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Determinants of inflation expectations in Colombia: a VAR-X analysis

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Abstract

Purpose – This study aims to investigate the determinants of inflation expectations in Colombia through a vector autoregression model with exogenous variables (VAR-X) and uses quarterly data for survey-based inflation expectations and different supply shocks.

Design/methodology/approach – We propose a VAR-X model. Despite data unavailability, we gathered quarterly data for the period 2005–2022 for the following variables: oil price, real exchange rate, headline inflation, output gap, policy interest rate and inflation expectations.

Findings – We identified significant responses to inflation expectations in the first quarter. Although we found a positive response of inflation expectations to the interest rate, the robustness tests show that the interest rate negatively affects inflation expectations in the long run. Additionally, we detected a pass-through effect regarding the positive response of inflation expectations to a real exchange rate shock and the inertia of inflation expectations to their own innovations.

Research limitations/implications – We must emphasize that reliable data from households would be preferred to follow the trend in international research and thus make feasible comparisons.

Practical implications – Inflation expectations play an important role in an inflation targeting scheme. Specifically, this scheme allows monitoring of how those approach the proposed target and how they change in the face of changes in total inflation, demand and supply shocks.

Originality/value – The inclusion of exogenous variables contributed to the stability of the model specification by capturing supply shocks not previously considered in the literature.

Keywords Inflation expectations, Inflation targeting, VAR models, Supply shocks

Paper type Research paper

1. Introduction

The inflation expectations variable has been important for monitoring inflation since adopting inflation-targeting strategies in many developed and emerging countries (Jahan, 2012). Since implementing 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 on how households and firms form price expectations, thus making necessary adjustments to correct any deviations from the inflation rate target (Gómez, 2006). Proper monitoring of inflation expectations contributes to the accountability and effectiveness of monetary policy through trust building (Woodford, 2005).

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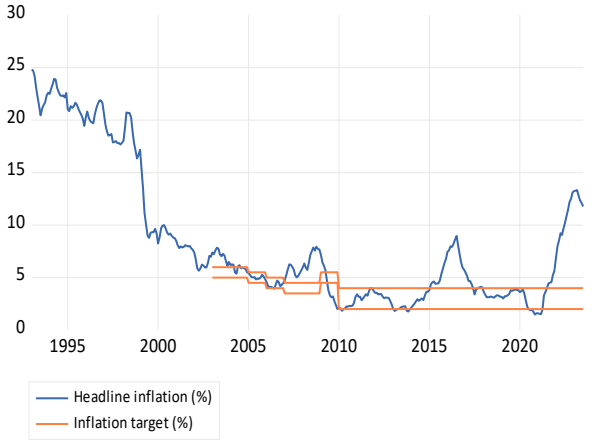
Indeed, inflation expectations play a crucial role in inflation targeting schemes, where central banks monitor the dynamics of this variable, its anchorage with headline inflation and its response to changes in policy interest rate and other variables. For this reason, researching determinants of inflation expectations and their heterogeneity contributes to understanding households' and firms' economic choices and 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.

This paper primarily explores the factors influencing inflation expectations in an emerging economy like Colombia. It emphasizes the impact of supply shocks and seeks to understand how inflation expectations are formed in an environment characterized by limited information, cognitive limitations and the use of heuristics. Although there has been considerable research on this subject in developed countries (Kapoor and Kar, 2023), information at the household level in emerging economies is often lacking. Moreover, with the inflationary trends observed globally since 2021, understanding the reasons behind the deviation of inflation from target levels has become increasingly important. Therefore, it is essential to identify and analyze the relevant supply and demand shocks affecting inflation expectations to facilitate a return to targeted levels.

In this study, we analyze the case of Colombia, to identify the determinants of inflation expectations. Colombia implemented an inflation-targeting strategy in 1999 under the authority of Banco de la República, its central bank and has been working with it for approximately 24 years. Figure 1 shows that, after the implementation of the inflation targeting strategy, inflation decreased toward the targets set by the Central Bank. Nevertheless, supply and demand contingencies, such as the 2007–2009 financial crisis, the fall in commodity prices and the depreciation of the Colombian peso after 2014, which led to a misalignment of economic agents' expectations, made it somewhat difficult to maintain inflation within the ranges established by the central bank. More recently, the COVID-19 pandemic, which triggered a shortage of containers and shipping services worldwide and the Russia–Ukraine war, which began in early 2022, have caused an upward shift in the trend of inflation expectations and inflation since mid-2021.

To the best of our knowledge, only a few studies have investigated inflation expectations and their determinants in Colombia and have considered them a key variable for monetary



Source(s): Own elaboration based on Banco de la República, Authors' own work

Figure 1. Headline inflation and inflation targeting in Colombia (2003–2023)

policy. The research on this phenomenon has focused on four main topics: estimation and determinants based on headline inflation, core inflation, interest rate and weather shocks (Misas and Vásquez, 2002; Vargas-Herrera *et al.*, 2009; González-Molano *et al.*, 2010; Vargas-Herrera, 2016; Romero and Naranjo-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, 2019a, b; Anzoátegui-Zapata and Galvis-Ciro, 2020).

Additionally, we integrate the approaches of Ueda (2010), Vargas-Herrera (2016) and Ghosh *et al.* (2021), who used vector autoregression (VAR) models, to study the determinants of inflation expectations associated with demand and supply shocks and the dynamic relationship between economic activity and monetary policy. Despite data unavailability, we gathered quarterly data for the period 2005–2022 for the following variables: oil price, real exchange rate, headline inflation, output gap, policy interest rate and inflation expectations. We employ headline inflation, despite Deacon and Derry's (1994) suggesting 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 survey participants and short-term focus economic agents.

The contributions of our study are twofold: first, the incorporation of exogenous variables related to supply shocks, such as social protests, the supply chain pressure index and the average temperatures in major cities. The inclusion of these supply shocks is of great relevance because many emerging economies are characterized by their high degree of openness, prolonged periods of drought, rain and extreme temperatures and weak political institutions. We aim to differentiate our research from others by addressing the limitations of the Ocean Niño Index (Vargas-Herrera, 2016; Romero and Naranjo-Saldarriaga, 2023), which is overly general and assumes uniform temperatures and climate conditions across different regions of Colombia. And, second, the comparative analysis was conducted using information from monthly surveys and several additional sources. In this sense, our study highlights the need for further investigation into inflation expectations at the household level. By doing this, we can collect more accurate and high-frequency data, which will enhance our understanding of how these expectations evolve over time. Given that few studies have explored the determinants of inflation expectations in Latin America and that previous research has mainly focused on anchoring these expectations and comparing metrics of disagreement, this study offers an updated perspective on the factors influencing the formation of inflation expectations, a crucial variable for monetary policy in Colombia and other emerging economies.

