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Abstract

In this paper we study how inflation expectations are formed and whether these change due to the occurrence of policy shifts or structural breaks. We conduct 4 experiments with 75 inexperienced subjects, in which we ask them to predict future home inflation and report confidence intervals. At three points in time during our experiments, we also ask our participants to provide additional information regarding the uncertainty about their expectations. Our design allowed us to gather 6750 home inflation point forecasts and confidence intervals. We find that: (1) inflation expectations are seldom rational; (2) our subjects generally ignore valuable information and, instead, tend to pay close attention to past trends; (3) the adoption of inflation targeting increases the amount of subjects that forecast in a rational fashion and reduces the uncertainty about future inflation; and (4) a recession reduces rationality among forecasters, yet induces them to expect inflation to revert to its mean.

KeyWords: Inflation Expectations, Experimental Analysis, Rational Expectations, Inflation Targeting, Structural Breaks.

JEL Codes: C90, E37

Resumen

En este documento se muestra cómo las expectativas de inflación son formadas y si cambios en la política o cambios estructurales influencian en dicha formación. Cuatro experimentos son realizados con 75 individuos no experimentados donde se solicita predecir la inflación doméstica futura y reportar intervalos de confianza. En tres momentos de los experimentos se solicita adicionalmente información referente a la incertidumbre de las predicciones. El diseño permite contar con 6750 puntos de predicción de inflación doméstica e intervalos de confianza. Los resultados muestran que: (1) las expectativas de inflación son raramente racionales; (2) en general, los individuos ignoran información valiosa y tienen tendencia a prestar atención al comportamiento tendencial pasado; (3) la adopción de metas de inflación aumenta el número de individuos que predicen en forma racional y reduce la incertidumbre acerca de la inflación futura; y (4) una recesión reduce el nivel de racionalidad entre los individuos, más aún los induce a esperar que la inflación revierta hacia su media.

Palabras Claves: Expectativas de Inflación, Análisis Experimental, Expectativas Racionales, Metas de Inflación, Cambio Estructural.

Classificación JEL: C90, E37

Inflation Expectations Formation in the Presence of Policy Shifts and Structural Breaks: An Experimental Analysis[1]

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1 Introduction

The current workhorse of macroeconomics–New Keynesian models – posits that the paths of macro variables depend on the expectations that individuals hold about future realizations. In this context, understanding the processes by which inflation expectations are formed is fundamental to the conduction of optimal monetary and fiscal policies. Additionally, policy design needs to take into account the fact that policy shifts and structural breaks may change the way individuals assess the occurrence of future uncertain events. In this paper, we conduct field experiments with both undergraduate- and graduate- economics students from Pontificia Universidad Católica del Perú (PUCP) to shed light on their expectations formation processes and whether these change when an economy experiences a policy shift or structural break.

Since their introduction in the early sixties, rational expectations (RE) have been the predominant paradigm for modeling expectations in macroeconomics and finance. This hypothesis asserts that "...expectations of firms (or, more generally, the subjective probability distribution of outcomes) tend to be distributed, for the same information set, about the prediction of the theory (or the "objective" probability distribution of outcomes)." (Muth, 1961: 316) It implies that economic agents generally do not waste information, that expectations formation depends on the structure of the economy, and that any differences between the expectations of the relevant theory and those held by them will be eliminated by arbitrage (Muth,

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1961). This hypothesis does not specify a particular expectations formation process, yet most models that incorporate RE become operable by assuming that individuals know the underlying structure of the economy, the values of the parameters, and the nature of the shocks (Evans and Honkapohja, 2001). Consequently, individuals are thought to exploit all the available information and make no systematic forecast errors.

Although there is no consensus on what the best test for rationality is, several papers [Adam (2007), Branch (2007), Curtin (2005), Hey (1994), Mankiw et al. (2003), Pfajfar and Zakelj (2009), among others] have relied on different tests – usually analyzing forecasting bias and efficiency – to examine whether inflation expectations behave rationally. The results have been mixed. Adam (2007), Branch (2007), Curtin (2005), and Mankiw et al. (2003) find evidence indicating departures from rationality. On the other hand, Pfajfar and Zakelj (2009) find, in their experimental analysis, that about 40% of their participants use predominately a rational forecasting rule; while Hey (1994), in another experiment, concludes that the expectations formation processes have characteristics of both rational and adaptative behavior.

The RE hypothesis, where agents have full information, has not only had mixed empirical support but is also inconsistent with certain characteristics of economic data. Particularly, it cannot account for observed inflation and output persistence, excess volatility in financial markets, deflationary periods followed by recessions, lagged policy effects, or financial bubbles. Accordingly, there have been various approaches aimed at reconciling dynamic macroeconomic models with the data. One of them, proposed by Caroll (2002) and Mankiw and Reis (2002), asserts that individuals hold RE yet, due to costs associated to gathering and processing information, only a fixed proportion of them is able to update its information. Mankiw and Reis (2002) find that their sticky-information model is able to replicate lagged policy effects, deflationary periods followed by recessions, and inflation persistence. Additionally, an empirical paper by Mankiw et al. (2003) provides further support for the sticky-information model showing that it explains many features of the central tendency and dispersion of inflation.

A second approach has been to introduce learning in the expectations formation process.[3] Unlike RE, where individuals are assumed to have perfect information, under learning they are assumed to act as econometricians – adjusting their forecasting rules as information becomes available. Support for the learning hypothesis can be found in Milani (2007) and Nunes

[3] See Evans and Honkapohja (2001) for a comprehensive review.

