

Has inflation targeting anchored inflation expectations? Evidence from Peru

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Abstract

Inflation expectations play a key role in inflation dynamics and monetary policy effectiveness. Thus, anchoring inflation expectations have become paramount for Central Banks across the world, mainly for inflation-targeting Central Banks. Yet, the evidence that inflation targeting has anchored inflation expectations in all inflation targeting economies is mixed. Although inflation volatility declined after the inflation-targeting regime came into force in most countries, inflation expectations may still be not anchored, and might just exhibit lower dispersion. The Central Bank of Peru conducts a monthly survey among 350 representative firms from the non-financial sector and 45 professional forecasters since 2002. Following Kumar et al. (2015) we evaluate how anchored inflation expectations in Peru are using four measures: (i) closeness to the Central Bank inflation target, (ii) dispersion across agents, (iii) forecast revisions, and (iv) co-movement between long-run inflation expectations and short-run inflation expectations. Although inflation expectations seem to be somehow anchored to the upper limit of the target band, they do not achieve some of the basic properties required under weaker definitions of anchored expectations. This ‘imperfect anchoring’ may seem precarious as any shock can move away inflation expectations from the Central Bank target and can limit monetary policy success.

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1. Introduction

Inflation expectations play a key role in inflation dynamics and monetary policy effectiveness. As stressed by Svensson (2010), monetary policy has an impact on the economy mostly through the private-sector expectations, which affect current pricing decisions and inflation for the next few quarters; the anchoring of private-sector inflation expectations on the inflation target is a crucial precondition for the stability of actual inflation. Thus, anchoring inflation expectations have become paramount for Central Banks across the world, mainly for inflation-targeting Central Banks. Under the inflation-targeting framework, it is expected that a credible and widely known inflation target helps to anchor the private sector's expectations (Blinder et al., 2008), by making the inflation target explicit, this scheme provides a pivotal point for the coordination of expectations among agents (Capristan and Ramos-Francia, 2007).

Yet, the evidence that inflation targeting has anchored inflation expectations in all inflation targeting economies is mixed. Evidence for developed countries show that the adoption of inflation targeting has resulted in better anchored expectations (Davis, 2014; Walsh, 2008; Capristan and Ramos-Francia, 2007; Gurkaynak et al. 2006). On the other hand, Moreno and Villar (2009) claim that inflation expectations could have become less anchored in the most recent period of financial distress and when fluctuations in commodity prices were large, and Kumar (2015) casts doubt on the anchoring of agents' beliefs in New Zealand, the first country to implement this monetary policy strategy. Andrade and Le Bihan (2010) find that professional forecasters are usually inattentive. As argued by Capristan and Ramos-Francia (2007) and Johnson (2002), presenting convincing empirical evidence on the effects of inflation targeting has proven difficult task in the last decade due to favorable worldwide conditions that have helped tame inflation around the world (autonomous Central Banks, fiscal policies favorable to low inflation, and openness to global trade), making it difficult to disentangle the specific contribution of this regime.

Although inflation volatility declined after the inflation-targeting regime came into force in most countries, inflation expectations may still be not anchored, and might just exhibit lower dispersion. The 'not anchored inflation expectations' may reflect poor information about inflation dynamics, such as an overreaction to inflation news (i.e. confusion between long-run and short-run inflation). Usually, this is more common in non-financial firms, as financial firms have better access to economic and financial news and reports. One key aspect is how to measure expectations, and whose expectations are we measuring. There are two main sources of inflation expectations: surveys and market measures. Market measures, such as bond yields, have higher frequencies but typically reflect only the expectations from the financial sector, and in countries where financial deepening is still low or the capital markets are underdeveloped, those measures might not be representative for the whole economy. On the other hand, surveys may gather expectations from other agents (e.g. non-financial firms, consumers) but their frequency tend to be lower.

In a similar fashion to Kumar et al. (2015), we investigate if inflation expectations are anchored in Peru using four different definitions of 'anchored expectations' based on the closeness of the beliefs to the Central Bank of Peru's target, the dispersion across agent's beliefs, the revisions in the forecasts, and the divergence among short-run and long-run inflation expectations. To achieve this, we rely on the Macroeconomic Expectations Survey conducted on a monthly basis by the Central Bank of Peru since 2002. This survey asks

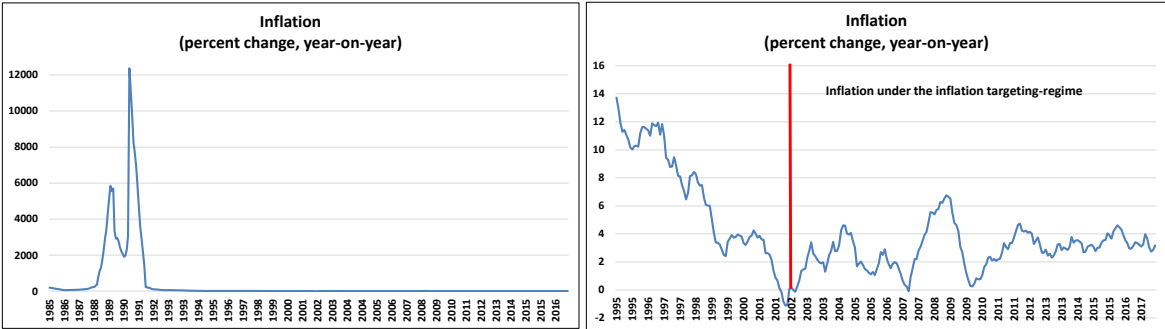
around 350 representative firms from the non-financial sector and 35-50 economic analysts and financial firms about their expectations on the main macroeconomic variables for the current year and the next two years. Hence, the survey does not cover only the typically well-informed professional forecasters, but also large and medium firms from across all sector of the economy, who may be poorly informed about the current and expected inflation dynamics. Not surprisingly, we find that economic analysts and financial firms exhibit better-anchored inflation expectations than non-financial firms, but both groups of agents fail to achieve to weakest measure of well-anchored expectations: co-movement between short-term and long-term inflation.

This paper is organized as follows. Section 2 describes the Macroeconomic Expectations Survey conducted by the Central Bank of Peru. Section 3 presents different measures of ‘anchored expectations’ and to which degree are the inflation expectations of the professional forecasters and the non-financial firms anchored to the Central Bank of Peru’s target. Section 4 concludes and gives avenues for further research.

2. Central Bank of Peru’s Macroeconomic Expectations Survey

The Central Bank of Peru implemented the inflation-targeting regime in 2002, and set a target of 2 percent within a band of +/- 1 percent. Previously, the Central Bank had followed a monetary policy based on monetary aggregates, which was successful to overcome hyperinflation at the beginning of the 1990 decade and to stabilize the economy during the following years. As inflation declined and the Central Bank was fully independent and had made remarkable improvements in transparency and accountability, the adoption of the inflation-targeting regime was deemed necessary.

Figure 1: Peru inflation rate



As part of the requirements of the inflation-targeting strategy, the Central Bank of Peru conducts since 2002 a quantitative monthly survey of expectations about the evolution of the main macroeconomic variables. This survey is applied to three different groups: (i) domestic and economic analysts from think tanks, universities, and research areas in banking; (ii) domestic financial institutions; and (iii) a representative stratified sample of firms from the non-financial corporate sectors, i.e. agriculture, fishing, mining, manufacturing, construction, commerce and non-financial services. In the case of the financial firms, the survey is responded by the treasurer or his deputy; and for non-financial firms the manager or the middle-managers are the usual respondents. This is particularly important as the managers are the typical decision-makers in price setting, investment in physical and human

capital, and employment. For the non-financial firms, the share of respondents from each sector in the sample is similar to the share of the sector in the total GDP. Since its inception, the number of participants have increased and from 2009 onwards the sample has been stable: around 50 economic analysts and financial institutions and 350 non-financial firms.

The survey gathers expectations about inflation, GDP, exchange rate and the policy rate for the end-of-the-current year and the next two years. In the case of inflation it also enquires about long-run inflation expectations (5 and 10 years inflation); yet, these questions were introduced in October 2015. The survey does not ask the agents to assign probabilities to expected outcomes. In the case of non-financial firms, they are also required to answer qualitative questions about current and expected production, sales, inventories, employment, in a similar approach to that of the Empire State Manufacturing Survey conducted by the Federal Reserve of New York.

Although the survey has been conducted since 2002 we narrow our sample and we begin in 2009. As mentioned before, the sample of non-financial firms exhibits large heterogeneity and the number of participants varies (sometimes significantly) before 2009.

