Box 1
Index of Common Inflation Expectations for Colombia

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This box outlines the uses and construction of *Banco de la República's* (*BanRep*) index of common inflation expectations for Colombia (ICEI for its initials in Spanish). This new tool of analysis captures commonalities within a wide array of indicators of expected inflation from diverse economic agents and across varying time horizons.

As mentioned in previous Monetary Policy Reports[1], inflation expectations provide vital information for central banks. They allow policymakers to evaluate the current and future states of the economy and can be used to guide monetary policy and compare inflation forecasts. In this context, the ICEI captures within a single indicator the commonalities contained within a diverse set of expected inflation indicators.

The construction of *BanRep's* ICEI follows closely on work published by Ahn et al. (2020) in the U.S. Federal Reserve's *Fed's Notes* on its own Index of Common Inflation Expectations (CIE). The Fed's index considers 21 indicators of expected CPI, core CPI, and personal consumption expenditures (PCE) inflation. The sources of information include surveys of various economic agents and information gleaned from financial markets

The following sections describe methodological aspects of *BanRep's* ICEI, the data sets used for its estimation, and its primary results.

1. Methodology

The ICEI estimate is based on a dynamic factor model (DFM)[2] that captures the common movements within a set of time series, extrapolating a unique unobservable[3] signal or common factor. *BanRep* has used this methodology in the past, for example for forecasts of economic activity (Galeano-Ramírez et al., 2021) and an indicator for the Colombian labor market (Cristiano-Botia et al., 2021).

ICEI construction standardizes[4] the measures of expected inflation to reduce possible estimation biases caused by the volatility of some series. As a result, the ICEI level cannot be interpreted in economic terms. However, the indicator does provide information over the common dynamic of the set of expectations being analyzed.

The space-state representation used in the construction of the ICEI is as follows:

$$Y_t = Z_t x_t + \varepsilon_t$$
$$x_t = \rho x_{t-1} + \eta_t,$$

Where Y_t is a vector of observed variables, Z_t is the vector of parameters to be estimated, and x_t is a latent factor that accounts for the common signal in the expectation measures and follows an AR(1) process. The terms ε_t and η_t denote shocks to the measurement and transition equations, respectively, and ρ is the persistence of the factor x_t. The ICEI contains both monthly and quarterly expectations. As a result, a weighing matrix of ones and zeros is introduced into the measurement equation, allowing for unobserved variables in the period t to be discarded in quarterly observations.

The estimate of the DFM parameters is done by maximizing the likelihood function through a particle swarm optimization (PSO) metaheuristic (Kennedy et al., 1995). In addition to the parameters of the model, the estimate of the common factor of the set of expectations under consideration is obtained through this exercise.

The ICEI could be projected[5] on a particular indicator of inflation expectations, or even on a series of observed inflation, to obtain an interpretable level. However, the results depend to a large degree on the individual indicator, whose selection is subjective. With that in mind, *BanRep* does not forecast the ICEI and the analysis is focused on its dynamic, more so than on its level in absolute terms. That said, relative comparisons can be drawn on the ICEI level over the length of the historical series of the indicator.

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1   See https://www.banrep.gov.co/es/informe-politica-monetaria-enero-2021-0 and https://www.banrep.gov.co/informe-politica-monetaria-abril-2021-0

2   Stock and Watson (2011) conducted a literature review related to the applications, empirical findings, and theoretical results of the DFM.

3   Ahn et al. (2020) represents the unobserved common factor as the measure considered by the set of inflation expectations, whose weights are directly related with collective movements of the series.

4   To standardize a series, the indicator average is removed and divided by its standard deviation. The new indicator will have an average of 0 and the standard deviation will equal 1.

5   The projection consists of reverting the standardization process used in the time series in question. For example, the Fed projects the CEI for expected inflation at 10 years from the Survey of Professional Forecasters.

2. Data

Construction of the ICEI considers 40 indicators of expected inflation, which include data on both the headline inflation basket and the basket excluding food. These indicators account for diverse terms, frequencies (monthly or quarterly), and sources of information (surveys and financial market information). Chart B1.1 illustrates the set of indicators included in the ICEI estimate. The sample period runs from January 2010 to January 2022, during which the average of the set of indicators of expected inflation is relatively stable around the long-term target.