(2005). The former demonstrates by means of Bayesian estimation that the persistence of macroeconomic variables is better explained by introducing learning in dynamic macroeconomic models than by utilizing RE with mechanical sources of persistence. In a theoretical paper, Nunes (2005) models the implementation of a disinflationary policy by simulating a new Keynesian model in which all agents are specified to follow a recursive least squares learning algorithm. He finds that, in agreement with the data, inflation is reduced sluggishly and that the economy experiences a recession, yet the speed of convergence is too slow. This inconsistency is solved by specifying that a fixed proportion of agents hold RE.

These two approaches face a long-standing criticism from the behavioral sciences – under the name of bounded rationality, urging economists to take into account people's cognitive limitations in modeling their behavior. "To the best of my knowledge, all these [naïve, adaptative, and RE] equations have been conceived in the shelter of armchairs; none of them are based on direct empirical evidence about the processes that economic actors actually use to form their expectations about future events." (Simon, 1980: 308) RE assume that individuals have perfect knowledge of the economy and unlimited computational capacities, while learning only relaxes the assumptions made on the availability of information. Studies in cognitive psychology, though, have demonstrated that people do not behave in the abovementioned ways and that, instead, they resort to heuristics to predict outcomes or probabilities associated with uncertain events [Kahneman and Tversky (1973) and Tversky and Kahneman (1974)].

The development of the bounded rationality literature and the concomitant permeation of cognitive psychology and evolutionary biology in economics have resulted in the creation of forecasting models based on heuristics and disciplined by evolutionary selection. In these models, at every point in time, individuals choose between a finite number of heuristics (or a combination of heuristics and sophisticated rules) in order to make their forecasts. These decisions are disciplined by evolutionary selection, meaning that individuals are specified to choose among forecasting rules based upon their past performance.[4] Simulation evidence by Anufriev and Hommes (2007) suggests that this class of models is able to match three convergence patterns observed in an experiment by Hommes et al. (2006): slow monotonic price convergence, oscillatory dampened price fluctuations and persistent price oscillations. Additionally, Branch (2007) provides non-parametric ev-

[4] See Hommes (2006) for a theoretical survey on this class of models and Simon (1987) for an introduction to the concept of satisficing.

idence suggesting that rationally bounded expectations formation models disciplined by evolutionary selection are a better match for survey data than sticky-information models.

In addition to point forecasting, the literatures on economic and psychological prediction have also developed theories on how people predict confidence intervals. Tversky and Kahneman (1974) assert that when individuals make use of the anchoring and adjustment heuristic to make predictions in the form of confidence intervals they think first of their best prediction and then adjust this value upwards and downwards to complete the task. Yet, the use of this heuristic impedes sufficient adjustment which results in the prediction of overly narrow confidence intervals. Additionally, Kahneman and Tversky (1973) show that individuals fail to expect mean-reversion even when it is bound to happen. The authors confirm this hypothesis by conducting an experiment in which they ask graduate students to report confidence intervals about an outlier observation. They observe that the majority of students reported symmetric confidence intervals, as opposed to intervals skewed towards the mean. Nevertheless, in the context of asset pricing, De Bondt (1993) finds the exact opposite. His experiment reveals that when prices are rising, people predict left skewed confidence intervals and, when prices are going down, they predict right skewed ones. De Bondt (1993) calls this phenomenon the hedging theory of confidence intervals.

The question of whether the processes by which individuals form their expectations are stable, or whether these are sensible to exogenous events has been addressed by the literature on decision making under uncertainty. The available experimental evidence tends to favor the latter hypothesis: "At times when they [individuals] view the world as stable or static, they place too much weight on past events in prediction; but when they perceive large structural changes taking place in the environment, they underestimate the significance of past experience for predicting the future." (Simon, 1987: 285) Additionally, both theoretical and empirical evidence support the hypothesis that ambiguity[5] conditions the way people assess uncertainty (Einhorn and Hogarth, 1987). In particular, one could expect that the occurrence of an exogenous event would induce greater ambiguity among individuals and, consequently, alter the way they assess the occurrence of future events.

In this paper we design field experiments aimed at studying the following: (1) how individuals form their expectations about future inflation; (2) how individuals assess the uncertainty about their inflation expectations; and

[5] "...ambiguity results from the uncertainty associated with specifying which of a set of distributions is appropriate in a given situation." (Einhorn and Hogarth, 1987: 45)

(3) whether the previous two processes are sensible to exogenous events. In particular, we explore whether a policy shift, such as the adoption of inflation targeting (IT), and a structural break in the form of a recession alter the way individuals assess future inflation. Our work follows a long line of experimental research on expectations formation [Adam (2007), De Bondt (1993), Dominitz and Manski (1994), Heemeijer et al. (2006), Hey (1994), Kahneman and Tversky (1973), Schmalensee (1976), Smith et al. (1988), Tversky and Kahneman (1974), among others]. In particular, the design of our experiment is similar to that of Pfajfar and Zakelj (2009); we expand their design by opening the experimental economy, introducing exogenous events to test for stability in the inflation forecasting processes, and allowing for an in depth analysis of inflation expectations uncertainty.

2 The Model

In this paper we consider a small open economy new Keynesian model with price rigidities, as presented by Gali and Monacelli (2005). The model can be described by a forward-looking dynamic IS curve (equation 1), a new Keynesian Phillip's curve (equation 2), and two equations: one describing the uncovered interest rate parity (equation 3) and another specifying the composition of CPI inflation (equation 4). Additionally, we close the model by introducing a Taylor rule (equation 5) that only considers lagged data. We do this in order to broaden the parameters space that allows for a determinate RE equilibrium (Baask, 2006).