3. Are inflation expectations anchored?

3.1. What are anchored expectations?

There is no widespread definition for “anchored expectations”. Traditionally, it has been understood as anchored those expectations that do not deviate from a Central Bank’s target or target band. Ball and Mazumder (2014) refines the concept and argues that anchored expectations imply that the average inflation expectation across agents, particularly at longer horizons, remains stable and close to the inflation target set by the Central Bank. But how do we measure this deviation? Should it be an absolute or relative measure? Should it be a cross-section or time series measure? In this regards, we follow Kumar et al. (2015), who consider five characteristics of inflation expectations, which allows us to rank the relative strength of these measures. The ranking of these measures is arbitrary as a Central Bank may consider some features more desirable in terms of monetary policy, yet Kumar et al. (2015) provide some mathematical considerations and proofs (see Annex 1).

- Ideally anchored expectations: Average beliefs are close to the Central Bank’s target.
- Strongly anchored expectations: Low dispersion across agents’ expectations.
- Weakly anchored expectations: Agents show confidence on their forecasts and exhibit little uncertainty on the long-run expectations.
- Consistently anchored expectations: Revisions in forecasts should decrease over time.
- Increasingly anchored expectations: Little co-movements between long-run inflation expectations and short-run inflation expectations.

Following Kumar et al (2015) we evaluate how anchored the non-financial firms’ inflation expectations are using four measures: (i) closeness to the Central Bank inflation target, (ii) dispersion across agents, (iii) forecast revisions, and (iv) co-movement between long-run inflation expectations and short-run inflation expectations. It is not possible for us to evaluate if inflation expectations are weakly anchored because this requires probabilistic

expectations, and the Survey of Macroeconomic Expectations does not have questions on this regard. In contrast to Kumar et al. (2015), we can assess the evolution in inflation expectations thanks to the monthly frequency of the survey.

3.2. Ideally anchored expectations

Expectations are ideally anchored if the average beliefs are close to the inflation target. Table 1 reports one-year inflation forecasts and 5-year and 10-year inflation forecasts of the economic analysts and financial firms (henceforth professional forecasters), and the non-financial firms for every quarter since 2009. For comparison purposes, we also report the official inflation forecast provided by the Central Bank and the observed inflation at the end of the quarter.

Although observed inflation has been above the upper limit of the target band most of the time, one-year forecasts are relatively close to the inflation target, and seem to be stable over time (see also figure 2). Professional forecasters' expectations were most of the time within the target band, but closer to the upper band of 3 percent than to the target of 2 percent. In the case of non-financial firms, their forecasts are constantly higher than the forecasts of the economic analysts and above 3 percent, but not far from the upper limit. Surprisingly, their mean and median expectations seem to be more stable than those of the professional forecasters. It is possible that expectations of the firms from the non-financial sectors were temporarily driven by transitory changes in economic conditions, such as a boom in commodity prices that disproportionately affected their expectations relative to those of the professional forecasters and financial firms. Yet, even when observed inflation is low, the difference persists.

Longer-horizon forecasts of non-financial firms are consistently above the upper band of the target, and do not seem to converge to the target of 2 percent. The 5-year and 10-year forecasts of the professional forecasters are within the target band, but as in the case of the non-financial firms, their expectations are consistently above the 2 percent target. In plain words, neither the professional forecasters nor the non-financial firms believe that the inflation target will be achieved in the long-run. We do not attempt to further explain the underlying cause: it could be sheer ignorance of the target (which seems unlikely in the case of professional forecasters); a lack of trust in the efficiency of the monetary policy conducted by the Central Bank of Peru; non-rational expectations, among others. Moreover, the 'not anchored inflation expectations' may reflect poor information about inflation dynamics, such as an overreaction to inflation news (i.e. confusion between long-run and short-run inflation).

Table 1. Inflation expectations

	Inflation (end-of-quarter) 1/	Central Bank 2/	Economic analysts and financial sector 3/			Non-financial firms 3/		
			Mean	Median	Standard deviation	Mean	Median	Standard deviation
					1-year forecast 4/			
Q1.2009	4,8	2,0	3,2	3,0	0,8	3,9	3,5	1,5
Q2.2009	3,1	1,8	2,6	2,3	0,7	3,6	3,3	1,6
Q3.2009	1,2	1,6	2,0	1,9	0,4	2,9	2,7	1,4
Q4.2009	0,2	2,0	2,4	2,5	0,6	2,8	2,5	1,4
Q1.2010	0,8	2,0	2,4	2,1	0,7	2,4	2,3	1,1
Q2.2010	1,6	2,1	2,5	2,5	0,5	2,5	2,3	1,1
Q3.2010	2,4	2,2	2,7	2,6	0,4	2,7	2,6	1,0
Q4.2010	2,1	2,0	2,5	2,5	0,6	2,6	2,5	1,0
Q1.2011	2,7	2,9	3,1	3,1	0,4	2,8	2,8	0,9
Q2.2011	2,9	2,9	3,2	3,1	0,5	3,2	3,1	1,0
Q3.2011	3,7	2,8	2,9	2,8	0,3	3,1	3,0	1,0
Q4.2011	4,7	2,0	2,7	2,5	0,8	3,4	3,0	1,3
Q1.2012	4,2	2,4	2,8	2,8	0,4	3,2	3,0	1,0
Q2.2012	4,0	2,3	3,0	3,0	0,3	3,3	3,1	1,2
Q3.2012	3,7	2,3	2,9	2,9	0,3	3,2	3,1	1,0
Q4.2012	2,6	2,0	2,5	2,5	0,4	2,9	3,0	0,9
Q1.2013	2,6	2,0	2,5	2,5	0,2	2,8	2,8	0,7
Q2.2013	2,8	2,0	2,5	2,5	0,2	2,8	2,8	0,8
Q3.2013	2,8	2,3	2,7	2,6	0,3	3,0	3,0	0,9
Q4.2013	2,9	2,0	2,6	2,7	0,3	2,9	3,0	0,7
Q1.2014	3,4	n.a.	2,7	2,7	0,3	2,9	3,0	0,9
Q2.2014	3,4	n.a.	2,8	2,8	0,3	3,0	3,0	0,9
Q3.2014	2,7	n.a.	2,8	2,8	0,2	2,9	3,0	0,8
Q4.2014	3,2	n.a.	2,6	2,5	0,3	2,9	3,0	1,0
Q1.2015	3,0	n.a.	2,7	2,7	0,3	2,8	2,9	0,9
Q2.2015	3,5	n.a.	2,8	2,9	0,2	3,0	3,0	0,9
Q3.2015	3,9	3,0	3,3	3,3	0,3	3,3	3,2	0,8
Q4.2015	4,4	2,8	3,4	3,5	0,3	3,3	3,3	0,8
Q1.2016	4,3	3,0	3,4	3,4	0,3	3,5	3,5	0,8
Q2.2016	3,3	2,5	3,2	3,2	0,3	3,3	3,3	0,7
Q3.2016	3,1	2,3	2,7	2,7	0,3	3,1	3,0	0,8
Q4.2016	3,2	2,3	2,9	3,0	0,2	3,1	3,0	0,7
Q1.2017	4,0	2,2	3,1	3,1	0,3	3,1	3,1	0,7
Q2.2017	2,7	2,2	2,8	2,9	0,3	3,0	3,0	0,7
	Inflation				5-years forecast			
Q4.2015	4,4	2,0	2,9	3,0	0,3	3,3	3,0	0,9
Q1.2016	4,3	2,0	2,9	3,0	0,4	3,4	3,3	1,0
Q2.2016	3,3	2,0	2,9	3,0	0,4	3,3	3,2	0,9
Q3.2016	3,1	2,0	2,7	2,7	0,3	3,1	3,0	0,9
Q4.2016	3,2	2,0	2,8	2,8	0,3	3,2	3,0	0,7
Q1.2017	4,0	2,0	2,9	3,0	0,3	3,1	3,0	0,8
Q2.2017	2,7	2,0	2,7	2,8	0,3	3,1	3,0	0,8
	Inflation				10-years forecast			
Q4.2015	4,4	2,0	2,7	2,7	0,4	3,2	3,0	1,1
Q1.2016	4,3	2,0	2,8	2,9	0,4	3,3	3,0	1,0
Q2.2016	3,3	2,0	2,8	2,8	0,4	3,3	3,1	1,0
Q3.2016	3,1	2,0	2,6	2,5	0,4	3,1	3,0	1,0
Q4.2016	3,2	2,0	2,7	2,6	0,4	3,2	3,0	0,9
Q1.2017	4,0	2,0	2,7	2,8	0,4	3,1	3,0	1,0
Q2.2017	2,7	2,0	2,6	2,6	0,4	3,1	3,0	1,0

Source: Central Bank's Macroeconomic Expectations Survey, National Institute of Statistics and Central Bank's Inflation Reports.

1/ Reports inflation at the end of the quarter.

