Experimental study on the effect of nominal price level versus inflation targeting with and without guidance

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Abstract

Since the 2007 crisis, macroeconomists have been interested in monetary policies that could help with stabilizing inflation and output (Honkapohja, 2015). Two ideas gained particular attention: (i) that inflation should be replaced by the nominal price level (PLT) as the target for central bank; and (ii) that the central bank should provide explicit guidance about its interest rate rule. We conduct an experiment to test the of these two hypotheses.

Our experiment is based on a simple DSGE economy with Euler learning (Assenza et al., 2014). Subjects are given only a qualitative description of the economy and are asked to predict inflation and output gap two-periods ahead for 50 periods. There are five treatments with six groups in each. Baseline treatment (1) incorporates a standard inflation targeting rule. The other four treatments utilize a PLT Taylor rule and are based on a two-by-two design: 'weak' rule (2) with guidance and (3) without guidance; and 'strong' rule (4) with guidance and (5) without guidance.

We find that subjects within each treatment coordinate on a similar behavior, but large differences between the treatments prevail. Guidance has a negligible effect, whereas the Taylor rule specification turns out to be crucial. PLT can be a rubust monetary policy, but only if it is sufficiently responsive to the deviations of the output and prices.

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1 Introduction

In this paper we report macroeconomic laboratory experiment, in which we evaluate alternative monetary polices: guidance and price level targeting. Subjects were tasked with forecasting inflation and output gap in a simple economy, which was based on a standard Dynamic Stochastic General Equilibrium model (DSGE) with zero lower bound condition on the interest rate of the central bank. We find that the additional information about the interest rate rule, which the central bank provides through the guidance, has negligible effect on the market dynamics. On the other hand, price level targeting can be a robust monetary policy, but only if the underlying Taylor rule is sufficiently reactive to the steady states deviations. This confirms insights from the literature, which suggest that price level is potentially a better target than inflation; but also shows that the subjects used simple forecasting rules.

Until the second half of the 2000's, most economists and policy makers believed that the monetary policy, embodied by the famous Taylor rule, reached mature and satisfying level. Central banks began adapting inflation target based interest rate rules in the 1980ties, and this coincided with a period known as the Great Moderation: a quarter of century of relatively small inflation and output volatility in developed countries. Many empirical studies would in fact identify the monetary policy as one of the most important factors leading to the Great Moderation, as it stabilized the propagation mechanisms of economic shocks (so called 'policy hypothesis', see Cogley and Sargent, 2005; Galí and Gambetti, 2009; Giannone et al., 2008, for an overview).

Once the 2007 crisis erupted, central banks accordingly cut their interest rates, but, as quickly became apparent, this response proved too slow to counter the unfolding recession. What made matters worse was that, despite the interest rates of many central banks approaching the zero lower bound, the recession remained rampart, leaving little space for conventional policies (Chen et al., 2015). For example, FED is keeping its interest rate at almost 0% level since 2009. Nevertheless, the GDP growth in the USA through the next years was close to only 2%, and the employment as of 2014 has not recovered to the pre-crisis level. Even more striking example comes with the events in Europe. ECB cut interest rates as FED did (though not as bravely), but after a brief recovery in 2009 and 2010, the Euro Area plummeted into the second wave of recession. In addition, this output contraction hit some countries particularly strong, causing political disturbances, as in the case of Greece or Spain. See also Reifschneider and Roberts (2006) for a study of a similar crisis in Japan.

The events of the crisis inspired a wave of macroeconomic literature on robust monetary policy (Boivin et al., 2010; Chung et al., 2014; Krugman, 2014; Summers, 2014; Woodford, 2012). The question is how to pull the economies from the current recession (Bech et al., 2014; Yellen, 2013), but also how to prevent such big recessions in the future. Two policy alternatives gained a particular attention: guidance and nominal price-level targeting (PLT) (Mitra and Honkapohja, 2014).

The usual definition of PLT is that the central bank follows a Taylor rule, trying to steer the inflation such that the whole *price level trajectory* follows a preplanned path with a fixed trend (Giannoni, 2010). Guidance in its broadest definition means that the central bank tries to manage inflation expectations by a public commitment to a certain policy (Magill and Quinzii, 2014). For instance, during a period of recession, the central bank could acknowledge to keep its interest rate at a low value for a longer period; or it could explicate conditions under which it would raise the interest rate again.

The underlying idea of both the guidance and the PLT policies is that they give economic agents more information about the monetary policy, see Covas and Zhang (2010) for a discussion about the PLT and Femia et al. (2013) for an empirical evaluation of FED's guidance. Under rational expectations (RE), this allows to curb the business cycle, and speeds up recovery from large technology shocks (Evans, 2012). However, much of these results rely on the assumption of RE. The recent crisis shows that the empirical validity of RE is questionable (Cornea et al., 2012), and as a result, these policy measures should be tested in a more realistic environment, which allows the agents to *learn and adapt new information* (Anufriev et al., 2013). One such interesting study was conducted by Mitra and Honkapohja (2014), who show that under adaptive (econometric) learning, PLT policy can be stabilizing only if the agents are aware of it, that is only if the bank provides some guidance about its policy. This is an important result, as adaptive learning is still quite a small departure from perfect rationality.

The goal of our paper is to provide an experimental test for the theoretical findings on PLT and guidance. Laboratory experiments are a novel approach in empirical macroeconomics (Assenza et al., 2011; Hommes et al., 2015). The idea is to take a macroeconomic model, and replace economic agents with real subjects. The subjects then are tasked to decide on consumption, or to forecast aggregate variables as in Learning to Forecast experiments (Hommes, 2011). There are several virtues of this approach. In an experiment, unlike in real economies, the researcher can easily control the setup of the markets and manipulate policy measures and fundamentals. It is possible to directly observe the decisions or expectations of the subjects, and to obtain rich samples, in terms of both the number of independent observations from a constant environment (groups within a treatment), as well as of the time span within each group (Hommes, 2011). Finally, macroeconomic models with microfoundations aim at describing the 'everyman', normal consumers, many of whom have little or no economic education, exactly like the subjects that were invited to our experiment.

To the best of our knowledge, there are no previous laboratory experiments on the role of guidance for monetary policy [Note to Cars: any of the CeNDEF's previous experiments?]. Furthermore, we are aware of only one experimental study on the role of PLT, namely a paper by Amano et al. (2011). The authors of this research use a standard DSGE model with inflation target and PLT Taylor rules to generate artificial, non-persistent inflation time series. Next, the authors task subjects with forecasting these inflation sequences. The authors find that the subjects predicted inflation as if it was persistent (compare with Huber et al., 2010), and that they under-reacted to the observed price level deviation. This is very interesting study, but uses exogenous inflation time-series, and therefore cannot reliably evaluate individual learning or stability properties of PLT monetary policy. Nevertheless, we will confirm the pattern of the individual behavior which was reported by Amano et al. (2011).

Our experiment is inspired by Mitra and Honkapohja (2014) and based on a simple DSGE model with Euler learning. We emphasize that we use the full nonlinear version of the model, which allows us to study the full off-equilibrium behavior of our subjects. This links our study to Hommes et al. (2015), though, unlike that paper, we focus on linear Taylor rules and constant fiscal policy. We run five treatments in total, which vary in terms of the monetary policy and subject information. First, we look at the baseline case of the inflationary targeting. All other four treatments are based on a PLT Taylor rule: with weak or strong response coefficients; and with or without guidance. The difference between the strong and weak PLT Taylor rules is that the weak one (which is suggested by Mitra and Honkapohja, 2014) is stable under adaptive learning, but not under naive expectations, unlike the strong one. We follow the methodology set up in Bao et al. (2015) to test the differences between the treatments, as well as to estimate the individual subject behavior.

In our experiment, following the definition of Mitra and Honkapohja (2014), we take guidance in its simplest form. To be specific, in the guidance treatments, the subjects are explicitly informed about the role of the price level deviation in the monetary rule; and during the experiment, this variable belongs to their information set.

The experiment results in two major findings. First one is that the guidance plays no role, as the difference between guidance and no-guidance treatments is negligible. This implies that the subjects either did not consider, or could not properly use the additional information given by the central bank. The second result is that the PLT treatments were stable only under the strong rule (with inflation even more stable than under the inflation treatment). Altogether this suggests that central banks should pay less attention to indirect expectations management measures, and instead directly focus on countering the business cycle by a firm response to the deviations from the full employment steady state.

This paper is organized in the following way. Second section discusses the experimental design and some theoretical issues, which underline our experiment. Third section shows the experimental results and quickly discusses the individual behavior. Finally, experimental instructions and details on the econometric analysis can be found in the appendices.

2 Experimental design

In this section we discuss the design of our experiment. We start with a detailed description of the design. Next two subsections discuss the information, which we have provided to the subjects, as well as the specific framing of the guidance. Section 2.4 shows the DSGE model, which was the corner stone of the experimental economy. In section 2.6 we formalize the hypotheses of our experiment.

2.1 Experimental treatments

Our experiment is based on standard DSGE model with zero-lower bound on the interest rate and Rotemberg price stickiness (see later part of this section for the details on the model). Central bank follows a Taylor rule with either inflation target or nominal price level target. There are in total three state variables in the model: output y_t, inflation π_t, and the interest rate R_t. The realized state of the economy depends on the expectations of future inflation and output. One can show that this model has two steady states (with self-fulfilling expectations): (1) full employment with inflation equal to the central bank's target π^* and the corresponding output y^* and interest rate R^*; and (2) zero-lower bound steady state (ZLB) such that $R^Z = 1$, with corresponding inflation $\pi^Z < 1$, and output, which is below its potential value with $y^Z < y^*$.

Regardless of the treatment, there are $I = 6$ six subjects per one group who participate in a 51 periods long session. Within each period, each subject is asked to provide his or her inflation forecast two periods ahead $\pi^e_{i,t+1}$ (the index indicates the period, for which the forecast is formulated), and his or her output gap forecast two periods ahead $o^e_{i,t+1}$.[1] In the instructions and experimental interface, these are framed as percentage points (for example $\pi^e_{i,t+1} = 1$ corresponds with a forecast of one percentage point of net inflation). These two forecasts are transformed into the average gross inflation forecast $\bar{\pi}^e_{t+1}$ and the average consumption level forecast $\bar{c}^e_{t+1}$, and used to determine the realized contemporary inflation π_t, output level y_t (which equals the realized consumption c_t plus fixed government spending $g_t = g$) and interest rate R_t. Subjects observe these variables, and the group moves to the next period.

The information provided to the subjects is discussed in detail in the next part of this section. In general, subjects are given only a qualitative description of the economy, and can only observe the aggregate variables and only their own forecasts and payoffs.

In all the treatments, subjects are paid in the same way. For every inflation and output gap forecast we compute score as

$$\begin{aligned} \text{Points}^\pi_{i,t} =& 100\frac{1}{1+|\pi^e_{i,t}-\pi_t|} \in (0,100], \\ \text{Points}^y_{i,t} =& 100\frac{1}{1+|o^e_{i,t}-o_t|} \in (0,100], \end{aligned}$$

so for example if a subject predicts -1% inflation, whereas the realized inflation is equal to -4%, the subject would receive 25 points for this forecast. At the end of the group's session, we add separately inflation and output gap scores for each subject, and pay only for inflation forecasting accuracy, or only for output gap forecasting accuracy (following a roll of dice), with the exchange rate of 0.75 Euro for every 100 points. This means that the subjects could earn anything between 0 and 37.5 Euro. We decided to pay randomly for one task only in order to motivate subjects to pay high attention to both tasks, and to discourage them from

[1] Note that the relationship between the output gap and output level is given by $o_t = 100\frac{y_t - y^*}{y^*}$.

hedging.

Our experiment has five treatments in total. There are two differences between them: the specification of the Taylor rule; and in addition, subjects in two treatments receive guidance in the form of additional information about the monetary policy of the central bank. These treatments are:

1. **INF** – Central Bank uses Taylor rule with *inflation target*, given by

$$\text{(1)} \qquad \text{IFT: } R_t = 1 + \max\left\{0, R^* - 1 + \psi_\pi\left(\pi^e_{t+1} - \pi^*\right) + \psi_y \frac{y^e_{t+1} - y^*}{y^*}\right\},$$

   which is bounded from below by unity and where $\psi_\pi = 1.5$ and $\psi_y = 1$ are two policy parameters. We used these values as they guarantee that the economy is stable under naive expectations (see the model discussion in the later part of this section). This is the baseline treatment.

In the other four treatments, Central Bank always uses *nominal price level target* in its Taylor rule, which is given by

$$\text{(2)} \qquad \text{PLT: } R_t = 1 + \max\left\{0, R^* - 1 + \psi_P \frac{P^e_{t+1} - \bar{P}_{t+1}}{\bar{P}_{t+1}} + \psi_y \frac{y^e_{t+1} - y^*}{y^*}\right\},$$

where $\bar{P}_t \equiv \pi^* \bar{P}_{t-1}$ defines the trajectory which the central bank takes as the intended price path (remark that it is based on the same inflation level as the target under the **INF** treatment). The following treatments are based on a 2×2 design, where the two policy measures are the strength of the Taylor rule and guidance:

2. **StrongNo** – Strong PLT rule (2) with *high* policy parameters ψ_P and ψ_y;

3. **WeakNo** – Weak PLT rule (2) with *low* policy parameters ψ_P and ψ_y;

4. **StrongGuid** – Strong PLT rule (2) with *high* policy parameters ψ_P and ψ_y and additional guidance provided by the central bank to the subjects;

5. **WeakGuid** – Weak PLT rule (2) with *low* policy parameters ψ_P and ψ_y and additional guidance provided by the central bank to the subjects.

The weak PLT rule corresponds with $\psi_P = 0.25$ and $\psi_y = 1$ (as in Mitra and Honkapohja, 2014), while the strong PLT rule corresponds with $\psi_P = 3$ and $\psi_y = 2$. Notice that the strong rule is quite harsh, as *eg.* one percentage point of output gap implies that the interest rate increases by two percentage points. The difference between weak and strong PLT rules is that only the strong one is stable under homogenous naive expectations. On the other hand, the weak rule turns out to be unstable under naive expectations, but it was suggested in the literature on adaptive learning (Mitra and Honkapohja, 2014) (see following part of this section for dicussion). Therefore, differences between treatments 2 and 3; and between 4 and

5 will allow us to test whether subjects are closer to a simple forecasting behavior, or whether they are actually able to use the sophisticated adaptive learning.

As will be explained in the next part of this section, guidance mean that the subjects are given additional information about the behavior of the central bank, namely that the central bank intends to keep prices at a certain trajectory. On the other hand, subjects in the two PLT treatments without guidance are given the same information as those in the inflation targeting. This allows us to directly test whether a simple version of guidance can help the central bank in stabilizing the business cycle.

2.2 Information provided to subjects

In all five treatments, subjects are told that they act as forecasting specialists for statistical bureaus. We provide the subjects with a qualitative description of the economy, in particular, subjects are informed about signs of the relationship between their forecasts, interest rate and the realized inflation and output gap. However, we never show the subjects the actual mathematical rules that govern these variables in the experimental economy, including the Taylor rule, with which the central bank sets the interest rate. In addition, we do not explicitly mention that the economy is a highly non-linear system. We do inform the subjects that they belong to a fixed group and that other subjects have the same task, but we do not specify the exact size or composition of their groups. Finally, we provide a detailed explanation of the payment scheme.