As a main result, we identified significant responses to inflation expectations in the first quarter. Although a positive relationship between the interest rate and inflation expectations is evidenced in the first quarters, associated with the transmission lags of monetary policy and its effect on inflation in a 9–12-month time frame, the vector error correction model (VECM) results show that the interest rate negatively affects inflation expectations in the long run. We do not observe any significant results for the real exchange rates. Additionally, we detect a pass-through effect regarding the positive response of inflation expectations to a real exchange rate shock and inflation expectations' inertia in response to innovation.

The remainder of this paper is organized as follows: Section 2 presents a brief literature review identifying the determinants of inflation expectations in Colombia. Section 3 describes our VAR with exogenous variables (VAR-X) methodology. Section 4 presents the analysis of empirical results and robustness tests. Section 5 discusses the theoretical and practical implications of our findings and, finally, Section 6 concludes.

2. Literature review

There are different reasons for studying the phenomenon of inflation expectations. As Galvis and Anzoátegui-Zapata (2019a, b) note, three previous groups of papers reflect the relevance of this topic in policy decision-making: (1) inflation expectation's role in monetary policy

(Mankiw *et al*., 2003; De Mendonça, 2007; Montes *et al*., 2016; Coibion *et al*., 2020); (2) convergence between inflation expectations and inflation targeting, transparency and accountability of monetary authorities (Johnson, 2003; Levin *et al*., 2004; Gürkaynak *et al*., 2010); and (3) 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; Beckmann and Czudaj, 2018; Coibion *et al*., 2019; Anzoátegui-Zapata and Galvis-Ciro, 2020).

From a behavioral economics perspective, Rötheli (2020) is one of the first textbooks that developed a behavioral approach to inflation expectations. It uses cognitive psychology in a bottom-up logic based on experiments and historical data. Additionally, Osorio-Barreto *et al*. (2022) provide a systematic literature review of inflation expectations based on three categories: inflation expectations, inflation expectations as a determinant of inflation and behavioral economics. In detail, this paper emphasizes a relevant limitation for understanding this phenomenon: data collection is limited in emerging countries because survey-based measures of inflation expectations are not available.

Regarding recent empirical papers, Sirakovova (2024) analyses the inflation expectations phenomenon from a behavioral macroeconomic perspective. Specifically, this paper examines the patterns in the expected inflation distribution for European Union countries and the USA, highlighting adaptive rationality and psychological decision-making psychological determinants. Lieb and Schuffels (2022), based on the Dutch Central Bank Household Survey, explore the relationship between a household's balance sheets, consumption reactions and inflation expectations via two channels: expected real wealth increases and affectations of the real interest rate. Related to the available data, Kikuchi and Nakazono (2023) find a heterogenous pattern in updating the information process for inflation expectations, combining the survey of Japanese consumers with the data on the actual expenditure of each respondent and examining the effects of purchasing behavior on their expectations.

From a different perspective, Kapoor and Kar (2023) indicate that inflation expectations can be grouped into the following research topics: heterogeneous inflation expectations and the new Keynesian Phillips curve, survey-based measures and information rigidity, monetary policy and authorities, forecasting and the transition to the Euro. These questions highlight that a large portion of the research in this area has been focused on developed countries, given their data availability, and that it is increasingly urgent to have models that empirically explain the behavior of this phenomenon worldwide. Considering that research about inflation expectations is addressed in most developed countries, understanding this phenomenon in emerging regions such as Latin America has gained significant relevance in recent years, especially when there is a great challenge to expand the methodologies for monitoring inflation expectations focused on household surveys (Appendix of Weber *et al*., 2022 lists the inflation expectations surveys around the world). As mentioned above, the analysis of the phenomenon of inflation expectations in emerging countries, such as Colombia, has gained great relevance in understanding how its central bank carries out a strict monetary policy designed to reach the goals specified by authorities.

Despite the importance of inflation expectations, its determinants in developing countries have not been extensively studied. Kapoor and Kar (2023) identify eight future research questions about inflation expectations, highlighting one of them: What benefits can a comprehensive research investigation of 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 still build up the institutions of central banks. Consequently, measuring inflation expectations is a recent challenge, as many of these countries have not developed projects to collect data from household surveys (Galvis and Anzoátegui-Zapata, 2019b).

Regarding the determinants of inflation expectations in Colombia, Table A1 summarizes previous studies on this phenomenon from different perspectives and models. We identified four common topics: (1) estimation and determinants, with different approaches for understanding the dynamics of inflation expectations and its determinants related to interest rates, headline inflation, core inflation, the real output gap and the identification of exogenous shocks (Vargas-Herrera, 2016); (2) measurement comparisons between survey- and market-based inflation expectations, given the available data and measurement implications (Arias *et al.*, 2006); (3) unbiased and efficient tests to identify adaptive or rational expectations and learning patterns (Zárate *et al.*, 2011; Huertas *et al.*, 2015); (4) anchoring of inflation expectations and disagreements between the central bank's communication and the agents' responses (Galvis and Anzoátegui-Zapata, 2019a, b). In this respect, our work differs from those because we include different exogenous variables, such as Colombian social protests and the global supply chain shocks, to account for the recent events that we believe have affected inflation expectations in Colombia.

Regarding the different empirical methods used in the literature, we identified three papers and used them as main references because of their close relationships with our topic. First, Ueda (2010) uses a structural VAR (SVAR) model that includes survey data on households' inflation expectations for Japan and the USA. This study investigates the determinants of inflation expectations and compares their dynamics and properties in the two economies. Specifically, the author imposes short-term non-recursive restrictions by considering the codependence between realized and expected inflation. Ueda finds that inflation expectations adjust more rapidly than realized inflation in response to changes in exogenous prices and monetary policy shocks. Second, Ghosh *et al.* (2021) used an SVAR model with exogenous variables (SVAR-X) to identify the determinants of households' inflation expectations in India. They focus on the endogenous variables proposed by Ueda (2010) and exogenous variables such as oil prices and financial volatility. They conclude that these global factors play a fundamental role in forming inflation expectations. Third, Vargas-Herrera (2016) analyzes different measurements of inflation expectations in Colombia, focusing on a model-based core inflation measure, including the incidence of supply shocks such as the oil price and the El Niño phenomenon (as exogenous variables). The latter is an extensive survey of inflation expectations in Colombia, thus opening a debate on the determinants of these expectations.