2.1 Surveys

Surveys explicitly delve into inflation expectations among diverse economic agents. *BanRep's* ICEI is constructed using several different surveys: a monthly survey of analyst expectations (EME for its initials in Spanish); a monthly survey of financial opinion (EOF) among analysts and portfolio managers; a monthly survey by Focus Economics; and a quarterly survey of economic expectations (ETE) among academics, union members, and business managers from diverse economic sectors[6].

Forecast horizons for the EME and ETE are up to 24 months, for the EOF to the end of the following year, and for the Focus Economics survey for the end of the year in progress and each of the following four years.

2.2. Financial Market

The ICEI also incorporates expected inflation indicators implicit in the sovereign bond market data, specifically breakeven inflation (BEI) and forward breakeven inflation (FBEI) rates.

BEI measures average inflation expected by economic agents investing in sovereign bonds. For Colombia, specifically, these illustrate the difference in yield between domestic currency bonds (TES in pesos) and inflation-linked bonds (TES in UVR). However, BEI rates can also reflect not just expected inflation but also uncertainty about those expectations, as well as liquidity frictions. In order to measure the specific component of BEI related to expected inflation (Exp_BEI), *BanRep* uses the decomposition methodology presented in Espinosa-Torres et al. (2015).

BanRep also monitors FBEI rates, which provide a measure of expected inflation that controls for the effects of short-term shocks. For example, the FBEI rate at two to five years reflects average inflation expected over the course of a five-year period that begins after two years. In this example, inflation expectations for the first two years would be removed from the analysis.

The ICEI incorporates information from the BEI and FBEI rates, including estimates of the specific component of expected inflation (Exp_BEI and Exp_FBEI) on different

Chart B1.1
Inflation expectations included in the ICEI[a/]

Frequency	Indicator	Inflation type	Time horizon			
			Short term		Medium term	Long term
			1 year	2 years	2-5 years	5+ years
Monthly	BEI	Headline	BEI 1Y	BEI 2Y, FBEI 1Y-1Y	BEI 5Y, FBEI 2Y-3Y	BEI 6-10Y, FBEI 5Y-5Y
	Disaggregated BEI	Headline	Exp_BEI1Y	EXP_BEI2Y, EXP_FBEI 1Y-1Y	Exp_BEI 5Y, Exp_FBEI 2Y-3Y	Exp_BEI 6Y-8Y, Exp_FBEI 5Y-3Y
	EME	Headline	EME 1Y	EME 2Y		
	EOF	Headline	EOF 1Y			
	Focus Economics	Headline			Year-end next 2, 3 and 4 years	
	EME	Excluding food	EME SY 1Y	EME SY 2Y		
Quarterly	ETE	Headline	Industrial 1Y	Industrial 2Y		
			Financial 1Y	Financial 2Y		
			Warehouses 1Y	Warehouses 2Y		
			Transport 1Y	Transport 2Y		
			Academics 1Y	Academics 2Y		
			Unions 1Y	Unions 2Y		

a/ Expected inflation taken from BEI disaggregated for expectations, inflation risk premium, and a component of relative liquidity of TES in pesos and TES UVR.
Sources: *Banco de la República*, Fedesarrollo, Focus Economics, SEN, and MasterTrader.

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6   *BanRep* administers the EME and the ETE. The EOF is administered by the Colombian stock exchange (BVC) and Fedesarrollo for analysts and portfolio managers.

time horizons (see Chart B1.1). How BEI and FBEI rates are calculated is illustrated in Annex B1.1.

Graph B1.1 shows the different inflation expectations included in the construction of the ICEI, illustrating the common movement among them over the sample period. For periods in which inflation has moved away from the target rate, financial market expectations have reacted faster than survey expectations. For example, since 2010 the standard deviation of the BEI to one year is 0.95 percentage points (pp), higher than for expected inflation in the EME in the same period (0.44 pp). The graph also shows that, during periods of high inflation, expectations from the ETE tend to be at the higher end of the distribution.

