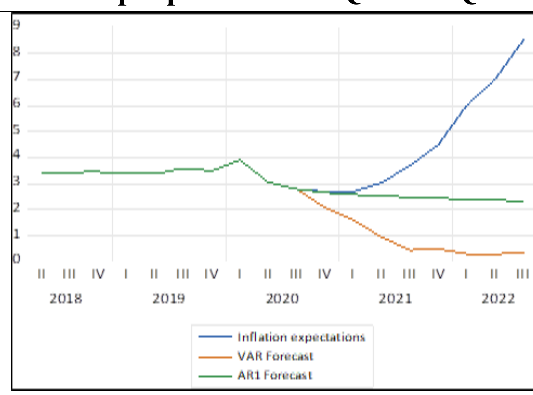


Figure A2 *Forecasted time series*

Dynamic Forecast	
Sample period: 2018Q1-2019Q4	**Sample period: 2020Q4-2022Q3**





Static Forecast	
Sample period: 2018Q1-2019Q4	**Sample period: 2020Q4-2022Q3**

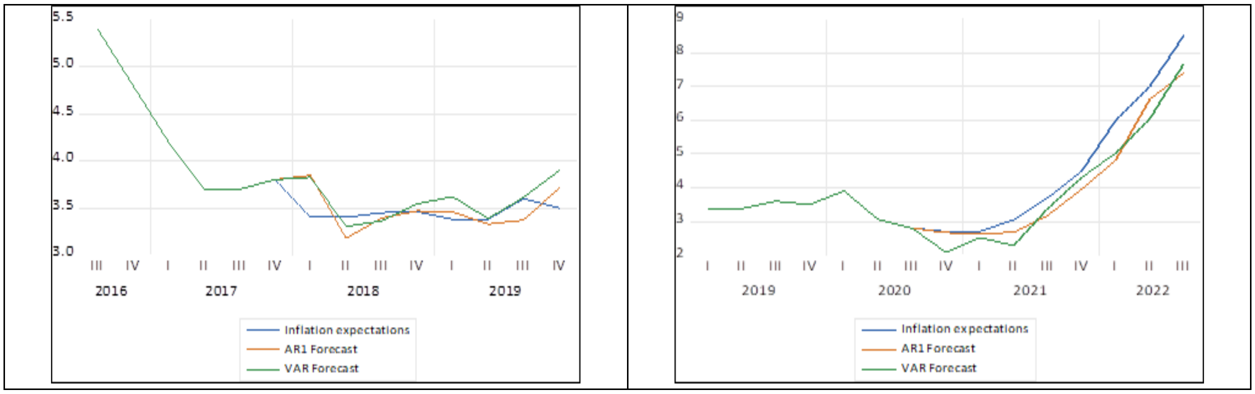


Table A1 *Publications in Colombia about inflation expectations*

Topic	**Papers**
Estimation and determinants	Misas and Vásquez (2002), Vargas et al. (2009), González et al. (2010), Vargas-Herrera (2016), Romero and Saldarriaga 2023)
Measures comparison	Arias et al. (2006)
Adaptive or rational expectations	Zárate et al. (2011), Huertas et al. (2015)
Anchoring and disagreement	Gamba-Santamaría et al. (2016), Galvis and Anzoátegui-Zapata (2019a,b), Anzoátegui-Zapata and Galvis-Ciro (2020)

Table A2 *Selection VAR lag order*

Lag	**AIC**	**SC**	**HQ**
0	-12.0298	-11.0179	-11.6312
1	-14.3235	-12.0971	-13.4464
2	-14.3085	-10.8678	-12.9530
3	-14.0794	-9.4243	-12.2455
4	-14.4858	-8.6164	-12.1735
5	-15.0809	-7.9971	-12.2903
6	-15.5956	-7.2974	-12.3265

AIC: Akaike Information Criterion, HQ: Hannan-Quinn, SC: Schwarz Criterion.