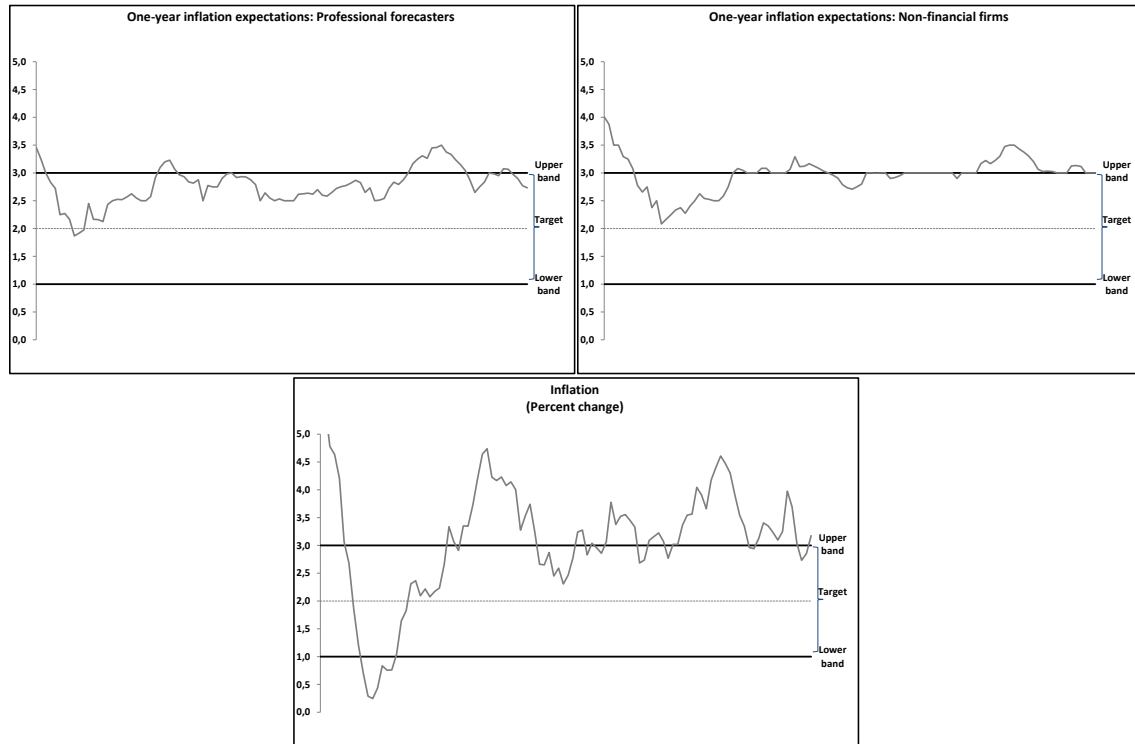
2/ Reported in the quarterly Inflation Report released by the Central Bank.

3/ Forecasts from the Central Bank Macroeconomic Expectations Survey.

4/ For each agent, one-year forecasts are estimated weighting the forecasts for the current year and the next year by the number of months to complete the year.

5/ Outliers were dropped.

Figure 2: One-year inflation forecasts and observed inflation



3.3. Strongly anchored expectations

Another key feature of anchored expectations is that they should display little dispersion as most agents believe that the Central Bank target will be realized. Thus, inflation expectations are strongly anchored if beliefs are not too dispersed across agents. Table 1 reports the cross-sectional standard deviation in inflation expectations for professional forecasters and non-financial firms. Dispersion of beliefs have been decreasing for both groups of forecasts. Yet, the dispersion in non-financial firms' expectations exceeds the dispersion of the professional forecasters' expectations. The distributions for one-year, five-year and ten-year inflation at the end of every year of our sample is shown in Annex 2.

It is possible to observe the evolution of the distributions for the inflation forecasts to assess how dispersion has evolved over time. This is a relevant issue because as it was aforementioned it is possible that observed dispersion may be driven by transitory shocks; hence evaluating a large period can show if the dispersion eventually decreases. Figure 3 and 4 presents the change in the distributions over time, where the darkest line is the median (50th percentile), and the lighter shaded areas represent upper and lower percentiles (similar to probabilistic fan chart). Although there is dispersion in their forecasts, professional forecasters' beliefs are concentrated around the upper limit of the target band, whereas non-financial firms exhibit a higher degree of dispersion.

It is worthy to note that dispersion in one-year inflation may be the result of higher observed inflation, but if inflation expectations are anchored then the dispersion in the longer-horizon inflations should be lower than the one-year inflation forecast. This is not the case. On the

contrary, dispersion in five and ten year inflation is higher for both groups of agents. As mentioned in Kumar et al. (2015), dispersion in beliefs about long-run inflation is particularly difficult to reconcile with anchored inflation expectations.

Figure 3: Evolution of the distribution of inflation expectations: Professional forecasters

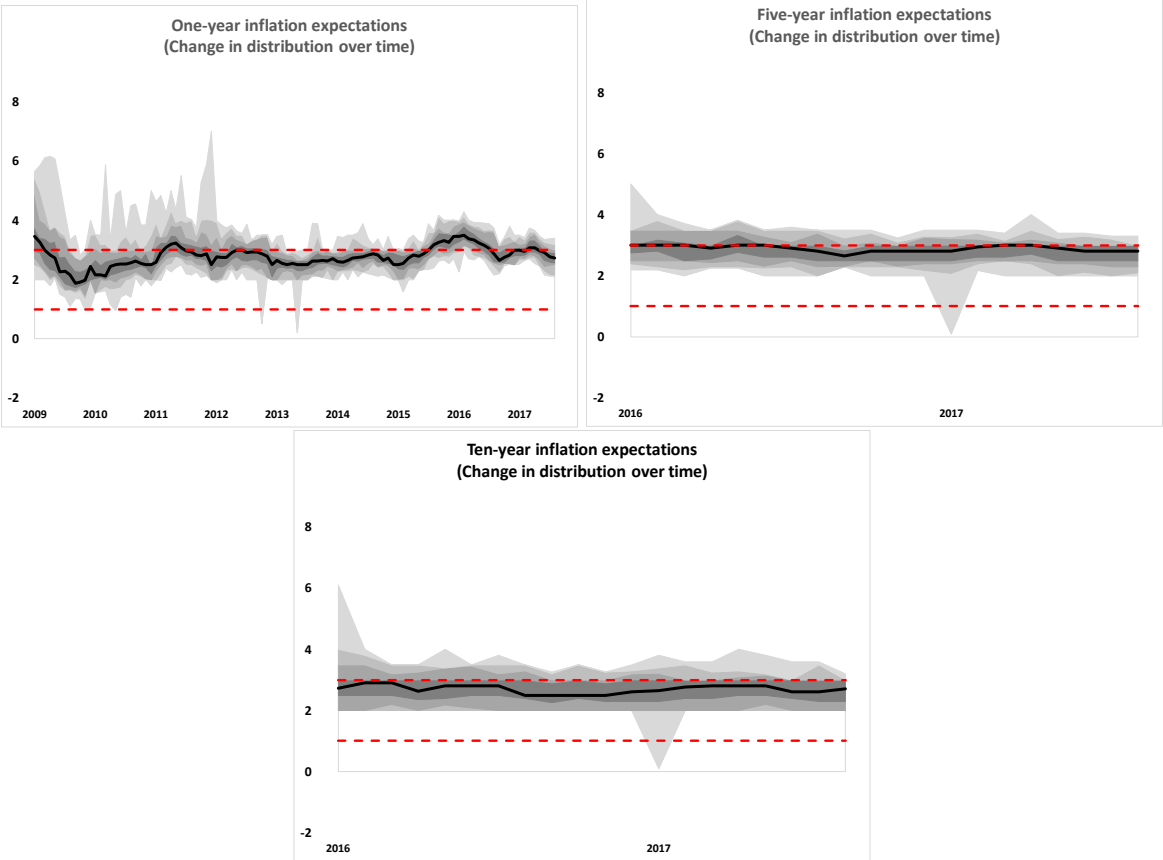
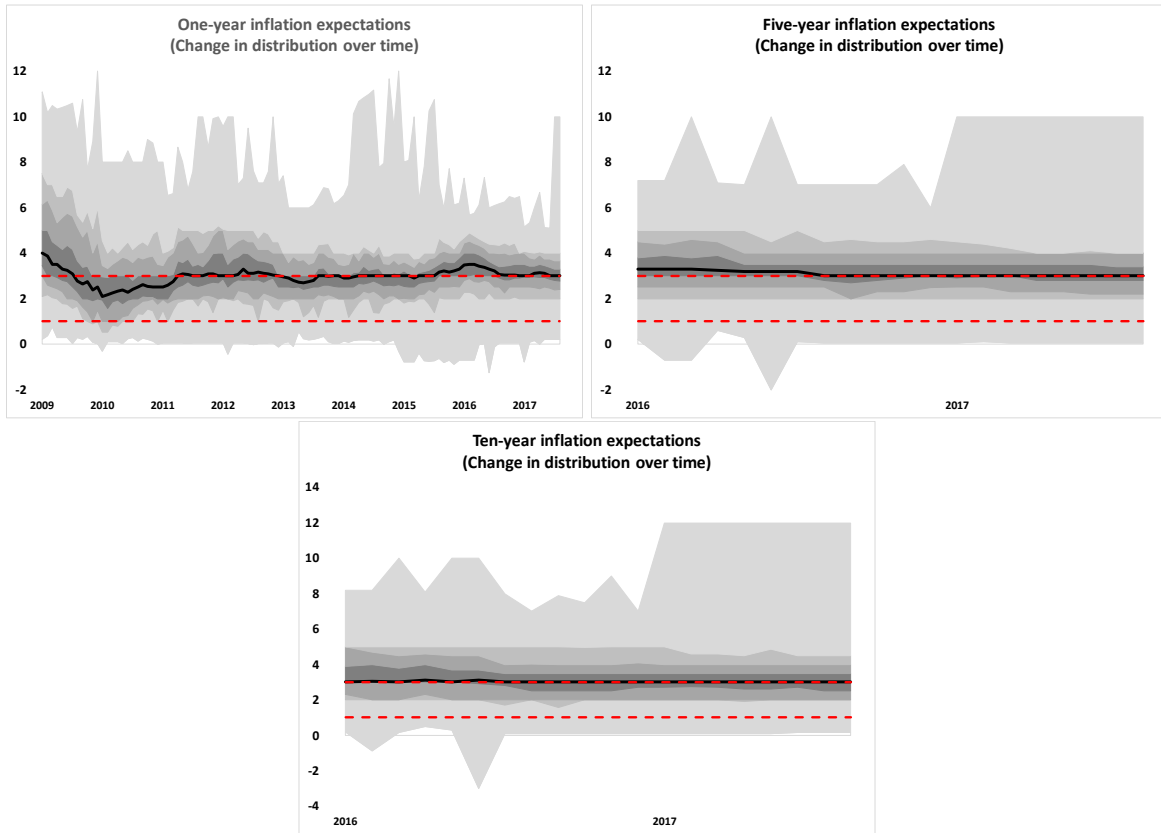