3. Main Results

The ICEI is estimated at different terms, with the goal of controlling for the potential effects that the aggregation of expected inflation at different time horizons could have

Graph B1.1
Inflation expectations in Colombia
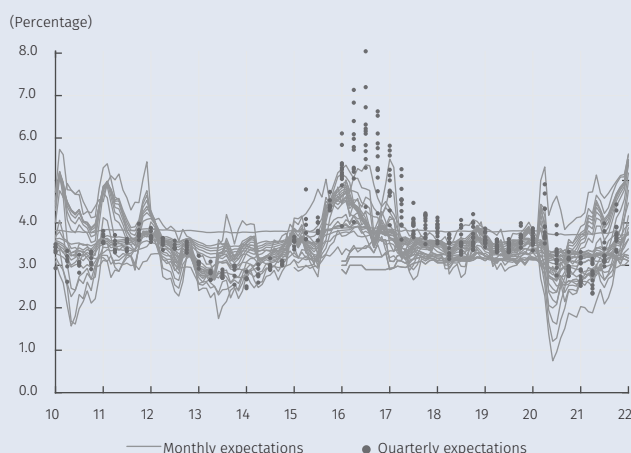
Sources: *Banco de la República*, Fedesarrollo, Focus Economics, SEN, and MasterTrader.

on the analysis of the indicator. Graph B1.2 illustrates the common factor in the short (less than two years, panel A), medium (between two and five years, panel B) and long term (more than five years, panel C). Inflation expectations used in the construction of the ICEI at each time horizon are shown in grey.

The ICEI also accounts for the effect that inflation and liquidity risk premiums could have relative to BEI and FBEI rates and, in turn, on the ICEI, primarily in the long term. To deal with this issue, Graph B1.2 shows the dynamic factor estimated with BEI and FBEI rates (blue line) and without them (yellow line).

For each time horizon under consideration, the recent ICEI behavior suggests a rapid fall in expected inflation in the first half of 2020, associated with the COVID-19 pandemic. Expected inflation has increased since then. However, the longer the time horizon, the more pronounced this upward trend appears. For example, the short-term ICEI suggests an upturn in expected inflation starting at the beginning of 2021, while the medium- and long-term indicators suggest an increase on these time horizons starting in the second half of 2020.
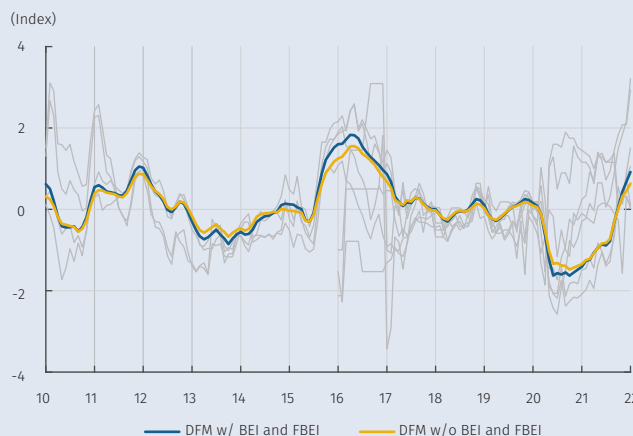
In general, the ICEI suggests expected inflation in January 2022 was higher than pre-pandemic levels, but lower than inflation levels expected by economic agents during the *El Niño* period that prevailed at the end of 2015 and in 2016.