This model requires individuals to hold expectations about the future exchange rate, home inflation, and output gap; yet, we consider that asking our experimental individuals to forecast all three variables and provide confidence intervals would be a task too taxing. Accordingly, we make our first departure from the standard model by specifying that output and exchange rate expectations are naïve, that is, $E_t\left[X_{t+1} \mid \Psi_{t-1}\right] = X_{t-1}$, where Ψ_t is the set of all the available information at time t.

Our second and final departure from the standard model is that the exchange rate adjusts only partially to the domestic and foreign interest rate spread. We do this to match a well documented stylized fact that, even though some central banks claim to have floating exchange rates, many of these do utilize their policy instruments to reduce the exchange rate volatility (Reinhart, 2000).

The model we utilize in our experiment is characterized by the following equations:

$$x_t = x_{t-1} - \frac{1}{\sigma_\alpha}\left(r_t - E_t^{AM}\left[\pi_{H,t+1}\right] - \overline{rr}\right) + \varepsilon_t^x \tag{1}$$

$$\pi_{H,t} = \beta E_t^{AM}\left[\pi_{H,t+1}\right] + k_\alpha x_t + \varepsilon_t^{\pi_H} \tag{2}$$

$$e_t = e_{t-1} + \lambda\left(r_{t-1} - r^*\right) + \varepsilon_t^e \tag{3}$$

$$\pi_t = (1-\alpha)\,\pi_{H,t} + \alpha\left(\Delta e_t + \pi^*\right) \tag{4}$$

$$r_t = \varphi_r r_{t-1} + (1-\varphi_r)\left[\varphi_\pi \pi_{t-1} + \varphi_x x_{t-1}\right] \tag{5}$$

Where x_t is the output gap, $\pi_{H,t}$ is the home inflation, π_t is the CPI inflation, e_t is the log exchange rate, r_t is the nominal interest rate, $\overline{rr}$ is the natural interest rate, π^* is the imported inflation, and r^* is the foreign nominal interest rate. $\varepsilon_t^{\pi_H}$, ε_t^x, and ε_t^e are serially autocorrelated home inflation, output gap, and exchange rate shocks, respectively. Additionally, Δ is the difference operator and $E_t^{AM}\left[\pi_{H,t+1}\right]$ indicates the arithmetic mean of the one-quarter-ahead home inflation expectations.[6]

For the calibration of our model, we borrow most of the profound parameters' values from Castillo et al. (2009) and Vega et al. (2009) to match the characteristics of the Peruvian economy. Additionally, we conduct static and deterministic one-step-ahead forecasts of our model to explore its ability to reproduce the observed data between 2001Q1 and 2010Q3. To this purpose, we had to specify the inflation expectations formation process. As with the other expectations, we set them to be naïve. The sample correlations between the observed and predicted values of the home inflation, output gap, interest rate, and exchange rate are 0.104, 0.761, 0.872, and 0.956, respectively. The poor performance of our model in replicating observed home inflation can be explained by the latter's forward-looking nature. Nevertheless, our predicted series does follow closely the lagged observed home inflation series, with a sample correlation of 0.969.

3 Experimental Design

In this paper we conduct 4 experiments in 9 group sessions aimed at analyzing whether the way individuals form their expectations about home infla-

[6] $E_t^{AM}\left[\pi_{H,t+1}\right] = \frac{\sum_{i=1}^{N} E_{i,t}\left[\pi_{H,t+1}|\Psi_{t-1}\right]}{N}$

tion changes with the occurrence of exogenous events. Accordingly, we implement a within-individuals design that allows for repeated measurements. All of our participants had taken at least two classes in macroeconomics.

In each group session, 6 to 10 students interact, at the same, time in a fictional economy. Each of them faces a computer screen (reproduced in Appendix 1) in which they are able to visualize all the variables in our model[7] as observations become available yet, they are never presented with the model's equations or the shocks to which these are exposed. At the beginning of the experiment, individuals are able to see 15 past realizations of all the variables; these were generated by assuming that individuals hold weak extrapolative expectations. Next, they are asked for their one-year-ahead home inflation forecast and its associated 95% confidence interval. These individual point forecasts are quarterized and averaged so that we can obtain $E_t^{AM}[\pi_{H,t+1}]$.[8] Given $E_t^{AM}[\pi_{H,t+1}]$ and the past values of all other variables, the model is able to compute next-period realizations. This process is repeated for 44 periods while the model is sporadically exposed to home inflation, output gap, and exchange rate shocks. Midway through each session (period 46^{th}), the model is exposed to an exogenous event or treatment and individuals are asked to keep on making forecasts for the last half of the session. In the post-treatment periods the model is exposed to the same shocks as in the pre-treatment periods.

In each of our experimental sessions we introduce a single exogenous treatment by either permanently changing the model's parameters, providing our participants with new information, generating a large shock, or a combination of the above. The four experiments are described below:

The above setup allows us to study the mean behavior of inflation expectations and, to some extent, the degree of uncertainty about these expectations. In an attempt to further our understating of the probability distribution of inflation expectations, at three instances, in each experimental session (one pre- and two post-treatment), we require our experimental individuals to provide additional information. In particular, following Dominitz and Manksi (1997), we ask them "What do you think is the percent chance that the home inflation will be less than Z?" We ask this last ques-

[7] All variables have a quarterly periodicity, nevertheless, given that the home inflation, the CPI inflation, and the output gap are regularly thought in annual terms, we annualize these variables before showing them to our participants.