We use these studies as a standard to outline our empirical methodology. First, based on Ueda (2010) and Ghosh *et al.* (2021), we identified key endogenous variables for our VAR-X model and introduced other exogenous variables based on Romero and Naranjo-Saldarriaga (2023) and Aastveit *et al.* (2023), following the analytical structure of Vargas-Herrera (2016). Similarly, as novelties, we include other exogenous variables that track Colombian social protests and global supply chain interruptions.

Only a few studies, such as that by Andriantomanga *et al.* (2022), have investigated the relationship between inflation and container shortages. This study examines the incidence of supply chain disruptions in different measures of inflation (headline, food and tradable inflation) and their implications for monetary policy in sub-Saharan Africa. Carrière-Swallow *et al.* (2023) examined the impact of global shipping costs on domestic prices in 30 developed and 16 emerging countries. However, this study only considers the incidence of shipping costs over inflation expectations as an indirect effect.

3. Method

3.1 Research design/model

Following Hansen's (2022) technical note, this VAR model 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 that they can help understand the relationships among endogenous variables, considering the economic settings defined in the exogenous

variables as critical aspects to understanding shocks. Therefore, based on Sims (1980, 1986), Enders (2015) and Stock and Watson (2001), the proposed VAR-X model can be written as:

$$z_t = A(L)\sum_{i=0}^{p} z_{t-i} + \varphi x_t + \varepsilon_t \quad (1)$$

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); $A(L)$ is a matrix in the lag operator L; x_t is a vector of h exogenous variables $x_1, \ldots, x_h$ (the global supply chain price 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 those in ε_t are white-noise disturbances, that is, $E(\varepsilon_t) = 0$, $E(\varepsilon_t, \varepsilon_t') = \Sigma$, $E(\varepsilon_t, \varepsilon_s) = 0\,\forall\, t \neq s$. Particularly, we use a VAR-X model based on recursive short-run restrictions, following Bernanke (1986), Blanchard and Watson (1986) and Lütkepohl *et al.* (2018).

3.2 Data/variables

The availability of statistics on inflation expectations is essential for the proper functioning of an inflation-targeting strategy. To this end, the literature identifies two forms for measuring inflation expectations: (1) market-based, which involves calculations of indicators such as break-even inflation derived from the yields of bonds with various maturities, including 1, 5 and 10 years and (2) survey-based, which are the most common sources of data used to examine and understand inflation expectations, as they capture the formation process influencing households and firms. Survey-based measurements are generally considered more relevant than market-based ones because they provide better insights into changes in expectations and the decision-making processes of diverse agents who may not actively participate in the financial markets that the market-based metrics rely on Ueda (2010).

Most studies in developed countries tend to focus on surveys conducted with households. However, due to the wide range of factors influencing expectations, the information available in Latin America often relates to monitoring the expectations of financial analysts, companies from various sectors, unions and academics.

In Colombia, two institutions collect data on inflation expectations: Banco de la República and Fedesarrollo. Banco de la República gathers monthly survey-based data on inflation expectations from the financial industry as well as quarterly data from a variety of economic sectors. On the other hand, Fedesarrollo, a private non-profit organization, conducts a monthly survey on households (see Table 1). From Table 1, we notice that the series of inflation expectations from Fedesarrollo has a higher mean and standard deviation than the most common survey-based inflation measures supplied by Banco de la República (see Table 1).

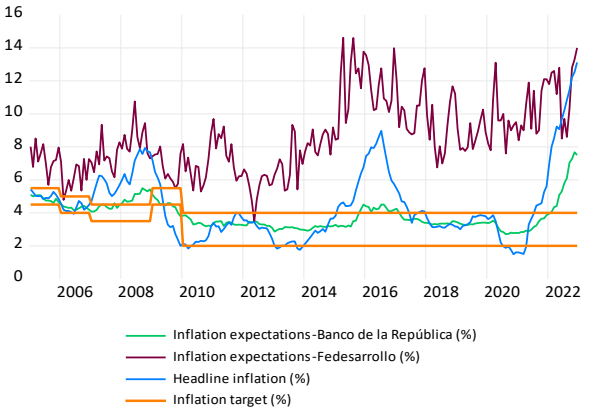
Figure 2 illustrates the time series of the available monthly survey data from Banco de la República and Fedesarrollo. The survey conducted by Banco de la República, which is the primary database used to study the determinants of inflation expectations, indicates that

Table 1. Descriptive statistics and variance ratio test

Measure/Descriptive statistics	Mean	Standard deviation	Coefficient of variation	Min	Max
Banco de la República	4.192639	1.281789	0.30572367	2.7	9
Fedesarrollo	8.720694	2.239695	0.25682532	4.81	14

$F = 0.3275$; degrees of freedom = 71,71; p-value = 0.0000

Source(s): Authors' own work



Source(s): Own elaboration based on Banco de la República and Fedesarrollo, Authors' own work

Figure 2. Headline inflation and inflation expectations for Colombia

inflation expectations are converging toward the proposed target range. This suggests that there is an anchoring effect related to the credibility of the central bank, even though headline inflation remains above the target. Conversely, the data from Fedesarrollo, while exhibiting greater volatility, shows higher expected inflation rates. Curtin (2019) suggests that this discrepancy may arise from a lack of financial and economic literacy, uneven income distribution and the perception among the public that prices are increasing more rapidly. This perception is likely influenced by the high percentage of household budgets that allocate spending toward goods and services in Colombia. For example, it appears that household expectations for inflation are generally higher than those of financial analysts. We choose to utilize quarterly data from Banco de La República because it encompasses a broader range of productive sectors in the economy, making it less biased and volatile than data focused solely on the financial sector or households.

As mentioned previously, we use quarterly survey-based data from the Colombian Central Bank for the 2005Q1–2022Q4 period. However, as we will show later, we contrast the main model's results with a model that includes the quarterly average of inflation expectations based on the survey provided by Fedesarrollo. Table 2 summarizes the descriptions of the variables in relevant studies that used these variables in their models. Figure 3 depicts the respective time series.

Additionally, we employ three exogenous and dummy variables for a more substantial decline in economic activity due to the COVID-19 pandemic in the second quarter of 2020. Table 3 summarizes the descriptions of the exogenous variables with relevant papers that use these variables in their models, and Figure 4 depicts their respective time series.