Table A3 *Autocorrelation LM Test for Residuals*

Lag	**LRE* stat**	**df**	**Prob.**	**Rao F-stat**	**df**	**Prob.**
1	33.9627	36	0.5658	0.9211	(36, 55.5)	0.5977
2	34.9428	36	0.5187	0.9547	(36, 55.5)	0.5520
3	41.5491	36	0.2417	1.1929	(36, 55.5)	0.2729
4	28.1147	36	0.8231	0.7303	(36, 55.5)	0.8408
5	24.4164	36	0.9287	0.6173	(36, 55.5)	0.9370

6	39.5856	36	0.3130	1.1198	(36, 55.5)	0.3466

H_0: No serial correlation at lag h

Table A4 *VAR Coefficients*

Variables	$\Delta Brent$	Δi	Δrer	$GDPgap$	$\Delta\pi_{t-1}$	$\Delta\pi^e$
	-0.269688	0.094705	-0.043442	0.012973	-0.052973	0.061074
$\Delta Brent$ $(Lag\ 1)$	(0.27759)	(0.09323)	(0.08544)	(0.01102)	(0.09265)	(0.09812)
	[-0.97152]	[1.01587]	[-0.50846]	[1.17730]	[-0.57173]	[0.62247]
	-0.759750	0.179377	0.076460	0.004219	-0.050423	0.151705
$\Delta Brent$ $(Lag\ 2)$	(0.27775)	(0.09328)	(0.08549)	(0.01103)	(0.09271)	(0.09817)
	[-2.73533]	[1.92302]	[0.89439]	[0.38263]	[-0.54390]	[1.54529]
	-0.257858	0.026238	0.011642	0.004453	0.081454	-0.054854
$\Delta Brent$ $(Lag\ 3)$	(0.30904)	(0.10378)	(0.09512)	(0.01227)	(0.10315)	(0.10923)
	[-0.83440]	[0.25281]	[0.12240]	[0.36296]	[0.78969]	[-0.50220]
	-0.433869	-0.057073	0.025965	-0.002758	-0.051677	0.093939
$\Delta Brent$ $(Lag\ 4)$	(0.28456)	(0.09557)	(0.08758)	(0.01130)	(0.09498)	(0.10058)
	[-1.52468]	[-0.59722]	[0.29646]	[-0.24414]	[-0.54409]	[0.93398]
	-0.471674	-0.283961	0.041459	0.000441	0.116809	-0.171006
$\Delta Brent$ $(Lag\ 5)$	(0.33230)	(0.11160)	(0.10228)	(0.01319)	(0.11091)	(0.11745)
	[-1.41944]	[-2.54455]	[0.40537]	[0.03344]	[1.05318]	[-1.45598]
	-0.031312	-0.044988	0.047580	-0.002572	-0.175728	0.160277
$\Delta Brent$ $(Lag\ 6)$	(0.28839)	(0.09685)	(0.08876)	(0.01145)	(0.09626)	(0.10193)
	[-0.10858]	[-0.46451]	[0.53604]	[-0.22470]	[-1.82562]	[1.57239]
	0.109906	-0.117326	-0.041595	-0.025937	0.436411	0.211730
Δi $(Lag\ 1)$	(0.62304)	(0.20924)	(0.19176)	(0.02473)	(0.20795)	(0.22021)
	[0.17640]	[-0.56074]	[-0.21691]	[-1.04870]	[2.09863]	[0.96148]
	0.334342	0.466560	-0.026006	0.031737	-0.014852	0.124773
Δi $(Lag\ 2)$	(0.65067)	(0.21852)	(0.20026)	(0.02583)	(0.21717)	(0.22998)
	[0.51384]	[2.13513]	[-0.12986]	[1.22873]	[-0.06839]	[0.54254]
	-0.022341	-0.003927	0.063160	0.019497	0.235763	0.143944
Δi $(Lag\ 3)$	(0.50746)	(0.17042)	(0.15619)	(0.02014)	(0.16937)	(0.17936)
	[-0.04402]	[-0.02304]	[0.40439]	[0.96784]	[1.39197]	[0.80254]
	0.555047	0.069320	-0.113267	-0.001322	0.266600	-0.309484
Δi $(Lag\ 4)$	(0.49522)	(0.16631)	(0.15242)	(0.01966)	(0.16529)	(0.17503)
	[1.12082]	[0.41682]	[-0.74313]	[-0.06725]	[1.61294]	[-1.76814]
	-0.156880	0.070627	0.119708	0.046720	-0.162165	0.131574
Δi $(Lag\ 5)$	(0.61410)	(0.20623)	(0.18901)	(0.02438)	(0.20497)	(0.21705)
	[-0.25546]	[0.34246]	[0.63335]	[1.91650]	[-0.79117]	[0.60619]
	0.070223	-0.226989	0.108523	0.009286	0.035039	-0.025454

