Anchoring of Inflation Expectations in Mexico

Marco A. Acosta

Abstract

This study analyzes short, medium and long run inflation expectations anchorage among professional forecasters from the private sector in Mexico before and after the financial crisis of 2008 by introducing a novel classification that catalogs to a large extent the econometric efforts that have been made for its measurement. The three dimensions covered by this classification are sensitivity, resilience and credibility. The results show that for the period evaluated after the 2008 financial crisis and as the horizon for which inflation forecasts are made increases, expectations are better anchored.

Keywords: inflation expectations, anchorage, sensitivity, resilience, credibility.

JEL classification: C12, C13, E31, D84.

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1. INTRODUCTION

The monetary policy of Banco de México aims to influence interest rates in order to bring price behavior into line with the path of inflation towards its long run target. Inflation expectations are therefore of utmost importance given that forecasts regarding the future costs and income of economic agents are crucial for setting the prices of the goods and services they supply. The greater the public's trust in the central bank, the better expectations will be anchored, which translates into an environment of low and stable inflation that in turn fosters conditions favoring sustained economic growth.

This paper analyzes the anchorage of inflation expectations among professional forecasters from the private sector at different horizons from January 2002 to May 2017, and for two subperiods divided by the 2008 financial crisis, using linear regressions and vector autoregressive (VAR) models. In specific, I assess three dimensions with respect to the anchoring of inflation expectations: *1)* the sensitivity of medium and long-term expectations to contemporary inflation and short-term expectations; *2)* resilience to inflation shocks; and *3)* the credibility of Banco de México. Documents found in the literature usually only focus on one of these three dimensions, naming the dimension they assess anchoring. This study therefore integrates the literature and categorizes existing types of anchoring in order to provide coherence to the findings.

The outcomes show how the behavior of inflation expectations has been consistent with the process of convergence towards low and stable inflation during recent years. It shows how the distribution of expectations has been centered around the permanent 3% target for inflation and the upper limit of the variability interval. Moreover, dispersion is modest, and bias is not statistically different from zero in most of the periods.

As for sensitivity, the paper shows that short-term inflation expectations, defined as those for the following 12 months, are associated to changes in the contemporaneous inflation

process. Medium-term expectations, which encompass forecasts from one- to four-year ahead, are less affected than short-term ones; while long-term expectations forecasting five- to eight-year ahead do not experience any effects. It also shows that long-term inflation expectations are not affected by short-term ones.

With respect to resilience, the outcomes reveal that inflation shocks do not influence the formation of expectations under the current economic setting, even including expectations over shorter horizons such as those for 12 months. It can also be seen that resilience coefficients for the estimations are not statistically significant for the periods before or after the 2008 financial crisis, revealing the stability of the inflation process since the start of the last decade.

The evidence suggests that credibility in the central bank's long-run inflation target grows as the horizon for which inflation forecasts are made increases. The credibility of implicit inflation derived from an autoregressive vector exercise displays a similar behavior: the longer the forecast horizon, the more credible the inflation target becomes. The aforementioned could be due to the capacity the central bank has demonstrated to respond to inflation shocks with the monetary policy and communication tools at its disposal in order to bring inflation into line with the 3% target.

The exercises for the periods before and after the 2008 financial crisis show that inflation expectations are better anchored at all forecast horizons for the dimensions of sensitivity and credibility postcrisis. As for the resilience indicator, expectations do not appear to have been affected in the pre- or postcrisis periods.

The rest of the paper is organized as follows. Section 2 presents the development of achievements in inflationary matters from 1994 to date. Section 3 describes the dimensions in which the anchoring of inflation expectations is analyzed. Section 4 presents an analysis of the data employed, particularly examining the dispersion, skewness and rationality of expectations.

The Section 5 describes the outcomes. Finally, concluding remarks are provided.

2. TRANSITION TOWARDS LOW AND STABLE INFLATION IN MEXICO

On account of the 1994-1995 crisis, Mexico adopted a set of measures aimed at maintaining inflation at low and stable levels. Among these stands out the establishment of a target for the current accounts commercial banks hold at the central bank, commonly known as the *short*, a tool that allows for controlling liquidity in the economy with the aim of eliminating inflationary pressures. In 1998, Banco de México accompanied its announcements of changes in the short with a discussion of the main reasons for such modifications, thereby making the application of monetary policy transparent. Subsequently, in the year 2000, the Bank began publishing quarterly inflation reports and in 2001 the process towards transparency was boosted by announcement of the adoption of an inflation targeting regime.[1,2]

The successful reduction of inflation in Mexico has been well documented due to the short time it took. Triple and double-digit inflation had been recorded in the eighties and nineties respectively, but after 2000 it fell to just single digits. Furthermore, as described by Chiquiar et al. (2007), inflation acquired important statistical properties: in specific, it switched from a nonstationary to a stationary process around the end of 2000 and the beginning of 2001. From an economics point of view, statistical behavior implies that shocks to inflation become diluted over time and do not generate second round effects that could alter the price formation process of

[1] For an in-depth discussion on the transition towards an inflation targeting regime see Ramos-Francia y Torres (2005).

[2] The works of Bernanke *et al.* (1999) and Corbo *et al.* (2001) illustrate the favorable behavior of inflation in countries with an inflation targeting regime as compared to other regimes.

the economy. Moreover, Acosta (2018) employs a quantile regression with structural changes approach to show that after the year 2000 inflation follows a stationary behavior in all its conditional quantiles.

Another important change is that inflation in Mexico became a mostly time-dependent process, which allows revisions to be made that do not depend on the state of the economy, allowing for better planning among the agents involved (see Gagnon, 2009). A downward flexibility in prices has also been observed during recent years as shown by Cortés et al. (2011) on the basis of the microdata used for calculating the national consumer price index. The majority of price revisions had previously been upwards.

Inflation's interaction with other macroeconomic variables that can influence it has also changed. Capistrán et al. (2011) and Cortés (2013) found a reduction in the pass-through of exchange rate fluctuations to inflation in the period after the inflation target was adopted. The aforementioned might respond to the absence of any second-round effects from international commodity price variations and the lack of any permanent effects on inflation from tax changes such as those implemented in 2010, as mentioned by Aguilar et al. (2014).

With respect to inflation expectations, the topic studied in this paper, the work on Mexico by García-Verdú (2012) stands out. The latter employs the model of Mankiw et al. (2003) to explore the dispersion of inflation expectations among professional forecasters from the private sector. The model of Mankiw et al. (2003) is based on the principle that there are costs implicit in collecting and processing information for readjusting inflation forecasts, meaning only some economic agents update them. This leads to dispersion between the expectations of agents who use recent and lagged data. The findings of García-Verdú (2012) show that a larger proportion of forecasters from the private sector update their inflation expectations, which coincides with lower levels of dispersion observed in the data. Likewise, García-Verdú (2012) study the

dispersion and skewness of expectations and determine that they have diminished, which they attribute to a more stable environment and the reduction of potential risks, respectively.

3. DIMENSIONS FOR THE ASSESSMENT OF THE ANCHORING OF INFLATION EXPECTATIONS

If inflation expectations were perfectly anchored there would be no relation at all between actual inflation and economic agents' forecasts. Nevertheless, this level of anchorage is not usually seen in the data, but it allows for carrying out a test in which anchorage is defined by the level of linear dependence displayed by inflation expectations with respect to observed and lagged inflation. Among the papers that have characterized the anchorage of expectations in this way are those of Levin et al. (2004) and Ehrmann (2015). The same principle is applicable to medium and long-term expectations with respect to short-term ones; that is, if inflation expectations at more distant horizons are well-anchored they should be insensitive to changes in expectations at shorter horizons. This hypothesis accepts movements in short-term expectations, meaning they are not perfectly anchored. It also sets forth a scenario where medium and long-term expectations can be anchored if they do not respond to their short-term counterparts. In particular, Łyziak and Paloviita (2017) study said anchorage for the European Union. Anchoring tests with the previously mentioned characteristics will be referred to as sensitivity tests.

If inflation expectations are well-anchored, shocks to inflation should not affect them, given that economic agents expect the central bank to act in line with its long-run inflation target. Among the papers that have characterized the anchoring of inflation expectations with respect to the linear impact of an inflation shock are Mariscal et al. (2014) and Aguilar et al. (2014). Those studies employ a variable that takes a maximum value of between one and the difference between lagged

inflation and its long-run target to define shocks to inflation. This type of tests shall be called resilience tests.

The anchoring of expectations for a central bank can be evaluated as the extent to which professionals from the private sector believe in the long-run inflation target. Bomfim and Rudebusch (2000) use a linear regression as a reference where the weighted sum of the long-term target and lagged values of inflation are made equal to inflation expectations in order to test said hypothesis. The coefficient given to the target is therefore the weight or degree of credibility professionals have in their central bank. Meanwhile, Demertzis et al. (2009) calculate the implicit anchoring of inflation expectations estimating a VAR model, using that methodology to assess whether implicit anchoring coincides with the long-run target for inflation. These measures are referred to as creditability.

