Uncertainty and monetary policy: the case of the Central Bank of Colombia

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1. Introduction

Apart from the Great Financial Crisis and a politically motivated closure of the Venezuelan market in 2008 and 2009, the Colombian economy went through a period of relative macroeconomic stability between 2004 and 2015. This period came to an end with the conclusion of the commodity super-cycle in 2014–15. The fallout of this shift included a loss of income and an increase in public debt. The latter implied greater vulnerability and a diminished ability to withstand new shocks. In this context, the pandemic came and, afterwards, a succession of domestic and foreign inflationary shocks, an even higher public debt ratio and heightened economic policy uncertainty significantly complicated the job of the central bank – to drive inflation back to target at a low cost in terms of economic activity.

Thus, the environment in which monetary policy operates has shifted markedly over the past five years. The series of unexpected supply shocks has made it difficult to produce and communicate a macroeconomic forecast, strengthening the case against the use of forward guidance. It has also forced the repeated postponement of convergence of inflation to target, with possible consequences for monetary policy credibility. At the same time, greater economic policy uncertainty and an increasingly complex fiscal outlook have pushed up the sovereign risk premium, long-term interest rates and the neutral interest rate.

The highly uncertain environment may have also changed some transmission mechanisms of monetary policy in substantial ways. For example, a loss of monetary policy credibility after the succession of inflationary shocks may have increased the incidence of indexation and thus the importance of past inflation in price formation. Likewise, Osorio (2025) shows that economic policy uncertainty has risen in the past decade, especially after the pandemic, and finds a negative effect of greater uncertainty on the demand and credit channels of monetary policy.[2]

This note outlines how the Central Bank of Colombia has addressed uncertainty in its monetary policy over the past five years. It first presents a brief review of the monetary policy framework and the performance of the Colombian economy. This is followed by a discussion of the types of uncertainty that are typically included in monetary policy analysis in Colombia and of the influence of uncertainty in monetary

policy decisions. Finally, the note describes the main features and some challenges involved in the central bank's communication of uncertainty.

2. The current monetary policy framework in Colombia

Monetary policy in Colombia has followed a fully fledged inflation targeting strategy since 1999. This scheme was successful in driving down inflation from about 10% to the 3% long-term target in 2009, and in maintaining it around target up until the post-pandemic inflationary episodes.

In 2019, the framework was enhanced to deepen the macroeconomic analysis and make policy decisions more robust. Specifically, the forecast rounds were expanded to include more analysis of the data and discussion among the staff and between the staff and Board members. New techniques and refined medium-term forecast models were introduced as well. These changes required the central bank to increase the length and scope of forecast rounds and, consequently, reduce the number of policy interest rate setting Board meetings from 12 in a year to eight.

Today there are four yearly forecast rounds, each including two monthly policy setting Board meetings. In each round, a detailed analysis of new internal and external data is presented to Board members. Then a GDP "nowcast" and short-term forecasts for inflation are prepared and presented to Board members. Next, based on these inputs and on the identification of the macro shocks embedded in them, general equilibrium models are used to produce a central ("modal") medium-term forecast, alternative risk scenarios and "predictive density functions" (measures of uncertainty) for the most important exogenous and endogenous macro variables. Finally, a monetary policy report (MPR) and the staff´s policy recommendation are written and presented to the Board. All along this process, there are several meetings in which Board members interact with the staff, so that the latter may address the former´s comments and concerns. Nevertheless, both the forecast and MPR are the staff´s.

After each monetary policy setting Board meeting, a press statement is released and a press conference is held in which the decision and the main factors behind it are explained to the public. Three working days later, the minutes of the Board meeting are published. They include a brief summary of the most important data considered in the decision, a recap of the main issues on which all Board members agree and a section in which they explain their differences (without identifying individual positions). Four times a year, this is accompanied by the publication and presentation of the MPR by the staff, including the main elements of the forecast and the key risks around it.