Δi (Lag 6))	(0.56234)	(0.18885)	(0.17308)	(0.02232)	(0.18769)	(0.19876)
	[0.12488]	[-1.20194]	[0.62702]	[0.41599]	[0.18669]	[-0.12807]
Δrer (Lag 1)	-1.744272	0.441815	0.011078	0.006507	0.127652	0.498961
	(0.85571)	(0.28738)	(0.26337)	(0.03397)	(0.28561)	(0.30245)
	[-2.03838]	[1.53741]	[0.04206]	[0.19156]	[0.44694]	[1.64972]
Δrer (Lag 2)	-0.879028	0.597639	-0.145631	0.037851	0.178181	0.498394
	(0.84612)	(0.28415)	(0.26042)	(0.03359)	(0.28241)	(0.29906)
	[-1.03890]	[2.10323]	[-0.55922]	[1.12692]	[0.63094]	[1.66654]
Δrer (Lag 3)	-0.593694	0.141122	0.022659	0.037065	0.321173	0.489879
	(0.90228)	(0.30301)	(0.27771)	(0.03582)	(0.30115)	(0.31891)
	[-0.65799]	[0.46573]	[0.08159]	[1.03483]	[1.06647]	[1.53610]
Δrer (Lag 4)	-1.049575	0.576531	0.133043	0.018353	0.115789	-0.089727
	(0.96459)	(0.32394)	(0.29688)	(0.03829)	(0.32195)	(0.34093)
	[-1.08811]	[1.77975]	[0.44813]	[0.47931]	[0.35965]	[-0.26318]
Δrer (Lag 5)	-1.283601	0.069268	0.027803	0.049706	-0.137120	-0.118275
	(0.92529)	(0.31074)	(0.28479)	(0.03673)	(0.30883)	(0.32704)
	[-1.38724]	[0.22291]	[0.09763]	[1.35322]	[-0.44399]	[-0.36165]
Δrer (Lag 6)	-0.146812	-0.052853	-0.068311	0.015870	-0.553144	-0.279823
	(0.92036)	(0.30909)	(0.28327)	(0.03654)	(0.30719)	(0.32530)
	[-0.15952]	[-0.17100]	[-0.24115]	[0.43438]	[-1.80067]	[-0.86020]
$GDPgap$ (Lag 1)	2.180994	1.767618	-0.953451	0.554215	0.489011	-1.233228
	(2.13911)	(0.71838)	(0.65838)	(0.08492)	(0.71397)	(0.75607)
	[1.01958]	[2.46056]	[-1.44818]	[6.52665]	[0.68492]	[-1.63111]
$GDPgap$ (Lag 2)	-3.548642	-1.263461	0.791999	-0.044533	-1.444906	1.341204
	(3.21086)	(1.07831)	(0.98825)	(0.12746)	(1.07169)	(1.13488)
	[-1.10520]	[-1.17171]	[0.80142]	[-0.34939]	[-1.34825]	[1.18181]
$GDPgap$ (Lag 3)	-0.664258	-1.049761	0.024685	-0.099886	1.408585	-1.928969
	(3.43551)	(1.15376)	(1.05739)	(0.13638)	(1.14667)	(1.21428)
	[-0.19335]	[-0.90986]	[0.02334]	[-0.73241]	[1.22841]	[-1.58857]
$GDPgap$ (Lag 4)	-0.373155	2.273746	-0.621300	0.266556	-0.947893	2.124376
	(3.61471)	(1.21393)	(1.11254)	(0.14349)	(1.20648)	(1.27762)
	[-0.10323]	[1.87304]	[-0.55845]	[1.85764]	[-0.78567]	[1.66276]
$GDPgap$ (Lag 5)	-3.149902	-1.367070	0.999305	-0.133794	-2.323134	-1.438959
	(3.14714)	(1.05691)	(0.96864)	(0.12493)	(1.05042)	(1.11236)
	[-1.00088]	[-1.29346]	[1.03166]	[-1.07094]	[-2.21162]	[-1.29361]
$GDPgap$ (Lag 6)	-1.288134	-2.070540	-0.438012	-0.226555	2.594717	0.126526
	(2.84280)	(0.95470)	(0.87496)	(0.11285)	(0.94884)	(1.00479)
	[-0.45312]	[-2.16878]	[-0.50061]	[-2.00757]	[2.73462]	[0.12592]
	-1.055154	-0.105517	0.042121	-0.014235	-0.179745	0.100010

