## EXTRACTION OF INFLATION EXPECTATIONS FROM FINANCIAL INSTRUMENTS IN LATIN AMERICA

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*We estimate inflation expectations for several Latin American countries using an affine model that takes as factors the observed inflation and the parameters generated from zero-coupon yield curves of nominal bonds. By implementing this approach, we avoid the use of inflation-linked securities, which are scarce and less liquid in many of these markets, and obtain market measures of inflation expectations free of any risk premium, eliminating potential biases included in other measures such as breakeven rates. We find that inflation expectations in the long-run are fairly anchored in Chile and Mexico, while those in Brazil and Colombia are more volatile and less anchored. We also find that expected inflation increases at longer horizons in Brazil and Chile, while it is decreasing in Colombia and Mexico.*

### Introduction

Agents' inflation expectations are decisive for shaping households' and firms' decision making. They are also important when implementing monetary policy, especially for inflation-targeting central banks. However, these expectations are not observables, and there are different strategies to capture them. One of those approaches is based on the consensus view of specialist economic forecasters, such as the surveys of professional forecasters. A drawback of these surveys is that they are released relatively infrequently and, thus, the information received has a time lag.[1] Moreover, they only cover a small range of time horizons and, as identified in the literature (Ang et al., 2007; Chan et al., 2013), there is some bias and inertia in their responses. An alternative way of obtaining agents' inflation expectations is to use prices of market-traded financial instruments employed to hedge against inflation such us inflation-linked bonds, inflation swaps and inflation options. An advantage in comparison with surveys is that changes in expectations can be observed almost in real time. This makes it easier to identify the effect of specific events or decisions on inflation expectations. Unfortunately, there are not many markets of inflation-linked securities available for most countries.

[1] In Latin America, several central banks publishes surveys about inflation expectations. For example, the central banks of Chile, Colombia and Mexico publish a monthly survey about inflation expectations; the Bank of Brazil publishes a daily survey.

For example, in Latin American only a few have inflation-linked bonds and there are no markets for inflation options at all. Another problem of obtaining inflation expectations using this approach is the presence of various risk premia, which are included in the prices of the underlying financial assets and which may also vary over time. Due to the lack of inflation-linked securities in Latin American markets, we use an alternative approach developed by Gimeno and Marques (2012) to obtain inflation expectations: an affine model that takes as factors the observed inflation and the parameters generated in the zero-coupon yield curve estimation of nominal bonds. Also, by implementing this approach, we obtain a measure of inflation expectations free of any risk premia, since the model breaks down nominal interest rates as the sum of real risk-free interest rates, expected inflation, and the risk premium.

### Obtaining inflation expectations from public debt markets

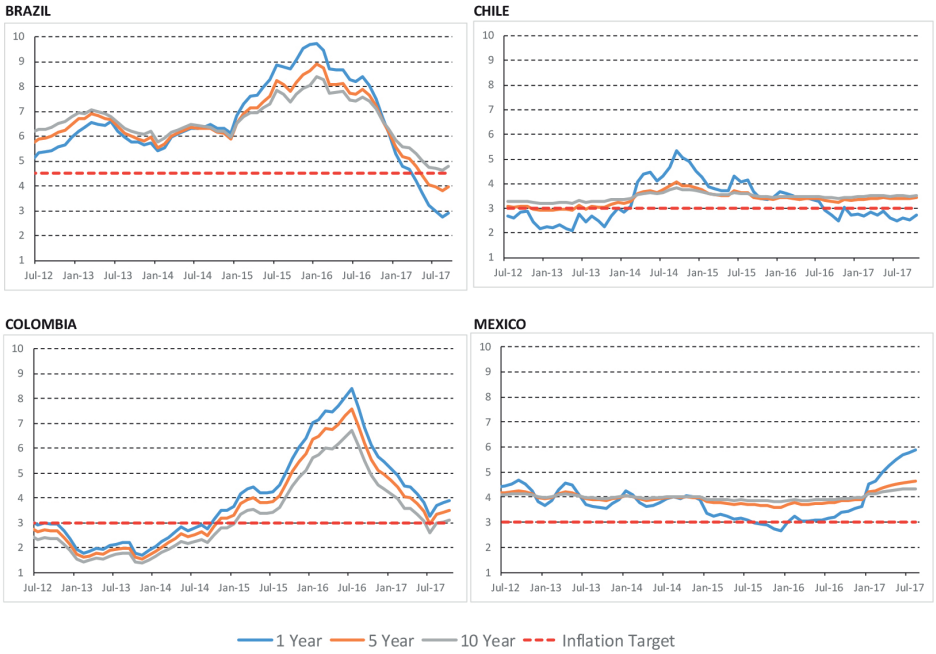
The methodology we implement decomposes nominal interest rates into three components from an affine model of the nominal term structure, incorporating macro-determinants into a multi-factor yield curve model with non-arbitrage opportunities. Interest rates are affine relative to a vector of factors $(X_t)$ that includes inflation rates and exogenously determined factors based on the Nelson–Siegel exponential components of the yield curve (Nelson and Siegel, 1987), in a similar vein to Carriero et al. (2006) and Diebold and Li (2006). In our case, we include the condition of non-arbitrage opportunities along the yield curve and take into account risk-aversion. Taking these two conditions together allows us to decompose nominal interest rates as the sum of real risk-free interest rates, expected inflation and risk premium.