3.3 Analytical procedures

According to the literature, the interpretation of VAR results does not rest on each variable's estimated contemporaneous and lagged coefficients from the regression model but on two critical elements of the moving average representation: the impulse-response functions (IRF) and forecast error variance decomposition (FEVD). According to Hansen (2022), the IRF of variable *i* concerning innovation *j* is the change in the time *t* projection of the *i*th variable $z_{i,t+h}$ due to the *j*th innovation e_{jt}. In this case, we use a generalized impulse function based on Pesaran and Shin's (1998) study to estimate the IRF and avoid defining the order of the series.

In contrast, the FEVD decomposes multistep forecast error variance by component shock, indicating which shocks contribute the most to the variability of the endogenous variables in

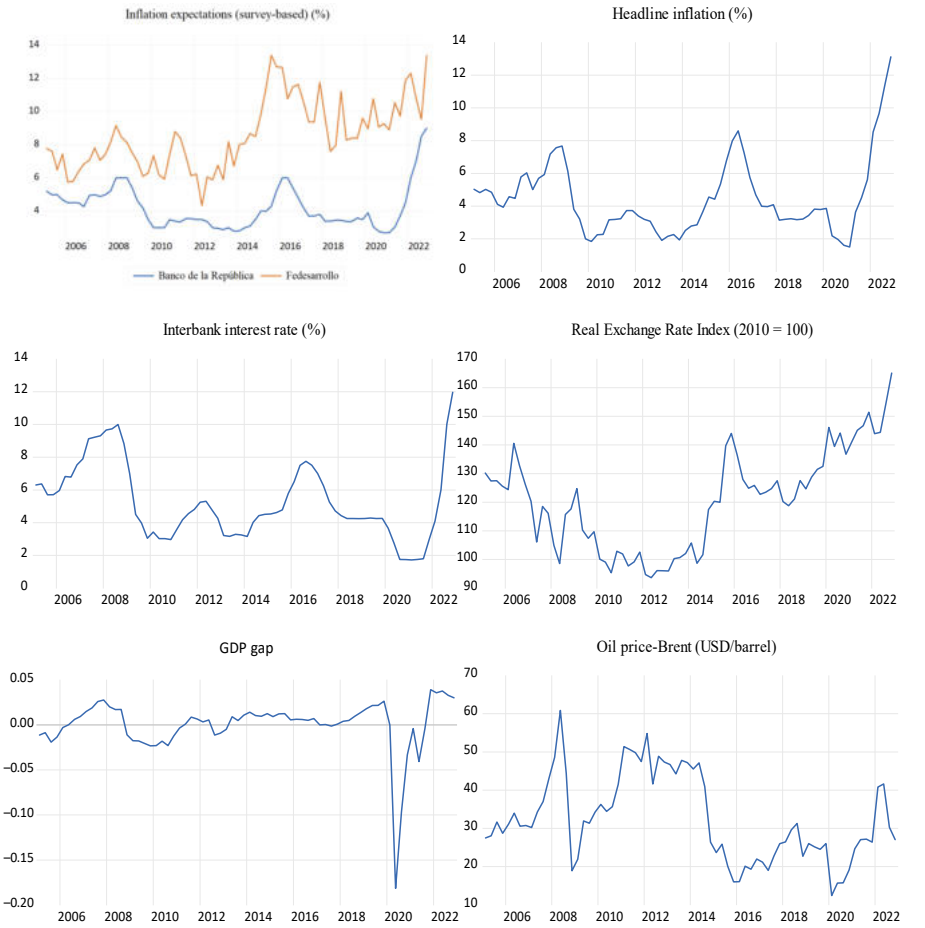
Table 2. Endogenous variable description

Variable	Reference papers	Description
Inflation expectations		*Banco de la República:* Data collected at the end of the year from the following economic sectors based on a quarterly survey: 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 *Fedesarrollo:* Quarterly average of Consumer Opinion Survey based on two questions: (1) Do you believe that over the next 12 months, prices of things in general will go up, go down, or stay the same as they are today? and (2) Percentage-wise, how much do you believe prices of things in general will (rise/fall) over the next 12 months?
Oil price	Huang *et al.* (2016), Szyszko and Rutkowska (2019), Ueda (2010), Aastveit *et al.* (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

Source(s): Authors' own work

the system. Following Ueda (2010) and Ghosh *et al.* (2021), we apply the following Cholesky decomposition ordering (starting with the least to the most endogenous variable) to obtain the variance decompositions. First, we set the Brent crude oil price as a reference, given Colombia's economic dependence in terms of production and export revenues. Second, short-term interest rates are strongly linked to policy interest rates. Third, the real exchange rate index is a key variable in a small open economy. Fourth, the GDP gap captures the movements in output and economic activity around its trends. Fifth, lagged 1-period headline inflation because agents tend to form heuristics with the closest information. And, finally, inflation expectations were obtained from a quarterly survey-based database.

The IRF and variance decompositions of our model enable us to assess how inflation expectations change and evolve in response to shocks or innovations affecting both endogenous and exogenous variables. Additionally, we can calculate the percentage of variability in the variance decomposition of inflation expectations that can be attributed to each specific shock (Galvis and Anzoátegui-Zapata, 2019a, b).



Source(s): Authors elaboration based on the Banco de la República, DANE and EIA, Authors' own work

Figure 3. Time series of endogenous variables

4. Results

4.1 Descriptive analysis

Before we estimate our VAR-X model, we test for the presence of unit roots in the series using the augmented Dickey–Fuller and the Phillips–Perron tests. Table 4 presents the results of the series in logarithms.

Upon inspection, the results indicate that both the GDP gap and protests are stationary, I(0). In contrast, the other series examined are non-stationary, or integrated of order 1, I(1). Consequently, since all series except for the GDP gap and protests are I(1), we will estimate the model using first differences (log differences).