[8] Note that we are assuming that the quarterized-one-year-ahead- and the one-quarter-ahead- home inflations are equivalent. Although it is reasonable to believe that this assumption is not binding for inexperienced subjects, sophisticated forecasters might judge these two significantly different due to the difference in time spam.

tion five times for different values of Z. Let $\tilde{\pi}_{H,t,i}$ be the value that results from rounding participant i's home inflation point forecast, at time t, to the closest number in the following sequence $\{..., -0.5, 0, 0.5, 1, 1.5, 2, ...\}$. The five values we use for the question above result from adding -1, -0.5, 0, 0.5, and 1 to $\tilde{\pi}_{H,t,i}$.

In order to induce our experimental individuals to make an effort to forecast carefully, each of them is given appropriate incentives through a performance function (equation 6). It depends negatively on the size of absolute value of the subject's forecast error ($f_{i,t} = E_{i,t-1}\left[\pi_{H,t+3}|\Psi_{t-2}\right] - \pi^a_{H,t}$) and the amplitude of the corresponding 95% confidence interval ($CI_{i,t} = E_{i,t-1}\left[Ubound_{i,t+3}\right] - E_{i,t-1}\left[Lbound_{i,t+3}\right]$). Henceforth, superscript a indicates annualized. The performance function is:

$$p_{i,t} = \frac{10}{1+|f_{i,t}|} + \frac{15 \cdot dum_t}{1+CI_{i,t}} \tag{6}$$

$$\text{with } dum_t = \begin{matrix} 1 \text{ if } \pi^a_{H,t} \in \left[E_{i,t-1}[Ubound_{i,t+3}]\ ,\ E_{i,t-1}[Lbound_{i,t+3}]\right] \\ 0 \text{ if } \pi^a_{H,t} \notin \left[E_{i,t-1}[Ubound_{i,t+3}]\ ,\ E_{i,t-1}[Lbound_{i,t+3}]\right] \end{matrix}.$$

At every moment in time, starting at $t = 2$, our experimental individuals are able to see the value of their performance function ($p_{i,t}$) and its average up to that moment $\left(\overline{p}_{i,t}\right)$.[9] All the participants in our experiment received credit in a macroeconomics class; the amount earned by each of them was proportional to their final average score $\left(\overline{p}_{i,90}\right)$.

Range effects, such as practice, sensitization, and carry-over regularly arise in within-individuals designs, challenging the internal validity of the experiment [Greenwald (1976) and Poulton (1973)]. Because of the nature of our experiments, unwanted sensitization is ruled out *ex ante*. In treatments where we do not want our experimental individuals to know what the treatment is, due to the controlled nature of the environment, we can ensure that this will be so; and, in the cases where our participants do know what treatment they are a part of (e.g. the adoption of inflation targeting), it is because we want to measure the effects of both the announcement of the treatment (sensitization) and the treatment itself. Carry-over effects could arise in our experiments if the shocks that we introduce in our model persist at the time our experimental individuals are exposed to the treatment. In order to avoid this, we stop shocking the model seven periods prior to the introduction of

[9] $\overline{p}_{i,t} = \left[\sum_{t=2}^{t} p_{i,t}\right] / (t-1)$

each experimental treatment. Practice could also arise as an unwanted range effect if our participants are not familiar with the experimental setting and the task they are asked to undertake. In this case, their expectations formation processes could change not only due to the occurrence of the event we want to account for but also because of a better understanding of the model (learning). In order to avoid this unwanted effect, following the suggestions by Greenwald (1976), we require our experimental individuals to practice interacting with our model prior to their scheduled group session. This was accomplished by providing our participant with a user name and password that allowed them to access a shorter online version of our experiment (30 periods) in which $E_t^{AM}\left[\pi_{H,t+1}|\Psi_{t-1}\right] = E_{i,t}\left[\pi_{H,t+1}|\Psi_{t-1}\right] + noise$. Only students that completed at least two online practice sessions were allowed to participate in our group sessions.

4 Results

4.1 Rationality Analysis

We carry on two tests aimed at determining whether our participants' expectations are in agreement with the RE hypothesis. First, we check if home inflation expectations are unbiased or, alternatively, if they systematically deviate from the observed home inflation. We do this by running the following regression for each of our participants:

$$\pi^a_{H,t} = c + \beta E_{i,t-1}\left[\pi_{H,t+3}|\Psi_{t-2}\right] \tag{7}$$

The unbiasnedness of home inflation expectations implies, in terms of equation 7, that $c = 0$ and $\beta = 1$; we determine if these restrictions hold by means of a Wald test (0.05 significance level).

Second, we check if home inflation expectations behave efficiently, that is to say, if individuals exploit all the available information when making forecasts. We do this by regressing each subject's forecast errors ($f_{i,t}$) on Y_{t-2} and Y_{t-3}, where $Y_t = [x_t, r_t, e_t, \pi_t, \pi_{H,t}]$. If expectations are efficient, then no variable should have explanatory power. Again, we test this by means of a Wald Test (0.05 significance level).

When expectations are both unbiased and efficient, we deem them rational.

One important result from Table 3 is the notable impact of new information on increased rational behavior. In the IT adoption experiment, there was a 17%, 21%, and 29% increase in the amount of participants whose forecasts were unbiased, efficient, and rational, respectively. It is particularly interesting to note that, in the post-treatment period, all the individuals in the experiment were forecasting in an unbiased fashion. Similar results were obtained in the IT announcement experiment. In the IT with no communication experiment, where the Central Bank adopted a more aggressive policy to control inflation but did not communicated this change to the audience, rational behavior seldom increased. Additionally, in the first two experiments, there were no participants whose expectations were unbiased in the pre-treatment sample, but biased in the post-treatment sample. In the third experiment there was no variation of the percentage of participants who forecasted in an unbiased fashion yet, there was a significant percentage of participants whose expectations became or ceased to be unbiased.