4. DATA

Data employed in this paper is taken from Banco de México's Encuestas de los Especialistas en Economía del Sector Privado (EEBM, Surveys of Forecasters on Economics from the Private Sector), which has been conducted on a monthly basis since September 1994 and includes forward-looking questions on economic matters aimed at obtaining expectations regarding important macroeconomic variables such as the exchange rate, interest rates, wages and inflation, among others.[3] The collected information is used to prepare a monthly report that is published at the start of each month and shows the consensus of professionals' forecasts for each variable and time horizon. Said consensus is represented by the average and median of the forecasts.

[3] In the period studied 86, 68 and 59 institutions or individuals participated answering questions on their short, medium and long-term inflation expectations, providing an average of 30, 28 and 27 answers to each survey, respectively.

This paper analyzes the medians of inflation expectations at three time horizons because they better capture the consensus of economic forecasters as an extreme value could substantially alter the average, without changing that of the median.[4] The short-term horizon refers to the forecasts professionals make 12-month ahead for annual inflation; the medium-term includes forecasts made four- year ahead; while the long-term considers the forecasts of economic agents for a time interval of five- to eight-year ahead.

Figure 1 shows the performance of headline inflation observed during the study period and expectations for it at the three time horizons specified above. The series have different starting points because the EEBM began to ask questions regarding medium and long-term expectations in January 2004 and August 2008, respectively. Although for short-term expectations the EEBM contains data available for periods before January 2002, I decided to begin on that date because it is the first full year in which inflation follows a stationary path.[5]

Although the medians of answers are taken as the consensus among professionals, it is important to test whether the median actually does represent the central tendency of the answers and whether they are converging towards the target.[6] To that end, I analyze empirical density functions, dispersion and skewness of forecast data, as well as its rationality. With respect to density, Figure 2 presents the empirical distributions of inflation expectations at different horizons. Expectations for 12-month ahead are mostly concentrated in the 3% to 6% interval. Nonetheless, it can be seen how densities shifted to the left, towards the long-run inflation target, as time progressed, and in recent years it

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[4] The anchoring of inflation forecasts at time horizons that may change, such as in the case of year-end inflation forecasts, are not studied.

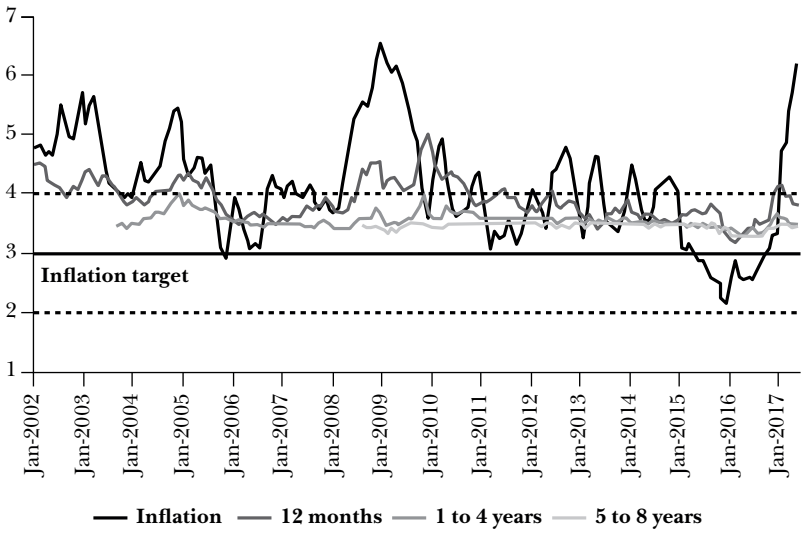
[5] Chiquiar *et al.* (2007) point out that in December 2000 and April 2001, headline as well as core inflation underwent a structural change shifting from a nonstationary to a stationary process.

[6] Carrera (2012) uses histograms to show that inflation expectations in Peru are centered.

Figure 1

SHORT-, MEDIUM- AND LONG-TERM EXPECTATIONS

Annual variation in percentages



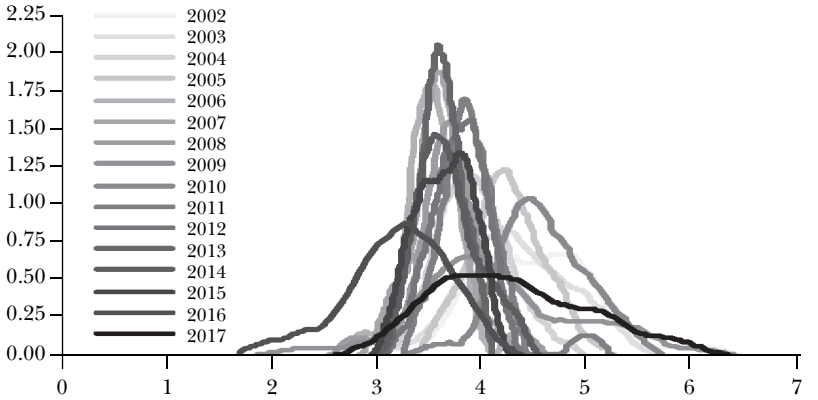
is located in a narrower interval, between 3% and 4.5%. Inflation expectations for one- to four-year ahead are concentrated between 3% and 4.5%, while long-term ones are centered between the 3% inflation target and the upper bound of the variability interval.

Dispersion, calculated as the month to month interquartile range inside which economic agents specified their expectations, is low (Figure 3). Said characteristic is key for assessing anchorage given that a smaller dispersion implies greater agreement among professionals. In particular, on average, the interquartile ranges of inflation expectations from shorter to longer horizons are 54, 34 and 34 basis points. Moreover, it can be seen that during periods of high economic uncertainty dispersion increases at all horizons, a characteristic clearly observable between 2008 and 2010 (Figure 3d). Nevertheless, this growth is modest and temporary, evidence of rigidity among professionals to change their forecasts.

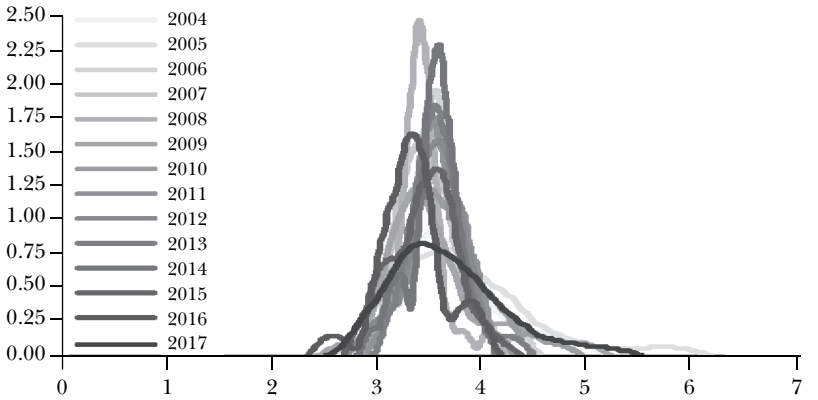
Figure 2

EMPIRICAL DISTRIBUTION OF THE SPECIALISTS' EXPECTATIONS[1]

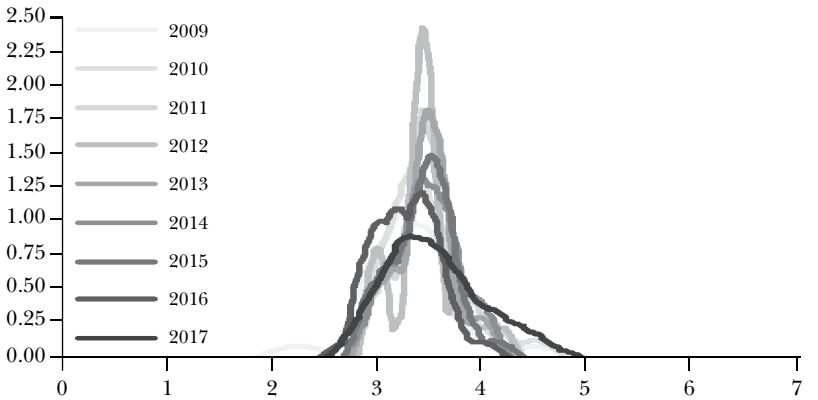
A. 12 MONTHS



B. ONE- TO FOUR-YEAR



C. FIVE- TO EIGHT-YEAR

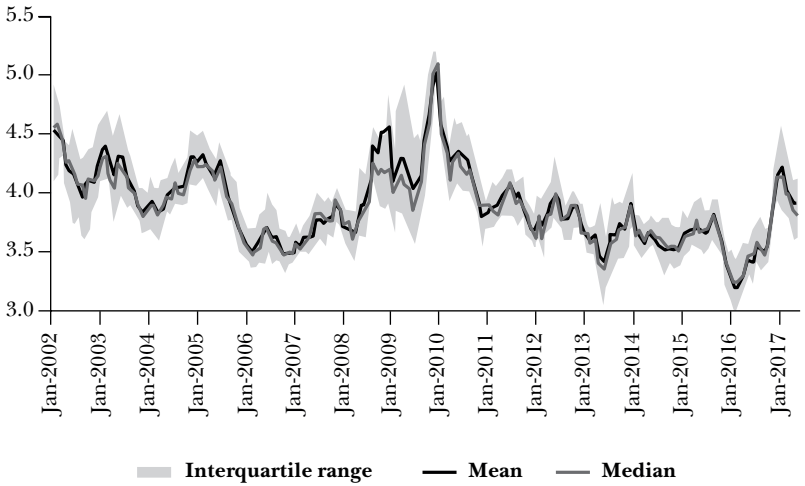


[1] Expectations correspond to January of each year.