Every subject is informed that she or he will observe the past realized inflation, output gap and interest rate, as well as her or his own past inflation and output gap forecasts, and the corresponding earnings. However, no subject is ever shown the forecasts or score of any other subject. Finally, the experimental economy is based on a two-period ahead feedback, we therefore inform the subjects that they will first receive information about their performance and the realized variables only after the first two sets of forecasts. In order to guide them in these 'blind' periods, we mention in the instructions that both the inflation and output gap 'have historically been between -5% and 8%'.

The difference between treatments 1, 2 and 3 (no guidance) on one hand, and 4 and 5 (guidance) on the other, is that the subjects *in the guidance treatments 4 and 5 receive additional information*. Namely, we explain in detail (using the word 'guide') that the central banks wants the price level to follow a certain trajectory. We inform them that they cannot directly observe that path, but they will be given the exact value of the deviation of the prices from this path, namely the realized $\left(P_{t-1} - \bar{P}_{t-1}\right) / \bar{P}_{t-1}$ variable.

The only constraint on the subjects' behavior is that both inflation and output gap forecasts have to stay within the $[-5\%, 15\%]$ interval (regardless of the treatment). We disallowed more extreme forecasts in order to rule out explosive dynamics. However, we did not want to rule out the run-away trajectories by the framing itself, as not to interfere with the initial learning periods. Therefore, subjects were not initially informed about the constraint on their forecasts.

The instructions cover in detail this information. In addition, they contain a table and graph of the payoff function, and explain a screenshot of the subject screen. During the session, subject's screen displays graphs and tables of the realized variables (inflation, output gap, interest rate; and under the guidance treatments the price level deviation), the individual past forecasts and scores (per period and accumulated), number of the current period and the remaining number of forecasts that the subjects should submit this period. We use a number of control questions to test whether the subjects understand the instructions. Appendix A contains the instructions and control questions.

2.3 Guidance specification

In our experiment, guidance implies that (1) the subjects are explicitly told about the fact that the central bank tries to minimize price level deviation, and (2) throughout the session the subjects are informed about the realized values of this variable. This version of guidance is the simplest possible. It means that the subjects actually know the target of the central bank, and they know how the monetary authority reacts to the deviations from that target. In addition, the subjects are explicitly told that the central indeed *commits* to this policy for the whole duration of the experimental session. In contrast, under the non-guidance treatments, subjects can only guess how the central bank will react to a certain level of inflation, and when and which levels of inflation are 'high' enough for the interest rate to be increased.[2]

2.4 Experimental economy

The economy in our experiment is based on the standard DSGE model with zero lower bound and Rotemberg price stickiness. For the derivation of the model, see for example Mitra and Honkapohja (2014).[3] The model is based on a representative Ricardian consumer-firm owner, who maximizes an infinite discounted sum of utility subject to standard production, saving and market clearing conditions. Assuming fixed government spending $g_t = g$, non-distortionary lump-sum taxes and an interest rate rule $R_t(\cdot)$, the model can be described as a two dimensional system such that in period t, consumption level c_t and gross inflation π_t are a function of the two-period ahead consumer expectations of these two variables. The relationship is given by the following set of equations:

[2] Literature offers many explications of the term 'guidance' in the context of monetary policy. Another popular is one in which the central bank announces (and commits to) that if the inflation or output fall under a specific threshold, the central bank will keep the nominal interest rate at some low level for a predetermined number of periods. This interesting version of guidance requires a number of arbitrary choices (like the threshold conditions, value and duration of the 'low nominal interest rate'), which can be evaluated with a laboratory experiment. We leave this for further research.

[3] Remark that Mitra and Honkapohja (2014) further solve the model under the so called steady state learning, instead of leaving it in the Euler learning form. We decided not to follow this approach, as the DSGE model under steady state learning is extremely explosive under naive expectations. As it will be apparent in the next section, naive expectations fit the behavior of our subjects better than the adaptive learning.

1. The aggregate consumption:

$$c_t = c^e_{t+1}\left(\frac{\pi^e_{t+1}}{\beta R_t}\right)^{1/\sigma} + \varepsilon^c_t. \tag{3}$$

2. The Phillips curve:

$$\pi_t = Q^{-1}[K(c_t, \pi^e_{t+1})] + \varepsilon^\pi_t, \tag{4}$$

where

$$Q(\pi_t) = (\pi_t - 1)\pi_t$$

and

$$\begin{aligned} \kappa(c_t, \pi^e_{t+1}) =& \beta\pi^e_{t+1}(\pi^e_{t+1} - 1) + \frac{\nu}{\alpha\gamma}(c_t + \bar{g})^{(1+\varepsilon)/\alpha} + \frac{1-\nu}{\gamma}(c_t + \bar{g})c_t^{-\sigma}, \\ K(c_t, \pi^e_{t+1}) =& \begin{cases} \kappa(c_t, \pi^e_{t+1}) & \text{if } \kappa(c_t, \pi^e_{t+1}) > -0.25 \\ -0.25 & \text{else.} \end{cases} \end{aligned} \tag{5}$$

The last condition in equation (5) is necessary to avoid complex values of the realized inflation. Notice that the interest rate rule $R_t(\cdot)$ depends on the treatment. It is either based on an inflation target (1) or price level target (2). See Table 1 for the parameter interpretation and values, and the corresponding full employment and ZLB steady states. Finally, the two random errors in equations (3) and (4) are uncorrelated IID noise terms to the consumption and inflation, such that $\varepsilon^c_t \sim NID\left(0, (0.0005c^*)^2\right)$, $\varepsilon^\pi_t \sim NID\left(0, 0.0005^2\right)$ and $Cov\left(\varepsilon^c_t, \varepsilon^\pi_t\right) = 0$. The variance of the two noise terms was chosen in such a way, that if the agents would repeatedly forecast the full employment steady state, realized inflation and consumption should both stay within one permil point (!) of the steady state 95% of time.

Under rational expectations, the model is solved to obtain the model consistent expectations such that for every period t it holds that $\pi^e_{t+1} = E(\pi_{t+1})$ and $c^e_{t+1} = E(c_{t+1})$, that is the representative consumer does not make systematic errors. However, in the experiment we take the average net inflation and output gap forecasts of the six subjects, transform them into the consumption level and gross inflation level forecasts and directly input them into the interest rate rule ((1) in treatment **INF**, and (2) in treatments **StrongNo**, **WeakNo**, **StrongGuid** and **WeakGuid**), the consumption rule (3) and hence the Phillips curve (4). Notice that the permited forecasting intervals (between -5% and 15%) allow for coordination on the ZLB steady state, as well as on interesting dynamics around that point.

Previous experimental work suggest that subjects will fail to form rational expectations. Instead, we expect their forecasts to be much closer to naive expectations. One can show that under pure naive expectations, treatment **INF** is stable. As for the PLT treatments, guidance plays no role under naive expectations. On the other hand, the Taylor rule parametrization is crucial. PLT Taylor rule with $(\psi_P, \psi_y) = (0.25, 1)$ (as in Mitra and Honkapohja, 2014) is highly

Parameter	**Notation**	**Value**
Number of agents/subjects	I	6
Discount factor	β	0.99
Government spending	$\bar{g}$	0.2
Output elasticity	α	0.7
Rotemberg price stickiness	γ	350
Labor supply elasticity	ϵ	1
Demand's elasticity of substitution	ν	21
Consumption elasticity	σ	1
Gross inflation target	π^*	1.05
Steady state gross interest rate	R^*	1.(06)
Steady state consumption	c^*	0.745358
Steady state output	y^*	0.945358
ZLB gross inflation	π^Z	0.99
ZLB gross interest rate	R^Z	1
ZLB consumption	c^Z	0.742765
ZLB output	y^Z	0.942765
ZLB output gap	o^Z	-0.2766%
Taylor rules		
Inflation target rule	(ψ_π, ψ_y)	$(1.5, 1)$
Weak PLT rule	(ψ_P, ψ_y)	$(0.25, 1)$
Strong PLT rule	(ψ_P, ψ_y)	$(3, 2)$

Table 1: Experimental economy parametrization.

unstable under naive expectations. Therefore, we decided to run additional PLT treatments with $(\psi_P, \psi_y) = (3, 2)$, for which the system becomes stable. Hence, an educated guess is that the treatment **StrongNo**, unlike **WeakNo**, will yield converging dynamics. Furthermore, with the strong PLT Taylor rule and expectations, the eigenvalues of the system are very close to the edge of the unit circle. As a result, one would expect that the **StrongNo** groups will actually require some time to converge. Therefore, if the guidance has a stabilizing effect on subjects, our design should be sufficiently sensitive to identify this effect both under weak and strong PLT Taylor rule. For a detailed discussion on the properties of our experimental economy under naive expectations, refer to Appendix D.

2.5 Experiment

We run 6 groups per each of the 5 treatments, recruiting 180 subjects in total. The sessions were conducted at the CREED laboratory, University of Amsterdam, in November and December 2015, and January 2016. We wrote the experimental software in C++, using standard library and Wt, a C++ Web Toolkit under the standard GNU General Public License.[4] The duration of each session was typically around two hours. We asked subjects for 51 pairs of

[4]The Wt library is available at `http://www.webtoolkit.eu/wt`. The software (compiled for the Windows 7 operating system), as well as the source code can be provided on demand.

forecasts, which results in full 50 periods of data per group.[5]

2.6 Testable hypotheses

Under Rational Expectations, the experimental economy should immediately (in the very first period) converge to either the ZLB or the full employment steady state. However, previous experimental evidence suggests that the subjects either never truly converge to a steady state, or they do so only after a prolonged spell of a business cycle type of dynamics. Therefore, our experiment will serve to directly test the following hypotheses:

Hypothesis 1 Weak PLT rule is sufficient to stabilize the economy. All the four PLT treatments (**StrongNo**, **WeakNo**, **StrongGuid** and **WeakGuid**) will exhibit stable dynamics (convergence or mild oscillations).

Hypothesis 2 Guidance *will* help in stabilizing the economy, which implies that treatment **StrongGuid** is *more stable* than treatment **StrongNo**, and treatment **WeakGuid** is *more stable* than **WeakNo**.

Hypothesis 3 Subjects will learn sophisticated forecasting behavior, in particular they will use forecasting rules that emphasize full employment steady state.

Hypothesis 1 and **Hypothesis 2** can be directly translated into statistical tests. Following the literature, we will compare the relevant treatments by testing the differences in the distribution of inflation and output gap stability. We will quantify this with Relative Absolute Deviations (Stöckl et al., 2010). Under adaptive (econometric) learning, both **Hypotheses 1** and **2** should be true (Mitra and Honkapohja, 2014). Hence, if both will be rejected, we will conclude that the **Hypothesis 3** is false. In this case, we will estimate simple behavioral forecasting rules for each subject and investigate the resulting distribution.

3 Experimental results

In this section we discuss the results from our experiment. We will start with a general overview of the dynamics, which was observed in the five treatments. In section 3.2, we will test the differences between the treatments in terms of stability. Section 3.3 will give a brief description of the individual behavior.

[5] Due to an unexplained software or hardware failure, the last period was not recorded in the case of four groups, leaving only 49 data points. These groups are INF05, PLTStrongGuid01, PLTWeakGuid02 and PLTWeakGuid05. In addition, one subject in group INF07 was extremely slow. Despite the help of the experiment's staff, he was unable to act efficiently throughout the session, which then had to be terminated after period 41. We leave this group out of the following analysis, though the group's results are presented in the Appendix B.

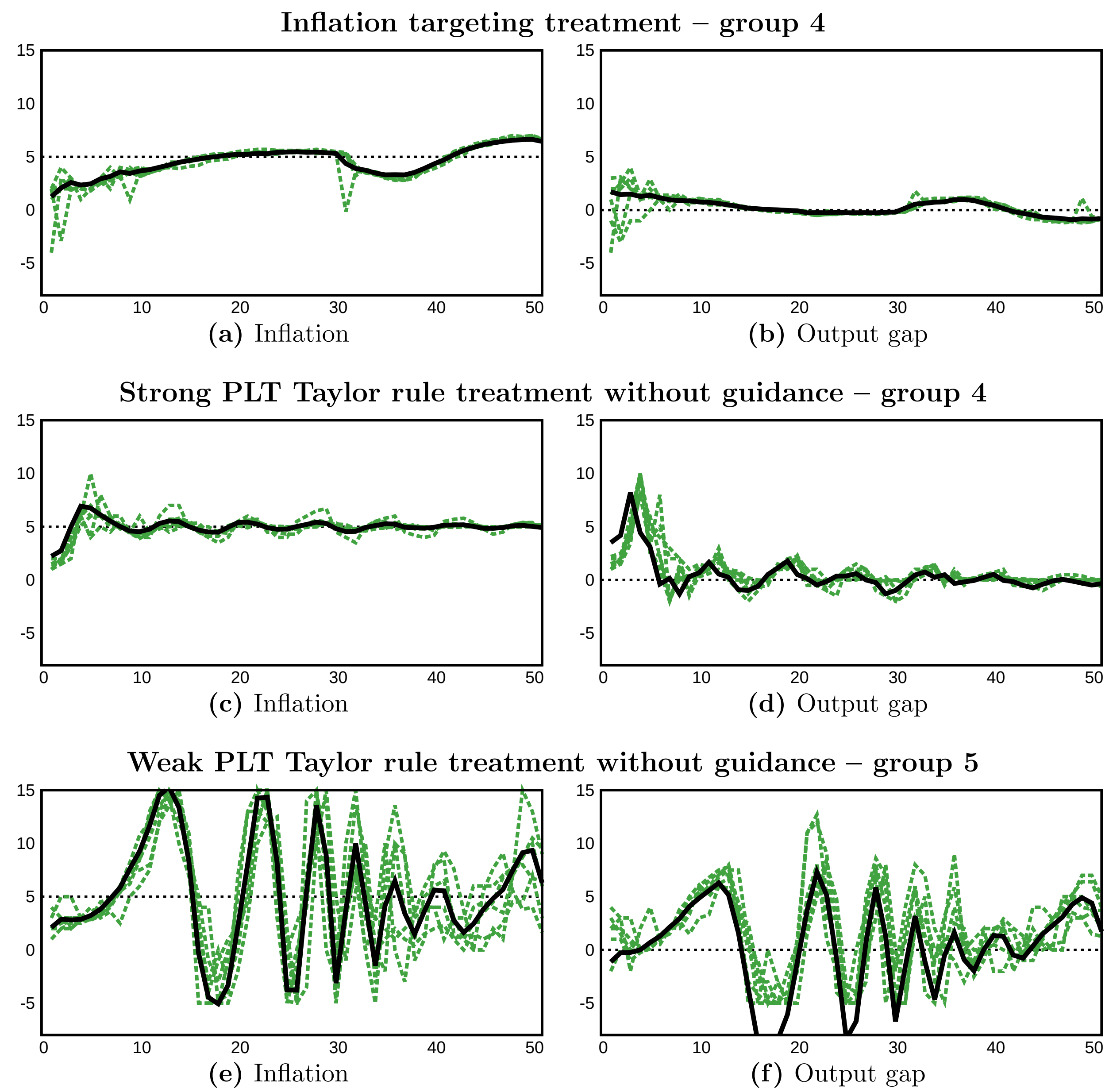


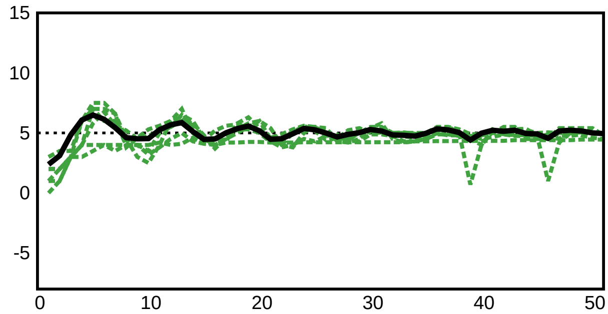
Figure 3.1: Example experimental results, with one representative group per treatment. Left panels display the inflation, and right panels the output gap. In each figure, the realized variable is shown with black line, while the corresponding six subject forecasts are shown with dashed green lines.