Neither the forecast path of interest rates nor the staff´s policy recommendation is published. Since the forecast stems from the staff´s assumptions and assessments, the interest rate path does not necessarily reflect the collective or individual views of the Board. Hence, its publication may complicate the communication of the policy decision and the forecast. For most audiences, the distinction between the Board and the staff of the central bank is blurry. In this context, explaining differences between a published path and policy decisions, or changes in a published path, may prove cumbersome. For the most sophisticated audience (market analysts), the MPR provides a qualitative comparison between the forecast interest rate path and the median of a central bank survey among analysts. Namely, the MPR indicates whether

the forecast interest rate path is, on average, above or below the median of the survey responses. The staff´s policy recommendation is not published, in order to keep communication between the Board and the staff frank and open, without any hindrance from outside.

3. The performance of the Colombian economy in the past five years: a slew of large shocks

Since the pandemic, monetary policy has been made in an environment of heightened uncertainty. During the pandemic, uncertainty was particularly of the "Knightian" type, because of the shock itself and the extraordinary public policy responses that affected the transmission mechanisms and distorted some traditional indicators (eg core inflation and rents).

The pandemic has been followed by a succession of large and sometimes persistent external and domestic shocks. The disruption of global supply chains, increased costs of international trade and Russia´s invasion of Ukraine were relevant external shocks that influenced monetary policy everywhere. In Colombia, internal shocks were perhaps as important as, or even more important than, the external ones.

A serious social unrest episode in 2021 had large effects on the risk premium, the exchange rate and food supply. The "La Niña" and "El Niño" phenomena also disturbed the food and (hydroelectric) energy supply. Political risk and fiscal deterioration raised risk premia and prompted a currency depreciation in 2021 and 2022. These shocks hit an economy characterised by strong demand, following the pandemic-related macro policy stimuli and a significant expansion of the domestic loan supply. Afterwards, a large correction of heavily subsidised fuel prices in 2023 and remarkably high increases of the minimum wage in the past four years have had substantial effects on local prices.
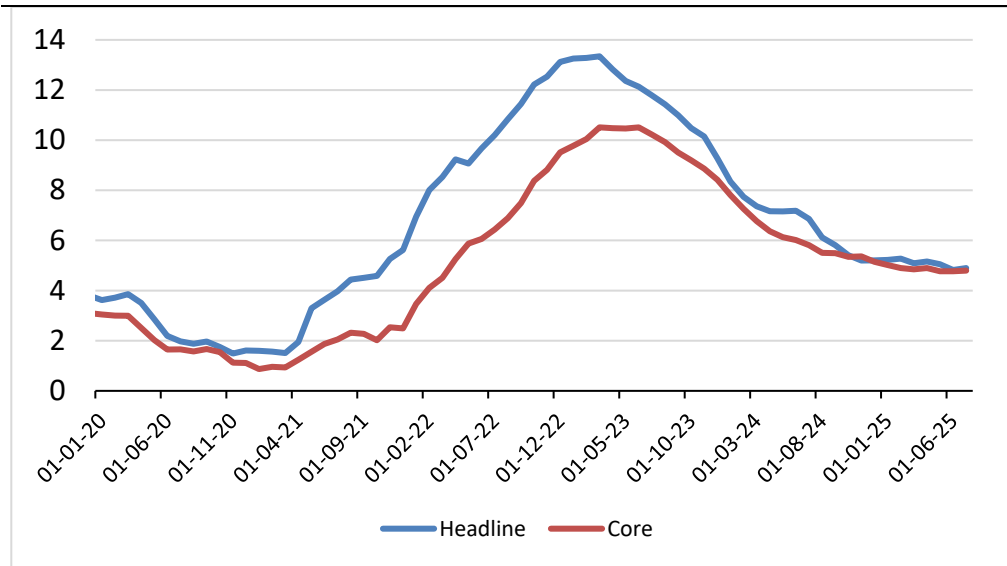
As a result, there have been large and persistent inflation deviations from target in the past four years (Graph 1). Consequently, the central bank has faced serious difficulties with bringing inflation back to target without heavy losses in economic activity and has had to deal with a deterioration of the credibility of the inflation target, possibly increasing the degree to which prices are indexed to past inflation.