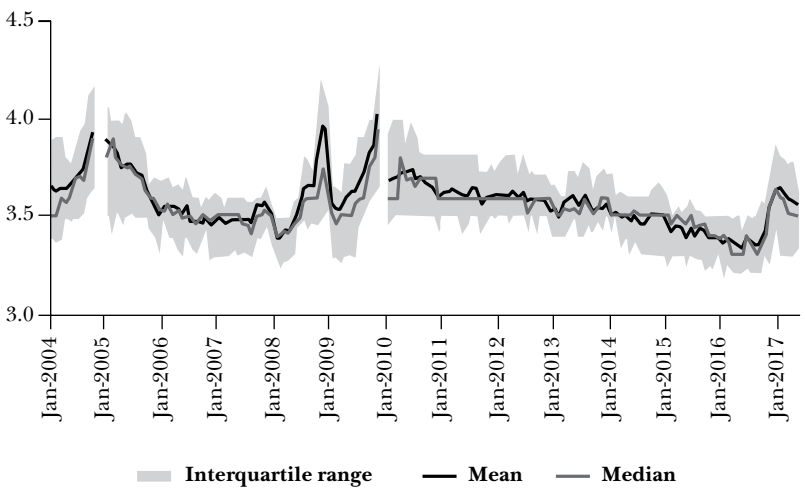
Figure 3

DISPERSION, MEAN, AND MEDIAN OF THE SPECIALISTS' EXPECTATIONS[1]

A. 12-MONTH EXPECTATIONS



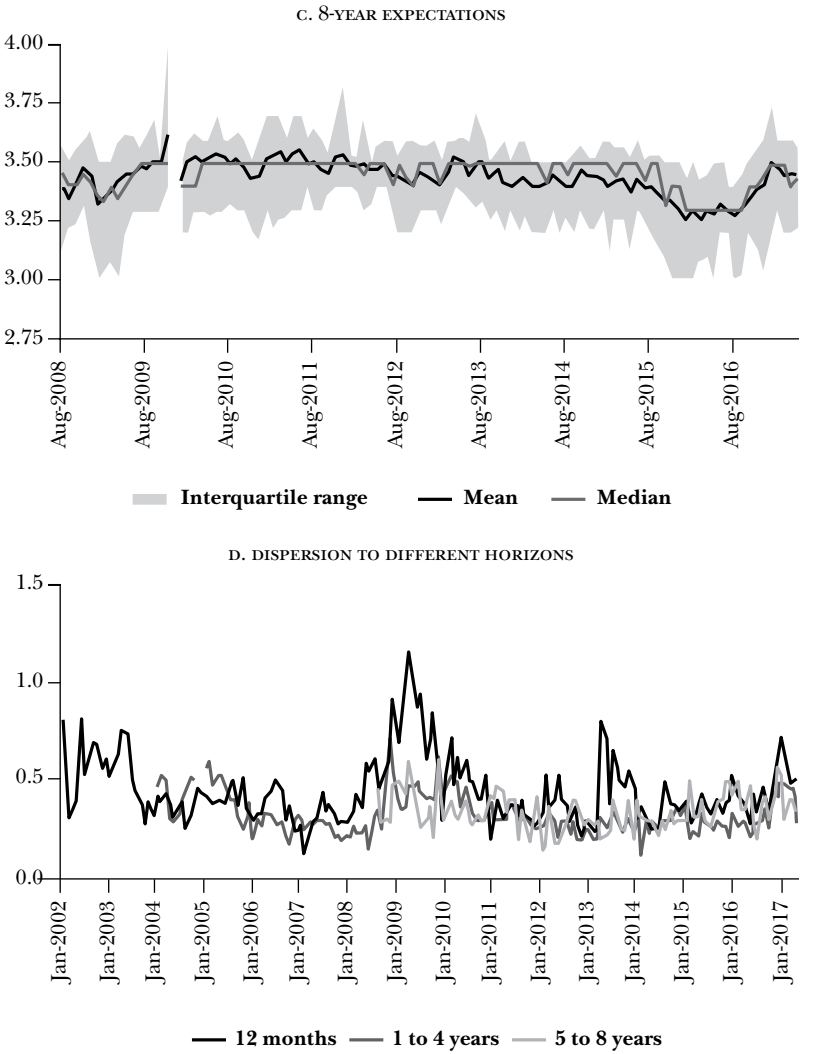
B. ONE- TO FOUR-YEAR EXPECTATIONS



[1] Expectations correspond to January of each year.

Figure 3 (cont.)

DISPERSION, MEAN, AND MEDIAN OF THE SPECIALISTS' EXPECTATIONS[1]



[1] Expectations correspond to January of each year.

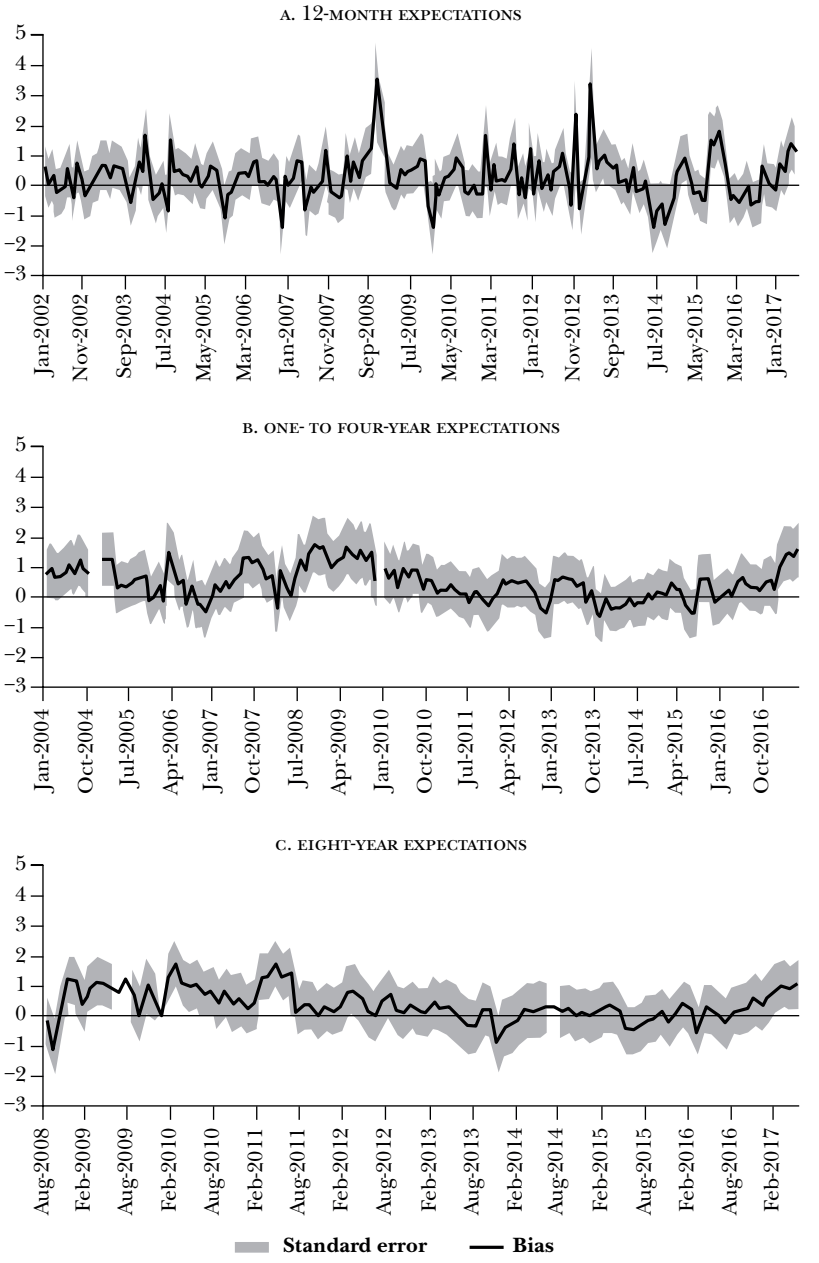
Bias is interpreted as the existence of upward risks if its value is positive and downward risks if it is negative. Expectations at all horizons appear to exhibit neutral risk; that is, their bias is not statistically significant for the majority of periods (Figure 4). Nevertheless, for medium and long-term horizons there appear to be consecutive data sets in which professionals forecast upward risks characterized by positive biases (Figures 4b and 4c) that coincide with periods of greater volatility. Hence, it is possible to see periods where inflation expectations experienced higher uncertainty represented by upward risks in the inflation process. Nonetheless, this was not the case for the majority of periods which presented null skewness and low levels of volatility.

Many papers focus on exploring the coherence between inflation expectations and the rational expectations hypothesis, understood as the impossibility of obtaining predictable errors in the forecasts. To explore whether inflation expectations fulfill the defined characteristic, I perform a set of tests commonly used in the literature and reported in Mankiw et al. (2003) for the case of the United States.