We obtain inflation expectations from a VAR equation which includes the vector of factors $X_t$. Since vector $X_t$ includes current inflation $(\pi_t)$, expectations on this variable can be computed from projections of the dynamics of the affine factors in the VAR equation.

$$E_t[X_{t+h}] = (1 + \phi + \phi^2 + \cdots + \phi^{h-1})\,\mu + \phi^h X_t$$

There are several advantages in using this method to obtain inflation expectations. First, there is a large

INFLATION EXPECTATIONS AT DIFFERENT HORIZONS CHART 1




degree of flexibility, as we can estimate expectations at different horizons. Moreover, we can also compute forward rates, allowing us to estimate, for example, the expected inflation over the five year period that begins five years from today. This is a measure commonly used by central banks to analyze the anchoring of inflation expectations in the long-run. It is difficult to obtain these estimates in markets without inflation-linked securities and, to the best of our knowledge, this is the first time that these kinds of estimates are computed for Brazilian, Colombian, Chilean and Mexican markets. Also, as we pointed out in the introduction, using existing surveys on inflation expectations provides a limited picture, as the horizons are usually short and the frequency of publication is only monthly at best.

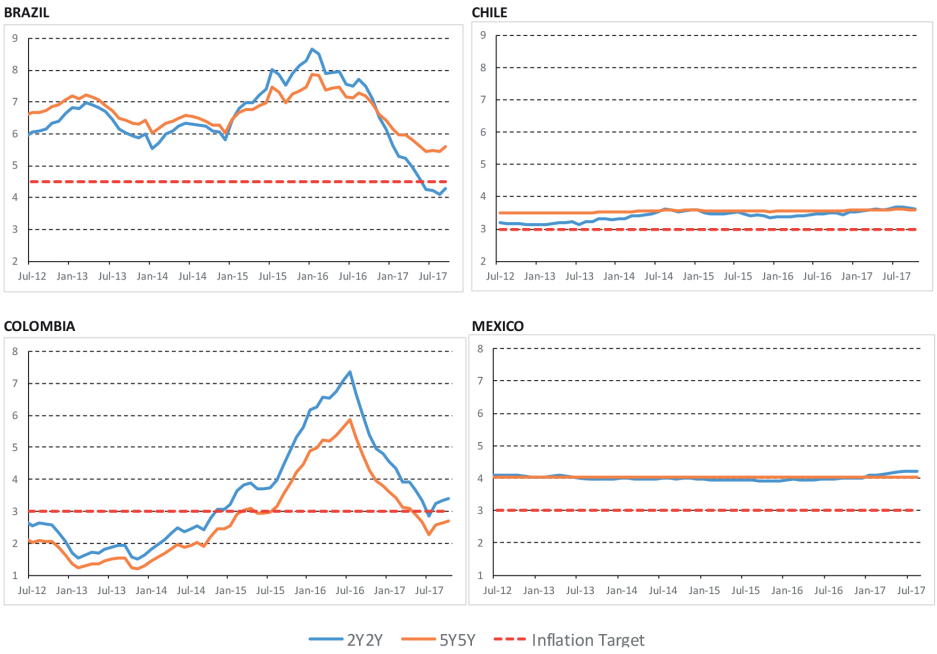
## Results

Chart 1 shows inflation expectations for the 1 year, 5 year and 10 year horizons, as well as the inflation targeting level established by the central bank in each country. We can see the different degree of anchoring by comparing the evolution of expectations for the 1 year horizon with those for the 5 year and 10 year horizons. Inflation expectations in Brazil and Colombia show a similar pattern for all horizons while expectations in Chile and Mexico are more volatile over the 1 year horizon, showing little changes over longer horizons.