$\Delta\pi_{t-1}$ $(Lag\ 1)$	(0.58966)	(0.19803)	(0.18149)	(0.02341)	(0.19681)	(0.20842)
	[-1.78943]	[-0.53284]	[0.23209]	[-0.60811]	[-0.91329]	[0.47986]
$\Delta\pi_{t-1}$ $(Lag\ 2)$	-0.098146	-0.205056	-0.064955	-0.048035	-0.079772	0.073473
	(0.57564)	(0.19332)	(0.17717)	(0.02285)	(0.19213)	(0.20346)
	[-0.17050]	[-1.06071]	[-0.36662]	[-2.10208]	[-0.41520]	[0.36112]
$\Delta\pi_{t-1}$ $(Lag\ 3)$	-0.118753	-0.001393	-0.138105	-0.030998	-0.037211	-0.047212
	(0.47212)	(0.15855)	(0.14531)	(0.01874)	(0.15758)	(0.16687)
	[-0.25153]	[-0.00879]	[-0.95042]	[-1.65399]	[-0.23614]	[-0.28293]
$\Delta\pi_{t-1}$ $(Lag\ 4)$	-0.147980	0.123532	-0.047010	-0.020045	-0.308081	-0.065834
	(0.45486)	(0.15276)	(0.14000)	(0.01806)	(0.15182)	(0.16077)
	[-0.32533]	[0.80868]	[-0.33579]	[-1.11015]	[-2.02927]	[-0.40949]
$\Delta\pi_{t-1}$ $(Lag\ 5)$	-0.555641	-0.108489	0.002146	-0.024324	-0.397160	0.015400
	(0.51971)	(0.17453)	(0.15996)	(0.02063)	(0.17346)	(0.18369)
	[-1.06915]	[-0.62160]	[0.01341]	[-1.17902]	[-2.28961]	[0.08384]
$\Delta\pi_{t-1}$ $(Lag\ 6)$	0.078914	-0.046901	-0.194166	-0.030465	0.019124	0.034888
	(0.39314)	(0.13203)	(0.12100)	(0.01561)	(0.13122)	(0.13895)
	[0.20073]	[-0.35524]	[-1.60467]	[-1.95210]	[0.14574]	[0.25108]
$\Delta\pi^e$ $(Lag\ 1)$	0.496843	0.407844	0.132700	0.035479	1.273815	0.463539
	(0.58098)	(0.19511)	(0.17881)	(0.02306)	(0.19391)	(0.20535)
	[0.85518]	[2.09032]	[0.74211]	[1.53837]	[6.56901]	[2.25735]
$\Delta\pi^e$ $(Lag\ 2)$	1.090282	0.122916	0.132241	0.007597	0.111081	-0.501426
	(1.20977)	(0.40628)	(0.37234)	(0.04802)	(0.40378)	(0.42759)
	[0.90123]	[0.30254]	[0.35516]	[0.15820]	[0.27510]	[-1.17268]
$\Delta\pi^e$ $(Lag\ 3)$	-0.276738	0.349192	0.042295	0.079563	0.112571	0.053969
	(1.13467)	(0.38106)	(0.34923)	(0.04504)	(0.37872)	(0.40105)
	[-0.24389]	[0.91638]	[0.12111]	[1.76639]	[0.29724]	[0.13457]
$\Delta\pi^e$ $(Lag\ 4)$	0.072135	-0.427316	0.239238	0.025879	0.093007	-0.200841
	(0.94291)	(0.31666)	(0.29021)	(0.03743)	(0.31471)	(0.33327)
	[0.07650]	[-1.34946]	[0.82436]	[0.69140]	[0.29553]	[-0.60264]
$\Delta\pi^e$ $(Lag\ 5)$	0.714283	0.014188	0.017530	0.016674	0.050901	0.271553
	(0.88176)	(0.29612)	(0.27139)	(0.03500)	(0.29430)	(0.31166)
	[0.81007]	[0.04791]	[0.06459]	[0.47635]	[0.17295]	[0.87132]
$\Delta\pi^e$ $(Lag\ 6)$	-0.058957	0.009245	0.192337	0.021543	0.487902	-0.050235
	(0.90976)	(0.30553)	(0.28001)	(0.03611)	(0.30365)	(0.32155)
	[-0.06480]	[0.03026]	[0.68690]	[0.59651]	[1.60679]	[-0.15623]
$Intercept$	0.010637	-0.005647	0.005047	0.003368	0.005777	0.007800
	(0.03196)	(0.01073)	(0.00984)	(0.00127)	(0.01067)	(0.01130)
	[0.33280]	[-0.52610]	[0.51303]	[2.65421]	[0.54150]	[0.69038]
	-0.159661	-0.027718	0.041718	-0.002508	0.045794	0.022957