3.1 Overview

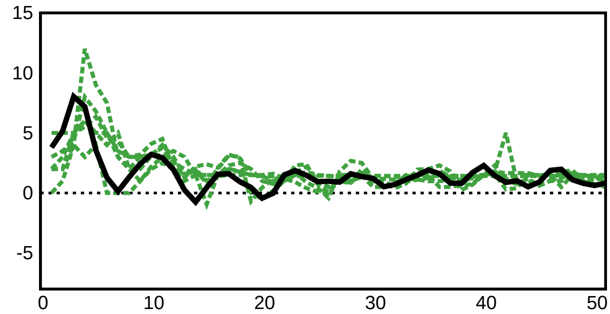
An important observation is that all the 30 groups in our treatment seem to have started close to each other, with both the initial inflation and the initial output gap in the vicinity of 2.5% level. The experiment resulted in clear differences between the treatments. Figure 3.1 shows sample group inflation and output gap results for every treatment (remark that this Figure is spread over two pages). Figure 3.2 shows realized inflation and output gap paths separately for each treatment. Full figures for every group can be found in Appendix B.

Under the inflation treatment (**INF**), two types of dynamics are possible. First, mild oscillations appear in some of the groups, as in the case of group 4 from that treatment

Strong PLT Taylor rule treatment with guidance – group 2

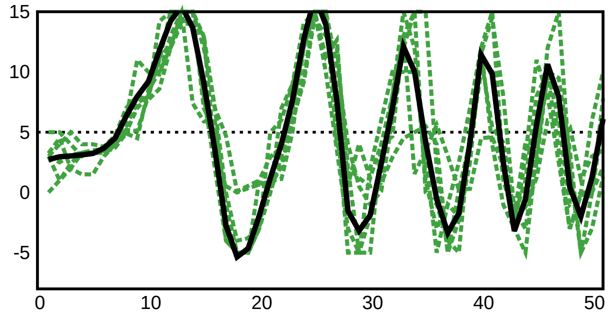


(g) Inflation

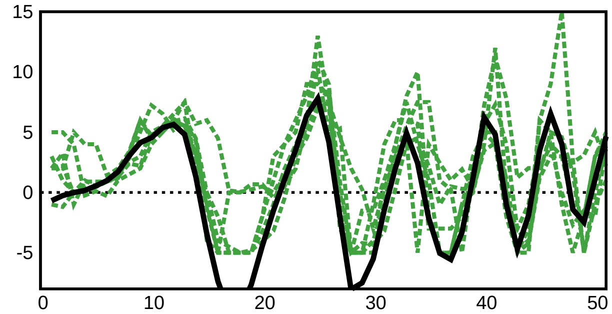


(h) Output gap

Weak PLT Taylor rule treatment with guidance – group 3



(i) Inflation



(j) Output gap

Figure 3.1: (Cont.) Example experimental results, with one representative group per treatment. Left panels show the results for the inflation, and right panels for the output gap. In each figure, the realized variable is shown with black line, while the corresponding six subject forecasts are shown with dashed green lines.

(Figures 3.1a and 3.1b). Despite some instability, subjects are well coordinated and quickly learn to predict accurately both variables. Second, some of the groups exhibit convergent dynamics, as in the case of group 5 (Appendix B). Even though the economy does not always converge to the full employment steady state, this treatment seems comparatively stable.

Similar dynamics appear under the strong Taylor rule PLT treatment without guidance (**StrongNo**). Figures 3.1c and 3.1d present example results for group 4, in which again we observe a high degree of coordination and converging dynamics. The groups under this treatment seem to be more unstable in the initial periods, and they tend to generate faster business cycle than under the inflation treatment **INF**, but they all eventually settle down close to the full employment steady state. On the other hand, under the no guidance treatment with weak PLT Taylor rule (**WeakNo**), all the six groups exhibited explosive dynamics. Subjects repeatedly hit the upper and lower boundaries on their forecasts, which results in fast oscillations with high amplitude. If not for the forecasting constraints, these economies would likely collapse to zero output or diverge. In addition, subjects find it much more difficult to coordinate in this unstable environment, and they make higher forecasting errors.

Interestingly, the guidance seems to have little effect on the dynamics under the PLT Taylor rule. Figures 3.1g and 3.1h show results from group 2 from the strong PLT treatment with guidance (**StrongGuid**), and Figures 3.1i and 3.1j shows results from group 3 under the weak PLT treatment with guidance (**WeakGuid**). The realized inflation and output gap in

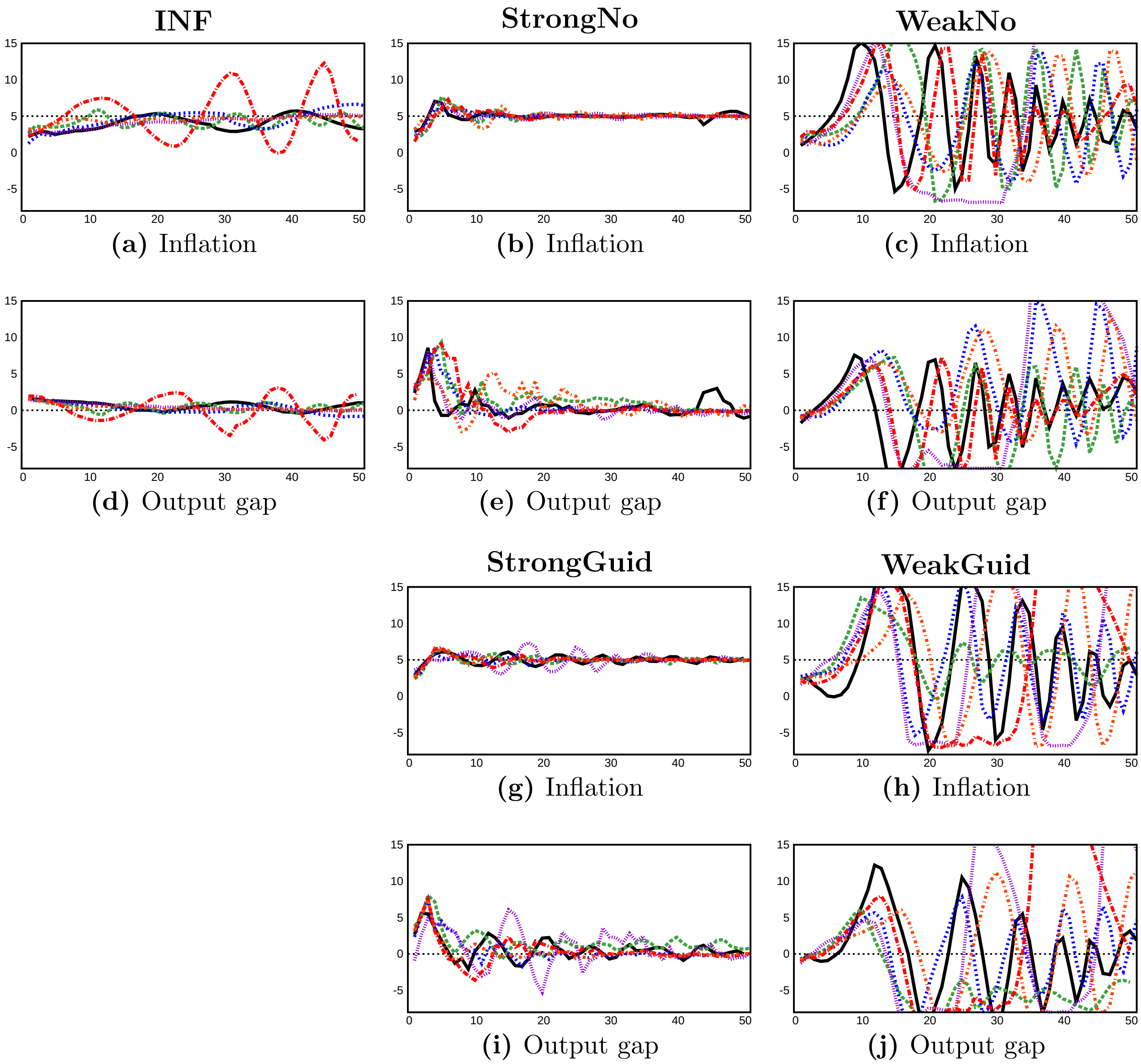


Figure 3.2: Realized inflation and output gap for each treatment. Each graph shows either realized inflation, or realized output gap, in six groups from the specified treatment.

these two groups look remarkably similar to these from their no guidance counterparts.

3.2 Measuring the stability of the treatments

We use the standard measure of Relative Absolute Deviation (RAD) to quantify the degree, to which the five different monetary policies stabilized the economy (see Stöckl et al., 2010, for a general definition and discussion). RAD measure for variable x and group g is defined as

$$RAD_g = \frac{1}{T-10} \sum_{t=11}^{T} \frac{|x_{g,t} - x_t^f|}{x_t^f}, \tag{6}$$

where T denotes the length of the session of the group g, $x_{g,t}$ denotes the realize value of x in period t in group g and x_t^f denotes the fundamental value of variable x in period t. In our case, the fundamental inflation is $\pi^* = 1.05$, while the RAD for the output by definition coincides with the average absolute output gap (which in the full employment steady state is equal to zero). Remark that we exclude the initial 10 observations, as we interpret these as the initial learning phase.

Group	**INF**	**StrongGuid**	**StrongNo**	**WeakGuid**	**WeakNo**
			Inflation		
#1	0.85	0.37	0.207	5.934***	4.31***
#2	0.805	0.241	0.146	2.308	6.066***
#3	0.77	0.133	0.0557	5.275***	4.803***
#4	0.531	0.66	0.206	9.1***	10.13***
#5	2.937***	0.165	0.118	8.903***	4.26***
#6	0.336	0.0847	0.337	6.858***	4.742***
Average	1.038	0.2753	0.1783	6.396	5.719
			Output gap		
#1	0.503	0.822	0.674	5.058	3.663
#2	0.51	1.175	0.953	5.741***	4.992
#3	0.452	0.339	0.194	4.334	5.689***
#4	0.316	1.745	0.495	9.126	11.09
#5	1.731	0.553	0.49	9.795	3.534
#6	0.221	0.235	1.28	6.191	5.025
Average	0.6219	0.8113	0.6811	6.708	5.666

Table 2: Relative Absolute Deviation (RAD) of the experimental **inflation** and **output gap** for the five treatments, in percentages. $***$ ($**$) denotes groups for which the average RAD from the last 40 periods is larger than 2% on 1% (5%) significance level.

The RAD measures can be found in Table 2. Furthermore, we test the RAD distribution differences between the treatments with Mann-Whitneu U test (MWU test), and the results are reported in Table 3. The first clear observation is that there is little variation between the guidance and their respective no guidance treatments (**StrongGuid** versus **StrongNo** and **WeakGuid** versus **WeakNo**). This is confirmed by MWU test, according to which there is no significant difference between the distribution of inflation and output gap RAD measures between these two pairs of treatments. From this, we conclude that **Hypothesis 2** is rejected: guidance, as framed in our experiment, does not have a significant effect on the stability of the economy.

Second observation is that there are significant differences (according to MWU tests) between the two weak PLT Taylor rule treatments and the three other treatments. Under the weak PLT Taylor rule the economies have explosive dynamics, while the strong PLT Taylor rule can enforce convergence to the full employment steady state. In addition, RAD measures imply that the PLT treatments with the strong Taylor rule outperform the inflation target rule in terms of the inflation stability, but not in terms of the output gap stability. We conclude that, in line with the theoretical literature, the price level target indeed can be a promising

Treatment	StableGui	StableNo	UnstableGui	UnstableNo
		Inflation		
INF	3*	1*	1*	0*
StrongGuid		13	0*	0*
StrongNo			0*	0*
WeakGuid				13
WeakGuid				13
		Output gap		
INF	12	15	0*	0*
StrongGuid		16	0*	0*
StrongNo			0*	0*
WeakGuid				10

Table 3: Mann Whitney U test statistics for the differences in the distribution of the Relative Absolute Deviation of the experimental **inflation** and **output gap** for the five treatments. For a 6×6 sample the critical value for 5% p-value is equal to 5. $*$ denotes treatments for which the difference between the treatments is statistically significant.

monetary policy, but only if sufficiently reactive. This rejects **Hypothesis 1** and implies that the weak PLT Taylor rule is not sufficiently responsive to the business cycle to stabilize it. Instead, central bank can use a PLT rule, but only if it is sufficiently harsh.

3.3 Individual behavior

Since the experimental results reject both **Hypothesis 1** and **2**, this in addition is a strong proof against the **Hypothesis 3**. This implies that our subjects were more likely to use simple forecasting rules instead of the sophisticated adaptive learning. In the following, we estimate and interpret these behavioral prediction rules for our subjects.

In the experiment, we organized 6 groups per treatment, which in total gives us a sample of 180 subjects. Following the previous literature, we assume that the subject forecasting can be explained by the following (two dimensional) first-order rule:

$$\begin{aligned} \pi^e_{t+1} &= c^\pi + \alpha^\pi_1 \pi^e_t + \alpha^\pi_2 \pi_{t-1} + \alpha^\pi_3 o_{t-1} + \beta^\pi(\pi_{t-1} - \pi_{t-2}) \\ &\qquad + \delta^\pi r_{t-1} + \gamma^\pi D_{t-1} + \varepsilon^\pi_t, \\ o^e_{t+1} &= c^o + \alpha^o_1 \pi^e_t + \alpha^o_2 o_{t-1} + \alpha^o_3 \pi_{t-1} + \beta^o(o_{t-1} - o_{t-2}) \\ &\qquad + \delta^o r_{t-1} + \gamma^o D_{t-1} + \varepsilon^o_t, \end{aligned} \tag{7}$$

where the superscript e denotes forecasts, π denotes the inflation, o denotes the output gap, r denotes the net interest rate and D denotes the price level deviation. For the clarity of presentation, we suppress subject index, but in principal subjects can use very different specifications of (7). Remark that D is used only in the guidance treatments, otherwise γ's are set to zero. Finally,

$$\begin{pmatrix} \varepsilon_t^{\pi} \\ \varepsilon_t^{o} \end{pmatrix} \equiv \varepsilon_t \sim NID\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{\pi}^2 & \rho_{\pi,o}\sigma_{\pi}\sigma_o \\ \rho_{\pi,o}\sigma_{\pi}\sigma_o & \sigma_o^2 \end{pmatrix} \right) \tag{8}$$

are jointly normally distributed random errors, which are are pairwise independent in the dimensions of time and subjects, but not necessarily for one subject in one period ($\rho_{\pi,o} \neq 0$).