In our last experiment, the recession slightly increased the formation of unbiased expectations, while it significantly reduced efficiency and rationality by 31% and 32%, respectively. This result comes as no surprise since the large and negative shock may have been perceived by our participants as a change in the model's structure, inducing them to disregard previous valuable information and engage in a learning period.

Finally, an eye-catching result drawn from this analysis is that, in none of our experiments, individuals that behaved rationally in the pre-treatment sample stopped doing so in the post-treatment sample. This evidence suggests that the ability to forecast in an unbiased and efficient manner may be seen as an innate or acquired quality that is never lost.

4.2 Model Selection

In this section we try to shed light on our participants' expectations formation processes. To this purpose, we determine if said processes can best be described as naïve (equation 8), adaptative (equation 9), trend extrapolative (equation 10), as following the anchoring and adjustment heuristic[10] (equation 11) or as incorporating information from all the available variables (equation 12)[11].

$$E_{i,t}\left[\pi_{H,t+4}|\Psi_{t-1}\right] = c + \beta\pi^{a}_{H,t-1} \tag{8}$$

[10] The specification of equation 11 is similar to that of the anchoring and adjustment heuristic in Anuriev and Hommes (2007). $A_t = \left(\sum_{t=1}^{t} \pi^{a}_{H,t}\right)/t$.

[11] N is the optimal number of lags, according to the Schwarz criterion, of the following VAR: $Y_t = c + \beta_1 Y_{t-1} + ... + \beta_2 Y_{t-N}$.

$$E_{i,t}\left[\pi_{H,t+4}|\Psi_{t-1}\right] = c + \beta_1 \pi^a_{H,t-1} + \beta_2 E_{i,t-1}\left[\pi_{H,t+3}|\Psi_{t-2}\right] \quad (9)$$

$$E_{i,t}\left[\pi_{H,t+4}|\Psi_{t-1}\right] = c + \beta_1 \pi^a_{H,t-1} + \beta_2(\pi^a_{H,t-1} - \pi^a_{H,t-2}) \quad (10)$$

$$E_{i,t}\left[\pi_{H,t+4}|\Psi_{t-1}\right] = c + \beta_1(A_{t-1} + \pi^a_{H,t-1}) + \beta_2(\pi^a_{H,t-1} - \pi^a_{H,t-2}) \quad (11)$$

$$E_{i,t}\left[\pi_{H,t+4}|\Psi_{t-1}\right] = c + \beta_1 Y_{t-1} + ... + \beta_N Y_{t-N} \quad (12)$$

We determine which model fits best each subject's forecasts by comparing each regression's Schwarz criterion. Additionally, we conduct Chow tests to determine if the abovementioned models are stable.

An important result from the above analysis is that 72% of our participants' expectations formation processes could be described by mid-complexity heuristics (equations 9, 10, and 11). Additionally, none of them predicted in a naïve manner, while 28% incorporated information from all the variables in the model for forecasting purposes. A closer look at our data reveals that out of the 7 participants whose expectations were deemed rational - for the full sample, only 3 of them were found to use the full information model. This result may be explained by the forward-looking nature of home inflation. If several participants in a session utilize heuristics to make predictions, then most of the home inflation's volatility will be explained by the variables that are taken into account in said heuristics.

When our participants' optimal models are not stable, we recursively estimate all the models by mean of a rolling window - of 30 periods - for each of them. We deem that a participant is using one of the models mentioned above if said model was the optimal one for the last three periods. In 1.4%, 10.1%, 35.8%, 13%, and 39.7% of the times, our experimental individuals used the naïve, adaptative, trend extrapolative, anchoring and adjustment, and full information models, respectively. Additionally, these individuals switched models, on average, 5 times during their sessions.

4.3 Mean-Reversion

The hedging theory of confidence intervals (HTCI) asserts that, when series are stationary, individuals predict point forecasts by extrapolating recent trends and predict confidence intervals skewed in the expected trend's opposite direction (De Bondt, 1993). Computer simulations with naïve, trend extrapolative and rational home inflation expectations showed that our model is stationary. Accordingly, in this section, we test whether our participants' home inflation subjective probability distributions take into account the mean-reverting behavior of the series.

First, we create a measure of skewness (S) as follows: $S_{i,t} = (E_{i,t}\left[Ubound_{i,t+4}\right] - E_{i,t}\left[\pi_{H,t+4}\right]) - (E_{i,t}\left[\pi_{H,t+4}\right] - E_{i,t}\left[Lbound_{i,t+4}\right])$. The HTCI proposes that, when individuals expect home inflation to increase, they will predict left skewed confidence intervals ($S < 0$) and vise versa when they expect said variable to decrease.

$$S_{i,t} = c + \beta(E_{i,t}\left[\pi_{H,t+4}\right] - \pi^{a}_{H,t-1}) \tag{13}$$

We regress equation 13 for each of our experimental individuals. We determine if individuals behave in agreement with the HTCI by testing whether β is significantly negative (0.05 significance level).

Insert Table 5

Table 5 shows that, in each of our first three experiments, between 25% and 33% of our participants expected home inflation to revert to its mean. There are no notable differences between the pre- and post-treatment periods. Yet, when analyzing the recession experiment we realize that, conditional on the occurrence of a recession, there was a 19% increase in the amount of individuals that expected mean-reversion. This finding led us to analyze whether there were other variables in our model that could condition the HTCI.