$\Delta GSCPI$	(0.07759)	(0.02606)	(0.02388)	(0.00308)	(0.02590)	(0.02742)
	[-2.05785]	[-1.06379]	[1.74702]	[-0.81429]	[1.76839]	[0.83715]
$\Delta Temperature$	2.799694	-3.069865	-0.256071	-0.032132	0.371573	-1.293343
	(3.18608)	(1.06999)	(0.98062)	(0.12648)	(1.06342)	(1.12612)
	[0.87873]	[-2.86907]	[-0.26113]	[-0.25405]	[0.34941]	[-1.14850]
$Dummy\_Covid$	0.459584	-0.335646	-0.126401	-0.180855	-0.071800	-0.270537
	(0.38389)	(0.12892)	(0.11815)	(0.01524)	(0.12813)	(0.13568)
	[1.19719]	[-2.60349]	[-1.06980]	[-11.8679]	[-0.56037]	[-1.99387]
$\Delta Protests$	-0.035063	0.008141	-0.011624	0.000282	0.014490	-0.000726
	(0.04502)	(0.01512)	(0.01386)	(0.00179)	(0.01503)	(0.01591)
	[-0.77879]	[0.53842]	[-0.83882]	[0.15764]	[0.96422]	[-0.04562]
R-squared	0.608473	0.930307	0.493402	0.970203	0.957338	0.788125
Adj. R-squared	-0.072442	0.809101	-0.387639	0.918383	0.883142	0.419646
Sum sq. Resids	1.162443	0.131104	0.110118	0.001832	0.129499	0.145220
S.E. equation	0.224813	0.075499	0.069194	0.008924	0.075036	0.079460
F-statistic	0.893610	7.675420	0.560022	18.72246	12.90290	2.138859
Log likelihood	37.45542	107.2887	112.8706	243.9504	107.6829	104.0163
Akaike AIC	0.110768	-2.071521	-2.245956	-6.342201	-2.083841	-1.969260
Schwarz SC	1.493803	-0.688486	-0.862922	-4.959167	-0.700806	-0.586225
Mean dependent	-0.001999	0.007136	0.004194	0.000622	0.014303	0.011614
S.D. dependent	0.217088	0.172799	0.058739	0.031238	0.219503	0.104305

Determinant resid covariance (dof adj.)	1.45E-15
Determinant resid covariance	3.11E-18
Log likelihood	745.0586
Akaike information criterion	-15.59558
Schwarz criterion	-7.297376
Number of coefficients	246

ΔBrent: Brent (log differences), Δi: Inter-bank interest rate (log differences, seasonally adjusted), Δrer: Real exchange rate index (log differences), GDPgap: GDP gap (Based on Hodrick-Prescott Filter), $\Delta\pi_{t-1}$: Headline inflation (log differences, lag 1), $\Delta\pi^e$: Survey-based inflation expectations (log differences), ΔGSCPI: Global Supply Chain Pressure Index (first differences), ΔTemperature: Average temperature (log differences), Dummy_Covid: Dummy variable (1 = 2020q2, 0 otherwise), ΔProtests: Google Trends Index about "protests" (log differences).

Standard errors in ( ) and t-statistics in [ ]