For each subject, we estimate the forecasting rule (7) *jointly* with a simple Maximum Likelihood estimator, which allows us to use the Likelihood Ratio test for all the following tests, for the two rules jointly. We add lags of the two forecasts until there is no evidence of auto-correlation, and hence eliminate the insignificant variables until the two rules contain only significant ones (if any). For the details on the estimation algorithm, and the full results, see Appendix C.

We were able to estimate a two-dimensional rule for all the subjects, and most of these rules are non-trivial (that is they contain significant variables). Average estimated coefficients, as well as number of significant coefficients per treatment, are provided in Table 4. See also Appendix C for the full estimation results. From these 180 two-dimensional rules, some stylized fact emerge:

1. Subjects remained largely heterogeneous within groups, within treatments and between treatments. This means that they used both different values and different subsets of coefficients, even if they belonged to the same group.

2. In general the inflation rules are simpler: they contain fewer significant coefficients.

3. A clear between-treatments pattern is that the subjects used simpler rules under the inflation targeting **INF** and strong Taylor rule PLT treatments **StrongNo** and **StrongGuid**. We interpret this as a sign that in a more difficult, unstable environment, subjects try to use more information.

4. Subjects learn to incorporate guidance information and the interest rate mostly under the unstable treatment **WeakGuid**. For example, δ^{π} is significant for 13 subjects under **StrongGuid** and for 23 subjects under **WeakGuid** treatment. This leads to an interesting result that people seek the monetary authority's guidance if times are unstable, but this does not counter the effect of a relatively weak response of the central bank. It also corresponds well with the previous styilzed finding.

5. A typical result is that the subjects used 'close to' adaptive rules (with significant weights on past forecasts and/or past observations, not necessarily adding up to unity). In addition, trend chasing is popular, with both β 's often significant and then positive.

6. In general, subject rules are far from a fundamentalist rule (forecasting only the full employment steady states values of inflation and output gap), but constants equal to these fundamental values do appear. This implies that some of the subjects learned

	Inflation forecasting rule							Output gap forecasting rule						
	c^π	π^e_t	π_{t-1}	o_t	$\Delta\pi_{t-1}$	r_{t-1}	D_{t-1}	c^o	o^e_t	o_{t-1}	π_{t-1}	Δo_{t-1}	r_{t-1}	D_{t-1}
INF	0.568	0.373	0.431	0	0.586	0.0528	n/a	0.512	0.176	0.539	−0.0638	0.413	−0.022	n/a
(SD)	(1.3)	(0.443)	(0.528)	(0)	(0.645)	(0.279)		(1.44)	(0.3)	(0.558)	(0.263)	(0.609)	(0.174)	
Sign.	11	16	18	0	18	3		18	17	27	2	15	14	
SNo	1.72	0.193	0.484	0	0.397	−0.0229	n/a	0.633	0.178	0.653	−0.105	0.17	0.00328	n/a
(SD)	(1.94)	(0.303)	(0.517)	(0)	(0.763)	(0.097)		(2.89)	(0.249)	(0.437)	(0.524)	(0.408)	(0.351)	
Sign.	19	16	18	0	13	9		23	22	32	6	10	18	
WNo	1.88	0.131	0.0522	0.327	0.496	0.276	n/a	1.17	0.101	0.801	−0.478	0.436	0.293	n/a
(SD)	(1.92)	(0.303)	(0.742)	(0.535)	(0.312)	(0.369)		(1.44)	(0.292)	(0.47)	(0.473)	(0.277)	(0.389)	
Sign.	26	22	25	13	29	21		32	35	36	31	36	36	
SGu	1.42	0.212	0.507	−0.0967	0.299	−0.0249	−0.394	1.17	0.206	0.455	−0.193	0.216	0.00106	−0.276
(SD)	(2.7)	(0.344)	(0.665)	(0.572)	(0.542)	(0.189)	(1.01)	(3.88)	(0.305)	(1.39)	(0.998)	(0.496)	(0.486)	(2.31)
Sign.	19	16	18	1	13	9	13	23	27	31	9	18	22	22
WGu	0.616	0.15	0.632	−0.112	0.513	0.106	−0.0313	−0.32	0.127	0.467	−0.118	0.428	0.277	−0.0455
(SD)	(3.66)	(0.286)	(0.801)	(0.99)	(0.354)	(0.319)	(0.212)	(4.23)	(0.271)	(1.16)	(0.865)	(0.302)	(0.553)	(0.236)
Sign.	19	22	32	10	34	23	23	24	28	32	29	32	33	28

Table 4: Average estimated forecasting rules. SNo, WNo, SGu and WGu denote **StrongNo**, **WeakNo**, **StrongGuid** and **WeakGuid** treatments respectively. SD denotes standard deviation *across the subjects from the treatment* and Sign. denotes number of subjects, for which the coefficient was significant on 5% significance level.

the value of the steady state inflation and output gap, but they would still follow the business cycle.

Altogether, these results confirm **Hypothesis 3**. Furthermore, they are in line with Amano et al. (2011), who in their experimental study demonstrate that the subjects under-react to the price-level deviation and instead use forecasting rules with a high weight on the realized inflation.

4 Conclusions

In this paper we report a simple Learning-to-Forecast experiment on the relevance of guidance and Price Level Targeting (PLT). We focus on a standard DSGE economy, in which the realized inflation and output gap depend on two-period ahead forecasts of these two variables and the specific (linear) Taylor interest rate rule. We ask the subjects to forecast the inflation and output gap and pay them for their forecasting efficiency. Subjects are given only a qualitative description of the economy. We consider five treatments: (1) with inflation target Taylor rule; and with PLT Taylor rule with (2) strong parametrization, (3) weak parametrization, (4) strong parametrization and guidance, and (3) weak parametrization and guidance. We frame the guidance as an additional information: subjects (a) are explicitly informed about how the interest rate rule depends on the price level deviation, and (b) can observe the realized price level deviation throughout the session. We find that the guidance has no effect on the subjects. PLT rule can be a robust monetary policy, but only if it reacts sufficiently strong to the price level deviation and output gap, otherwise the realized dynamics are highly unstable. This shows that the subjects do not follow sophisticated adaptive (econometric) learning, but instead use simple forecasting heuristics.

After the recent financial crisis of 2007, developed economies plummeted into a prolonged recession. Central banks failed to stimulate the economies with interest rates cuts, as they hit the so called zero-lower bound constraint. This shows the relevance of the zero-lower bound steady state, which is characterized by a spiral of deflation and output contraction. Macroeconomic literature focused on developing monetary policies that could pull the economies from the recession, and prevent future crises of a similar magnitude. Two prominent ideas are guidance and Taylor rule based on nominal price level target (PLT). Guidance means that the central bank more openly discloses (and commits to) its monetary policy rule.

Both PLT and guidance have promising properties under Rational Expectations, since they give the economic agents more information about the monetary policy, and thus allow for a faster convergence towards the full employment steady state. Nevertheless, Rational Expectations require unrealistic cognitive load from economic agents such as consumers or firms. On the other hand, even a small departure from Rational Expectations, can lead to different evaluation of PLT and guidance. For instance, Mitra and Honkapohja (2014) show that under adaptive (econometric) learning, PLT Taylor rule actually requires the guidance to stabilize the economy.

The main goal of our paper is to provide an experimental test to the robustness of guidance and PLT monetary policies. We regard our work as complementary to the theoretical literature. We consider guidance framed as in Mitra and Honkapohja (2014): additional information, which the agents receive about the target of the central bank. In addition, we look at PLT Taylor rules with two sets of parameters: (1) as suggested in the adaptive learning literature, and (2) much more harsh parametrization, which is required to stabilize the economy under pure naive expectations.

There are two main findings of our experiment. First, the strong PLT Taylor rule was required to stabilize the economy, and in terms of inflation stability can even outperform the classical inflation based Taylor rule. On the other hand, under the weak PLT Taylor rule the experimental sessions resulted in explosive dynamics. This suggest that our subjects were less sophisticated than what is required by the adaptive learning. Instead, the subjects followed much simpler forecasting rules. We find that a simple first-order heuristic could explain their behavior well, which is in line with the literature on the Learning-to-Forecast experiments.

Second main finding of our experiment is that the guidance had no visible effect on the behavior of the subjects. Estimations demonstrate that they would consider the additional information of the guidance much more often under the Weak PLT Taylor rule treatment. Nevertheless, this would not offset the under-reaction of the monetary authority to the deviations from the full employment steady state. In total, our two findings suggest that in practice, central banks should rely less on an indirect expectations management (such as guidance), and instead directly focus on smoothing the business cycle.

Estimations of the individual behavior in our experiment lead to one additional interesting outcome. Subjects under the two Weak PLT Taylor rule treatments, with much more unstable dynamics, would use more complicated forecasting heuristics. We interpret this finding in the following way. The level of sophistication of individual behavior is not simply a constant that depends on individual characteristics. Instead, the subjects will increase the complexity of their behavior if they face more complicated environment. This insight may have important consequences for economic models of learning, and should be studied more carefully in the future.

The design of our experiment can be easily extended to incorporate alternative monetary policies. One interesting question is whether more involved form of guidance (such as a public commitment to a specific path of interest rate) can have a stabilizing macroeconomic effect, in particular whether a more involved communication of the central bank can anchor individual expectations. The results of our experiment suggest that this may be difficult to achieve, but this issue requires systematic study.

References

Amano, R., Engle-Warnick, J., and Shukayev, M. (2011). Price-level targeting and inflation expectations: experimental evidence. Bank of Canada working paper.

Anufriev, M., Assenza, T., Hommes, C., and Massaro, D. (2013). Interest rate rules and macroeconomic stability under heterogeneous expectations. *Macroeconomic Dynamics*, 17(08):1574–1604.

Assenza, T., Heemeijer, P., Hommes, C., and Massaro, D. (2011). Individual expectations and aggregate macro behavior. CeNDEF Working paper 11-01.

Bao, T., Hommes, C., and Makarewicz, T. (2015). Bubble formation and (in) efficient markets in learning-to-forecast and-optimise experiments. *Economic Journal, Forthcoming*, pages 15–107.

Bech, M. L., Gambacorta, L., and Kharroubi, E. (2014). Monetary policy in a downturn: are financial crises special? *International Finance*, 17(1):99–119.

Boivin, J., Kiley, M. T., and Mishkin, F. S. (2010). How has the monetary transmission mechanism evolved over time? National Bureau of Economic Research.

Chen, Q., Filardo, A., He, D., and Zhu, F. (2015). Financial crisis, us unconventional monetary policy and international spillovers. *Journal of International Money and Finance*.

Chung, H., Herbst, E., and Kiley, M. T. (2014). Effective monetary policy strategies in new keynesian models: A re-examination. National Bureau of Economic Research.

Cogley, T. and Sargent, T. J. (2005). Drifts and volatilities: monetary policies and outcomes in the post wwii us. *Review of Economic dynamics*, 8(2):262–302.

Cornea, A., Hommes, C., and Massaro, D. (2012). Behavioral heterogeneity in us inflation dynamics. CeNDEF Working paper 12-03.

Covas, F. and Zhang, Y. (2010). Price-level versus inflation targeting with financial market imperfections. *Canadian Journal of Economics/Revue canadienne d'économique*, 43(4):1302–1332.

Evans, C. (2012). Monetary policy in a low-inflation environment: Developing a state-contingent price-level target. *Journal of Money, Credit and Banking*, 44:147–155.

Femia, K., Friedman, S., and Sack, B. P. (2013). The effects of policy guidance on perceptions of the fed's reaction function. *FRB of New York Staff Report*, 652.

Galí, J. and Gambetti, L. (2009). On the sources of the great moderation. *American Economic Journal: Macroeconomics*, 1(1):26–57.

Giannone, D., Lenza, M., and Reichlin, L. (2008). Explaining the great moderation: It is not the shocks. *Journal of the European Economic Association*, 6(2-3):621–633.

Giannoni, M. P. (2010). Optimal interest-rate rules in a forward-looking model, and inflation stabilization versus price-level stabilization. National Bureau of Economic Research.

Hommes, C. (2011). The heterogeneous expectations hypothesis: Some evidence from the lab. *Journal of Economic Dynamics and Control*, 35(1):1–24.

Hommes, C., Massaro, D., and Salle, I. (2015). Monetary and fiscal policy design at the zero lower bound–evidence from the lab. In *Workshop on Socio-Economic Complexity*, volume 23, page 27.

Huber, J., Kirchler, M., and Stöckl, T. (2010). The hot hand belief and the gambler's fallacy in investment decisions under risk. *Theory and Decision*, 68(4):445–462.

Krugman, P. (2014). Four observations on secular stagnation. *Secular stagnation: Facts, causes and cures*, page 61.

Magill, M. and Quinzii, M. (2014). Term structure and forward guidance as instruments of monetary policy. *Economic Theory*, 56(1):1–32.

Mitra, K. and Honkapohja, S. (2014). Targeting nominal gdp or prices: Guidance and expectation dynamics. Technical report, Bank of Finland.

Reifschneider, D. L. and Roberts, J. M. (2006). Expectations formation and the effectiveness of strategies for limiting the consequences of the zero bound. *Journal of the Japanese and international economies*, 20(3):314–337.

Stöckl, T., Huber, J., and Kirchler, M. (2010). Bubble measures in experimental asset markets. *Experimental Economics*, 13(3):284–298.

Summers, L. H. (2014). US economic prospects: Secular stagnation, hysteresis, and the zero lower bound. *Business Economics*, 49(2):65–73.

Woodford, M. (2012). Inflation targeting and financial stability. National Bureau of Economic Research.

Yellen, J. L. (2013). Challenges confronting monetary policy. Speech at the 2013 National Association for Business Economics Policy Conference, Washington, DC, March 4, 2013.

Appendices

A Experimental instructions and control questions

The first set of instructions was given to the subjects from the treatments **INF**, **StrongNo** and **WeakNo** (treatment without guidance). The second set of instructions was given to subjects from the treatments **StrongGuid** and **WeakGuid** (treatments with guidance).

All subjects had to answer control questions 1, 2 and 3. In addition, subjects from the treatments **StrongGuid** and **WeakGuid** (treatments with guidance) had to answer control question 4 in order to start the experiment.

Experimental instructions

Welcome to this experiment! The experiment is anonymous, the data from your choices will only be linked to your station ID, not to your name. You will be paid privately at the end, after all participants have finished the experiment. After the main part of the experiment and before the payment you will be asked to fill out a short questionnaire. On your desk you will find a calculator and scratch paper, which you can use during the experiment.