Graph B1.2
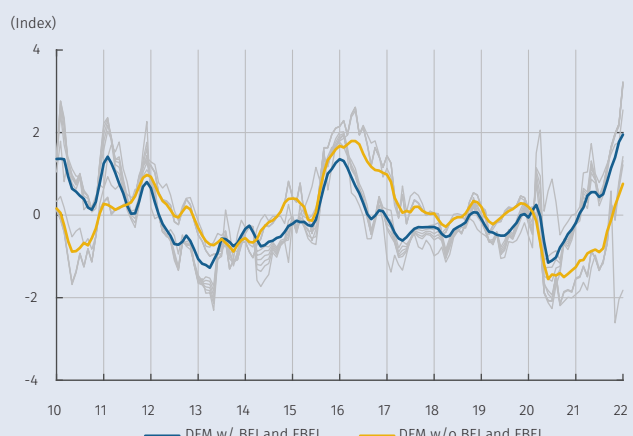Common indicator of annual inflation expectations (ICEI)
(January 2010 to January 2022)
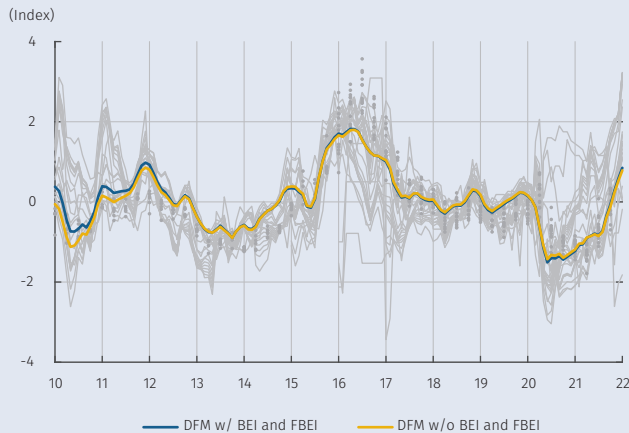
A. Short Term
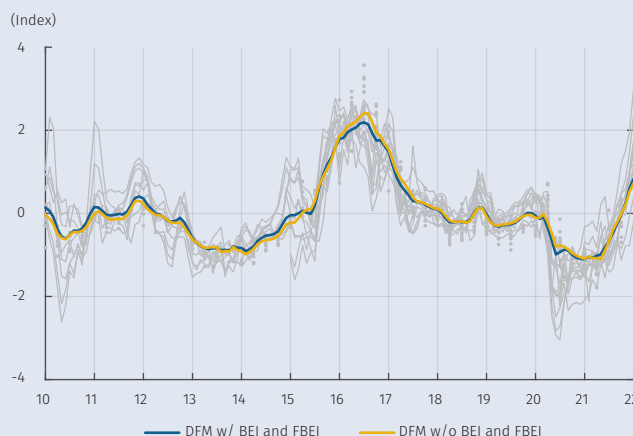
B. Medium term

C. Long term

Sources: *Banco de la República*, Fedesarrollo, Focus Economics, SEN, and MasterTrader; calculations by *Banco de la República*.

Graph B1.2 (continued)
Common indicator of annual inflation expectations (ICEI)
(January 2010 to January 2022)

D. All terms

Sources: *Banco de la República*, Fedesarrollo, Focus Economics, SEN, and MasterTrader; calculations by *Banco de la República*.

On the long-term horizon, which includes the BEI and FBEI, the ICEI suggests a rapid increase in expected inflation after the pandemic, higher than expected by economic agents in the peak of 2016. The difference in these two indicators is due primarily to the inflation risk premium, which at this term implies a significant difference between the BEI overall and the component of BEI that specifically reflects expected inflation. On the remaining time horizons, the differences in the ICEI estimated using the DFM with and without the BEI and FBEI are small.

The ICEI constructed using expected inflation indicators on all time horizons reflects a similar dynamic to the medium-term indicator.

These results underline the ways in which the ICEI offers *BanRep* a new tool to analyze expected inflation at different terms. It captures, in one series, the dynamics implicit in a diverse set of indicators. The index suggests that expected inflation has been on an upward trajectory since the end of 2020, and that as of January 2022 was above pre-pandemic levels.

References

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Annex B1.1

This annex presents technical details on the calculation of BEI and FBEI rates:

Breakeven Inflation (BEI)

The BEI rate $\pi_t^{e,n}$ in time t at term n years is defined as follows:

$$\pi_t^{e,n} = \frac{(1+i_t^n)}{(1+r_t^n)} - 1$$

where i_t^n and r_t^n correspond to the bond return at a nominal rate (e.g: TES pesos) and a real rate (e.g.: TES UVR) respectively. The bonds have the same term of n years, and the same credit quality. The BEI rate $\pi_t^{e,n}$ reflects the average inflation expected over the course of the next n years.

2. Forward breakeven inflation (FBEI)

The FBEI rate $\pi_t^{e,a-b}$ represents the average inflation expectation over the course of b years beginning after a years. The FBEI rate $\pi_t^{e,a-b}$ is represented as follows:

$$\pi_t^{e,a-b} = \left[\frac{(1+\pi_t^{e,n})^n}{(1+\pi_t^{e,a})^a} \right]^{1/b} - 1$$

where $\pi_t^{e,a}$ and $\pi_t^{e,n}$ correspond to the BEI rates at terms a and n years, where $n = a + b$.