Table 1 presents the results of the tests of expectation rationality. Panel A reports these results, regressing forecast errors on a constant. This is a simple test to evaluate whether inflation expectations are centered on the correct value. The value of the constant is not significant, meaning the forecast errors of professionals are therefore centered on the correct value. Panel B tests whether there is information available in these expectations that can be used to predict forecasting errors. The null hypothesis is that the regression should have no predictive power. As can be seen, the null hypothesis is rejected, meaning there is information that can be exploited. Panel C tests whether today's errors can be forecasted based on yesterday's errors; that is, if there is autocorrelation. The coefficient associated with autocorrelation is not statistically significant. Finally, Panel D assesses whether inflation expectations take account of available macroeconomic information to make the forecasts. The null hypothesis is that macroeconomic variables should not help to predict forecasting errors. However, the null hypothesis is rejected because all the macroeconomic variables help to improve the forecasts.

Figure 4

BIAS OF INFLATION EXPECTATIONS



In sum, the medians are a good indicator for the central tendency of inflation expectations from the private sector. Dispersion is modest, and in most periods, skewness is not statistically different from zero. As for the rationality of expectations, the forecasts are not efficient because they do not leverage all the information from previous periods or available macroeconomic data. Nevertheless, they do not exhibit bias and forecast errors diminish over time. For this reason, median inflation expectations are the indicator recommended as a measure of the central tendency of the data for performing an assessment of the anchoring of inflation expectations.

Table 1

TEST OF FORECAST RATIONALITY

A. Skewness test $\pi_t - \pi^e_{t|t-12} = \alpha$

α	0.05 (0.15)				

B. Is information in the forecast fully exploited? $\pi_t - \pi^e_{t|t-12} = \alpha + \beta\pi^e_{t|t-12}$

α	2.94[a] (0.54)	β	−0.71[a] (0.11)		
$H_o: \alpha = \beta = 0$		value p= 0.00			

C. Are forecasting errors persistent? $\pi_t - \pi^e_{t|t-12} = \alpha + \beta\left(\pi_{t-12} - \pi^e_{t|t-24}\right)$

α	0.07 (0.46)	β	0.10 (0.15)		

D. Are macroeconomic data fully exploited?
$\pi_t - \pi^e_{t|t-12} = \alpha + \beta\pi^e_{t|t-12} + \gamma\pi_{t-13} + \kappa CETES + \xi IGAE$

α	4.92[a] (0.80)	β	−1.09[a] (0.24)	γ	−0.42[a] (0.11)
κ	0.24[a] (0.04)	ξ	−0.13[a] (0.03)		
$H_o: \gamma = \kappa = \xi = 0$		value p= 0.00			

Note: [a], [b] and [c] denote statistical significance at the 10%, 5% and 1% levels, respectively.

5. EMPIRICAL ANALYSIS

In a monetary policy credibility framework, deviations of inflation from its long-term target should be transitory. Thus, economic agents should perceive observed deviations as something transitory that will converge to its target over the long-run and remain there. Nevertheless, there are different risks due to which economic agents' expectations regarding inflation might undergo changes that include: contamination of medium and long-term expectations due to modifications in contemporaneous inflation or short-term expectations (sensitivity), inflation shocks negatively influencing the behavior of expectations at all horizons (resilience) or a central bank that is more tolerant of deviations from its long-run target (credibility). It is therefore important to monitor inflation expectations to enable early detection of any adverse effects in them. Thus, this empirical analysis presents a complete methodology for evaluating expectations in order to identify and classify the type of impact expectations could undergo.

5.1 Sensitivity of Expectations

The sensitivity of inflation expectations is assessed in two different ways in this paper. The first consists of assessing whether changes in the contemporaneous inflation process impact inflation expectations in line with Ehrmann (2015). Thus, short-term expectations are expected to be strongly affected, medium-term ones affected to a lesser extent than short-term ones, while long-term expectations are not affected at all. The second evaluation highlights that medium and long-term inflation expectations should not be affected by changes in short-term ones. The methodology employed follows that specified by Łyziak and Paloviita (2017).

5.1.1 Relation of Inflation Expectations with Respect to Lagged Inflation

If medium and long-term expectations are well-anchored they should not be affected at all by movements in lagged inflation, while short-term ones can be affected by the lagged inflation process. To test this assertion following the methodology of Ehrmann (2015), I estimate

$$\pi^{e}_{t|t+n} = \alpha + \beta\pi_{t-1} + \varepsilon_t, \quad (1)$$

where $\pi^{e}_{t|t+n}$ is inflation expectations formed in period t at the forecast horizon $t+n$; π_{t-1} is lagged inflation; α is the regression constant; β is the lagged inflation coefficient; and ε_t is the regression error. If β is not significant or very close to zero it would indicate that expectations are not contaminated by the inflation process.

Given that the anchoring of expectations might have undergone changes due to the reduced global demand stemming from the 2008 financial crisis I estimate

$$\pi^{e}_{t|t+n} = (1-CF)(\alpha_{ACF} + \beta_{ACF}\pi_{t-1}) + CF(\alpha_{DCF} + \beta_{DCF}\pi_{t-1}) + \varepsilon_t. \quad (2)$$

The variable *CF* represents the 2008 financial crisis and takes a value of zero for each of the periods before April 2008 and one for subsequent periods just as in Łyziak and Paloviita (2017). To test for robustness, equation 1 is estimated with six-year rolling windows.

Table 2 shows the outcomes of equations 1 and 2. The lagged inflation coefficient (β) for the full sample of 12-month ahead expectations is significant and takes the value of 0.22, which leads to adjustments in expectations after changes in observed inflation. Meanwhile, for medium and long-term expectations said coefficient is small and only significant for four-year ahead

expectations; that is, actual inflation does not appear to affect expectations at longer horizons.

Coefficient β for expectations in periods after the 2008 financial crisis exhibits a substantial reduction. In particular, the coefficient for 12-month ahead expectations shift from 0.31 to 0.19, and for one to four-year ahead expectations it decreases from 0.18 to 0.04, the spread being statistically significant in both cases (Table 2).

Table 2

RELATION OF INFLATION EXPECTATIONS WITH RESPECT TO LAGGED INFLATION

	β	R^2	β_{ACF}	β_{DCF}	R^2	$H_0 : \beta_{ACF} = \beta_{DCF}$
Twelve-month ahead expectations	0.22[a]	0.36	0.31[a]	0.19[a]	0.38	2.71
Four-year ahead expectations	0.06[a]	0.20	0.18[a]	0.04[b]	0.35	2.93
Eight-year ahead expectations	0.01	0.03	na	na	na	na

Note: Ordinary least square estimates were performed with Newey-West standard errors. [a] and [b] denote statistical significance at the 1% and 5% level, respectively. The value reported for the hypothesis test is the *t* statistic. na stands for not available.

Figure 5a shows the lagged inflation coefficient of the six-year rolling window regressions, which diminished from May 2008 to May 2017, reaching statistically nonsignificant values after June 2015. Meanwhile, Figures 5b and 5c illustrate that although the lagged inflation coefficient for medium and long-term expectations increased between 2015 and 2016, it exhibited relatively small values. The aforementioned is consistent with that seen in Łyziak and Paloviita (2017) for periods after the 2008 financial crisis.

The increase in the sensitivity of medium and long-term expectations seen in the later periods could be explained by the volatility of energy prices in Mexico stemming from a regime change they have undergone since the energy reform. In specific, the initial falls in energy prices observed at the start of 2015 appear to have pushed long and medium-term expectations downwards. These moved closer to the long-run inflation target at the end of 2015 when headline inflation was below target. Another possible explanation is the increase in exchange rate volatility caused by the start of electoral campaigning in the United States (USA). In particular, from June 2015 to November 2016 (the start of campaigning up until when the elections are held in the USA), the Mexican peso depreciated around 25%. Nevertheless, the increased sensitivity observed in medium and long-term expectations appears to have been temporary, with even a slight downward trend being seen in the coefficient associated to sensitivity during the later periods (Figures 5b and 5c).