During the experiment you are not allowed to use your mobile phone. You are also not allowed to communicate with other participants. If you have a question at any time, please raise your hand and someone will come to your desk.

General information and experimental economy

All participants will be randomly divided into groups of a fixed size. The group composition will not change during the experiment. You and all other participants will take the roles of statistical research bureaus making predictions of inflation and the so-called "output gap". The experiment consists of 50 periods in total. In each period you will be asked to predict inflation and output gap for the next period.

The economy you are participating in is described by three variables: inflation π_t, output gap y_t and interest rate R_t. The subscript t indicates the period the experiment is in. In total there are 50 periods, so t increases during the experiment from 1 to 50.

Inflation (π_t) measures the percentage change in the price level of the economy. In each period, inflation depends on inflation predictions of the statistical research bureaus in the economy (that is on your own forecast as well as on the forecasts of the other bureaus in the experiment), on output gap, on interest rate and on a small random term. There is a **positive** relation between the actual inflation and (i) the inflation predictions and (ii) the actual output gap. This means that if the inflation predictions of the research bureaus or the actual output gap increase, then actual inflation will also increase (everything else equal). In economies similar to this one, inflation has historically been between -5% and 8%.

Output gap (y_t) represents the amount of goods produced by firms and consumed by households in the economy. In each period, output gap depends on inflation predictions and output gap predictions of the statistical research bureaus in the economy (that is on your own forecast as well as on the forecasts of the other bureaus in the experiment), on the interest rate and on a small random term. There is a **positive** relation between the actual output gap and both the inflation predictions and output gap predictions. This means that if the inflation predictions or output gap predictions of the research bureaus increase, then actual output gap will also increase (everything else equal). There is a **negative** relation between output gap and the interest rate. This means that if the interest rate increases, then actual output gap will instead decrease (everything else equal). In economies similar to this one, output gap has historically been between -5% and 8%.

Interest rate (R_t) measures the cost of borrowing money and is determined by the central bank. The central bank sets the interest rate in response to the inflation and the output gap. In each period, if inflation and output gap forecasts are considered too high, the central bank increases the interest rate. If inflation and output gap forecasts are considered too low, the central bank decreases the interest rate. The interest rate cannot take negative values.

Prediction task

Your task in each period of the experiment is to predict inflation and output gap in the next period. For example, in period 21 you have to predict inflation and output gap in period 22. When the experiment starts, you have to predict inflation and output gap for the first two periods, i.e. π_1^f and y_1^f and then π_2^f and y_2^f. The superscript f indicates that these are forecasts. When all participants have made their predictions for the second period, the actual inflation (π_1), the interest rate (R_1) and the actual output gap (y_1) for period 1 are announced. Then period 2 of the experiment begins. In period 2 you make inflation and output gap predictions for period 3 (π_3^f and y_3^f). When all participants have made their predictions for period 3, actual inflation (π_2), interest rate (R_2) and output gap (y_2) for period 2 are announced. This process repeats itself for 50 periods.

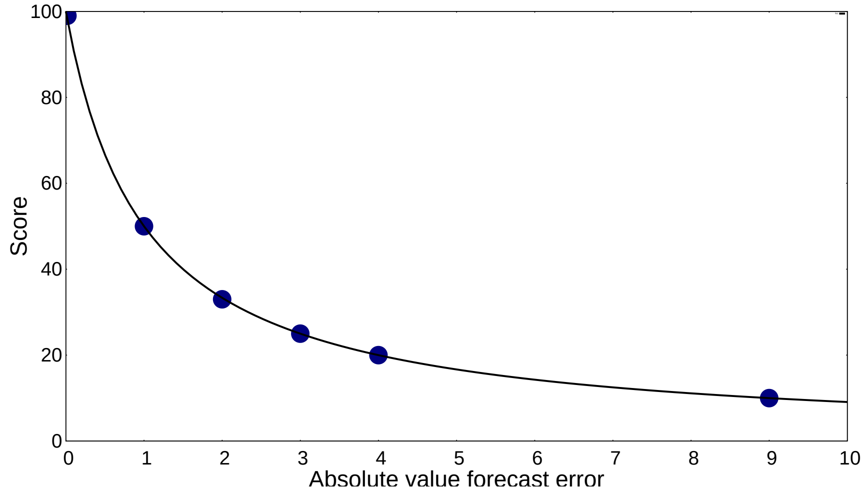
Thus, in a certain period t when you make predictions of inflation and output gap for the next period $t+1$, the following information is available to you:

- realized values of inflation, interest rate and output gap, up to and including period $t-1$;
- Your predictions up to and including your prediction for period t;
- Your prediction scores up to and including period $t-1$ (see below).

Payments

Your payment will depend on the accuracy of your predictions. You will be paid either for predicting inflation or for predicting output gap. The accuracy of your predictions is measured by the absolute distance between your prediction and the actual values (this distance is the prediction error). For each period the prediction error is calculated as soon as the actual values are known; you subsequently get a prediction score that decreases as the prediction error increases. The table below gives the relation between the prediction error and the prediction score. The prediction error is calculated in the same way for inflation and output gap.

Prediction error	0	1	2	3	4	9
Score	100	50	33.33	25	20	10



Example: If (for a certain period) you predict an inflation of 2%, and the actual inflation turns out to be 3%, then you make an absolute error of $3\% - 2\% = 1\%$. Therefore you get a prediction score of 50. If you predict an inflation of 1%, and the actual inflation turns out to be negative, for example -2%, you make a prediction error of $1\% - (-2\%) = 3\%$. Then you get a prediction score of 25. For a perfect prediction, with a prediction error of zero, you get a prediction score of 100.

The figure above shows the relation between your prediction score (vertical axis) and your prediction error (horizontal axis). Points in the graph correspond to the prediction scores in the previous table. At the end of the experiment, you will have two total scores, one for inflation predictions and one for output gap predictions. These total scores simply consist of the sum of all prediction scores you got during the experiment, separately for inflation and output gap predictions. **When the experiment has ended, one of the two total scores will be randomly selected for payment.**

Your final payment will consist of 0.75 euro for each 100 points in the selected total score (200 points therefore equals 1.50 euro). This will be the only payment from this experiment, i.e. you will not receive a show-up fee on top of it.

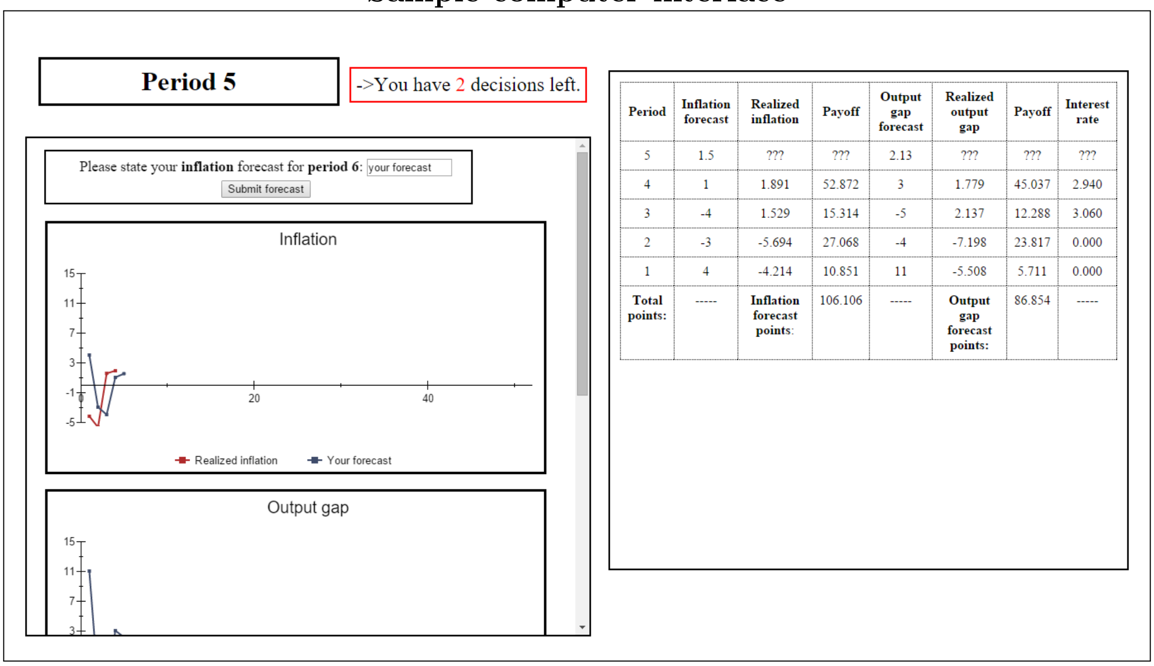
Computer interface

The computer interface will be mainly self-explanatory and example screenshot is presented below. The top part of the screen will tell you the current period, and how many decisions (forecasts) you still have to make in the current period (if you made all the forecasts, you will be asked to wait for other subjects). The right part of the screen will show you a table with all of the information available up to the period that you are in. That is, in period t, i.e. when you are asked to make your prediction for period $t+1$, this will be actual inflation, interest rate and output gap until period $t-1$, your predictions until period t, and the prediction scores arising from your predictions until period $t-1$ for both inflation and output gap. The sum of the prediction scores over the different periods are shown in the bottom right of the screen, separately for your inflation and output gap predictions. Once the current period will become large, you may need to scroll down the table to see the early periods.

The left part of the screen will show you the information on inflation, interest rate and output gap in graphs. The axis of the inflation graph shows values in percentage points (i.e. 3 corresponds to 3%). Please note that maybe you need to scroll the graph box down to see bottom figures and the decision box for the output gap forecast (compare the last two figures).

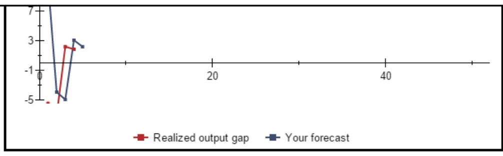
In this panel you will also be asked to enter your predictions. When submitting your prediction, use a decimal point if necessary (not a comma). For example, if you want to submit a prediction of 2.5% type "2.5"; for a prediction of -1.75% type "-1.75". The order of the boxes in the panel is: box for inflation forecast, three graphs with inflation, output and interest rate information and box for output gap forecast.

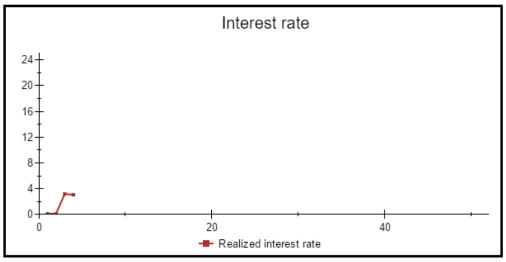
Sample computer interface



Period 5

->You have 2 decisions left.





Please state your **output gap** forecast for **period 6**: your forecast

Submit forecast

Period	Inflation forecast	Realized inflation	Payoff	Output gap forecast	Realized output gap	Payoff	Interest rate
5	1.5	???	???	2.13	???	???	???
4	1	1.891	52.872	3	1.779	45.037	2.940
3	-4	1.529	15.314	-5	2.137	12.288	3.060
2	-3	-5.694	27.068	-4	-7.198	23.817	0.000
1	4	-4.214	10.851	11	-5.508	5.711	0.000
Total points:	-----	**Inflation forecast points:**	106.106	-----	**Output gap forecast points:**	86.854	-----

Experimental instructions

Welcome to this experiment! The experiment is anonymous, the data from your choices will only be linked to your station ID, not to your name. You will be paid privately at the end, after all participants have finished the experiment. After the main part of the experiment and before the payment you will be asked to fill out a short questionnaire. On your desk you will find a calculator and scratch paper, which you can use during the experiment.

During the experiment you are not allowed to use your mobile phone. You are also not allowed to communicate with other participants. If you have a question at any time, please raise your hand and someone will come to your desk.

General information and experimental economy

All participants will be randomly divided into groups of a fixed size. The group composition will not change during the experiment. You and all other participants will take the roles of statistical research bureaus making predictions of inflation and the so-called "output gap". The experiment consists of 50 periods in total. In each period you will be asked to predict inflation and output gap for the next period.

The economy you are participating in is described by three variables: inflation π_t, output gap y_t and interest rate R_t. The subscript t indicates the period the experiment is in. In total there are 50 periods, so t increases during the experiment from 1 to 50.

Inflation (π_t) measures the percentage change in the price level of the economy. In each period, inflation depends on inflation predictions of the statistical research bureaus in the economy (that is on your own forecast as well as on the forecasts of the other bureaus in the experiment), on output gap, on interest rate and on a small random term. There is a **positive** relation between the actual inflation and (i) the inflation predictions and (ii) the actual output gap. This means that if the inflation predictions of the research bureaus or the actual output gap increase, then actual inflation will also increase (everything else equal). In economies similar to this one, inflation has historically been between -5% and 8%.

Output gap (y_t) represents the amount of goods produced by firms and consumed by households in the economy. In each period, output gap depends on inflation predictions and output gap predictions of the statistical research bureaus in the economy (that is on your own forecast as well as on the forecasts of the other bureaus in the experiment), on the interest rate and on a small random term. There is a **positive** relation between the actual output gap and both the inflation and output gap predictions. This means that if the inflation predictions or output gap predictions of the research bureaus increase, then actual output gap will also increase (everything else equal). There is a **negative** relation between output gap and the interest rate. This means that if the interest rate increases, then actual output gap will instead decrease (everything else equal). In economies similar to this one, output gap has historically been between -5% and 8%.

Interest rate (R_t) measures the cost of borrowing money and is determined by the central bank. The central bank sets the interest rate in response to the output gap and the relative deviation of the price level from its intended level (see below). In each period, if output gap forecasts are considered too high, the central bank increases the interest rate. If output gap forecasts are considered too low, the central bank decreases the interest rate. The interest rate cannot take negative values. Furthermore, throughout all 50 periods the central banks commits to the following inflation stabilizing policy.

The central banks wants to guide the actual inflation (price growth) in such a way that the actual **price level** P_t will not deviate from its intended path P_t^{int}, in which price growth (actual inflation) is neither too large nor too low. The intended price level, which the central bank desires for a specific period, can vary between periods. This intended price level is not known, but what is known is the *relative* deviation of the price level from this intended level. In each period, if price level forecasts are considered too high relative to the intended level, the central bank increases the interest rate. If price forecasts are considered too low relative to the intended level, the central bank decreases the interest rate. The interest rate cannot take negative values.

Prediction task

Your task in each period of the experiment is to predict inflation and output gap in the next period. For example, in period 21 you have to predict inflation and output gap in period 22. When the experiment starts, you have to predict inflation and output gap for the first two periods, i.e. π_1^f and y_1^f and then π_2^f and y_2^f. The superscript f indicates that these are forecasts. When all participants have made their predictions for the second period, the actual inflation (π_1), the interest rate (R_1), the actual output gap (y_1) and the relative deviation of the price level ($\frac{P_1-P_1^{int}}{P_1^{int}}$) for period 1 are announced. Then period 2 of the experiment begins. In period 2 you make inflation and output gap predictions for period 3 (π_3^f and y_3^f). When all participants have made their predictions for period 3, inflation (π_2), interest rate (R_2), output gap (y_2) and $\frac{P_2-P_2^{int}}{P_2^{int}}$ relative deviation of the price level for period 2 are announced. This process repeats itself for 50 periods.