4.2 VAR model

Using the Akaike Information Criterion (AIC), we identified and selected a stable model with six lags, which demonstrated no autocorrelated residuals (see Figure A1 and Tables A2 and A3). It is crucial to emphasize that, while it might seem counterproductive to include oil prices

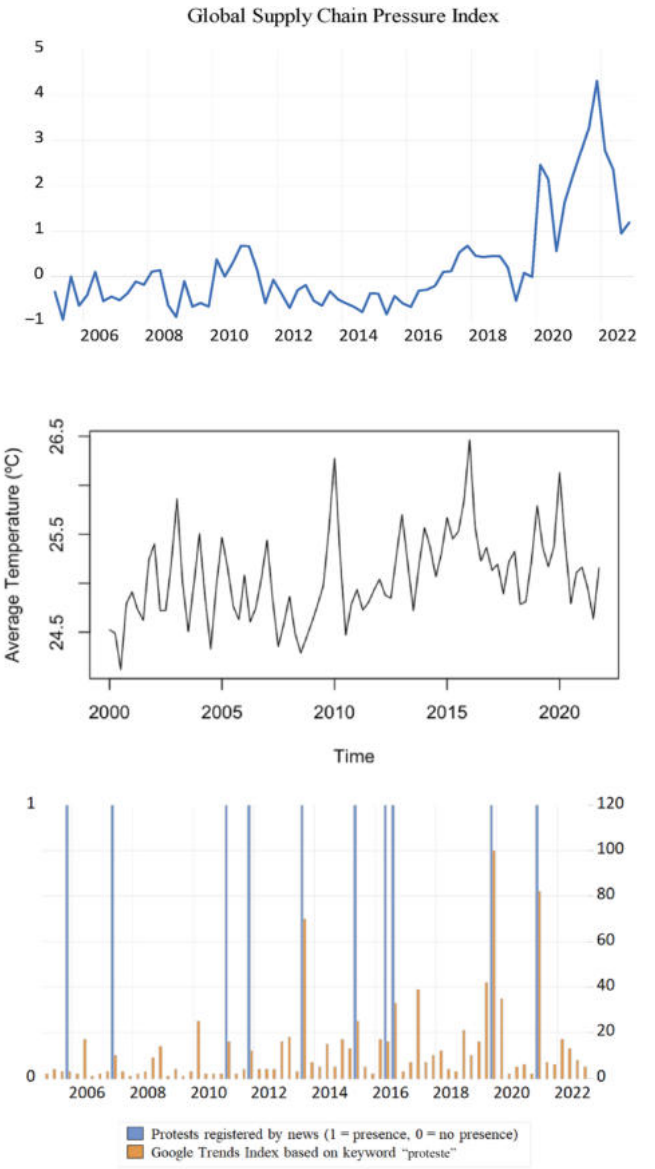
Table 3. Exogenous variable description

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 US 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 USA *Source*: Federal Reserve Bank of New York
Climate supply shock	Vargas-Herrera (2016), Meinerding *et al.* (2022), Romero and Naranjo-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 4 shows the Google Trends index and a dummy variable that takes the value of 1, when these protests and strikes 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

Source(s): Authors' own work

as an endogenous variable, this decision actually strengthens the model's stability. As a result, we classify oil prices as the least endogenous variable for variance decomposition, adhering to Cholesky's ordering. Remarkably, similar outcomes can be achieved if we estimate the IRF based on the Cholesky ordering as well. Figure 5 showcases the IRFs of inflation expectations in response to various innovations with a single generalized standard deviation. Importantly, when examining alternative models that incorporate variables such as climate or protests as endogenous, we find that the patterns of significant shocks remain intact.

Inspection of the IRFs allows us to identify two main effects. First, a significant and positive response of inflation expectations to interest rate shocks in Quarters 3 and 4. This result is consistent with Shults's (2020) findings, which use a model incorporating adaptive and/or static expectations along with bounded rationality for Russia. This model reveals an inertial pattern in inflation expectations and indicates that interest rates have a positive long-term effect on inflation in the Russian economy. Although this result seems counterintuitive at first glance, it makes sense to recognize imperfect knowledge's presence in forming expectations. This information asymmetry may affect the persistence of this variable and



Source(s): Own elaboration based on IDEAM, FED and Google, Authors' own work

Figure 4. Time series of exogenous variables

headline inflation despite contractionary monetary policies, as Orphanides and Williams (2004) suggest. In this sense, this result highlights the non-formation of rational expectations of economic agents, as emphasized by behavioral macroeconomics (De Grauwe and Ji, 2019). Although the IRFs presented in Figure 5 show a positive response of inflation expectations to an interest rate shock within the first quarter, which might be associated with the transmission

Table 4. Unit root tests for endogenous and exogenous variables (series in levels)

Variable	Spec.	Augmented Dickey–Fuller Lags	Test	Phillips–Perron Band	Test
Inflation expectations (Banco de la República)	T, C	1	−1.643912	5	−0.693455
Inflation expectations (Fedesarrollo)	T,C	1	−2.835086	3	−3.456270
Headline inflation	T, C	1	−1.336739	5	−0.988401
GDP gap	T, C	0	−4.222435	4	−4.230041
Interest rate	T, C	1	−2.418756	5	−1.603189
Real exchange rate	T, C	0	−1.910118	5	−1.674525
Oil price	T, C	0	−2.814296	3	−2.853834
GSCPI	T, C	0	−3.235399	1	−3.191502
Protests	T, C	0	−7.754241	6	−7.830609
Average temperature	T, C	2	−1.624668	8	−3.558819

Note(s): Spec. = Specification, CV = critical value. 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
Source(s): Authors' own work

lags of monetary policy and its effect on inflation in a 9–12-month time frame, the VECM results (shown later) indicate that the interest rate negatively affects inflation expectations in the long run.

Second, inflation expectations respond significantly and positively to real exchange rate shocks in 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 by Ghosh *et al.* (2021). Finally, we find an inertial pattern when we analyze inflation expectations' response to their own innovations, which corresponds to adaptive behavior during the first seven-quarters.

Figure 6 presents the variance decomposition results. These suggest that regardless of inflation expectations being highly significant in explaining their own variability – accounting for more than 75% in the short run and 33% in the long run – the real exchange rate (24.87%) and the Brent oil price (18.80%) also become important contributors to the variability of inflation expectations in the long run once the weights stabilize. Additionally, the interest rate (9.93%), lagged headline inflation (6.85%) and GDP gap (5.43%) contribute to a lesser extent to the variability in inflation expectations. These results are consistent 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, that is, the prices of goods and services, their share in household budgets, interest rates, gas and oil prices and exchange rates. At last, it is necessary to highlight that these results are qualitatively similar when we alter the order of the series.

4.3 Robustness

To contrast the previous results, we replicated the structure of the VAR model using the data provided by Fedesarrollo as a measure of inflation expectations. We transformed Fedesarrollo's monthly inflation expectations into quarterly data. This approximation is relevant in emerging countries such as Colombia, considering the need for data to understand the formation process of this phenomenon in households, as occurs primarily in developed countries. Similarly, with the first model, using the AIC, we identify and select a stable model with six lags (see Figure A2 and Table A4) that shows no evidence of autocorrelated residuals (Table A5). Figure 7 displays the IRFs of inflation expectations for different innovations with one generalized standard deviation.