Figure 4: Evolution of the distribution of inflation expectations: Non-financial firms



3.4. Consistently anchored expectations

Inflation expectations are consistently anchored if individuals' revisions in their inflation forecasts tend to be small. If agents expect that the Central Bank will keep inflation stable (even if it is not stable at the inflation target rate) in the long-run, then they will not frequently update their inflation expectations.

As we did for the case of strongly anchored expectations, we plot the evolution of the distributions of revisions in inflation forecasts. Revisions are estimated as the difference between the forecast in the current period and the forecast in the previous period. If the expectations were consistently anchored, then the revision's distribution should collapse to zero. One-year inflation forecasts may be influenced by transitory shocks, and revisions may occur, but given the stability of inflation in Peru in the last decade these revisions should be sparse. Moreover, revisions in five-year and ten-year inflation forecasts should be zero all the time.

This is not the case. Five-year and ten-year inflation expectations exhibit constant revisions. Non-financial firms are constantly updating their forecasts for both the shorter and longer horizons. The magnitude of the revisions is lower for professional forecasters, but are still many observations different from zero. Only the revision in one-year inflation expectations of professional forecasters exhibit a behavior which corresponds to well-anchored expectations.

Figure 5: Evolution of the distribution of revisions in inflation expectations: Professional forecasters

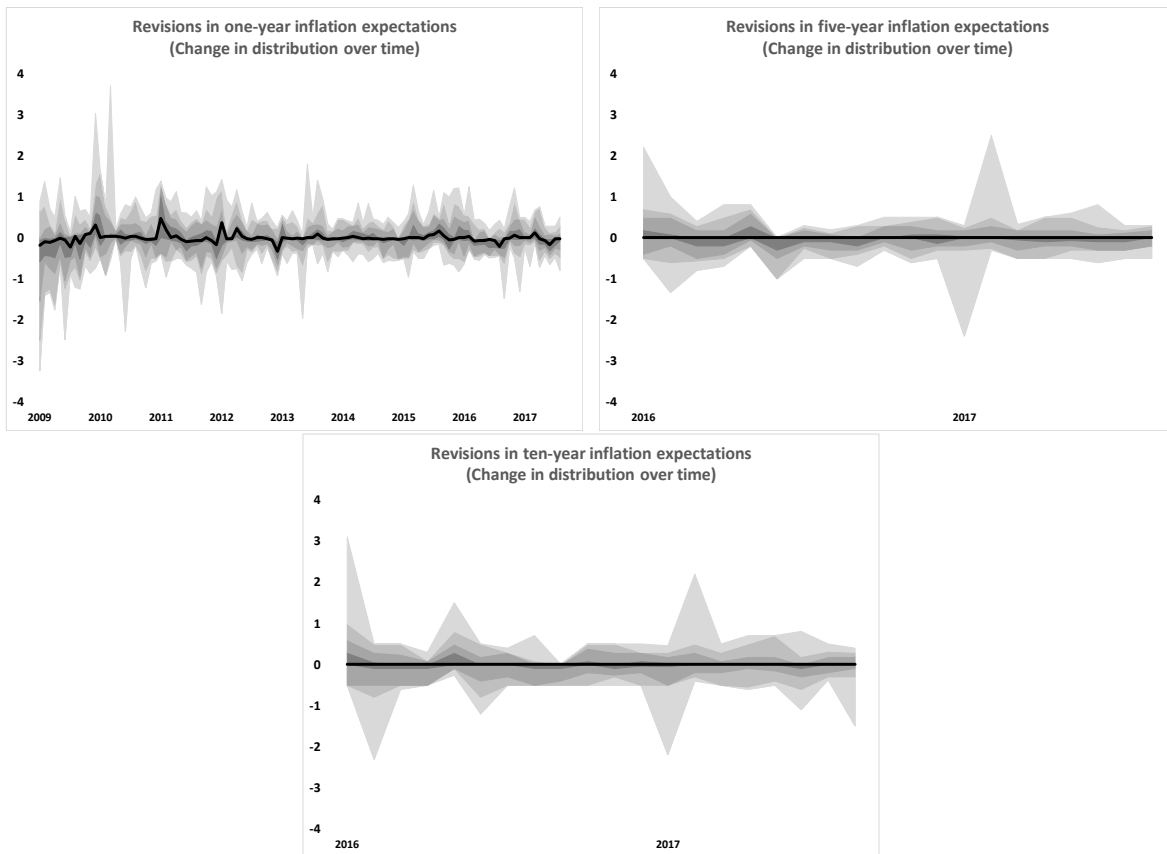
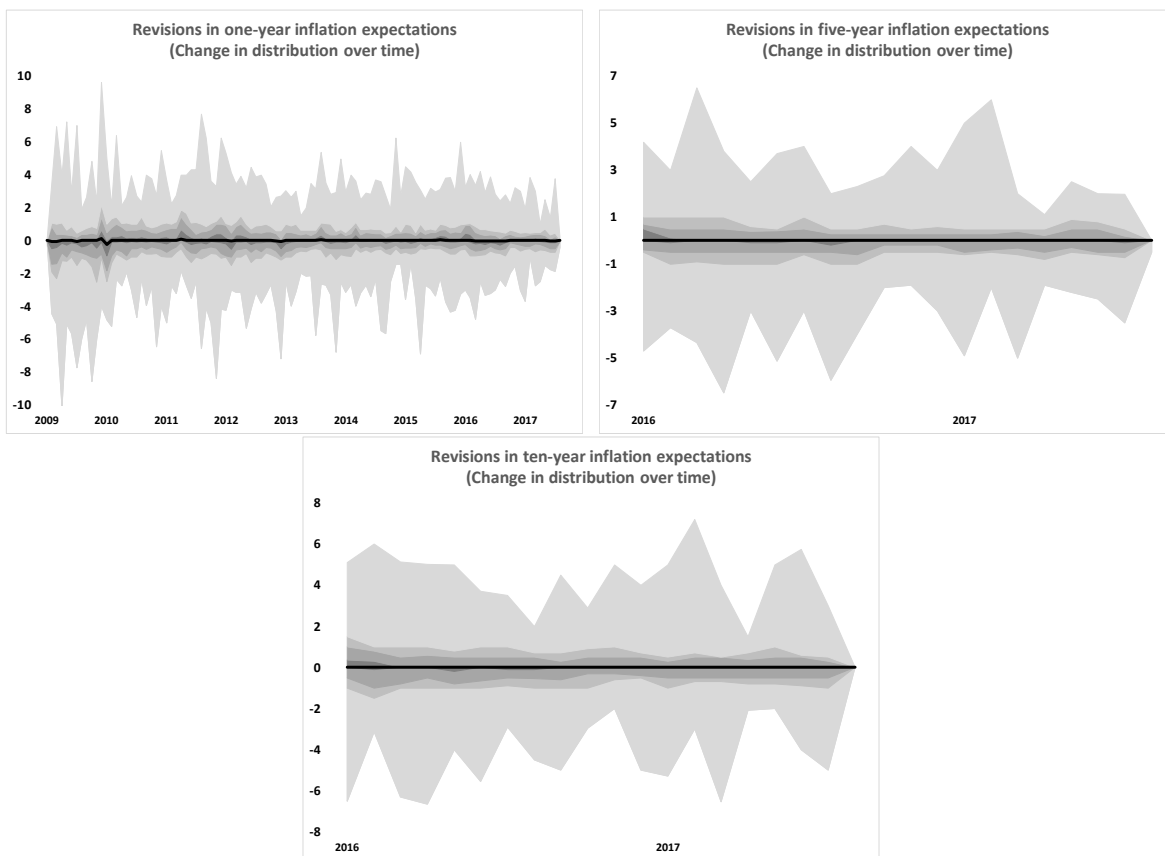