Insert Table 6

One main result from the above analysis is that in both the IT adoption and IT announcement experiments the percentage of participants that complied with the HTCI increased in the post-treatment sample, conditional on CPI and home inflation variations. The increased mean-reversion is consistent with the announcement of an explicit inflation target, when the announcement is credible. We caveat the reader that our participants were all from Peru, country that has managed to keep inflation low and close to its target in past years; this experience might have bolstered the announcement's credibility.

4.4 Uncertainty

In this section we analyze whether the treatments that were implemented in each experiment altered the way our participants perceived future home inflation uncertainty. For this purpose we make use of our participants' answers to the questions "What do you think is the percent chance that the home inflation will be less than Z?" Since we ask this question for five different values of Z, we measure each participant's uncertainty, at time t, as the percent chance that the one-year-ahead home inflation will be less than $\tilde{\pi}_{H,t,i} - 0.5$ or greater than $\tilde{\pi}_{H,t,i} + 0.5$ - we call this measure $\Omega_{t,i}$. The shaded area in figure 1 illustrates how this measure of uncertainty was calculated.

We designed all our experiments so that we could calculate $\Omega_{t,i}$ in the 30^{th}, 48^{th}, and 75^{th} periods. We do this because we are interested in measuring the average short run treatment effect (Δ^{sr}) and the average long run treatment effect (Δ^{lr}) in each experiment.[12] Note that $\Omega_{30,i}$ and $\Omega_{75,i}$ are perfectly comparable since shocks in the pre- and post-treatment samples were the same and our design controls for unwanted range effects.

Our results indicate that the adoption of IT significantly (0.1 significance level) reduced perceived uncertainty in the short run by 13.56%. The IT announcement and IT without communication experiments also shrunk uncertainty in the short run, nevertheless, these results were not significant at conventional levels. Moreover, none of these treatments had significant long run effects on perceived uncertainty.

In the last experiment, one could have expected perceived uncertainty to increase after the recession. Our participants did not know if the large and negative output gap shock was transitory or persistent, or how would the other variables react to this unprecedented event. Notwithstanding, table 7 indicates that there were no significant short or long term effects. This result is consistent with the results obtained in the model selection section, where it was shown that most participants used mid-complexity heuristics, excluding relevant variables such as the output gap, for forecasting purposes.

5 Conclusion

Neoclassical theory assumes that all individuals behave rationally in a myriad of activities. For example, when modeling market behavior, sellers are

[12] We define $\Delta^{sr} = \sum_{i=1}^{N} (\Omega_{48,i} - \Omega_{30,i})$ and $\Delta^{lr} = \sum_{i=1}^{N} (\Omega_{75,i} - \Omega_{30,i})$, where N is the number of participants in the respective experiment.

thought to set their prices in a “rational” way, as not doing so would drive them off the market. In the context of inflation forecasting, our experiments provide evidence against the rationality assumption, as only 9.3% of all our participants could be described as having both unbiased and efficient expectations throughout the whole experiment. A closer look at our participants' forecasts reveals that 78% of them predicted by means of mid-complexity heuristics. That is to say, most individuals did not pay attention to all variables in the economy, but rather just a few. Additionally 63% of our participants' expectations could be best described by trend extrapolative and anchoring and adjustment models; both of these highlight the central role of past trends in the expectations formation process. These results not only provide evidence against RE, but indicates the need to incorporate heuristics - especially those that include past trends - in macroeconomic models.

Since New Zealand adopted IT in 1990, several countries, both industrialized and developing, have followed the same path. Accordingly, in recent years, several empirical papers [Ball and Sheridan (2005), IMF (2005), Mishkin (2007), Petursson (2004), Vega and Winkelried (2005), among others] have studied whether this new monetary policy scheme has improved macroeconomic performance – as measured by inflation persistence, economic growth, and exchange rate volatility. Notwithstanding, understanding how IT affects home inflation expectations is fundamental to policy-making and macroeconomic success. This paper contributed to fill this void by analyzing the effects of IT adoption, IT announcement, and IT with no communication on forecast rationality, compliance with the HTCI, and home inflation uncertainty. Our findings highlight the importance of the availability of new information on our participants' expectations formation processes. In the IT adoption and IT announcement experiments, rational forecasting among our experimental individuals increased by 29% and 22%, respectively. Additionally, we found that, conditional on CPI or home inflation variations, there was a significant increase in the percentage of individuals that expected home inflation to revert to its mean – or target. Finally, the adoption of IT proved to have a significant short-run effect over average home inflation uncertainty, reducing it by 13.6%. The effect is not significant in the IT adoption experiment nor in the IT without communication experiment. From a policy-making standpoint, this result highlights the need for clear communication with the audience and increased aggressiveness to counter inflation if a central bank is to peg people's expectations to its target and reduce home inflation uncertainty.

Our forth experiment was aimed at analyzing the effect of a recession over inflation expectations. Our results indicate that there was a 32% decrease in the amount of participants that forecasted in a rational fashion. Additionally, the recession also induced a 19% increase in the amount of individuals that complied with the HTCI. This result comes as a surprise, as previous results had indicated that most of our experimental individuals ignored the output gap throughout the experiment. Additionally, this suggests that individuals are nonlinearly-inattentive. That is to say, when some variables – as the output gap – exhibit "normal" behavior they are disregarded for forecasting purposes yet, when abnormalities occur, these alter the individuals' expectations formations processes. Finally, the recession increased perceived uncertainty about future home inflation in the short- and long-run, yet these results were not statistically different from zero.