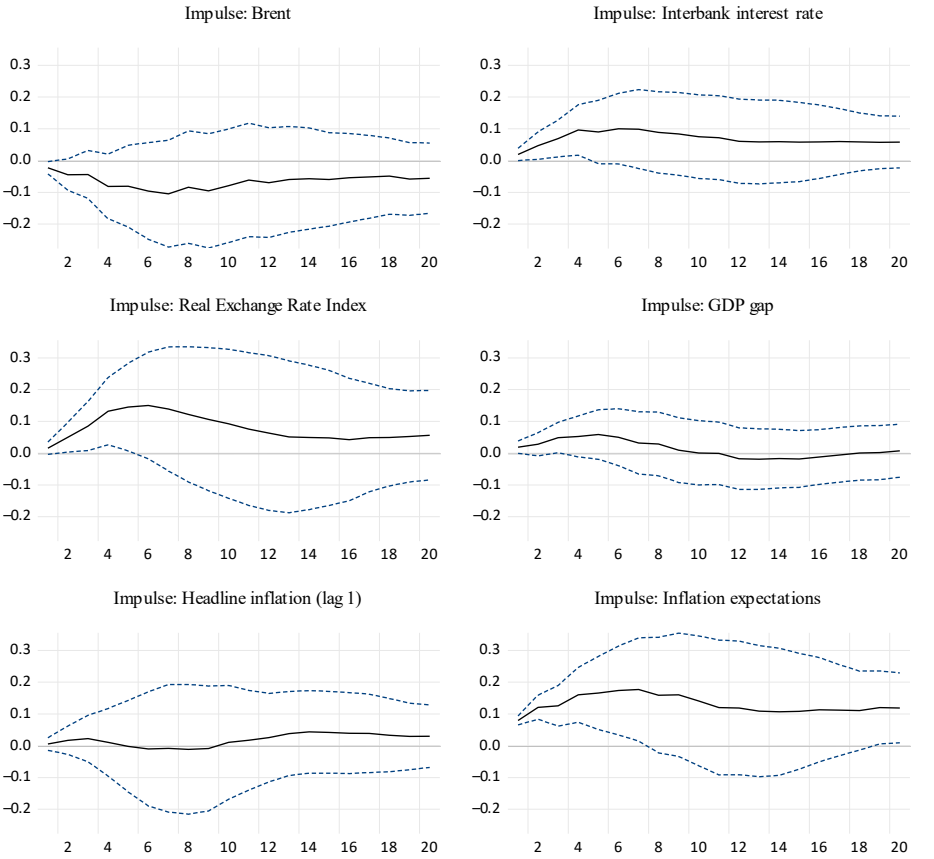


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Figure 5. Accumulated IRF (response variable: inflation expectations, Banco de la República – survey-based)

Compared with the original results, we find a slightly significant positive response of inflation expectations to interest rate shocks in the IRF in Quarter 2, following the same pattern as the previous model. According to the nature of the inflation expectation household survey, this is an interesting result. It reveals an insight into the non-formation of rational expectations of economic agents, especially in the short run. Like the first model, inflation expectations respond significantly and positively to real exchange rate shocks in the first three-quarters, highlighting a pass-through pattern with the same inertial behavior when we analyze inflation expectations' response to their own innovations.

Figure 8 presents the forecast error variance decomposition results. The figure suggests that regardless of inflation expectations being highly significant in explaining their own variability in the short run, the contributions of the real exchange rate (12.30%), oil price (Brent) (12.48%) and one-lag headline inflation (12.75%) have a lower contribution as sources of inflation expectation variability in the long run compared with the previous results.

Considering that the measure of inflation expectations captures the household's behavior, there is an interesting difference compared with results from the model that analyzes the supply formation process. Inflation expectations have a higher contribution to explaining its variance in the long run (52.88%). This result highlights the need for further research to uncover

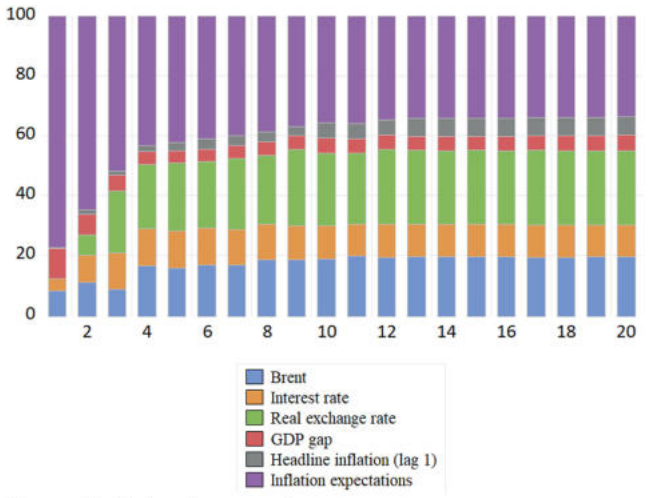

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Figure 6. Variance decomposition of inflation expectations

additional determinants of household behavior, particularly within the behavioral macroeconomics framework that considers an adaptive pattern and bounded rationality. Lastly, to determine whether these results were robust, we changed the ordering of the series for the variance decomposition. Nevertheless, the results are qualitatively similar to the ones reported in Figure 6.

Given the surprising and counterintuitive finding that inflation expectations significantly and positively respond to interest rate shocks in the initial quarters, we will investigate whether these variables are co-integrated or exhibit a long-run equilibrium relationship, that indicates that they tend to converge over time (Engle and Granger, 1987; Johansen, 1991). Hence, we estimate a VECM using Johansen's (1991) methodology to test for co-integration and consider only three variables – the interest rate, real exchange rate and inflation expectations – and the following co-integrating equation, based on the analytical framework of Bogdanski *et al.* (2000):

$$\pi_t^e = f(i_t, rer_t) \tag{2}$$

where π_t^e is the inflation expectation, i_t is the nominal interest rate and rer_t is the real exchange rate. According to this representation, we expect to see a negative relationship between inflation expectations and the nominal interest rate. This is based on the traditional monetary interest rate mechanism and its subsequent effects on inflation expectations through adjustments made by economic agents. We also expect a direct or positive relationship between inflation expectations and the real exchange rate, given the pass-through effect on headline inflation and, consequently, on inflation expectations. The results are summarized in Table 5. The trace co-integration test statistics with no intercept or trend show that one co-integrating relationship is statistically significant at the 1% level. We obtained white-noise residuals for this model, given the *p*-value of the Q-Stat observed in the correlograms (Figure A3).