5.1.2 Sensitivity of Medium and Long-term Inflation Expectations to Short-term Ones

If inflation expectations are well-anchored, medium and long-term expectations should not respond to movements in short-term ones. To examine said relation I use the methodology proposed by Łyziak and Paloviita (2017). In particular, I estimate

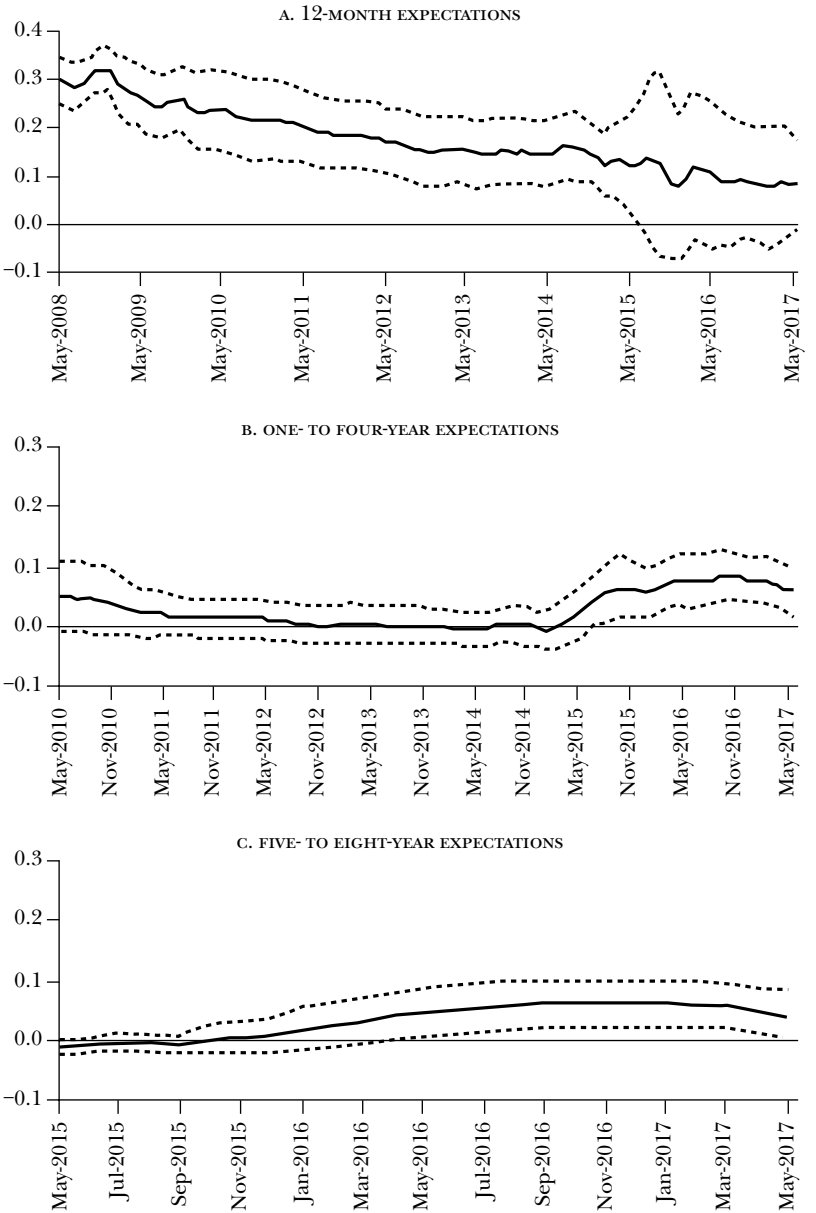
$$\pi^{e}_{t|t+n} = \alpha + \lambda \pi^{e}_{t|t+m} + \varepsilon_t, \quad (3)$$

where $\pi^{e}_{t|t+n}$ refers to inflation expectations formed in period t for the forecast horizon $t+n$; $\pi^{e}_{t|t+m}$ is inflation expectations formed in period t for the forecast horizon $t+m$; α is the regression constant; λ is the lagged inflation coefficient; and ε_t is the regression error.

Figure 5

RELATION OF INFLATION EXPECTATIONS TO LAGGED INFLATION

Six-year rolling windows (coefficient β)



It is important to mention that $t+n>t+m,$ given that the dependent variable are medium and long-term expectations. If the coefficient λ is not significant or close to zero it indicates that long-term inflation expectations are insensitive to fluctuations in short-term ones. Due to the fact that the 2008 crisis could have affected the relation between expectations I estimate

$$\pi^{e}_{t|t+n}=(1-CF)\left(\alpha_{ACF}+\lambda_{ACF}\pi^{e}_{t|t+m}\right)+CF\left(\alpha_{DCF}+\lambda_{DCF}\pi^{e}_{t|t+m}\right)+\varepsilon_{t}. \quad (4)$$

With these equations it is possible to estimate how long-term expectations respond to adjustments in short-term ones. To identify any possible changes in the coefficient of short-term expectations I estimate equation 3 with six-year rolling windows.

Expectations for one- to four-year ahead exhibit a significant, although relatively small coefficient, which translates into a modest impact deriving from the behavior of short-term expectations. Furthermore, the coefficient decreases after the 2008 financial crisis, to be specific, it shifted from 0.49 to 0.23 (Table 3). Meanwhile, long-term expectations do not respond to movements in short-term ones, which can be interpreted as a better anchoring of inflation expectations (Table 3).

Table 3

RELATION OF LONG-TERM INFLATION EXPECTATIONS WITH SHORT-TERM ONES

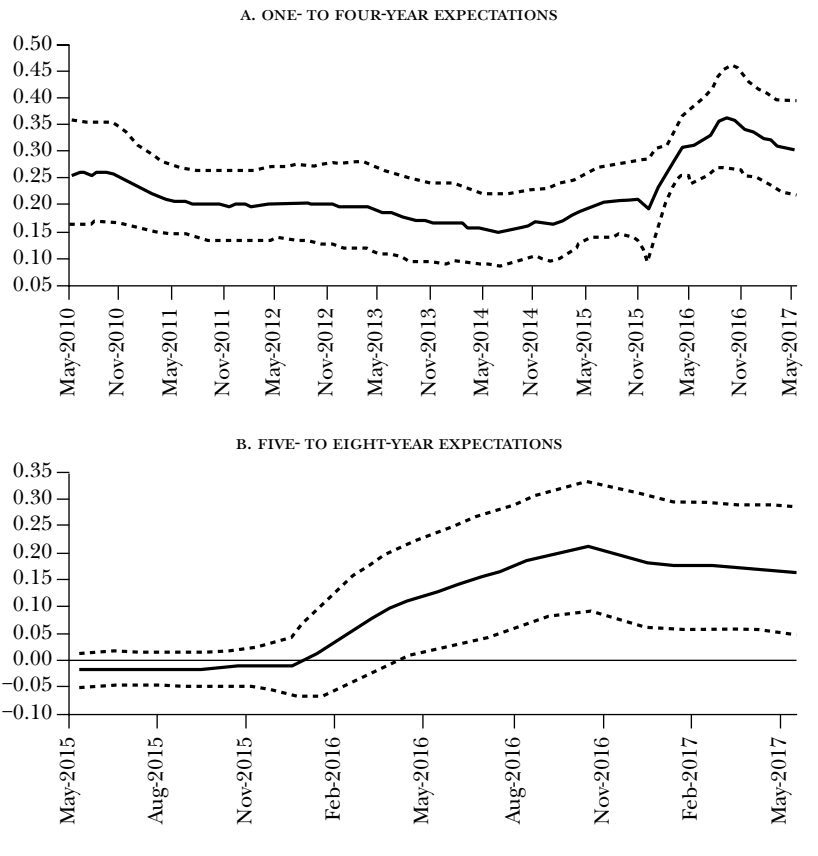
	λ	R^2	λ_{ACF}	λ_{DCF}	R^2	$H_0:\lambda_{ACF}=\lambda_{DCF}$
Four-year ahead expectations	0.28[a]	0.52	0.49[a]	0.23[a]	0.64	3.32
Eight-year ahead expectations	0.05	0.06	na	na	na	na

Note: Ordinary least square estimates were performed with Newey-West standard errors. [a] and [b] denote statistical significance at the 1% and 5% level, respectively. The value reported for the hypothesis test is the *t* statistic. na stands for not available.

Figure 6

RELATION OF LONG-TERM TO SHORT-TERM INFLATION EXPECTATIONS

Six-year rolling windows (coefficient λ)



Figures 6a and 6b depict the coefficient λ associated to six-year rolling window regressions. There is a rebound in both expectations in December 2015, while in medium-term ones the coefficient increases, in long-term ones it shifts from being statistically nonsignificant to significant. Short-term expectations are affected by current inflation, meaning the recent instability of energy prices and exchange rate volatility have probably caused a similar effect to that described in the previous section for medium and long-term expectations.

5.2 Resilience Expectations to Inflation Shocks

The effects of inflation shocks on expectations is captured as the impact caused by an increase that exceeds the upper limit of the long-term inflation target. Based on the methodology of Mariscal et al. (2014) for measuring the anchorage of inflation expectations and employed by Aguilar et al. (2014) to calculate the effect of inflation shocks, equation 1 can be modified by adding some variables and being written as:

$$\pi^{e}_{t|t+n} = \alpha + \beta\pi_t + \gamma\pi^{e}_{t-1|t+n} + \delta \max[\pi_{t-1} - \pi^{Obj}, 1] + \varepsilon_t. \quad (5)$$

In order to measure the impact of shocks on expectations. It is important to point out that lagged expectations are added to equation 1 to denote that the model focuses on the fluctuations of inflation expectations. The aforementioned can be more easily seen by rearranging equation 5 as

$$\pi^{e}_{t|t+n} - \gamma\pi^{e}_{t-1|t+n} = \alpha + \beta\pi_t + \delta \max[\pi_{t-1} - \pi^{Obj}, 1] + \varepsilon_t.$$

I also include the variable $\max\left[\pi_{t-1} - \pi^{Obj}, 1\right]$ that takes the value of lagged inflation minus the long-term target when said value is greater than one or one if not. In this way the added variable captures variations in periods when inflation exceeded the upper limit of the variability interval set for the long-run inflation target. Hence, δ is the coefficient associated to inflation shocks. To calculate whether there were more pronounced effects before or after the 2008 financial crisis I estimate

$$\begin{aligned}\pi^{e}_{t|t+n} = {} & (1-CF)\Big(\alpha_{ACF} + \beta_{ACF}\pi_t + \gamma_{ACF}\pi^{e}_{t-1|t+n} + \\ & + \delta_{ACF} \max\left[\pi_{t-1} - \pi^{Obj}, 1\right] + \varepsilon_t\Big) + (CF)\Big(\alpha_{DCF} + \beta_{DCF}\pi_t + \\ & + \gamma_{DCF}\pi^{e}_{t-1|t+n} + \delta_{DCF} \max\left[\pi_{t-1} - \pi^{Obj}, 1\right] + \varepsilon_t\Big). \quad (6)\end{aligned}$$

Table 4 shows the coefficient for the impact of inflation shocks on expectations. The coefficients are not statistically significant at all expectation horizons, except for 12-month ahead inflation expectations prior to the crisis. It is therefore possible to infer that inflation does not influence the formation of expectations under the current economic environment, even for expectations at shorter horizons such as those for 12 months ahead. Moreover, it is possible to observe that the resilience coefficients (δ) for the estimations are not statistically different for pre- or postcrisis periods, revealing the stability of inflation after it became a stationary process.