Figure 6: Evolution of the distribution of revisions in inflation expectations: Non-financial firms



3.5. Increasingly anchored expectations

Inflation expectations are increasingly anchored if central banks are able to stabilize beliefs about long-run inflation to a target and short-run and transitory fluctuations in inflation are not related to long-run forecasts, i.e. the correlation between short-run and long-inflation is zero. Under this definition, it is not relevant if short-run or long-run expectations are anchored to the Central Bank target, or if they are anchored it all, it does only matter that agents can differentiate that the shocks affecting inflation in shorter-horizons do not have an impact on longer-horizon inflation.

This prediction does not hold in our data. Graphically, it can be seen that agents who expect higher one-year inflation normally expect higher inflation in the next five years and ten years (see Annex 4). To formally assess this, we run regressions where the dependent variable is the median inflation expectation for each agent over the next five years and ten years, and the independent variable is the median one-year inflation expectation for each agent. Given our large sample, it is possible to run a cross-section OLS regression for every month in the sample and then evaluate the evolution of the coefficients over the time. In addition, we perform pooled OLS regressions, fixed effects regressions and random effects regressions. If inflation expectations are increasingly anchored, coefficients will be zero or close to zero.

Figure 7: Coefficients and confidence intervals of cross-sectional regressions: Professional forecasters

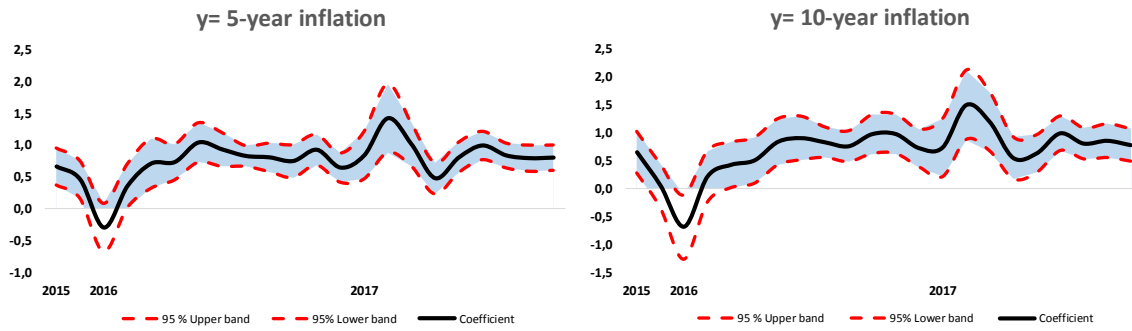


Figure 8: Coefficients and confidence intervals of cross-sectional regressions: Non-financial firms

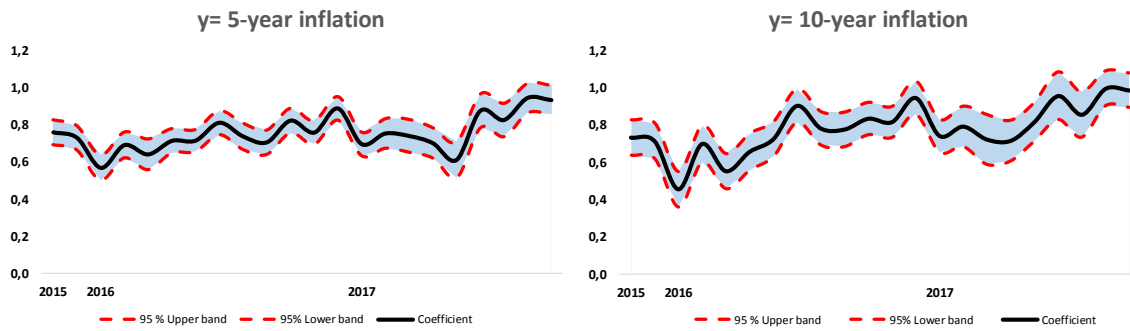


Table 2: Correlation between long-term and short-term inflation expectations

	Pooled (1)	Fixed effects (2)	Random effects (3)
Non-financial firms			
5-year inflation	0,74*** (.009)	0,57*** (.011)	0,60*** (.010)
<i># of obs.</i>	7620	7617	7617
10-year inflation	0,76*** (.012)	0,54*** (.013)	0,58*** (.013)
<i># of obs.</i>	7567	7564	7564
Economic analysts and financial sector			
5-year inflation	0,55*** (.029)	0,36*** (.023)	0,39*** (.023)
<i># of obs.</i>	831	831	831
10-year inflation	0,45*** (.039)	0,24*** (.028)	0,26*** (.028)
<i># of obs.</i>	830	830	830

Note: *** denotes significance at the 1% level.

Coefficients are significantly different from zero for both groups, except for a few months at the beginning of 2016 for professional forecasters. Thus, inflation expectations are not ideally anchored.

4. Conclusions

Inflation expectations in Peru seem to be not well-anchored: inflation expectations vary over time and cross-sectionally. We find that economic analysts and financial firms exhibit better-anchored inflation expectations than non-financial firms, which exhibit larger dispersion and more frequent revisions. Yet, both groups of agents fail to achieve to weakest measure of well-anchored expectations: co-movement between short-term and long-term inflation. This 'imperfect anchoring' may limit the efficacy of monetary policy in Peru. Moreover, given that inflation expectations are somehow anchored at the upper limit of the target band, any supply or demand shock can move away inflation expectations from the Central Bank of Peru's long-term inflation target.

The differences in anchoring between professional forecasters and non-financial firms also have monetary policy implications. Non-financial firms' expectations are not well-anchored even though the Central Bank of Peru enjoys great credibility and was quite successful in overcoming hyperinflation in the 90s. This could imply that managers of non-financial firms do not pay attention to the Central Bank target in determining their own pricing. Should the Central Bank do something about it? Whose expectations should the Central Bank anchor? As suggested in Kumar et al. (2015) and Coibion et al. (2017), it could be that non-financial firms do not care at all about the Central Bank and its monetary policy strategy, or that these firms do not keep track of inflation when it is low.

Many avenues of research remain open. A possible explanation to the lack of anchoring in non-financial firms' expectations could be the lack of awareness of the actions and objectives of monetary policy, or poor information about inflation dynamics, such as an overreaction to inflation news (i.e. confusion between long-run and short-run inflation). One possible way to assess this issue is to include questions in the Macroeconomic Expectations Survey regarding how firms form their expectations, if they are useful to their price formation-process and their general knowledge about the Central Bank. Another possible explanation for the difficulty in anchoring inflation expectations could be the divergence between core and headline inflation, as proposed in Arora et al (2013): a divergence of food and energy prices from other prices may be perceived as a signal of emerging inflation. In Peru, where the food component of the consumer's basket is large (38 percent), food inflation may have a persistent effect in expectations formation. Therefore, this hypothesis could be tested.

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Annex 1

Anchored expectations

Ideally anchored expectations

Definition 1. Inflation expectations at time t for any horizon $\tau \geq 0$ are *ideally ε -anchored* if the support of every agent's belief of inflation at that time and horizon lies within ε of the central bank's target. Meaning that

$$F_{t+\tau|t}^i(\pi^* + \varepsilon) - F_{t+\tau|t}^i(\pi^* - \varepsilon) = 1, \forall i \in [0,1].$$

Prediction 1: Average beliefs should be close to the inflation target. If inflation expectations at time t for any horizon $\tau \geq 0$ are ideally ε -anchored, then the belief about inflation should lie within ε of the central bank's target, so that

$$bias_{t+\tau|t} = |\overline{\pi_{t+\tau|t}} - \pi^*| < \varepsilon,$$

Where $\overline{\pi_{t+\tau|t}} = \int_0^1 \pi_{t+\tau|t}^i di$ is the average belief across agents and $\pi_{t+\tau|t}^i \equiv E_t^i\{\pi_{t+\tau}\} = \int_R x dF_{t+\tau|t}^i(x)$ is agent i 's time t expectations of inflation at horizon τ .