To bring inflation back to the 3% target, monetary policy has been **contractionary since mid-2022** (Graph 2). Inflation has fallen since the second quarter of 2023, after the effects of the shocks vanished and as a result of tight policy. The excess demand and large current account deficit observed in 2022 (6% of GDP) were corrected in 2023 (Graph 3). In 2025, convergence of inflation to target has slowed down and growth has gradually recovered, requiring a continued contractionary stance of monetary policy.

The succession of unanticipated large shocks has made it difficult to credibly communicate a time of convergence to target and may have reduced the credibility of the announcements in that regard. Hence, dealing with and communicating uncertainty have proven very difficult challenges for monetary policy in Colombia in the past five years.

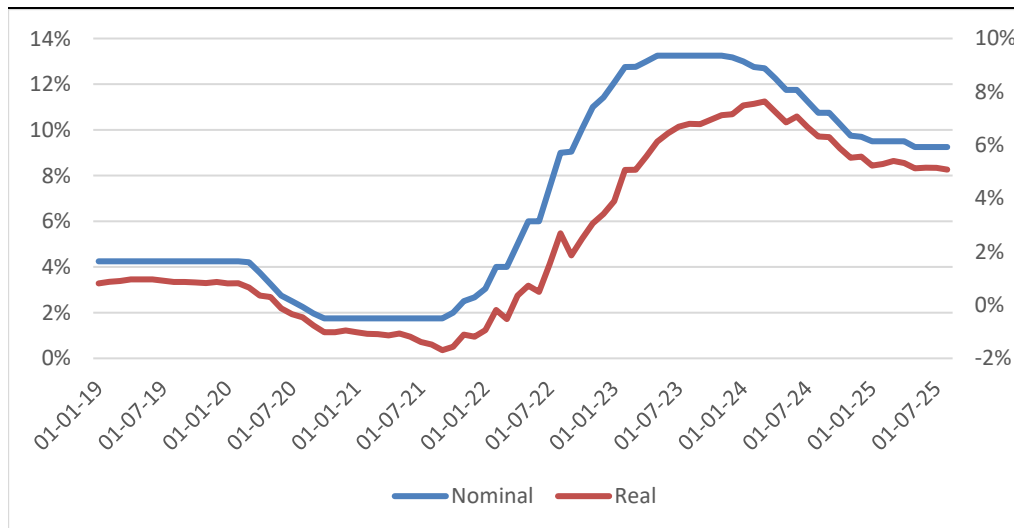## Headline and core CPI inflation

Graph 1

Core inflation excludes food and regulated prices.

Sources: Central Bank of Colombia; DANE.

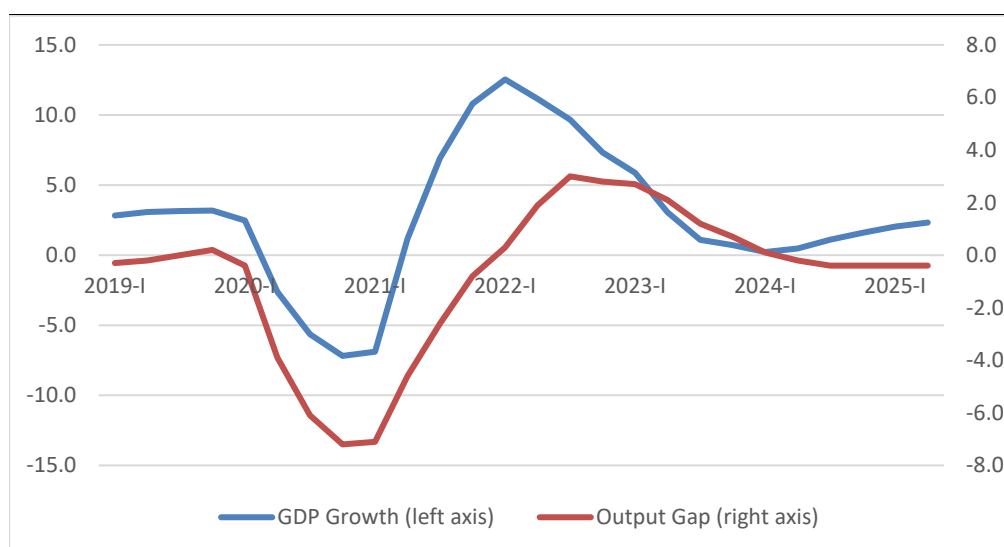## Nominal and real ex ante monetary policy interest rate