Table 4

RESPONSE OF EXPECTATIONS TO INFLATION SHOCKS

	δ	R^2	δ_{ACF}	λ_{DCF}	R^2	$H_0 : \delta_{ACF} = \delta_{DCF}$
12-month ahead expectations	0.05	0.87	0.10[b]	0.04	0.88	0.94
Four-year ahead expectations	0.00	0.78	0.09	0.00	0.80	1.68
Eight-year ahead expectations	−0.02	0.60	na	na	na	na

Note: Ordinary least square estimates were performed with Newey-West standard errors. [a] and [b] denote statistical significance at the 1% and 5% level, respectively. The value reported for the hypothesis test is the *t* statistic. na stands for not available.

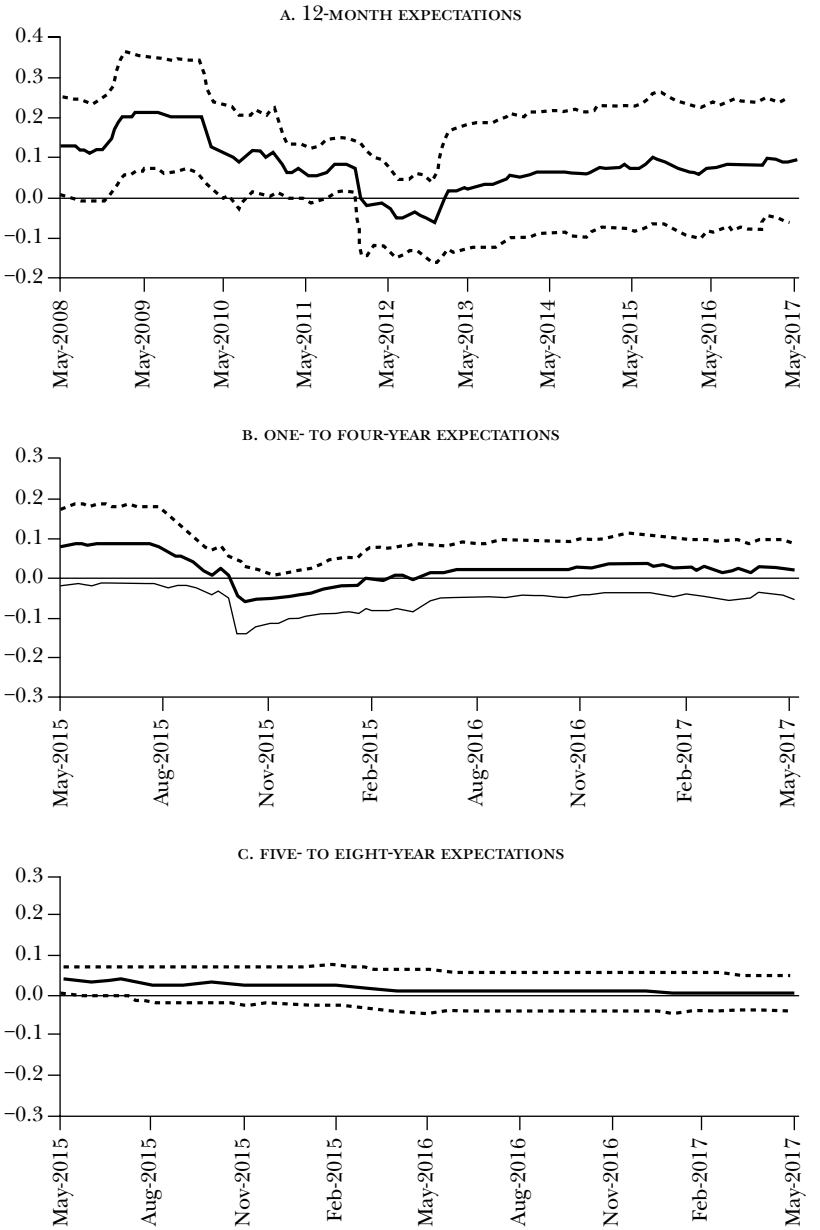
Using six-year rolling window regressions Figure 7a shows that during 2009 and up until the middle of 2010 short-term expectations were pushed upwards by fluctuations in inflation above the upper bound for the long-run inflation target. As of 2010 expectations remained insensitive to inflation shocks.

Figures 7b and 7c illustrate that medium and long-term expectations do not react to the spread between actual inflation and the upper limit of the inflation target given that during

Figure 7

RELATION OF EXPECTATIONS TO SHOCK ON INFLATION

Six-year rolling windows (coefficient δ)



most of the period the coefficient δ is not statistically significant, thus demonstrating that medium and long-term expectations are well-anchored and that inflation shocks do not affect them.

5.3 Credibility in Inflation Expectations

This paper measures the credibility of inflation expectations as the weight agents place on the central bank's long-run inflation target following the methodology of Bomfim and Rudebusch (2000). The analysis of credibility is also complemented by the VAR model proposed by Demertzis et al. (2008, 2009) which is used to calculate the anchorage and implicit credibility of inflation.

5.3.1 Credibility of Expectations with the Long-Run Inflation Target

This subsection examines how expectations are affected by the long-run target for inflation. The analysis uses the definition of Bomfim and Rudebusch (2000) for central bank credibility. In particular, the following equations are estimated:

7
$$\pi^{e}_{t|t+n} = \delta^{Obj}\pi^{Obj} + \left(1-\delta^{Obj}\right)\pi_{t-1} + \varepsilon_t,$$

8
$$\pi^{e}_{t|t+n} = \left(1-CF\right)\left(\delta^{Obj}_{ACF}\pi^{Obj} + \left(1-\delta^{Obj}_{ACF}\right)\pi_{t-1}\right) + \\ + \left(CF\right)\left(\delta^{Obj}_{DCF}\pi^{Obj} + \left(1-\delta^{Obj}_{DCF}\right)\pi_{t-1}\right) + \varepsilon_t,$$

where $\pi^{e}_{t|t+n}$ is inflation expectations formed in period t for the forecast horizon $t+n$; π^{Obj} is the inflation target; π_{t-1} is lagged inflation; δ^{Obj} is the weight of the inflation target in expectations; and ε_t is the regression error.

Table 5

CREDIBILITY OF EXPECTATIONS WITH THE INFLATION TARGET

	δ^{Obj}	δ^{Obj}_{ACF}	δ^{Obj}_{DCF}	$H_0 : \delta^{Obj}_{ACF} = \delta^{Obj}_{DCF}$
Twelve-month ahead expectations	0.42[a]	0.36[a]	0.47[a]	−1.73
Four-year ahead expectations	0.66[a]	0.53[a]	0.70[a]	−3.99
Eight-year ahead expectations	0.76[a]	na	na	na

Note: Ordinary least square estimates were performed with Newey-West standard errors. [a] and [b] denote statistical significance at the 1% and 5% level, respectively. The value reported for the hypothesis test is the t statistic. na stands for not available.

Table 5 reveals that the coefficient δ^{Obj} is significant for all forecast horizons and increases as the horizon becomes longer. For short-term expectations, δ^{Obj} takes a value of 0.42, for medium-term ones this figure is 0.66, and for long-term ones it is 0.76. The outcomes clearly demonstrate that the anchoring of inflation expectations is influenced by the announcement of a long-run inflation target.