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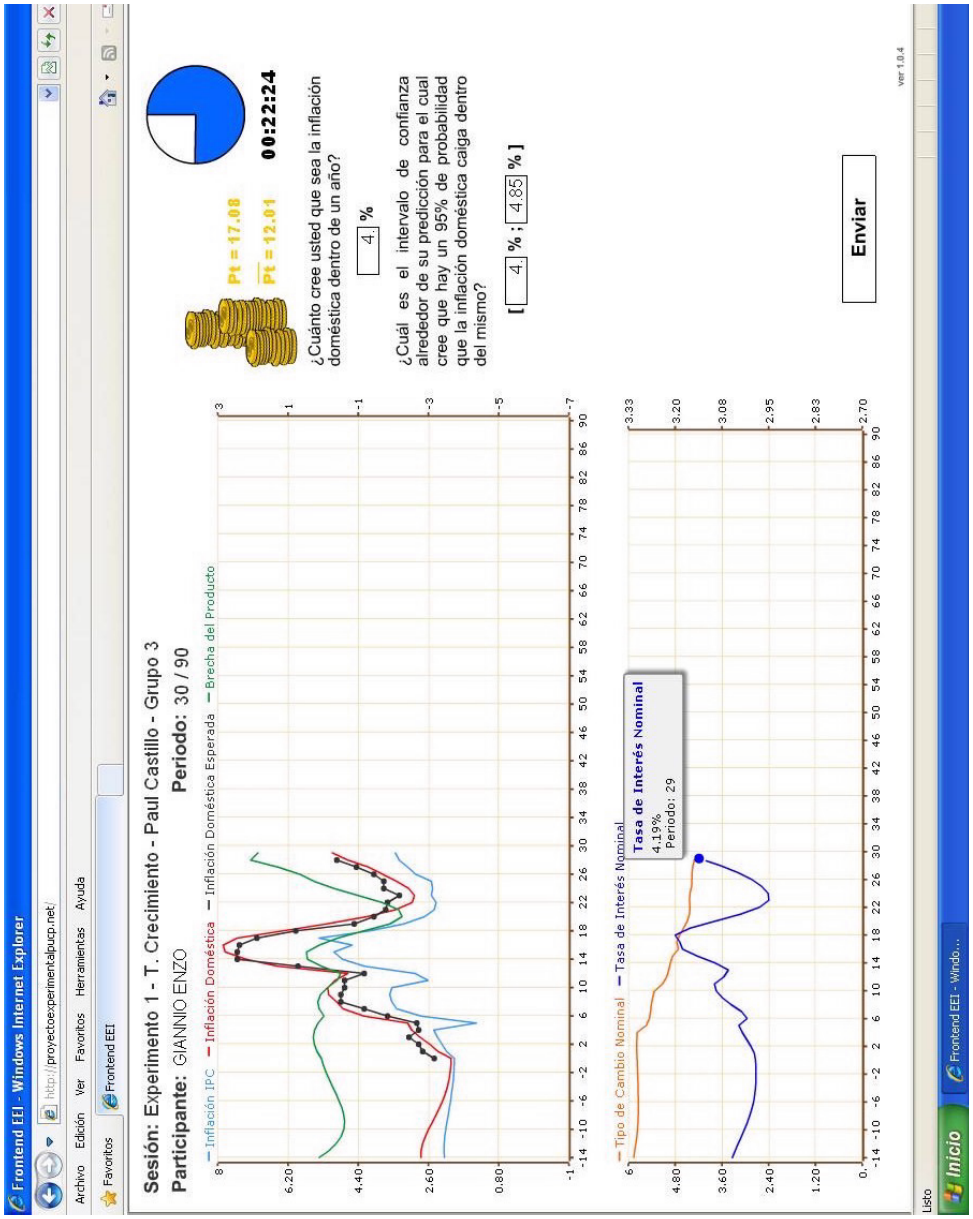
Appendix

A.1 Experimental Setting



Notes: (1) The above image reproduces one of our experimental subject's screen during a group session. (2) Subjects are able to see the numerical value of all the series they are presented with by placing the mouse pointer over them.

A.2 Inflation targeting announcement

CENTRAL RESERVE BANK

Press Note

The Board of the Central Reserve Bank, reassuring its commitment with monetary stability has agreed to:

1) Adopt the Inflation Targeting monetary policy scheme. The Central Reserve Bank commits itself to ensure that, in the medium run, the annual consumer price index inflation will be 2% with a 1% margin of error.

2) Regularly offer credit in local and foreign currency.

3) Limit the Central Reserve Bank's foreign exchange operations to abate exchange rate volatility.

Table 1: Calibration of the Parameters of the Model

Parameter	Value	Parameter	Value
σ_α	3.85	λ	0.2
$\overline{rr}$	0.023	r^*	0.0283
β	0.9975	φ_r	0.7
k_α	0.084	φ_π	5
α	0.4	φ_x	1.67
π^*	0.0043		

Source: Authors' calibration, Castillo et al. (2009), and Vega et al. (2009).