Graph 2

The real ex ante policy rate is calculated with one-year-ahead inflation expectations from the central bank's monthly experts survey.

Source: Central Bank of Colombia.

12-month GDP growth and output gap

Graph 3

Both the 12-month GDP growth rate and the output gap are calculated based on GDP series adjusted for seasonality and calendar effects.

Sources: Central Bank of Colombia; DANE.

4. Types of uncertainty and their treatment in monetary policy analysis

The typical monetary policy analysis at the Central Bank of Colombia takes into account uncertainty on the nature and duration of observed or expected shocks, as well as on the transmission channels of monetary policy (as reflected in the specification and parameters of the general equilibrium models used for forecast and policy simulation). Unknown unknowns are not usually considered in the analysis; the Covid-19 episode was a notable exception (Box 1).

Relevant sources of uncertainty are incorporated in the assessment of monetary policy through an explicit list of "key judgments" used to build the central forecast scenario. Deviations from those "key judgments" constitute key risks to the macro forecast and the policy interest rate path implicit in it. According to their importance, some of these risks are illustrated in scenarios presented to the Board along with the main messages about their consequences on the main macro variables (inflation, output and interest rates). During the forecast round, both the staff and Board members may suggest alternative scenarios.

Recent examples of these scenarios include the effects of anticipated, large increases of the minimum wage, loss of credibility of the inflation target, unexpected firming of US monetary policy and tighter external financial conditions resulting from increased risk aversion or fiscal deterioration. Scenarios related to shocks to exogenous variables are based on explicit assumptions about their nature and persistence, and are constructed using the core macro models (eg minimum wage,

Box 1

Monetary policy analysis during the Covid-19 episode

The Covid-19 crisis epitomises the challenges posed by an episode of "Knightian" uncertainty that requires an emergency shift in the process of monetary policy analysis and decision-making. There was no previous experience with or knowledge of a similar shock. There was no external benchmark or event that could shed light on an adequate response.

The shock was believed to have both supply and demand elements of unknown magnitude and persistence. Transmission mechanisms did not work as in normal times. In particular, the strict lockdowns and an unpredictable outlook implied a muted response of consumption and investment to monetary stimuli (Osorio (2025), Falconio and Schumacher (2025)). A financial, internal and external element of the shock became crucial, as the real effects of the pandemic coupled with heightened risk aversion compromised the functioning of the FX and public debt markets, endangered credit supply and threatened financial stability with a run on open-ended money market funds. Thus, a myriad of possible macro-financial outcomes emerged, the probabilities of which were very hard to assess and which required a comprehensive policy response involving several central bank tools (Cardozo et al (2023)). These factors and the simultaneous public policy responses in other fronts (sanitary, fiscal, financial) made it hard, if not impossible, to ascertain a "central scenario", let alone a probability distribution of exogenous and endogenous variables.

Because of the elevated uncertainty and the array of shocks hitting various markets, interest policy rate decision Board meetings were scheduled every month in 2020 (up from only eight a year in normal times). Staff produced and published relatively broad "forecast" ranges for the main variables, without probabilities associated to them. From the policy point of view, efforts concentrated on stabilising financial and credit markets, while the policy rate was reduced gradually. This feature of the policy response was shared by some central banks in Latin America (eg Brazil and Mexico) but differed from the reaction of other central banks in the region (eg Chile and Peru). In the case of Colombia, transmission through traditional demand and credit channels was deemed weak, while the impact of an aggressive interest rate reduction on volatile capital flows, risk premium and the exchange rate was considered risky (Cardozo et al (2023, pp 646–50)).