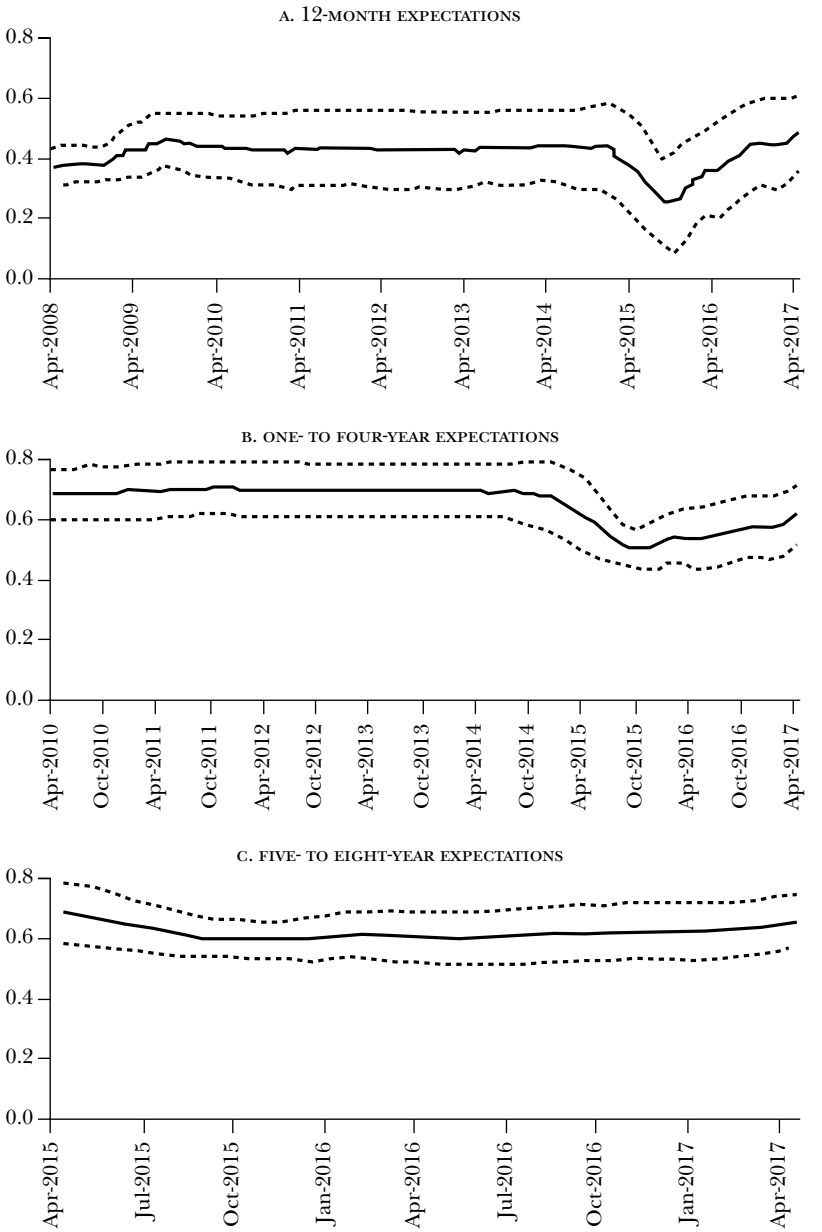
In addition to the above, it is important to underline that the coefficient δ^{Obj} displays an increase as compared to the value it showed before the 2008 crisis in short and medium-term expectations, which is mainly due to the communication tools used by the central bank during the last decade.

Figures 8a and 8b, employing six-year rolling regressions, reveal that the weight associated to the long-run target in short and medium-term inflation expectations has remained relatively stable most of the time, although it decreased at the start of 2015, possibly due to the volatile domestic and international economic environment. However, it is important to mention that said coefficient has returned to values similar

Figure 8

EXPECTATIONS CREDIBILITY WITH INFLATION TARGETING

Six-year rolling windows (coefficient δ)



to those registered before 2015 in both expectations. Meanwhile, Figure 8c shows that δ^{Obj} has remained unchanged for long-term expectations, which might be explained by the fact that long-term expectations are mainly determined based on the inflation target.

5.3.2 Credibility of Expectations, a VAR approach

This subsection follows the methodology of Demertzis et al. (2008, 2009) and uses a VAR model to assess the implicit anchoring of inflation expectations. In particular, long-term expectations are evaluated together with actual inflation. By being a VAR model, it attempts to explore the interdependence between both variables assuming that they are intrinsically related. The model seeks to measure the credibility of monetary policies given that if there is little correlation between the variables it would mean expectations are well-anchored. Due to the fact that a Cholesky decomposition is used to identify the model, the order of the variables is important. To maintain consistency with my earlier findings, in which expectations are not affected by contemporaneous inflation, the order employed in the VAR is to first specify the equation for inflation expectations followed by the equation for inflation. The selection of lags is carried out based on the Schwarz criterion. In specific, each model of 1 to 12 lags was evaluated, selecting the most parsimonious from them. The optimal number of lags is two for all the models. The generalization of the estimated model is as follows:

9
$$\pi^{e}_{t|t+n} = \gamma_0 + \gamma_1 \pi_{t-1} + \ldots + \gamma_p \pi_{t-p} + \theta_1 \pi^{e}_{t-1|t+n-1} + \ldots + \theta_p \pi^{e}_{t-p|t+n-p} + \varepsilon_{1t},$$

10
$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \ldots + \alpha_p \pi_{t-p} + \beta_1 \pi^{e}_{t-1|t+n-1} + \ldots + \beta_p \pi^{e}_{t-p|t+n-p} + \varepsilon_{2t}.$$

The long-run solution to equations 9 and 10 takes the form:

$$\pi = \frac{\alpha_0}{1-\alpha_1-\ldots-\alpha_p} + \frac{\beta_1+\ldots+\beta_p}{1-\alpha_1-\ldots-\alpha_p}\pi^e,$$

$$\pi^e = \frac{\gamma_0}{1-\theta_1-\ldots-\theta_p} + \frac{\gamma_1+\ldots+\gamma_p}{1-\theta_1-\ldots-\theta_p}\pi.$$

The solutions to inflation and credibility are:

$$\lambda\pi^* = \frac{\gamma_0}{1-\theta_1-\ldots-\theta_p},$$

$$1-\lambda = \frac{\gamma_1+\ldots+\gamma_p}{1-\theta_1-\ldots-\theta_p}.$$

Simplifying and rearranging the expressions implies that:

$$\pi^* = \frac{\gamma_0}{1-\theta_1-\ldots-\theta_p-\gamma_1-\ldots-\gamma_p},$$

$$\lambda = 1-\frac{\gamma_1+\ldots+\gamma_p}{1-\theta_1-\ldots-\theta_p}.$$

Table 6 shows the implicit anchor for inflation expectations at the three horizons, revealing that for all of them the estimated value is relatively close to the long-run target of 3% set by Banco de México, the value being closest to 3% corresponding to long-term expectations.[7] Meanwhile, the weights of

[7] Outcomes for implicit inflation and creditability remain stable when the number of lags is changed.

implicit anchors of inflation expectations grow with respect to the horizon of the expectations. Thus, said value is 0.74 for short-term expectations, 0.92 for medium-term ones and 0.95 for long-term ones. The evidence therefore suggests that the relative importance of implicit anchor behavior increases as the forecasting time horizon becomes longer.

In addition to the above, analysis of pre- and postcrisis periods is performed, revealing that after the 2008 financial crisis the weight assigned to expectations increases at all forecast horizons, suggesting central bank credibility has grown over the last decade.

Table 6

IMPLICIT ANCHORING AND ITS CORRESPONDING WEIGHT IN THE FORMATION OF EXPECTATIONS

Sample		*Complete*	*Precrisis*	*Postcrisis*
Twelve-month ahead expectations	π^*	3.79	3.67	3.85
	λ	0.74	0.63	0.75
Four-year ahead expectations	π^*	3.52	3.42	3.52
	λ	0.92	0.74	0.95
Eight-year ahead expectations	π^*	3.4	na	na
	λ	0.95	na	na

Note: the number of optimal lags was obtained using the Schwarz criterion. The value reported for the hypothesis test is the *t* statistic. na stands for not available.

Figure 9 depicts the responses of short, medium and long-term expectations to an inflation shock of one standard deviation. The short-term response is statistically significant five months after the shock occurred and becomes nonsignificant eighteen months after it. The response of medium-term

expectations is significant three months after the shock and its effect is not significant approximately one year after it. Finally, the response of long-term expectations to an inflation shock follows a similar path to that of medium-term ones, although to a lesser degree. In sum, the behavior of impulse responses at deferent horizons can be grouped into shocks that disperse faster and smaller impacts of inflation on expectations as the forecast horizon increases.

The speed with which impulse responses at different horizons become nonsignificant might be determined by the with which lag monetary policy operates; that is, after a shock, economic agents expect the central bank to act in a consistent manner to reduce its impact. The speed of adjustment would therefore depend on the persistence of inflation expectations in the face of different shocks, the structure of the economy, nominal and real rigidities, and the central bank's level of credibility among economic agents. Nevertheless, under a credible inflation targeting regime such as that in Mexico, shocks are expected to become diluted and impulse responses eventually converge to zero.

Figure 10 shows that the pre-2008 financial crisis vector autoregression exercise gives similar results to the exercise for the full sample, revealing that for medium-term expectations the shock dissipates in half the time taken for 12-month ahead expectations. Moreover, the size of the shock, in the same way as responses for the full sample, becomes smaller as the forecast horizon increases.

Performing the exercise for the postcrisis period it can be seen that for short-term expectations the period in which expectations respond to inflation decreases. The size of the shock is also smaller. Meanwhile, the response of medium-term expectations to an inflation shock is practically not significant for all the periods. The outcomes reflect a greater level of anchoring of expectations in the period after 2008 (Figure 11).