Thus, in a certain period t when you make predictions of inflation and output gap for the next period $t+1$, the following information is available to you:

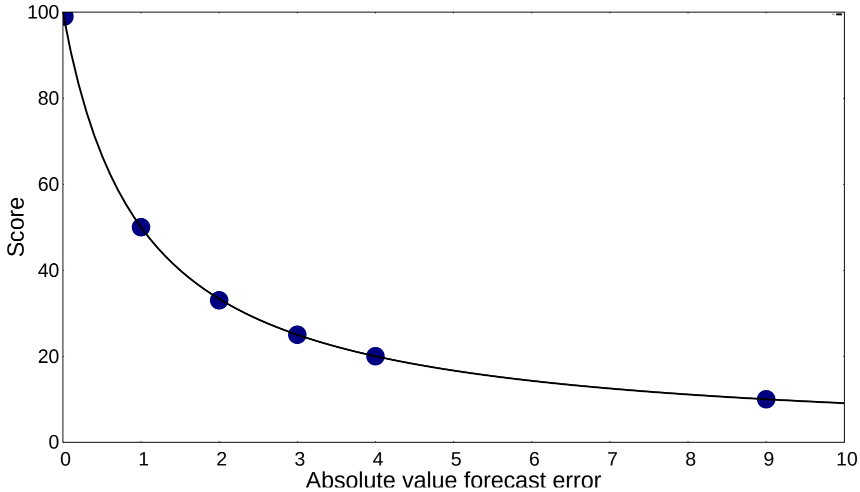
- realized values of inflation, output gap and deviations of the price level from the one intended by the central bank, up to and including period $t-1$;
- Your predictions up to and including your prediction for period t;
- Your prediction scores up to and including period $t-1$ (see below).

Payments

Your payment will depend on the accuracy of your predictions. You will be paid either for predicting inflation or for predicting output gap. The accuracy of your predictions is measured by the absolute distance between your prediction and the actual values (this distance is the prediction error). For each period the prediction error is calculated as soon as the actual values are known; you subsequently get a prediction score that decreases as the prediction error increases. The table below gives the relation between the prediction error and the prediction score. The prediction error is calculated in the same way for inflation and output gap.

Example: If (for a certain period) you predict an inflation of 2%, and the actual inflation turns out to be 3%, then you make an absolute error of $3\% - 2\% = 1\%$. Therefore you get a prediction score of 50. If you predict an inflation of 1%, and the actual inflation turns out to be negative, for example -2%, you make a prediction error of $1\% - (-2\%) = 3\%$. Then you get a prediction score of 25. For a perfect prediction, with a prediction error of zero, you get a prediction score of 100.

Prediction error	0	1	2	3	4	9
Score	100	50	33.33	25	20	10



The figure above shows the relation between your prediction score (vertical axis) and your prediction error (horizontal axis). Points in the graph correspond to the prediction scores in the previous table. At the end of the experiment, you will have two total scores, one for inflation predictions and one for output gap predictions. These total scores simply consist of the sum of all prediction scores you got during the experiment, separately for inflation and output gap predictions. **When the experiment has ended, one of the two total scores will be randomly selected for payment.**

Your final payment will consist of 0.75 **euro for each** 100 **points in the selected total score (**200 **points therefore equals** 1.50 **euro). This will be the only payment from this experiment, i.e. you will not receive a show-up fee on top of it.**

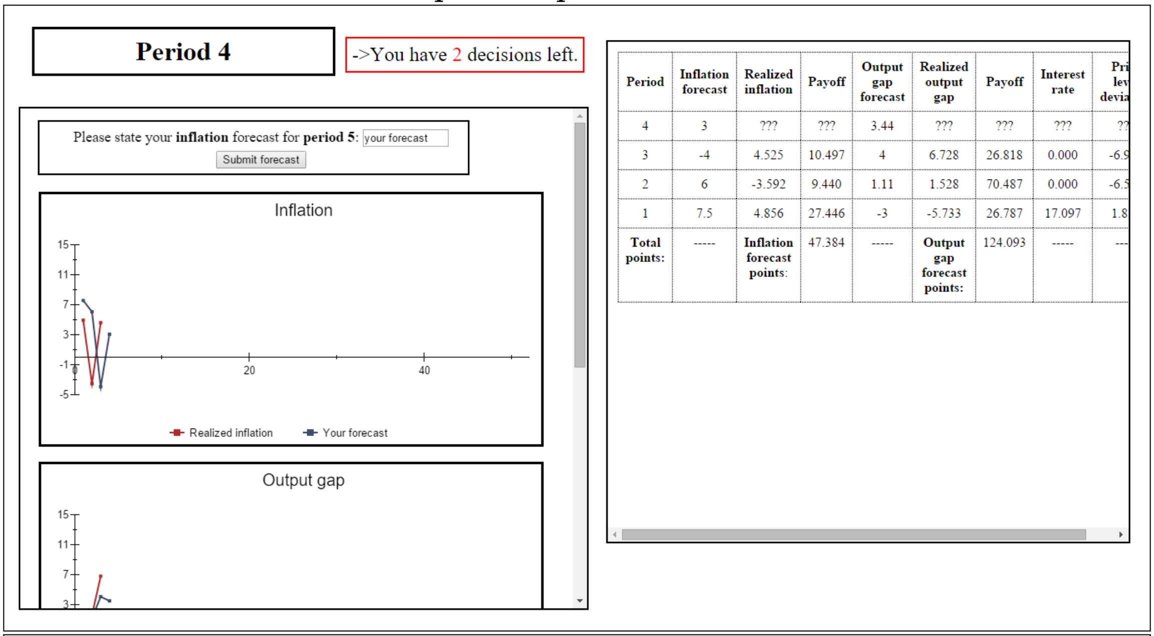
Computer interface

The computer interface will be mainly self-explanatory and example screenshot is presented below. The top part of the screen will tell you the current period, and how many decisions (forecasts) you still have to make in the current period (if you made all the forecasts, you will be asked to wait for other subjects). The right part of the screen will show you a table with all of the information available up to the period that you are in. That is, in period t, i.e. when you are asked to make your prediction for period $t+1$, this will be actual inflation, interest rate, output gap and deviation of price level from the level intended by the central bank until period $t-1$, your predictions until period t, and the prediction scores arising from your predictions until period $t-1$ for both inflation and output gap. The sum of the prediction scores over the different periods are shown in the bottom right of the screen, separately for your inflation and output gap predictions. Once the current period will become large, you may need to scroll down the table to see the early periods

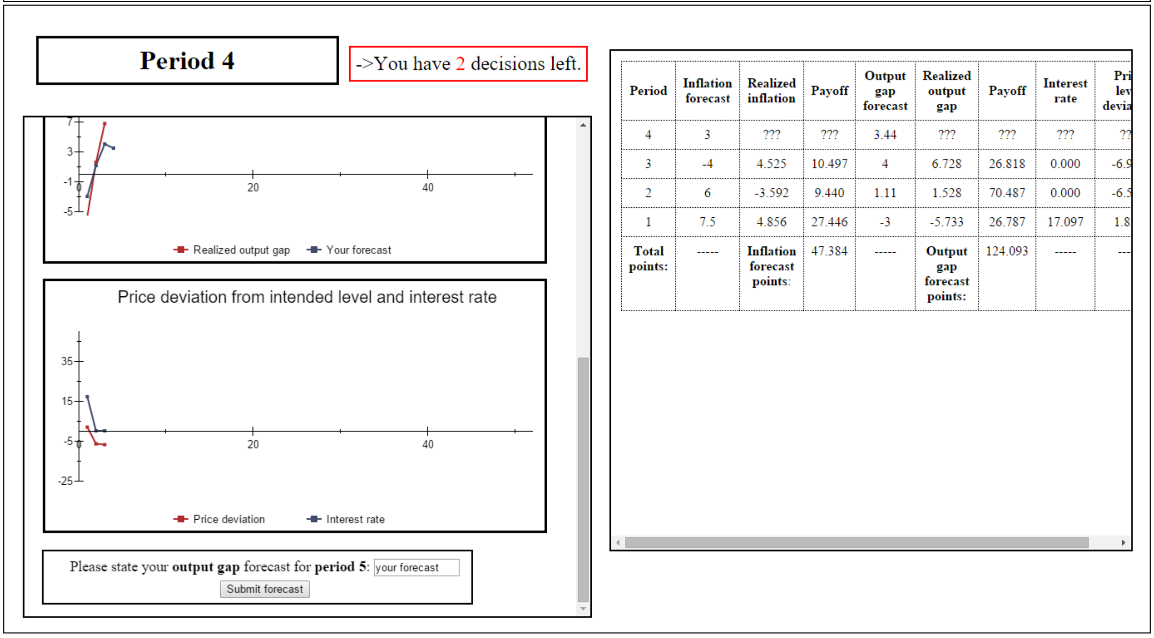
The left part of the screen will show you the information in graphs on inflation, output gap, interest rate and the relative deviation of the price level from its intended value. The vertical axis of the graph shows values in percentage points (i.e. 3 corresponds to 3%). Please note that maybe you need to scroll the graph box down to see bottom figures and the decision box for the output gap forecast (compare the last two figures).

In this panel you will also be asked to enter your predictions. When submitting your prediction, use a decimal point if necessary (not a comma). For example, if you want to submit a prediction of 2.5% type "2.5"; for a prediction of -1.75% type "-1.75". The order of the boxes in the panel is: box for inflation forecast, three graphs with inflation, output gap and interest rate/price deviation from the level intended by the central bank information;; and box for output forecast.

Sample computer interface



Period	Inflation forecast	Realized inflation	Payoff	Output gap forecast	Realized output gap	Payoff	Interest rate	Pri lev devia
4	3	???	???	3.44	???	???	???	??
3	-4	4.525	10.497	4	6.728	26.818	0.000	-6.9
2	6	-3.592	9.440	1.11	1.528	70.487	0.000	-6.5
1	7.5	4.856	27.446	-3	-5.733	26.787	17.097	1.8
Total points:	-----	Inflation forecast points:	47.384	-----	Output gap forecast points:	124.093	-----	---



Period	Inflation forecast	Realized inflation	Payoff	Output gap forecast	Realized output gap	Payoff	Interest rate	Pri lev devia
4	3	???	???	3.44	???	???	???	??
3	-4	4.525	10.497	4	6.728	26.818	0.000	-6.9
2	6	-3.592	9.440	1.11	1.528	70.487	0.000	-6.5
1	7.5	4.856	27.446	-3	-5.733	26.787	17.097	1.8
Total points:	-----	Inflation forecast points:	47.384	-----	Output gap forecast points:	124.093	-----	---

Control questions

Question 1

Suppose that the statistical bureaus predict that inflation will increase. Holding all other factors equal, including the interest rate, this means that:

(a) the output gap will be **increase**;

(b) the output gap will be **stay on the same level**;

(c) the output gap will be **decrease**;

Question 2

Suppose that the statistical bureaus predict that output gap in period decrease. Holding all other factors equal, this means that:

(a) the central bank will **increase** the interest rate, which in turn has a **positive** impact on the output gap;

(b) the central bank will **decrease** the interest rate, which in turn has a **negative** impact on the output gap;

(c) the central bank will **increase** the interest rate, which in turn has a **negative** impact on the output gap.

(d) the central bank will **decrease** the interest rate, which in turn has a **positive** impact on the output gap;

Question 3

Suppose that your inflation prediction for period 9 is -1%, and the realized inflation in that period is 3%. For this forecast you will receive score of

(a) 10 points;

(b) 100 points;

(c) 20 points;

(d) 33.33 points.

Question 4 – only for guidance treatment

Suppose that the prices fall below the intended level of the central bank. Holding all other factors equal, this means that:

(a) the central bank will **increase** the interest rate.

(b) the central bank will **decrease** the interest rate.

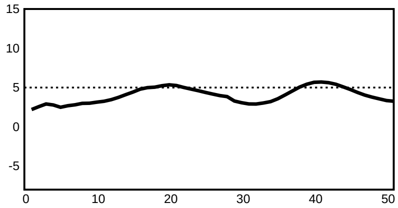
(c) the central bank will **not change** the interest rate.

(d) it is not possible to say what the central bank will do.

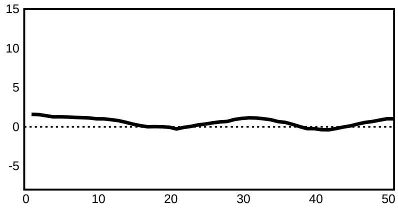
Solution:
1a, 2d, 3c, 4b

B Experimental results (graphical representation)

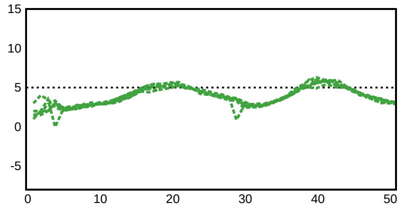
B.1 Inflation targeting



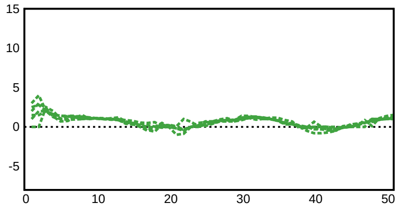
(a) Inflation



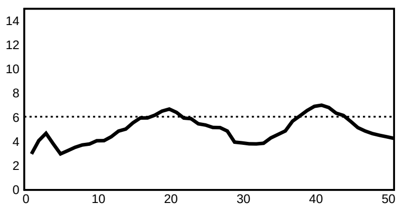
(b) Output gap



(c) Inflation forecasts

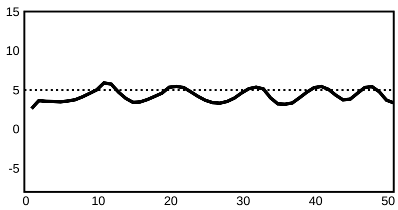


(d) Output gap forecasts

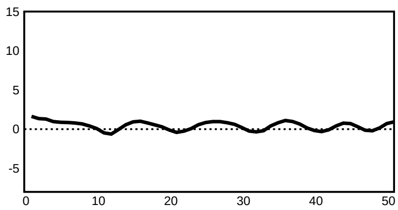


(e) Interest rate

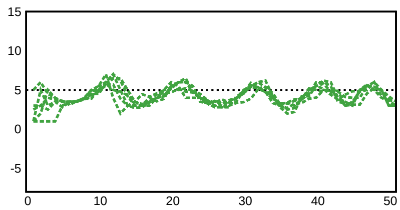
Figure B.1.1: Group number 1 (Inflation Targeting).