The gradualism of the interest rate reduction during the pandemic is an interesting issue from the point of view of optimal or robust policy responses. A robust control approach would minimise the maximum loss across a range of possible policy alternatives, even without any knowledge of the probability distribution of different scenarios. This framework seems appropriate when the cost of the worst outcomes from the policies considered is steep (Barlevy (2009, p 44)), as in the Covid-19 crisis. The sharp depreciation of the Colombian peso (COP), the run on open-ended money market funds and the uncertainty about the future effects of the pandemic entailed acute risks to capital flows and financial stability, especially if monetary policy was relaxed too fast. At the same time, a perceived muted response of aggregate demand to monetary policy easing reinforced the arguments for a gradual adjustment of the interest rate.

The gradualist approach taken by the Central Bank of Colombia can also be understood from the classical perspective of optimal monetary policy under uncertainty (Brainard (1967)), although with an interesting twist. As noted, the transmission of monetary policy to aggregate demand was muted by the features of the pandemic. Thus, there was some certainty about a diminished coefficient of the interest rate in an "IS" equation. Ceteris paribus, this would prompt a *more aggressive* policy response to a shock that reduced both activity and inflation (the "demand" component of the Covid-19 shock).

However, at the same time, the financial component of the shock markedly raised the uncertainty about the effect of interest rate shifts on the exchange rate and, thereby, on inflation. Following Brainard´s principle, this would favour a more gradual adjustment of the interest rate. Hence, there were two opposing forces regarding the optimal strength of the policy reaction to the shock. In particular, the gradualist approach could be optimal for a sufficiently large increase in the central bank's uncertainty about the response of the exchange rate to the interest rate. Notice that this argument follows from the narrow focus on inflation, without any consideration of financial stability. These ideas are illustrated in the Appendix through a simple model within Brainard´s framework.

external interest rates and risk premium shocks). Scenarios of policy credibility losses are built using satellite models in which the core specification and some parameters are adjusted to represent the risk.

Besides risk scenarios, four times a year the staff compute "predictive densities" for the main exogenous and endogenous variables of the forecast (Del Negro and Schorfheide (2013), Méndez-Vizcaíno et al (2021)). These are distributions based on the estimated probability densities of shocks in the general equilibrium models used to produce the forecast. The probability densities of these shocks are in turn informed by forecast errors, but their variance or asymmetry can be adjusted according to the staff´s assessment of the risks going forward. Draws from the shock distributions are then included in the general equilibrium models to compute equilibrium paths for the endogenous variables over the forecast horizon. Thus, complete distributions (predictive densities) for these variables are derived from multiple shock draws. Importantly, these distributions account only for the risks represented by the shocks considered. In particular, they do not include uncertainty about the parameters of the models or other sources of risk.

The predictive densities are a key tool to quantify uncertainty and estimate a balance of risks of monetary policy. They are presented to the Board with a discussion of their shifts and the policy trade-offs implied. For example, if supply or currency depreciation risks are prominent at some point in time, the predictive density of inflation will exhibit an upward bias and the probability of values of inflation close to target will be lower than usual, at least in part of the forecast horizon. Consequently, the predictive density of the policy interest rate will be skewed to the upside, while the GDP distribution will show a downward bias.

When providing the policy recommendation to the Board, the staff explicitly consider the initial state of the economy (inflation above/below target, excess demand or capacity, the current stance of policy), the central forecast and a balance of its risks (from predictive densities or risk scenarios). Suppose, for example, that inflation is above – but converging to – target and the policy rate is above neutral. If risks are tilted towards higher inflation over the forecast horizon, staff could recommend a more gradual relaxation of policy than the central scenario would imply.