Strongly anchored expectations

Definition 2. Inflation expectations at time t for any horizon $\tau \geq 0$ are *strongly ε -anchored* if the support of every agent's inflation expectations at the time and horizon lies within ε of the average belief, so that,

$$F_{t+\tau|t}^i(\overline{\pi_{t+\tau|t}} + \varepsilon) - F_{t+\tau|t}^i(\overline{\pi_{t+\tau|t}} - \varepsilon) = 1, \forall i \in [0,1].$$

Prediction 2: Beliefs should not be too dispersed across agents. If inflation expectations at time t for horizon τ are strongly ε -anchored, then the dispersion of agent's beliefs about inflation should be less than ε , meaning that

$$sd_{t+\tau|t} \equiv \left[\int_0^1 (\pi_{t+\tau|t}^i - \overline{\pi_{t+\tau|t}})^2 di \right]^{\frac{1}{2}} < \varepsilon.$$

Lemma 1. If inflation expectations are ideally $\varepsilon/2$ -anchored, then they are strongly ε -anchored.

Weakly anchored expectations

Definition 3. Inflation expectations at time t for any horizon $\tau \geq 0$ are *weakly ε -anchored* if the support of every agent's inflation expectations at that time and horizon lies within ε of that agent's belief, meaning that,

$$F_{t+\tau|t}^i(\pi_{t+\tau|t}^i + \varepsilon) - F_{t+\tau|t}^i(\pi_{t+\tau|t}^i - \varepsilon) = 1, \forall i \in [0,1].$$

Moreover agent i is ε -confident of his/her forecast/backcast if his/her own perception of the degree to which his/her inflation expectation has varied is less than ε^2 , that is:

$$E_t^i \left\{ (\pi_{t+\tau} - \pi_{t+\tau|t}^i)^2 \right\} < \varepsilon^2.$$

Prediction 3: Agents should show confidence in their forecasts. If inflation expectations are weakly ε -anchored for a given time and horizon, then all agents are ε -confident of their forecasts.

Lemma 2. If inflation expectations are ideally or strongly $\varepsilon/2$ -anchored then they are also weakly ε -anchored.

Consistently anchored expectations

Definition 4. Inflation expectations of agent i for any horizon $\tau \geq 0$ are *consistently ε -anchored* at t , if the total change in the cumulative distribution function of his belief from $t-1$ to t is less than ε in magnitude:

$$\int_R |F_{t+\tau|t}^i(x) - F_{t+\tau-1|t-1}^i(x)| dx < \varepsilon$$

Prediction 4: Agents should display small forecast revisions. The size of an agent's forecast revision of inflation at time t for any horizon $\tau \geq 0$ is less than ε if his/her inflation expectation for horizon τ is consistently ε -anchored at t .

Lemma 3. Define forecast revision for agent i at time t for horizon τ as $FR_{t+\tau|t}^i = \pi_{t+\tau|t}^i - \pi_{t+\tau|t-1}^i$. If inflation expectations for horizon τ are ideally $\varepsilon/2$ -anchored at $t-1$ and t , then they are also consistently ε -anchored. Moreover, if expectations for horizon τ are strongly $\varepsilon/2$ -anchored at $t-1$ and t , then they are also consistently $(\varepsilon + \delta')$ -anchored where $\delta' \equiv \left| \int_0^1 FR_{t+\tau|t}^i di \right|$ is the absolute size of average forecast revision across agents.

Increasingly anchored expectations

Definition 5. Given a sequence $\{\varepsilon_t\}_{\tau=0}^{\infty}$ at time t , inflation expectations are *increasingly T -anchored* at time t if for any $\tau \geq T$, expectations are strongly ε_t -anchored.

Increasingly T -anchored expectations are weaker than strongly anchored expectations when they are required to be strongly ε_t -anchored for $\tau \geq 0$, since this condition does not impose any restrictions on expectations over short-run horizons.

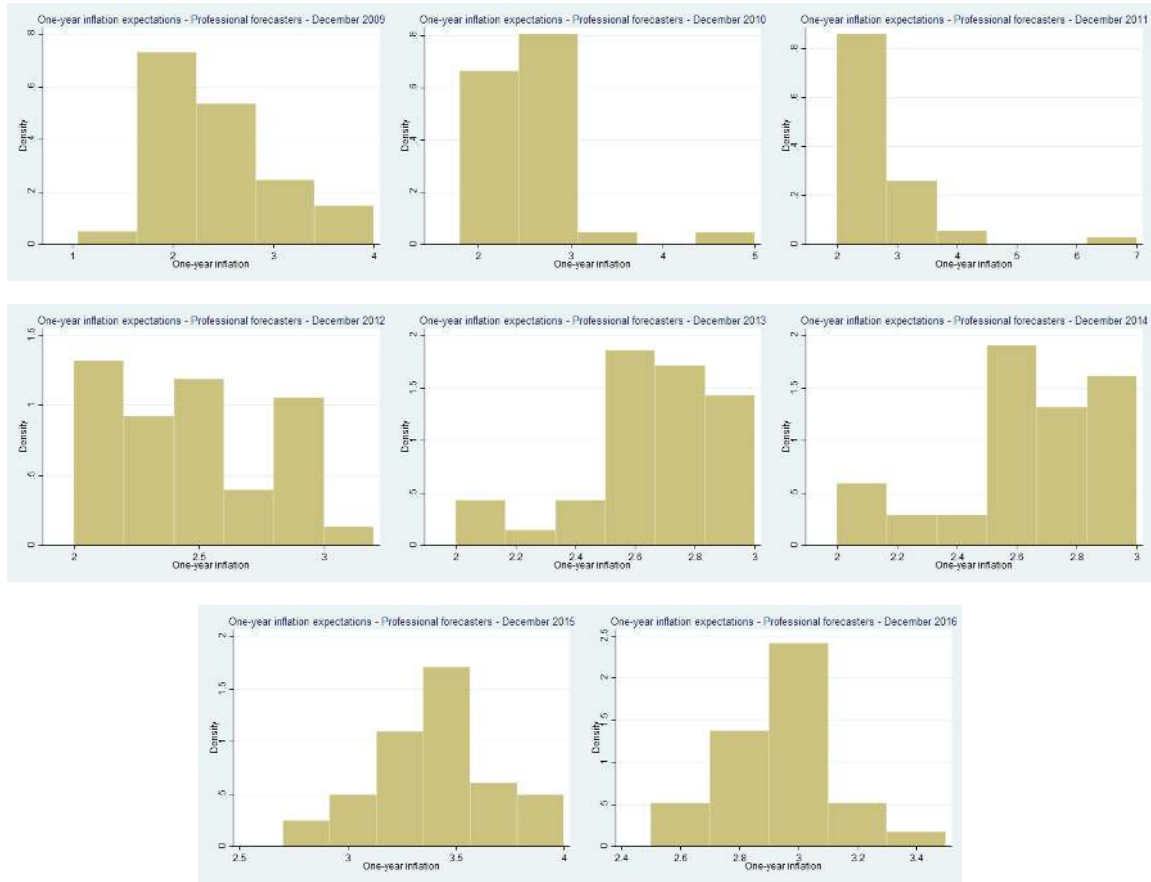
Prediction 5: Long-run expectations should be unpredictable using short-run expectations. Consider the following regression for time t data:

$$\pi_{t+\tau|t}^i = \alpha_\tau + \beta_\tau \pi_{t+1|t}^i + error_i.$$

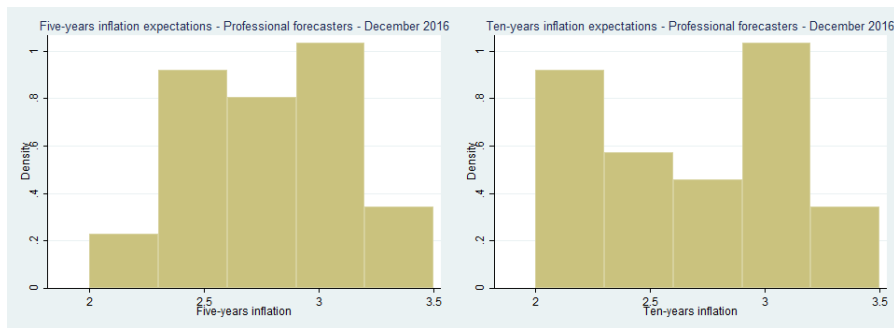
Given the sequence $\{\varepsilon_t\}_{\tau=0}^{\infty}$ such that $\lim_{\tau \rightarrow \infty} \varepsilon_\tau = 0$, suppose expectations are increasingly T -anchored for an arbitrary $T \geq 1$. Then $\lim_{\tau \rightarrow \infty} \beta_\tau = 0$.