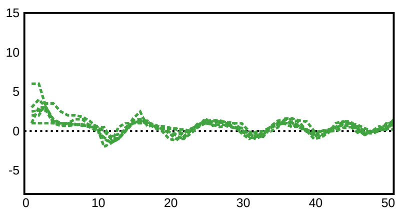
(a) Inflation



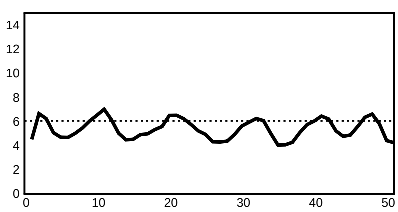
(b) Output gap



(c) Inflation forecasts

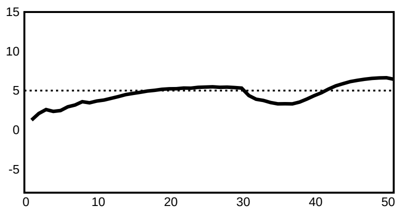


(d) Output gap forecasts

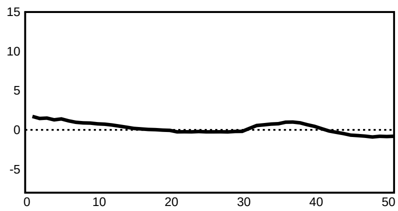


(e) Interest rate

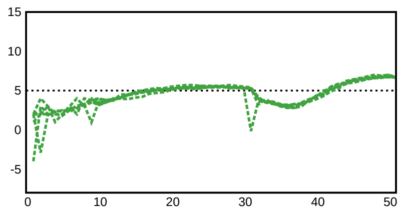
Figure B.1.2: Group number 2 (Inflation Targeting).



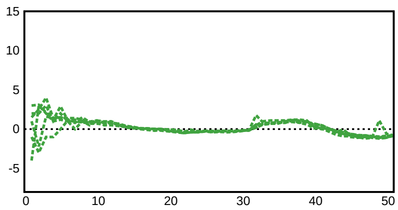
(a) Inflation



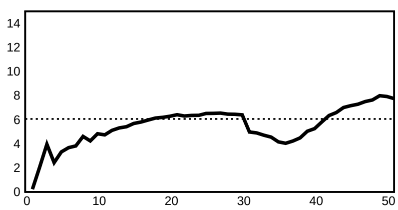
(b) Output gap



(c) Inflation forecasts

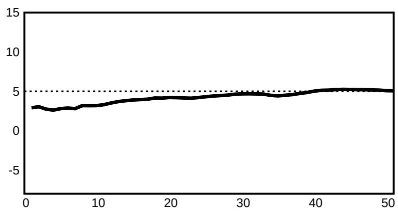


(d) Output gap forecasts

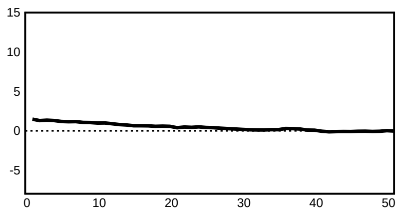


(e) Interest rate

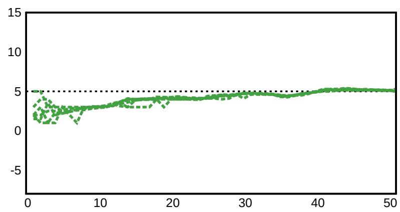
Figure B.1.3: Group number 3 (Inflation Targeting).



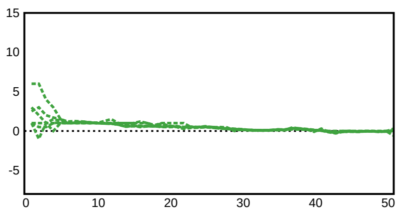
(a) Inflation



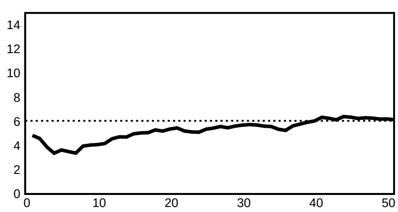
(b) Output gap



(c) Inflation forecasts

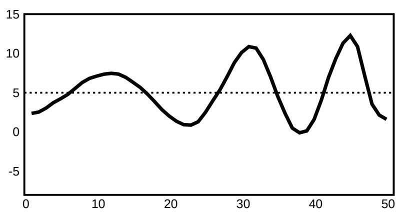


(d) Output gap forecasts

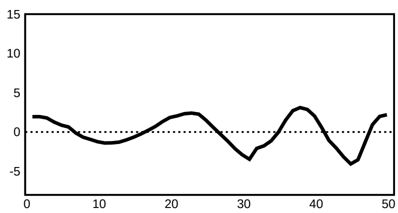


(e) Interest rate

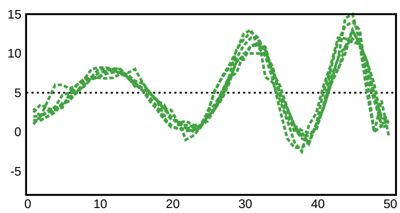
Figure B.1.4: Group number 4 (Inflation Targeting).



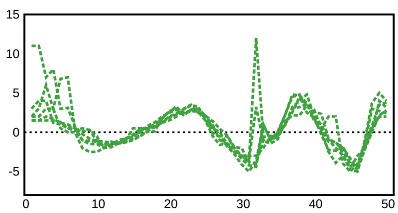
(a) Inflation



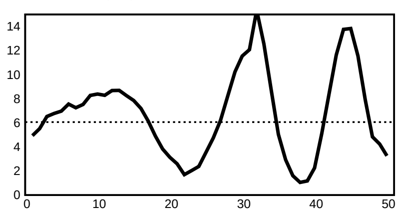
(b) Output gap



(c) Inflation forecasts

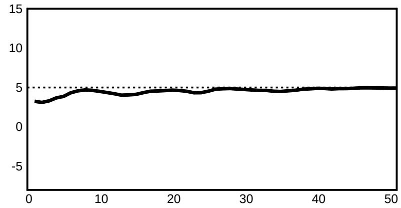


(d) Output gap forecasts

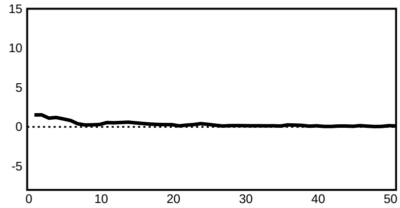


(e) Interest rate

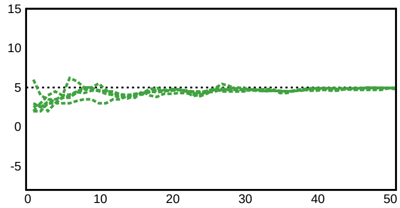
Figure B.1.5: Group number 5 (Inflation Targeting).



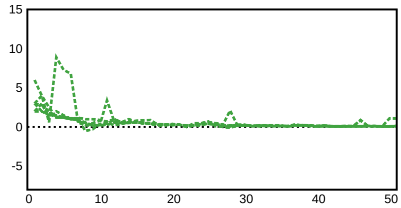
(a) Inflation



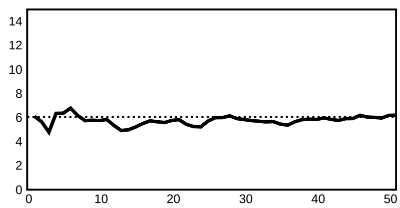
(b) Output gap



(c) Inflation forecasts

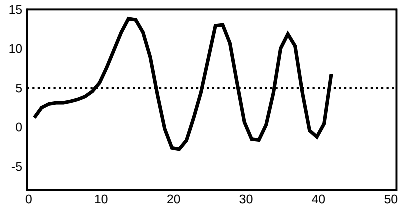


(d) Output gap forecasts

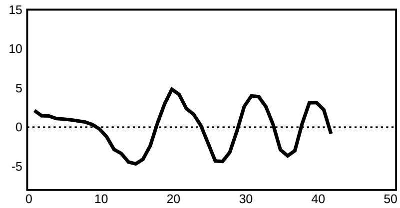


(e) Interest rate

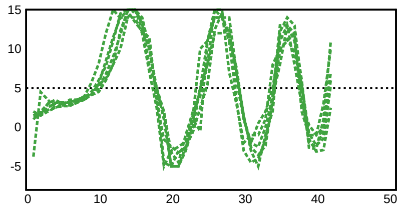
Figure B.1.6: Group number 6 (Inflation Targeting).



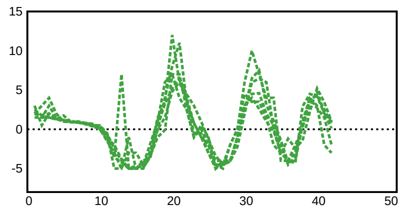
(a) Inflation



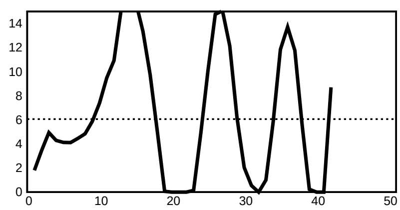
(b) Output gap



(c) Inflation forecasts



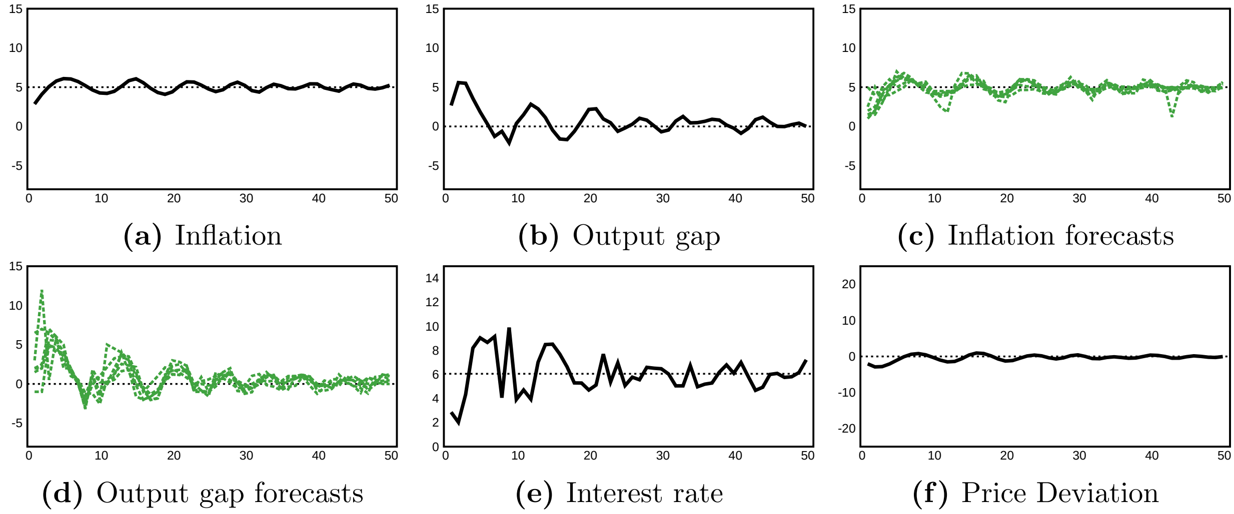
(d) Output gap forecasts



(e) Interest rate

Figure B.1.7: Group number 7* (Inflation Targeting). The group in which one of the subjects was extremely slow. The group was terminated after period 41 and not used in the econometric analysis.

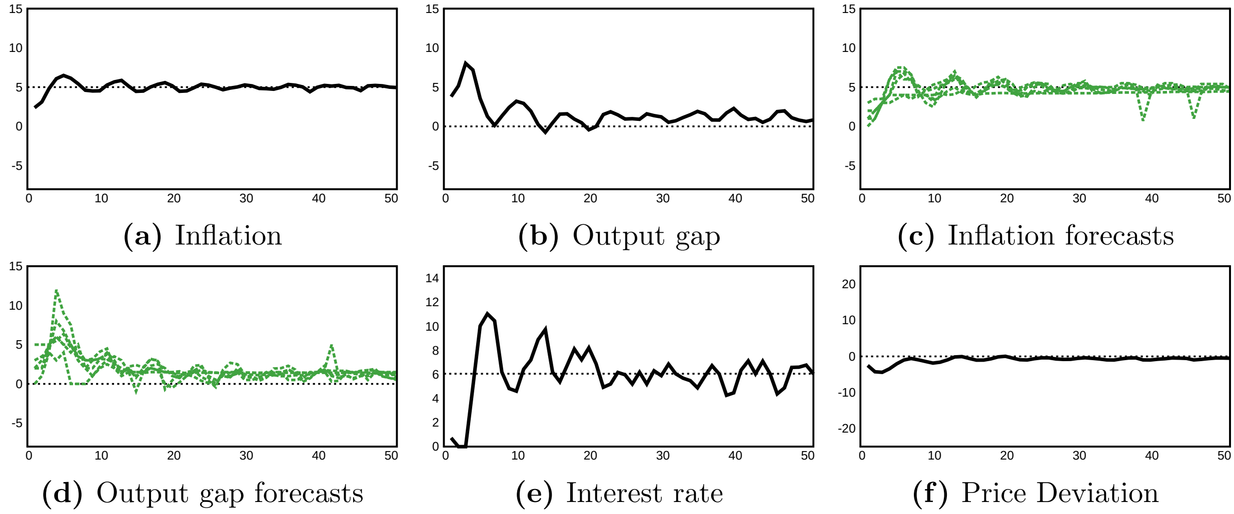
B.2 PLT: Stable with Guidance



(a) Inflation (b) Output gap (c) Inflation forecasts

(d) Output gap forecasts (e) Interest rate (f) Price Deviation

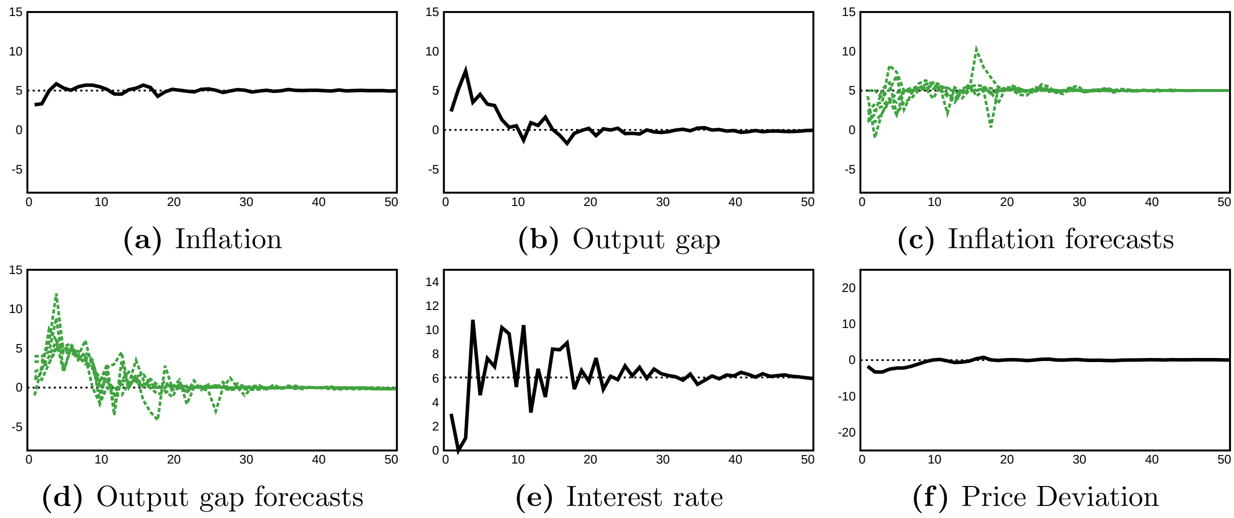
Figure B.2.1: Group number 1 (PLT: Stable with Guidance).