5. The influence of uncertainty on monetary policy decision-making

The Board of Directors is a plural body with differences among its members on the assessment of macro shocks, transmission mechanisms and risks to the forecast. Hence, it is difficult to think about a "policy reaction function" as a systematic response of the Board to a macro configuration. However, the evaluation of the balance of risks (based on the discussion of the staff´s) is a salient feature of the policymaking process and a key determinant of the policy decision.

More specifically, in the hiking phase of the policy interest rate cycle, the sheer size of the coinciding inflationary shocks and solid aggregate demand in 2022 required a strong policy response from the central bank. Moreover, other factors related to uncertainty, such as the risk of de-anchoring inflation expectations,

reinforced the case for large increases in the interest rate. Ex post, a weaker demand channel resulting from increased uncertainty of economic policy (Osorio (2025)) provides additional support for this course of action.

By contrast, the speed of interest rate cuts has been comparatively low, in view of the still sizeable deviation of inflation from target and the persistence of supply shocks (eg domestic fuel price increases of 45% in 2023). Furthermore, prudent policy responses resulted from an outlook with upside inflation risks or with risks of higher risk premia (with implications for the exchange rate or the neutral interest rate), stemming from a deterioration of public finances or greater international risk aversion. Likewise, the possibility of increased inflation inertia due to long deviations of inflation from target induced gradualism in policy rate cuts.

From the perspective of transmission mechanisms, the latter could be understood as increased "backward-looking" parameters in the Phillips curves that raise the "intrinsic" persistence of inflation. Interestingly, not only the size of but also the uncertainty around these coefficients is relevant as a rationale of a prudent approach to interest rate cuts. From a robust control perspective, a central bank facing greater uncertainty on past inflation coefficients in the Phillips curve would choose to assume large values for them, since they yield the greatest losses that policy should minimise (Barlevy (2009, pp 48–49)).

In the context of the sequence of large inflationary shocks which have occurred since 2021 and the ensuing postponement of the convergence to target, the Board has avoided specific forward guidance. Interest rates have been high and far from any effective lower bound, reducing the need for forward guidance to bolster policy effectiveness. Moreover, the burden of explaining repeated shifts in the expected policy rate path could be sizeable in junctures characterised by the close occurrence of several disturbances. For the same reason, it has been difficult to make statements on future conditional paths of the interest rate. The usual conditioning factors are endogenous variables (eg observed or expected inflation) that may respond differently to the myriads of shocks that may hit the economy. At a very basic level, one can hardly communicate what one cannot predict with some "reasonable" degree of certainty.

Consistent with its inflation targeting strategy, the Board prefers to be as predictable as possible in order to guide expectations along the policy objectives and enhance policy effectiveness. However, the very uncertainty of the environment in which monetary policy has been made in the past five years severely limits the policymaker´s ability to be predictable. It has not been a matter of "seeing through" a small number of conventional supply shocks, but of dealing with several overlapping, large shocks of varied nature, magnitude and persistence.

6. The communication of uncertainty

The communication of uncertainty has been a serious challenge for the central bank in the past five years because market analysts and the general public tend to focus on the "modal" or central scenario. Hence, a conscious effort has been made at the press conference after Board meetings and, especially, in the publication and presentation of the MPR, to emphasise the degree of general uncertainty of the forecast, its variation and its main sources.

The predictive densities for all variables except the interest rate are published in the MPR and a section on the risks to the forecast is included in this document. It discusses qualitatively the main risks and their effects on the outlook and policy. Quantitative risk scenarios have not been published so far to avoid confusion and long, complex descriptions of the magnitude and persistence of the shocks considered. In the presentation of the MPR, a list of the main risks to the forecast is included, along with their implications for inflation, economic activity and the interest rate. Box 2 shows an example of this list (translated into English). Risks are classified according to their effect on inflation, interest rates and growth, and their balance is consistent with the shapes of the predictive densities of those variables.