As an extension of our robustness test, we estimate an alternative VAR-X model by changing the classification of endogenous and exogenous variables. In this revised approach, we treat the GSCPI as an endogenous variable by positioning it second in the ordering (making

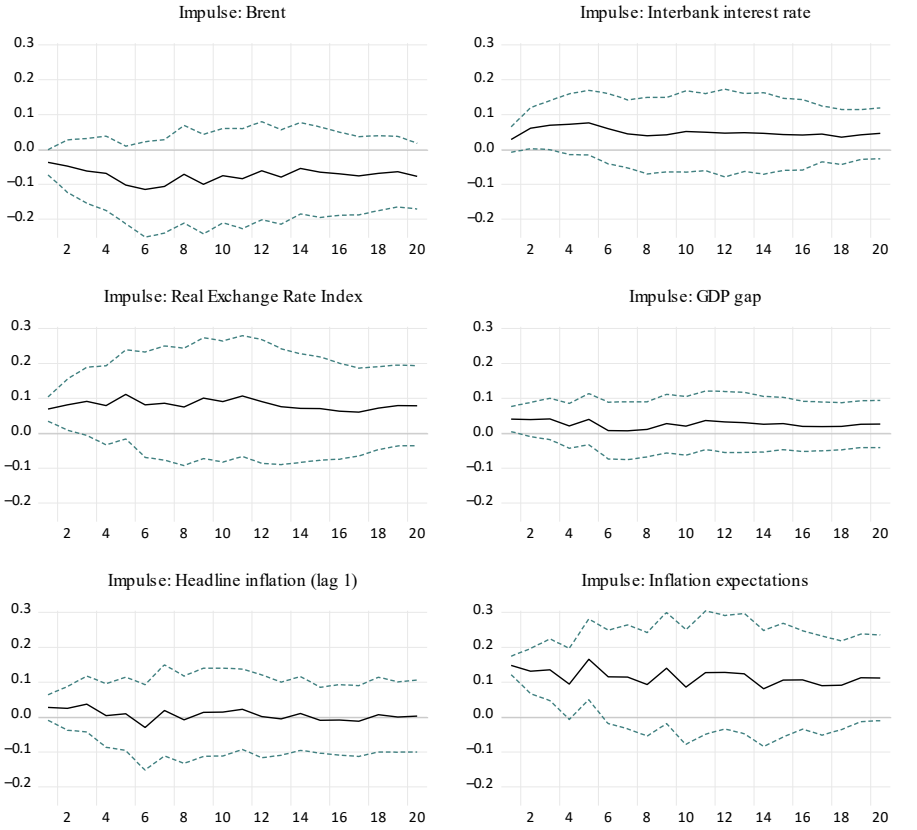

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Figure 7. Accumulated IRF (response variable: inflation expectations, Fedesarrollo – survey-based)

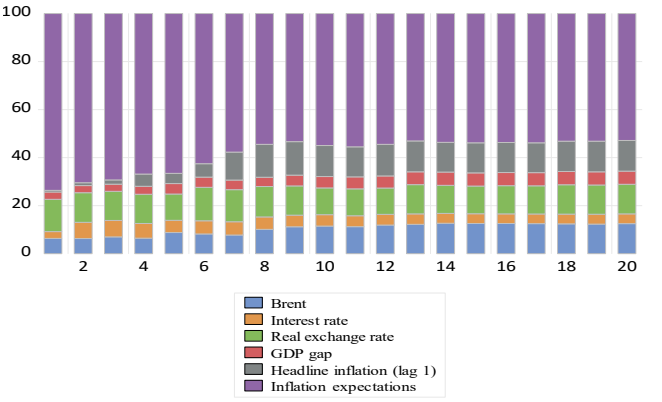

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Figure 8. Variance decomposition of inflation expectations (Fedesarrollo – survey-based)

Table 5. Co-integration test

Cointegration equation	Model
π_t^e	1
rer_t	−0.002598 [−0.61499]
i_t	−0.701786 [−7.67939]

Note(s): *t*-statistics in brackets
Source(s): Authors' own work

it the least endogenous variable), while keeping the other series in the same order as in the original VAR-X model.

Figure 9 illustrates the responses of inflation innovations, for which we use Cholesky decomposition to derive the moving average representation. Upon examining the IRF, we find that the results are qualitatively similar to those of the original model. Notably, we observed a significant and slightly positive impact of both the real exchange rate and the interest rate on inflation expectations in the first quarter. Furthermore, there is a positive and statistically significant response of inflation expectations to a GSCPI innovation that persists over a 20-quarter horizon. This finding is also reflected in the variance decomposition of inflation expectations, which indicates that 16.26% of the variance of the forecast error is attributed to shocks in the GSCPI.

It is important to note that this VAR analysis was conducted without including exogenous variables. Initially, there was a slightly positive significance of the GDP gap, but this significance diminished when supply shocks, such as those proposed in this study, were included. This indicates that the introduction of these variables reveals elements that were previously obscured.