Figure 9

COMPLETE SAMPLE 2002M1-2017M3

Inflation and expectations response to a one standard deviation shock on inflation

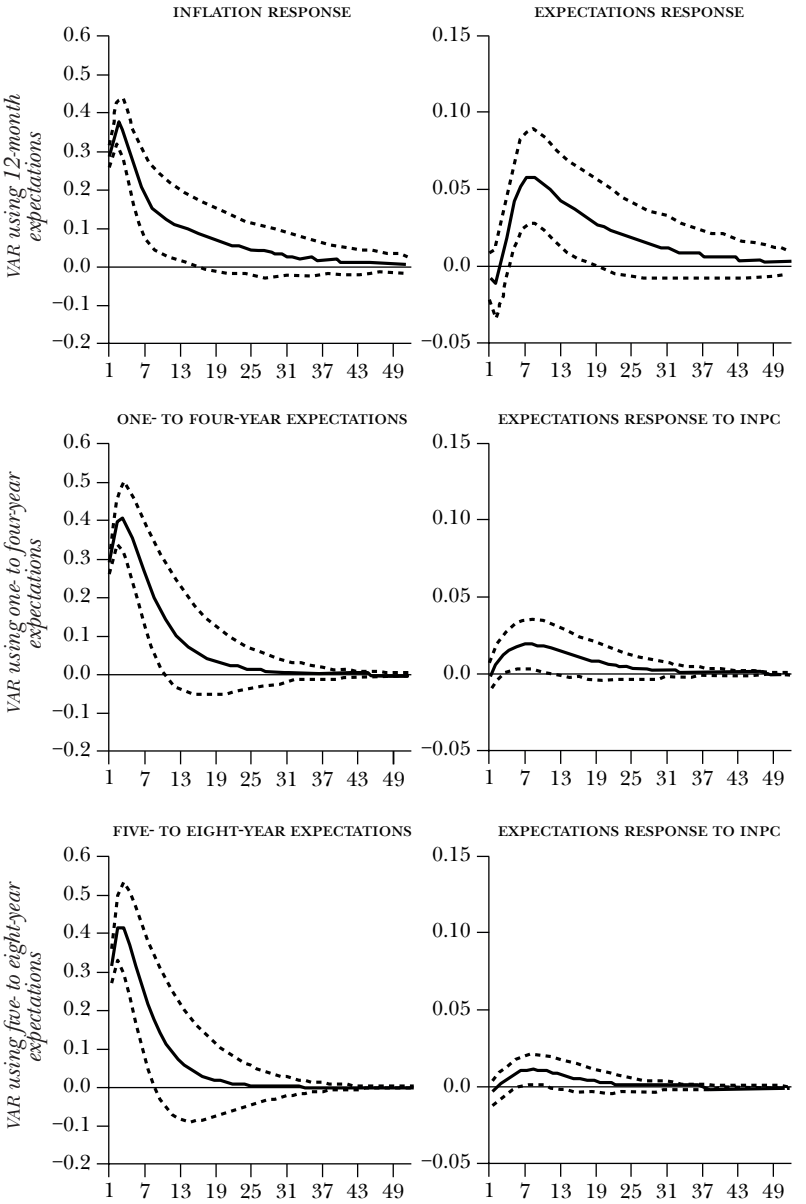


Figure 10

PRECRISIS SAMPLE 2002M1-2008M3

Inflation and expectations response to a one standard deviation shock on inflation

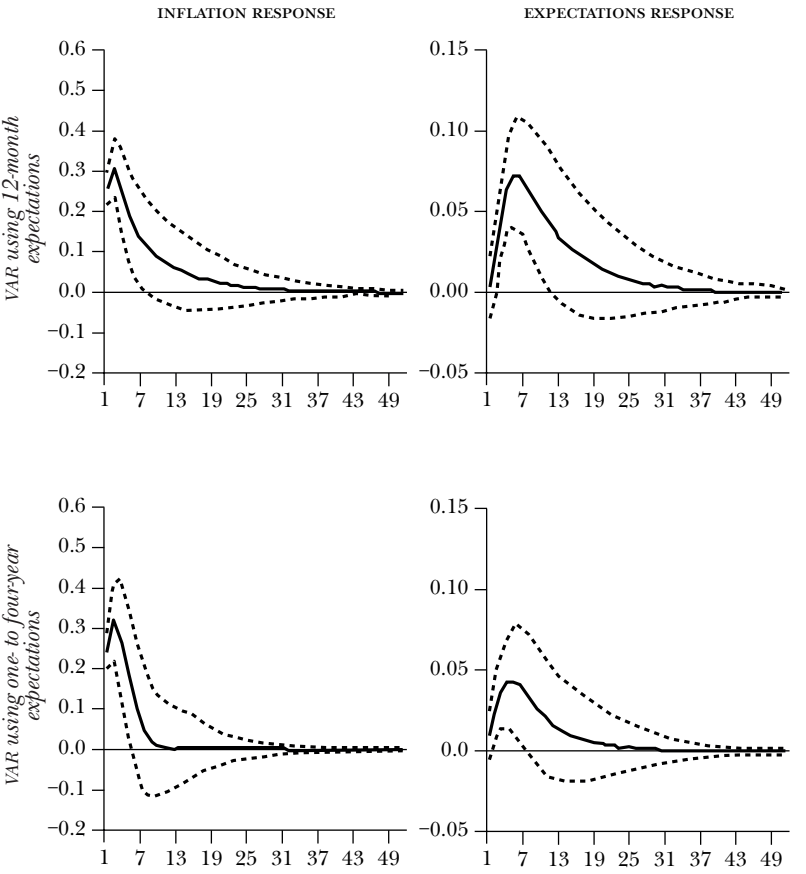
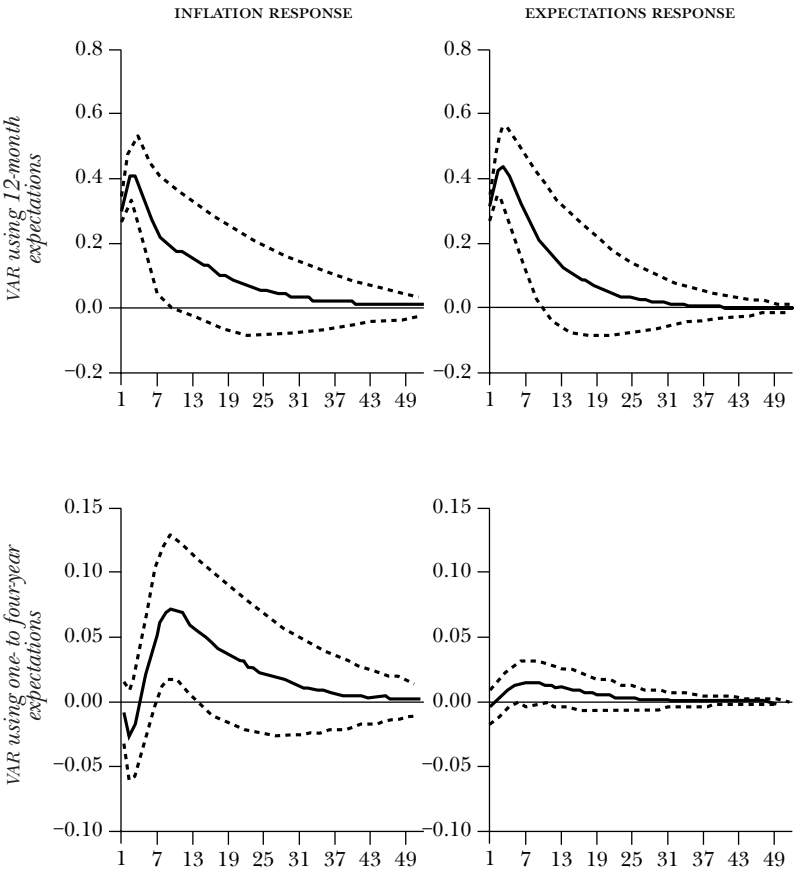


Figure 11

POSTCRISIS SAMPLE 2008M4-2017M3

Inflation and expectations response to a one standard deviation shock on inflation



6. CONCLUSION

This paper assessed the anchoring of inflation expectations introducing a novel classification according to the characteristic studied using econometric methods. In particular, three dimensions of anchorage were examined: sensitivity, resilience and credibility for the period between January 2002 and May 2017, as well as for two subsamples divided by the 2008 financial crisis.

The outcomes demonstrate that short-term expectations are more sensitive, followed by medium-term ones, while long-term ones are not affected by movements in inflation. They also highlight that after the 2008 financial crisis medium and long-term expectations are less sensitive to lagged inflation as well as short-term expectations.

Evidence was provided on how inflation shocks do not influence the formation of medium and long-term expectations, while short-term expectations are resilient to shocks after 2010 according to a moving windows analysis. Moreover, the credibility of Banco de México with regard to its long-run inflation target appears to have increased after the 2008 financial crisis despite substantial volatility in the markets.

It is evident that the analysis of anchoring using the dimensions of sensitivity, resilience and credibility not only facilitates study but also the reporting of outcomes. Nevertheless, this paper does not provide a guide on which of these dimensions is the most important with regards to deanchoring. For this reason, future efforts should focus on assessing the risks associated to each of those dimensions in order to reduce follow-up costs.

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