As mentioned in the previous section, because of the highly uncertain environment, no specific forward guidance is provided and the data dependence of future policy decisions is emphasised in public statements. Nevertheless, the Board and the staff have communicated in broad terms that, given the large distance of inflation from target, the policy stance will remain contractionary for a long period.

As indicated above, the sequence of shocks of the past four years has produced long departures of inflation from target and has complicated policy decisions and communication. The usual practice of assuming no large new shocks in the forecast has led to an underestimation of the convergence time to target, as such shocks have indeed appeared. In this context, uncertainty regarding future shocks and the future effects of current and past ones poses a challenge to the communication of a credible path of disinflation towards the target. A wide range for the inflation forecast path, reflecting high uncertainty, may undermine the signal of commitment to reaching the target within the policy horizon (typically two years).

Box 2

Forecast risks: The risk balance results in an **upward bias** on inflation and interest rates, and a **downward bias** on growth.

Risks:
- **+ Inflation/interest rates, – growth:**
  - Future real minimum wage increases above inflation + changes in productivity
  - Deterioration in external financial conditions or sovereign risk perception leading to exchange rate pressures or increases in the neutral real interest rate
    - Prospects of deteriorating public finances
    - Uncertainty about external financial conditions (eg Federal Reserve interest rates)
  - Larger adjustments in regulated prices (eg natural gas)
  - Greater inertia and de-anchoring of expectations due to persistent deviations of inflation from the 3% target
- **? Inflation/interest rates, – growth**
  - Impact of US tariff policies
- **– Inflation/interest rates, – growth**
  - Reductions in public spending required to avoid sharp increases in debt
- **+ Inflation/interest rates, + growth**
  - Greater persistence of already observed private domestic demand dynamics and stronger fiscal stimulus

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7. Conclusion

The marked increase in uncertainty has been a salient feature of the macroeconomic environment in the past five years. It has come with a slew of inflationary shocks that have posed the most serious challenge to the Central Bank of Colombia in its 26-year inflation targeting regime. Heightened uncertainty has affected the operation of monetary policy on many fronts. The succession of shocks has delayed the convergence of inflation to target, complicated the communication of a convergence horizon and compromised the credibility of the target. Greater external and internal risks have strengthened a forceful cycle of policy rate hikes and induced a cautious phase of interest rate cuts in the midst of large and persistent deviations of inflation from target. Some transmission mechanisms may have been affected by greater uncertainty on economic policy (the demand channel) and the long deviations from the inflation target (inflation inertia). Monetary authorities have avoided forward guidance in a highly uncertain environment and have reiterated the data dependence of future policy decisions.

Uncertainty has been incorporated into monetary policy analysis through risk scenarios and predictive densities of the main endogenous macro variables. The latter have reflected uncertainty in a way that preserves the general equilibrium consistency of the outcomes of different arrays of exogenous shocks. They are useful to assess the probability of specific intervals for inflation, growth and interest rates in the future, and, thereby, to quantify a balance of risks. Communication of uncertainty is carried out with the predictive densities and with a description of the main risks to the macroeconomic forecast and their balance.

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Appendix: a simple model of optimal interest rate policy during the pandemic

Consider a simple short-term macroeconomic model characterised by an IS curve, an open economy Phillips curve, and a negative relationship between the exchange rate (domestic currency units for one foreign currency unit) and the domestic interest rate, inspired by the framework posited by Barlevy (2009) and Brainard (1967):

$$y = x - k\,r \qquad \text{(IS)}$$
$$\pi = \pi^T + a\,y + b\,q \qquad \text{(Phillips curve)}$$
$$q = z - (c + \varepsilon)\,r \qquad \text{(Exchange rate)}$$

where y, r and q are measures of the output, interest rate and exchange rate gaps, respectively. The Phillips curve assumes perfect credibility of an inflation target, π^T, so that inflation expectations coincide with the target. Inflation deviations from target are due to output or exchange rate gaps. In turn, these gaps may emerge because of shocks x and z to aggregate demand and the exchange rate, respectively.