Annex 2

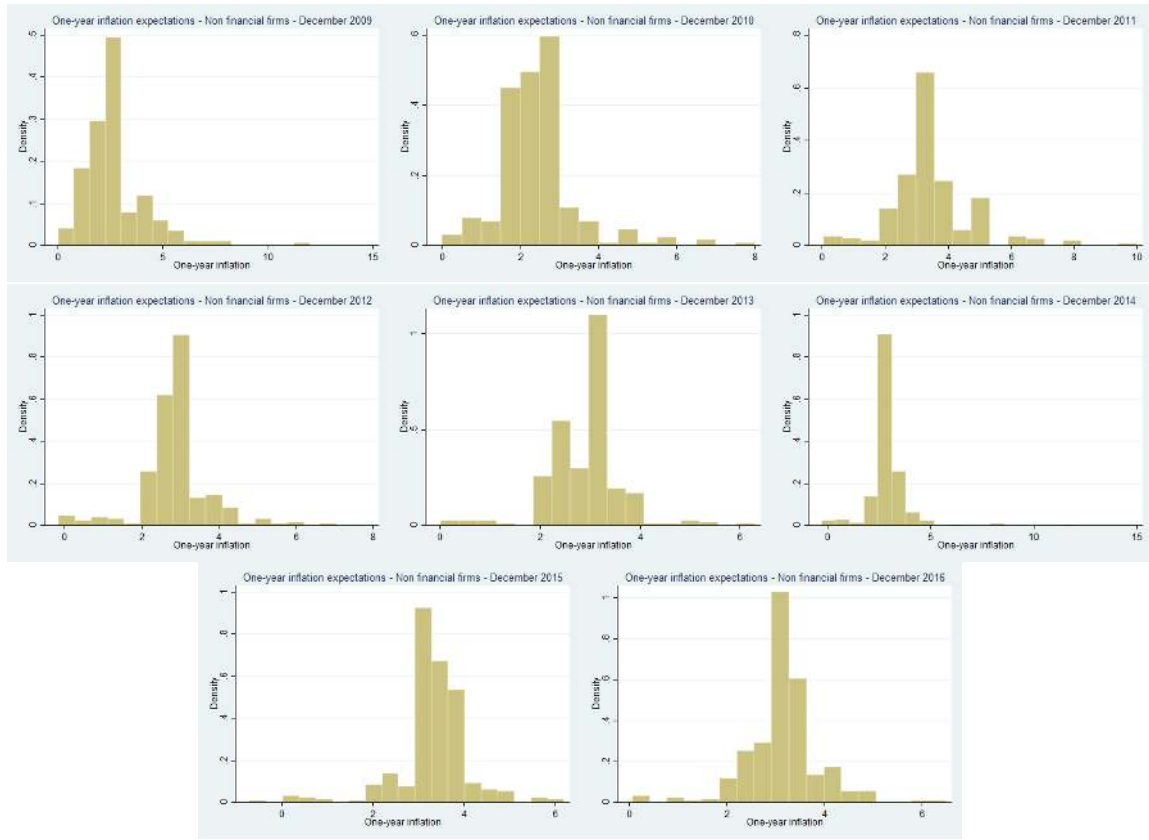
Distributions of one-year inflation forecasts: Professional forecasters



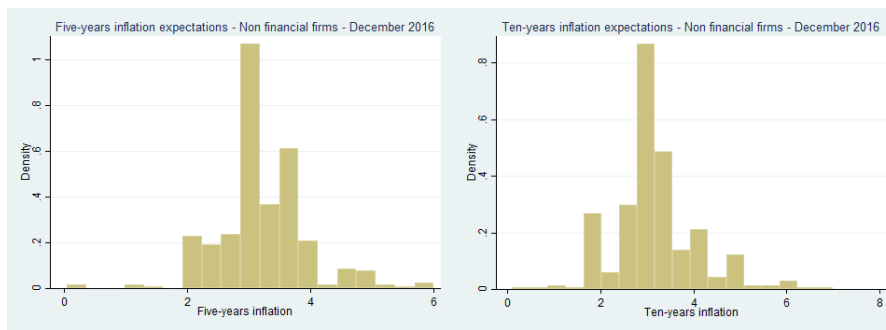
Distributions of five-year and ten-year inflation forecasts: Economic analysts and financial sector