Regarding the inflation targeting levels established by the central banks, most countries currently show inflation expectations at long horizons within the window limits,[2] although Brazil and Colombia have experienced recent periods where inflation expectations were well above these limits. In fact, both countries showed inflation expectations above 6% before the large decreased experienced since the beginning of 2016. On the other hand, Mexico shows long term inflation expectations slightly above the upper band of 4%, mainly due to the recent increase in expectations after the last U.S. presidential elections. This effect is more apparent for the evolution of the one year horizon, fading out at longer terms. Interestingly, it seems that the results of these elections have barely affected inflation expectations in the other countries. For Brazil, the deep recession of 2015-2016 have affected expectations, with a large decrease experienced since the beginning of 2016. The path of inflation expectations changed again for Brazil at the end of 2016, with expectations turning higher at longer horizons, which signals a possible recovery. In the case of Colombia, the monetary policy implemented by the central bank during 2016, with increases in the policy rate from 4.5% in September 2015 to 7.75% in August 2016, have contained inflation expectations, being now closer to the inflation target.

[2] The Bank of Brazil sets the inflation target at 4.5% with a window limit of ±1.5%. The central banks of Chile, Colombia and Mexico set the inflation target at 3% with a window limit of ±1%.

INFLATION EXPECTATIONS FORWARD RATES CHART 2




Being able to decompose the yield curve and extracting inflation expectations at different horizons let us compute forward rates as well. This is especially useful in order to analyze the anchoring of inflation expectations over the medium and long term. In fact, forward rates such as the 5Y5Y (expected inflation over the five year period that begins five years from today) are used by central banks to assess the level of long term inflation anchoring. Chart 2 shows the 2Y2Y and 5Y5Y forward rates of inflation expectations together with the inflation target established by each central bank.

Similarly to the behavior of the 10 year horizon inflation expectations, the forward rates for Chile and Mexico are more stable and hardly move over time. The levels are above the inflation target but within the window of ±1% for Chile and almost within that window for Mexico. These results show that investors have almost kept unchanged the level of long-term expected inflation for these two countries. On the contrary, inflation anchoring for Brazil and Colombia seems to be lower, with forward rates showing more volatility. In Brazil long-term inflation expectations are above the target level but below the upper limit of ±1.5%, due to the large decrease experienced since the beginning of 2016. For Colombia there is a similar pattern, with long-term inflation expectations currently below the target level of 3% after the decrease in the 5Y5Y forward rate experienced since mid-2016. The behavior of forward rates for Brazil and Colombia show that investors seem to face more uncertainty about the expected inflation in the long-term for these two countries. It could be also the case the government bond markets provide less information about future inflation for these two countries.

Finally, we compare the forecasting accuracy of the inflation expectations over one year obtained from our model with those provided by surveys and a simple autoregressive process AR(1). Table 1 shows the ratio of the MSE obtained using expectations from surveys, as well as from our model and the AR(1) process, to the MSE computed using current inflation as the predicted future value (like in a unit root process). If the ratio is lower than one, it means that the expected values provide a better prediction of future inflation than assuming inflation will remain the same as today. The three measures, inflation expectations from surveys, from the AR(1) and from our model show lower MSE than the unit root prediction. Comparing the three

EXPECTED INFLATION FORECAST ERRORS TABLE 1

| | Sample | Survey (a) | Model (a) | AR(1) (a) |
|---|---|---|---|---|
| Brazil | Feb 2007 - Oct 2016 | **0.5833** | 0.8812 | 0.8415 |
| Chile | Jul 2012 - Dec 2016 | 0.7813 | **0.6946** | 0.7148 |
| Colombia | Feb 2005 - Nov 2016 | **0.7956** | 0.9354 | 0.8015 |
| Mexico | May 2001 - Nov 2016 | 0.6350 | 0.7078 | **0.6324** |

**a** Ratio of mean square error of expected inflation from surveys, an AR(1) process and our model with respect to a naive prediction of expected inflation equal to current inflation. Expected inflation in 12 months for Brazil, Colombia and Mexico; 11 months for Chile.

measures, expected inflation from surveys show lower MSE for Brazil and Colombia. The model is the best predictor for Chile and the AR(1) process provides the lowest MSE for Mexico. It seems that our measures of expected inflation are more accurate for countries where expectations are fairly anchored in the long-run. Our measures do complement those from surveys in terms of predictability, providing additional forecasting power and a much richer set of expected inflation horizons, and frequency.

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