Monetary policy influences inflation through the demand channel (parameter k) and the exchange rate channel. The latter is subject to uncertainty, as reflected by a random component, ε, in the coefficient linking the interest rate to the exchange rate. ε has mean zero and variance σ^2. This is the only source of uncertainty in the economy and its probability distribution is known by the central bank.

According to the equations above, equilibrium inflation is:

$$\pi = \pi^T + a\,x + b\,z - (a\,k + b\,(c + \varepsilon))\,r$$

The central bank chooses the interest rate, r, to minimise the expected square deviations of inflation from target:

$$\underset{r}{Min}\ E[\,(\pi - \pi^T)^2\,] \quad \Rightarrow \quad \underset{r}{Min}\ E[\,(a\,x + b\,z - (a\,k + b\,(c + \varepsilon))\,r)^2\,]$$

The solution to this problem yields the optimal monetary policy response to the shocks:

$$r = (a\,x + b\,z)\,[\,(a\,k + b\,c) / (b^2\,\sigma^2 + (a\,k + b\,c)^2)\,]$$

Thus, the optimal interest rate response to the composite shock term, $(a\,x + b\,z)$, is given by:

$$h \equiv dr/d(a\,x + b\,z) = (a\,k + b\,c) / (b^2\,\sigma^2 + (a\,k + b\,c)^2) \qquad (1)$$

As noted in the text, the restrictions imposed by the lockdowns and the uncertainty surrounding the effects and duration of the pandemic reduced the transmission of interest rate shifts to aggregate demand (lower k). As a result, the policy response to a disinflationary shock would have to be stronger:

$$\partial h / \partial k = a\,(b^2\,\sigma^2 - (a\,k + b\,c)^2) / (b^2\,\sigma^2 + (a\,k + b\,c)^2)^2$$

It follows that $\partial h/\partial k < 0$ if $\sigma^2 < c^2 + [((ak)^2 + 2\,a\,k\,b\,c\,)/b^2]$. Notice that if $\sigma^2 = 0$, then $\partial h/\partial k < 0$. In other words, in the absence of uncertainty, the policy response to a shock to inflation becomes more aggressive as the reaction of aggregate demand to the interest rate falls. When uncertainty is present, this result will hold as long as the variance of the random component of the effect of the interest rate on inflation

is small with respect to the magnitude of the deterministic component.[3] Intuitively, with a weaker demand channel, the central bank will optimally become more responsive to inflation shocks, unless uncertainty about other transmission mechanisms is too high; in that case, a stronger policy response will raise the variance of inflation around the target and the central bank will opt for a more gradualist approach.

As stated in Box 1, the reduction of the response of aggregate demand to the interest rate during the pandemic came hand in hand with greater uncertainty about the effect of interest rate movements on the exchange rate in the midst of heightened risk aversion, financial market disruption, collapsing terms of trade and volatile capital flows. In the model, this would appear as a higher value of σ^2. A simple inspection of equation (1) reveals that $\partial h/\partial \sigma^2 < 0$.

Therefore, two opposite forces were affecting the intensity of the policy response to the Covid-19 shock. On the one hand, a weaker impact of the interest rate on aggregate demand required a greater movement of the interest rate. On the other, higher uncertainty about the effect of the interest rate on the exchange rate and inflation called for a more muted response. The final result depends on the perceived strength of these forces. For a sufficiently large increase in the uncertainty on the exchange rate reaction, the gradualist approach would prevail:

$\partial h/\partial k < 0$, $\partial h/\partial \sigma^2 < 0$, $\Delta k < 0$ and $\Delta \sigma^2 >> 0$ $\Rightarrow$ $\Delta h = \partial h/\partial k \, \Delta k + \partial h/\partial \sigma^2 \, \Delta \sigma^2 < 0$

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[3] For example, $\sigma^2 < c^2$ is a sufficient condition for this to be true. That is, if the standard deviation of the response of the exchange rate to the interest rate is lower than the mean value of this coefficient, then the result will hold.