Table 2: Description of the Experiments

Experimental Treatments	Changes in Parameters	New Information	Shock	Number of Sessions*
IT Adoption	We set $\varphi_\pi = 3.1$ and $\varphi_x = 3.1$ for the first half of the session. For the second half, we set $\varphi_\pi = 5$ and $\varphi_x = 1.67$.	Yes**	None	3 (7,8,9)
IT Announcement	None	Yes**	None	2 (9,9)
IT with No Communication	We set $\varphi_\pi = 3.1$ and $\varphi_x = 3.1$ for the first half of the session. For the second half, we set $\varphi_\pi = 5$ and $\varphi_x = 1.67$.	None	None	2 (8,9)
Recession	None	None	Yes***	2 (6,10)

Notes: *The numbers in parenthesis indicate the number of participants in each experimental session. **Halfway through the experiment, participants visualize a message indicating that the economy's Central Bank has adopted IT. An English translation of this announcement is reproduced in Appendix 2. ***Halfway through the experiment, we introduce a large and negative output gap shock.

Table 3: Rationality Test

	IT Adoption			IT Announcement			IT with No Communication			Recession		
Sample	U	E	R	U	E	R	U	E	R	U	E	R
Full	71	13	8	61	6	0	65	24	18	63	31	13
Pre-treatment	83	29	21	67	22	11	76	29	24	75	75	63
Post-treatment	100	50	50	83	44	33	76	29	29	81	44	31
New+	17	29	0	17	22	6	18	6	6	19	13	13
New-	0	8	0	0	0	0	18	6	0	13	44	0

Notes: (1) We report the percentage of participants in each experiment that passed the unbiasedness test (U), efficiency test (E), and both (R). (2) New+ indicates the percentage of participants that did not pass the U, E, and R tests, respectively, in the pre-treatment sample but that do in the post-treatment sample. (3) New- indicates the percentage of participants that did pass the U, E, and R tests, respectively, in the pre-treatment sample but do not in the post-treatment sample.

Table 4: Model Selection

	IT Adoption		IT Announcement		IT with No Communication		Recession		All (%)	
Naïve	0	[0]	0	[0]	0	[0]	0	[0]	0	[0]
Adaptative	2	[2]	2	[1]	1	[0]	2	[2]	9	[7]
Trend Extrapolation	8	[8]	4	[4]	4	[3]	7	[6]	31	[28]
Anchoring and Adjustment	6	[6]	3	[3]	9	[9]	6	[3]	32	[28]
Full Information	8	[5]	9	[7]	3	[1]	1	[1]	28	[19]

Notes: (1) We report the number of participants in each experiment whose expectations formation process can best be described, according to the Schwarz criterion, by the respective model. In brackets, we indicate how many of them pass the Chow Test for parameters stability, using the mid-session period as the break point. (2) When reporting information about the totality of the experiments, we present said information as percentages.

Table 5: HTCI Test

	IT Adoption	IT Announcement	IT with No Communication	Recession	All
Pre-treatment	29	33	29	25	29
Post-treatment	25	28	29	44	31
New+	21	11	12	25	17
New-	25	17	12	6	16

Notes: (1) We report the percentage of participants in each experiment that passed the HTCI test. (2) New+ indicates the percentage of participants that did not pass the HTCI test in the pre-treatment sample but that do in the post-treatment sample. (3) New- indicates the percentage of participants that did pass HTCI test in the pre-treatment sample but do not in the post-treatment sample.

Table 6: Asymmetric Confidence Intervals Hedging

		IT Adoption	IT Announcement	IT with No Communication	Recession	All
Increasing π	pre-	29	22	41	25	29
	post-	42	33	29	44	37
Decreasing π	pre-	21	33	35	31	29
	post-	33	28	18	25	27
Increasing π_H	pre-	33	22	29	25	28
	post-	38	28	29	31	32
Decreasing π_H	pre-	21	11	41	38	27
	post-	25	33	12	25	24
Increasing x	pre-	21	28	35	19	25
	post-	17	28	29	44	28
Decreasing x	pre-	21	39	35	31	31
	post-	25	22	18	25	23
Increasing r	pre-	33	28	41	31	33
	post-	21	28	29	19	24
Decreasinf r	pre-	21	11	29	6	17
	post-	17	22	18	44	24
Increasing e	pre-	25	17	29	19	23
	post-	21	33	29	31	28
Decreasing e	pre-	25	44	41	19	32
	post-	29	22	24	38	28

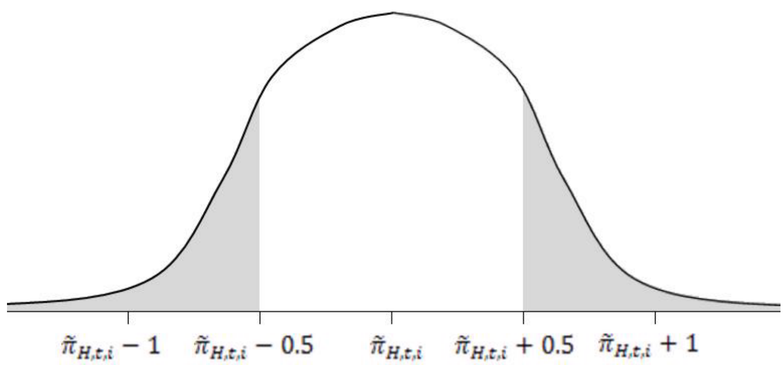
Note: We report the percentage of participants in each experiment that passed the HTCI test.

Table 7: Dispersion Analysis

	IT Adoption	IT Announcement	IT with No Communication	Recession
Pre-treatment mean dispersion	60.63	62.81	52.33	58.67
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Short run treatment effect	-13.56	-1.63	-3.18	3
	[0.0738]	[0.8188]	[0.7453]	[0.6837]
Long run treatment effect	-8.42	4.25	-0.67	7.80
	[0.2527]	[0.5734]	[0.9399]	[0.2370]

Notes: (1) We report regression coefficients. (2) P-values are shown in brackets.

Figure 1: Dispersion Measure



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