Distributions of one-year inflation forecasts: Non-financial firms

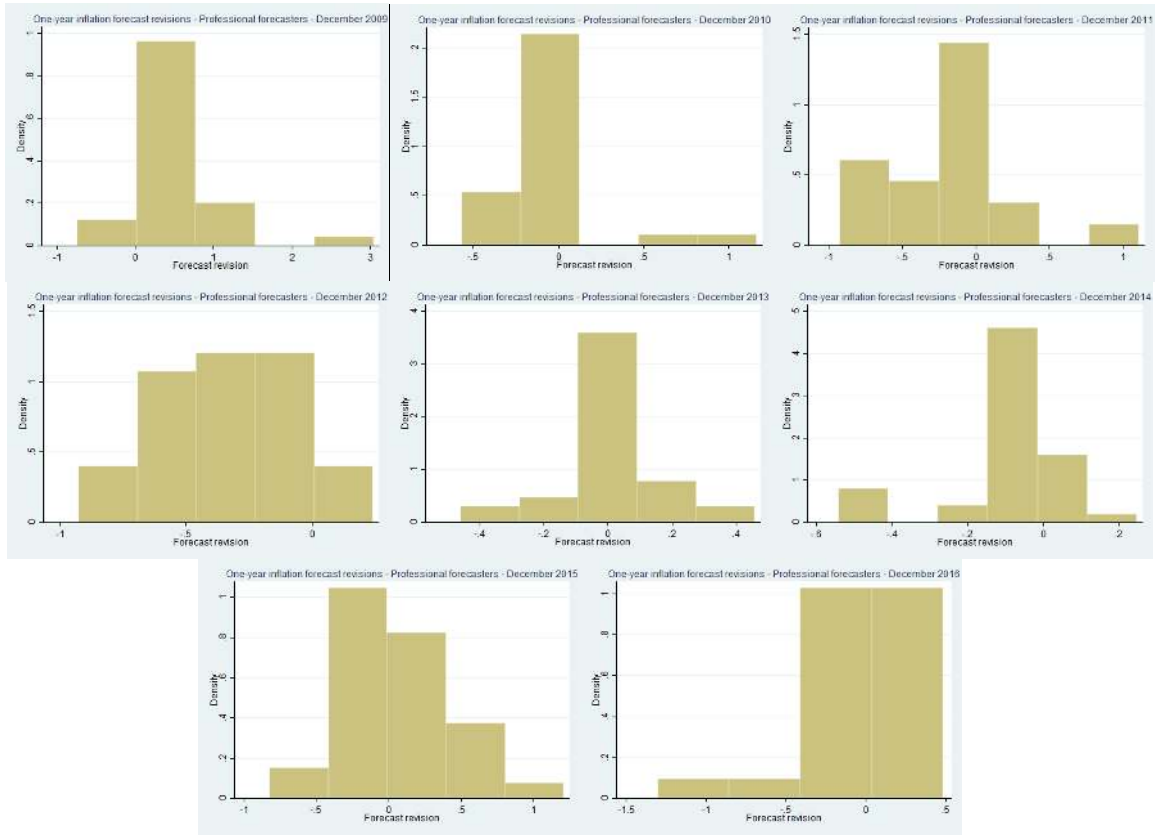


Distributions of five-year and ten-year inflation forecasts: Non-financial firms

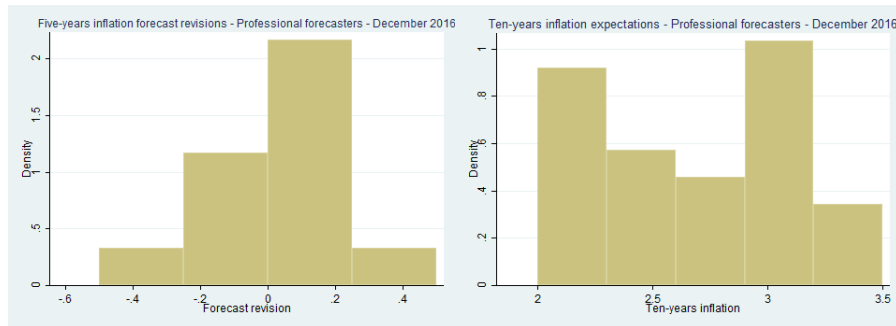


Annex 3

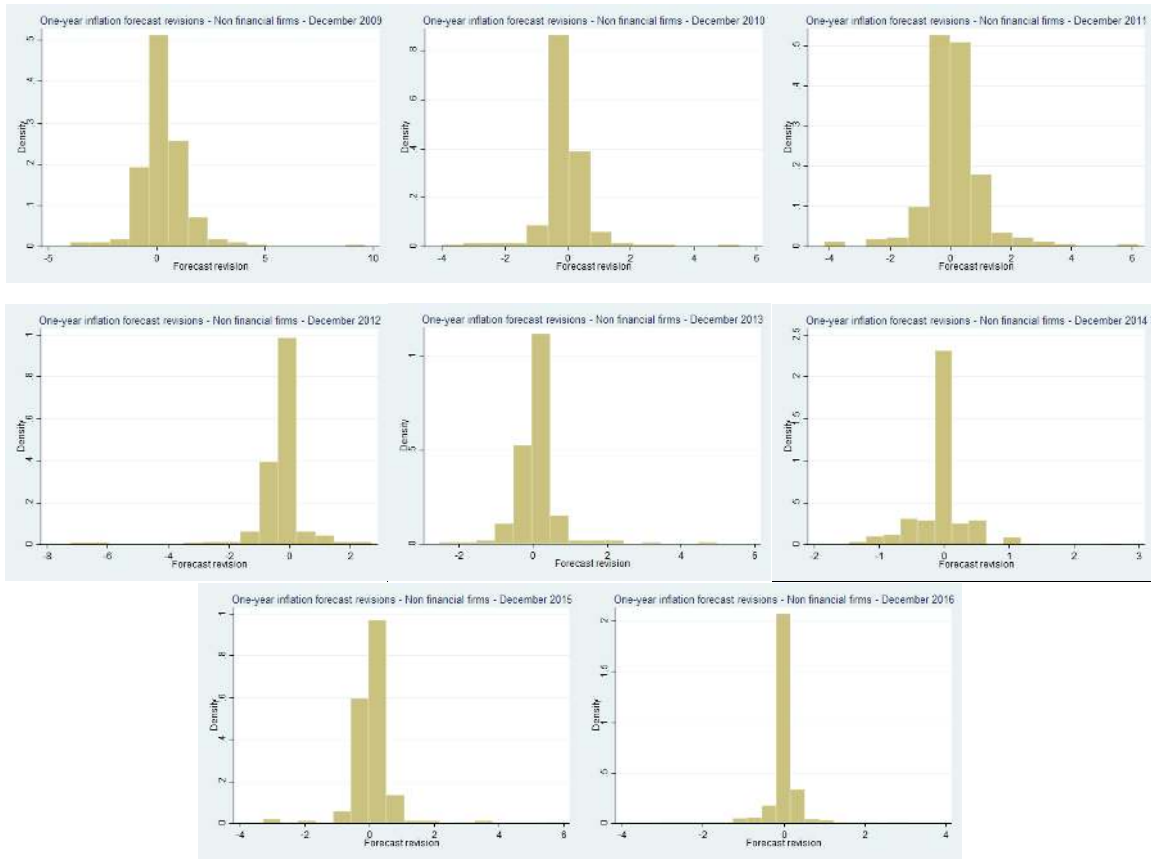
Distributions of revisions in one-year inflation forecasts: Economic analysts and financial sector



Distributions of revisions in five-year and ten-year inflation forecasts: Economic analysts and financial sector



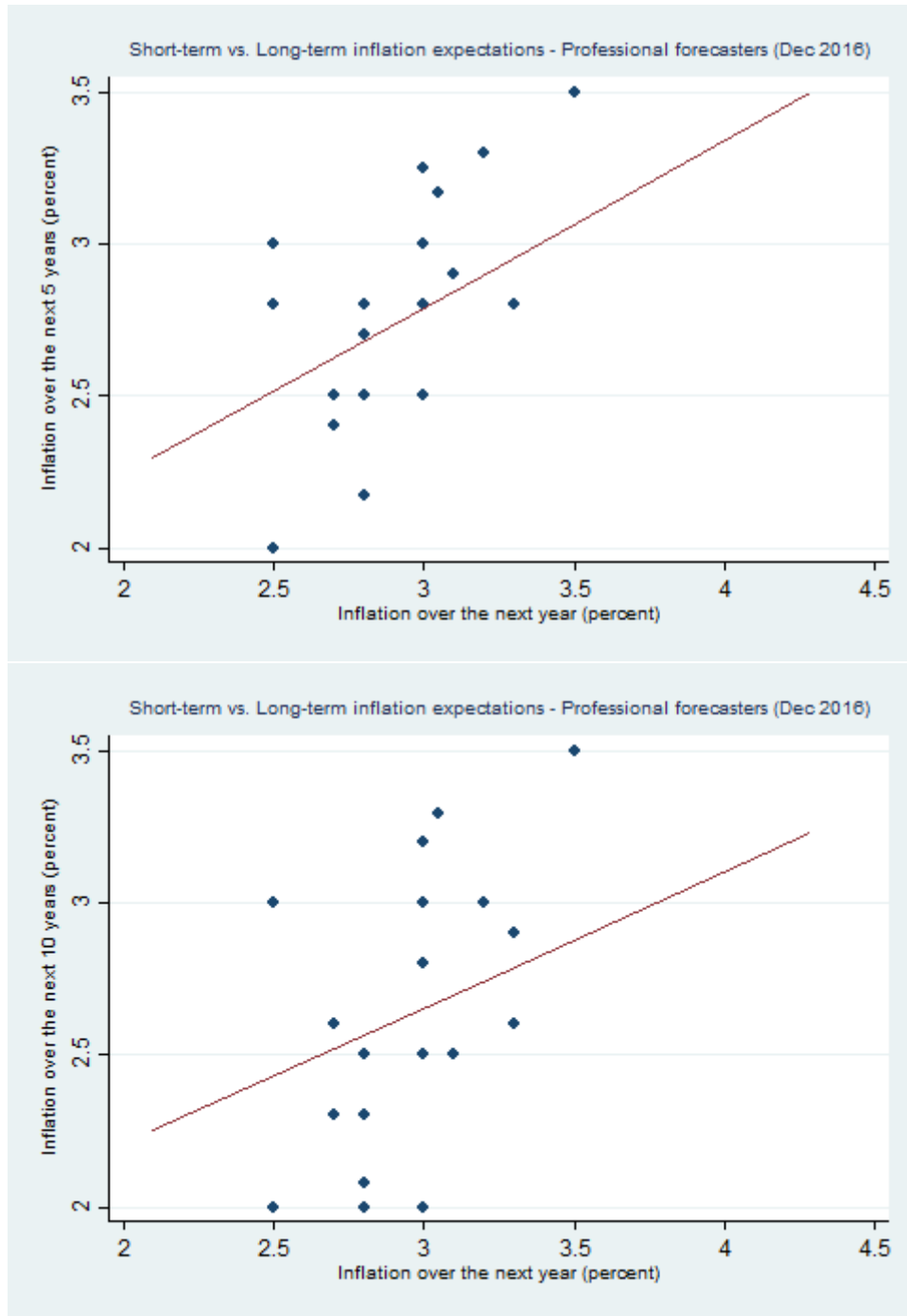
Distributions of revisions in one-year inflation forecasts: Non-financial firms



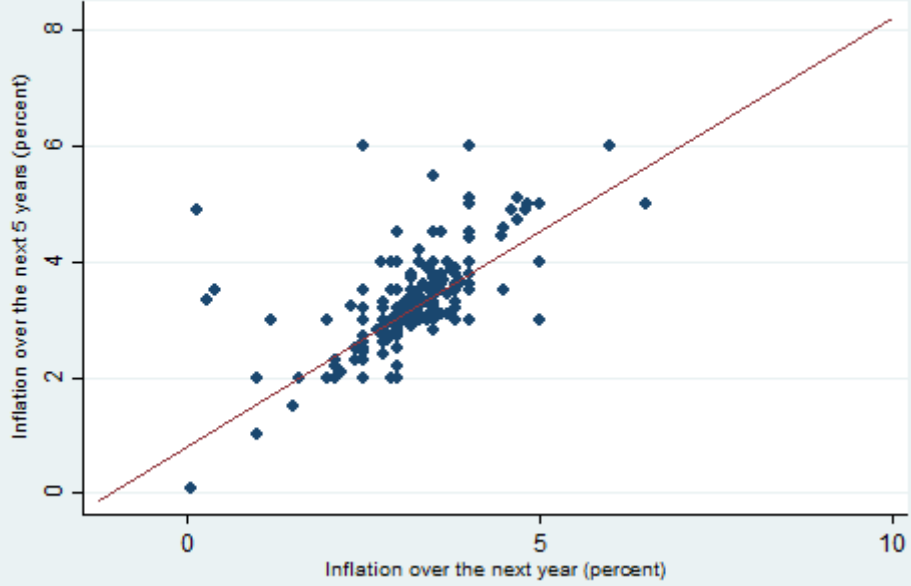
Distributions of revisions in five-year and ten-year inflation forecasts: Non-financial firms



Annex 4



Short-term vs. Long-term inflation expectations - Non financial firms (Dec 2016)



Short-term vs. Long-term inflation expectations - Non financial firms (Dec 2016)