5. Discussions

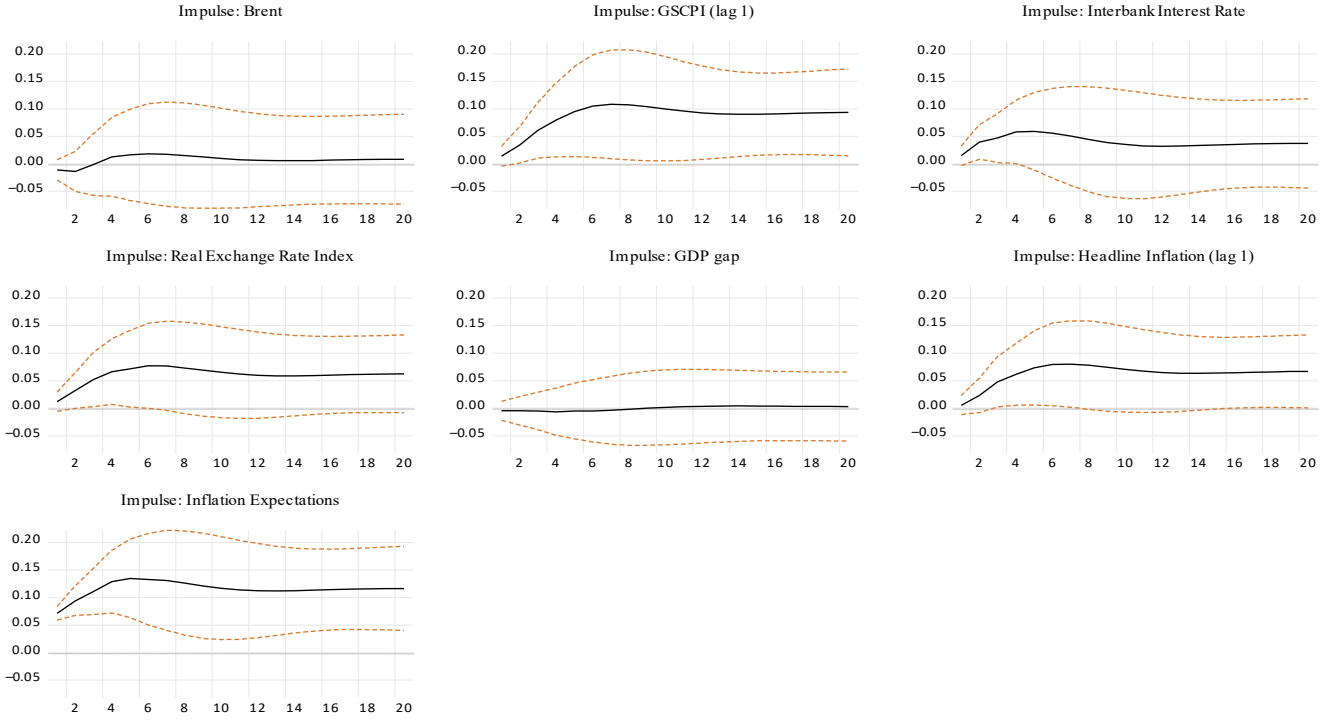
5.1 Theoretical implications

In an inflation-targeting framework, supply shocks – such as those resulting from supply chain disruptions, social protests, pandemics and climate change – present a significant challenge for central banks. These shocks can cause inflation to deviate from its target, forcing central banks to make tough decisions. They must choose between stabilizing inflation, potentially leading to an economic recession, or prioritizing output stabilization while allowing inflation to temporarily exceed the target. This situation creates a trade-off between price stability and economic activity.

This dilemma arises because tightening monetary policy to combat inflation by raising interest rates may further reduce economic activity and exacerbate the output decline caused by the supply shock. While the goal of inflation targeting is price stability, it generally permits some flexibility to accommodate temporary inflation deviations resulting from supply shocks, especially if the central bank views the shock as transitory. Therefore, the effectiveness of monitoring relevant indicators of the state of the economy for decision-making is crucial, as it enables monetary authorities to identify the nature of the shock and assess whether it is likely to be transitory or permanent. In these situations, clear communication from the central bank about the temporary nature of the supply shock and its commitment to restoring inflation to the target level can help anchor inflation expectations.

5.2 Managerial/policy implications

The effectiveness of the inflation-targeting strategy implemented by Banco de La República relies on the monetary board members' understanding of the economy, their ability to make decisions that promote price stability and sustainable growth and their capacity to



Source(s): Authors' own work

Figure 9. Accumulated IRF (response variable: inflation expectations)

communicate the central bank's commitment to addressing both demand and supply shocks in the economy. In this context, the lack of dependable monthly data on inflation expectations is significant. This highlights the need for Banco de La República to develop a project aimed at collecting reliable data on the inflation expectations of households and firms. Having a deeper insight into how households and firms form their expectations, the distinct types of information these groups handle, as well as the differences in their decision-making processes, would provide monetary authorities with valuable insights for implementing effective monetary policy. This knowledge would help in setting an appropriate inflation target and choosing the right policy instruments to achieve the central bank's goals.

Furthermore, the independence of Banco de La República is essential and must be safeguarded. This independence allows monetary authorities to make tough decisions aimed at achieving their goals without succumbing to political pressure from other branches of government. Ultimately, this independence enhances the public's trust in their central bank and facilitates anchoring inflation expectations.

5.3 Limitations and future research agenda

The most important limitation that we faced was the unavailability of reliable and stable monthly data on inflation expectations from households and firms' managers. We noticed the differences that exist between the household inflation expectation data collected by Fedesarrollo and the data from the Banco de La República. As mentioned above, reliable data on the inflation expectations of households and firms will enhance our understanding of the differences in how households and firms form their expectations.

In recent years, two significant events – the COVID-19 pandemic and the supply chain crisis – have highlighted the need to explore the factors influencing inflation expectations related to supply shocks not only in Colombia but also in other developing countries where inflation is relatively high and more volatile. This is essential for understanding monetary policy in our current era of uncertainty and volatility. However, the impact of these events on inflation expectations has been studied only to a limited extent in those countries.

6. Conclusions

Inflation expectations are crucial in an inflation-targeting scheme. This framework enables monitoring of how these expectations align with the proposed target and how they adjust in response to changes in total inflation, demand and supply shocks.

This paper examines the factors influencing inflation expectations in the emerging economy of Colombia. It utilizes quarterly survey-based data on inflation expectations and employs a VAR-X. The empirical findings reveal significant responses to inflation expectations during the first quarter. Specifically, there is a positive correlation between interest rates and inflation expectations, indicating an imperfect understanding of economic events (imperfect knowledge) in the formation of these expectations. Although this positive relationship between interest rates and inflation expectations is observed in the first quarter – attributable to the transmission lags of monetary policy and its effects on inflation over a 9- to 12-month period – the results from a VECM indicate that this relationship is only temporary. In the long run, the interest rate has a negative impact on inflation expectations. Additionally, we find no significant effects on the real exchange rate.

We observe a pass-through effect in which inflation expectations respond positively to real exchange rate shocks, alongside notable inertia of inflation expectations to their own innovations. The addition of exogenous variables enhances the stability of our model by accounting for supply shocks that have not been thoroughly examined in the existing literature. These results underscore the importance of a more comprehensive analysis of the identified determinants from a behavioral macroeconomics perspective, acknowledging the bounded rationality of economic agents.

Moreover, we emphasize the need for reliable household data to align with international research trends, enabling feasible comparisons. Given our findings that inflation expectations significantly influence variance decomposition, it is crucial to investigate how households form their expectations within the context of behavioral economics. We believe it is both possible and practical to conduct experiments aimed at understanding the individual-level expectation–formation process. This approach will allow for an analysis of inflation expectations from regional and local perspectives, thereby enhancing our understanding of their explanatory power in the context of inflation-targeting strategies, which often lack depth in exploring potential regional disparities caused by monetary policy.

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Supplementary Material
The supplementary material for this article can be found online.

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