(a) Inflation (b) Output gap (c) Inflation forecasts

(d) Output gap forecasts (e) Interest rate (f) Price Deviation

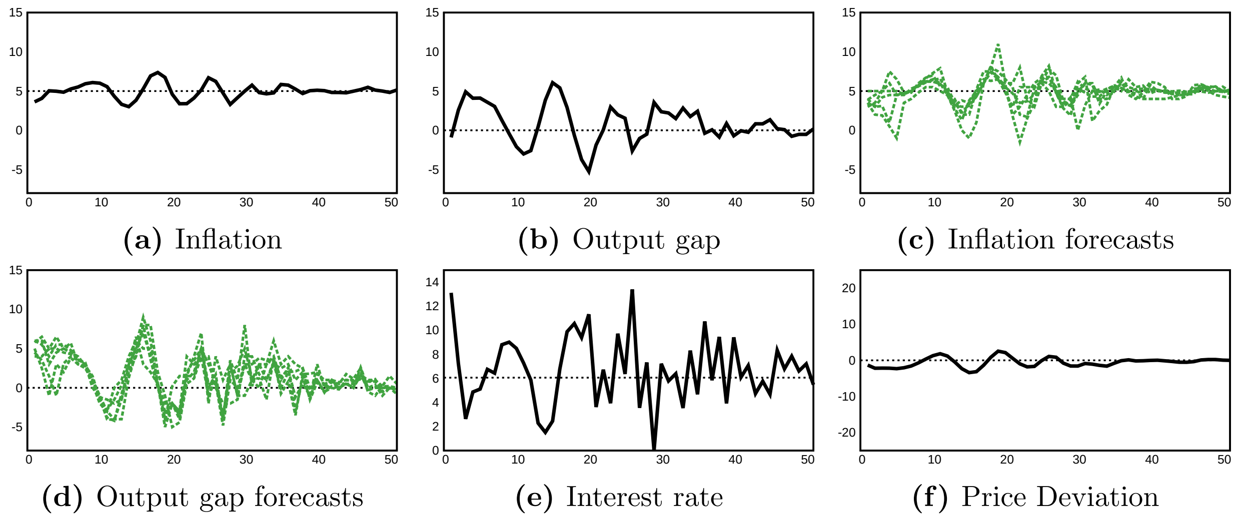
Figure B.2.2: Group number 2 (PLT: Stable with Guidance).



(a) Inflation (b) Output gap (c) Inflation forecasts

(d) Output gap forecasts (e) Interest rate (f) Price Deviation

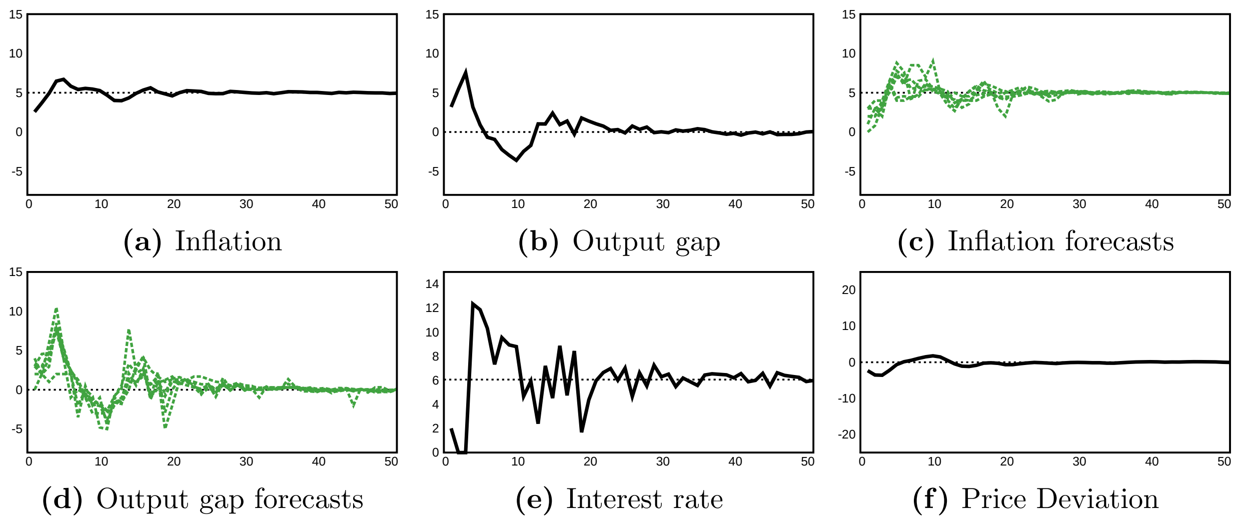
Figure B.2.3: Group number 3 (PLT: Stable with Guidance).



(a) Inflation (b) Output gap (c) Inflation forecasts

(d) Output gap forecasts (e) Interest rate (f) Price Deviation

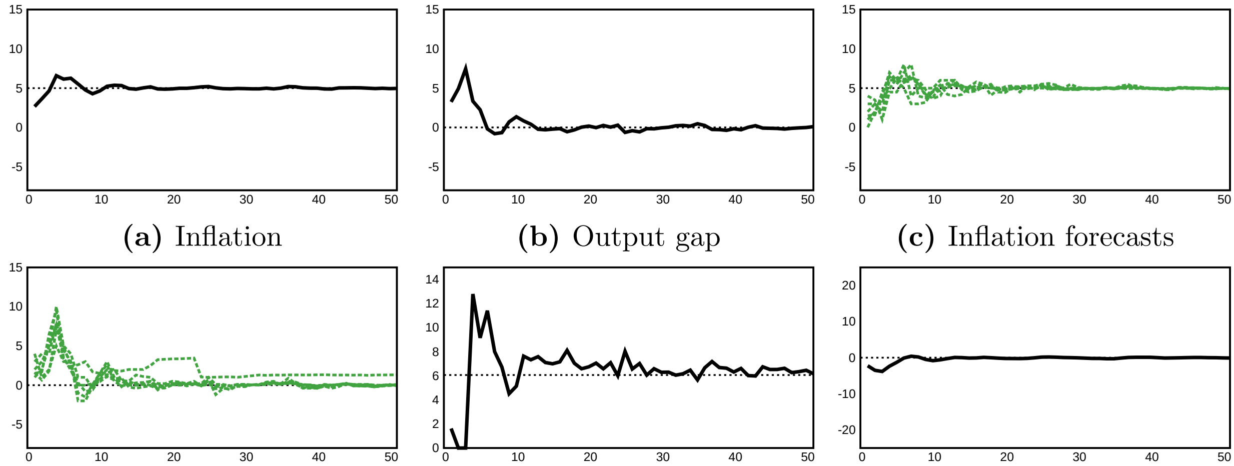
Figure B.2.4: Group number 4 (PLT: Stable with Guidance).



(a) Inflation (b) Output gap (c) Inflation forecasts

(d) Output gap forecasts (e) Interest rate (f) Price Deviation

Figure B.2.5: Group number 5 (PLT: Stable with Guidance).

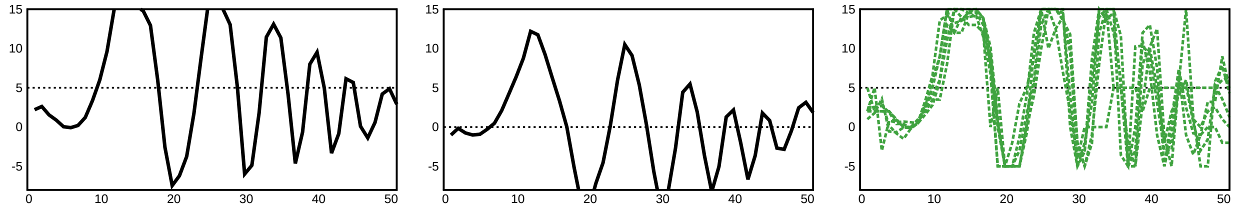


(a) Inflation **(b)** Output gap **(c)** Inflation forecasts

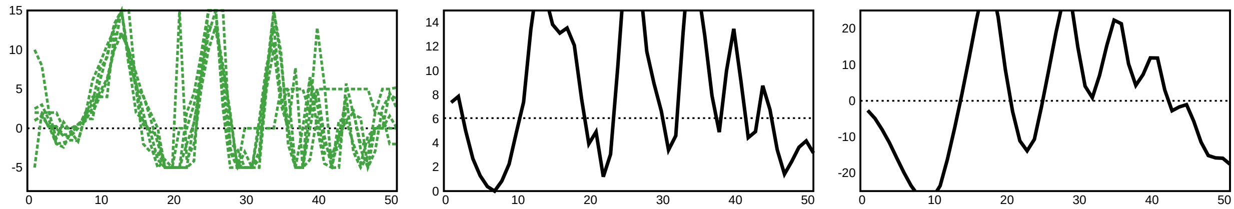
(d) Output gap forecasts **(e)** Interest rate **(f)** Price Deviation

Figure B.2.6: Group number 6 (PLT: Stable with Guidance).

B.3 PLT: Unstable with Guidance

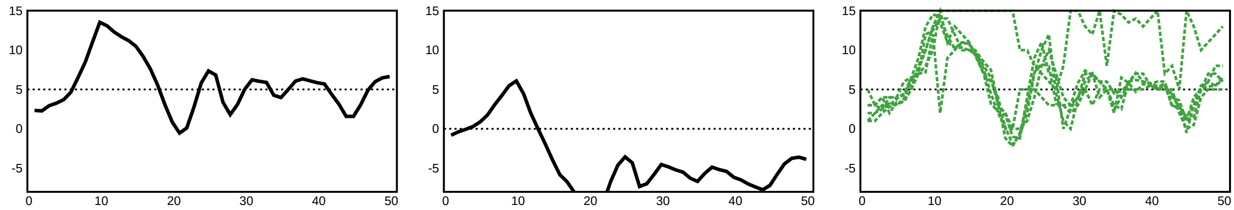


(a) Inflation (b) Output gap (c) Inflation forecasts

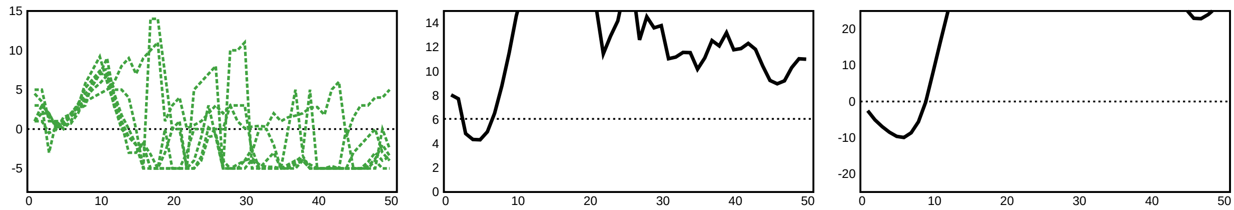


(d) Output gap forecasts (e) Interest rate (f) Price Deviation

Figure B.3.1: Group number 1 (PLT: Unstable with Guidance).

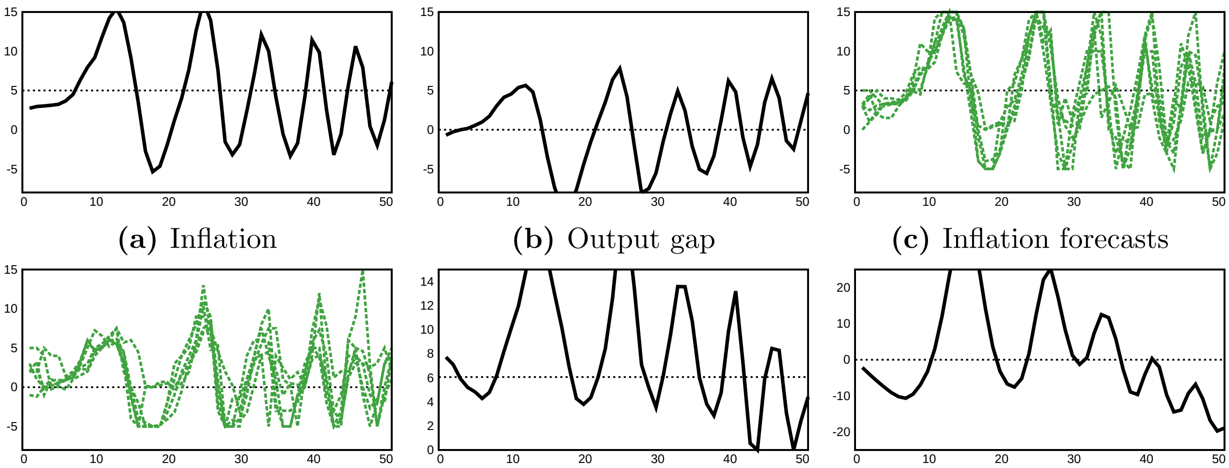


(a) Inflation (b) Output gap (c) Inflation forecasts



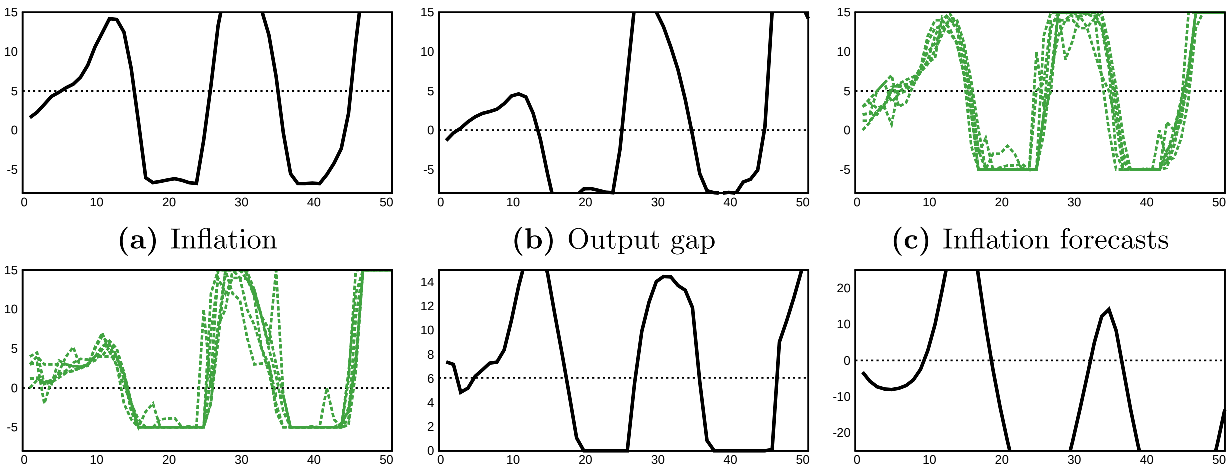
(d) Output gap forecasts (e) Interest rate (f) Price Deviation

Figure B.3.2: Group number 2 (PLT: Unstable with Guidance).



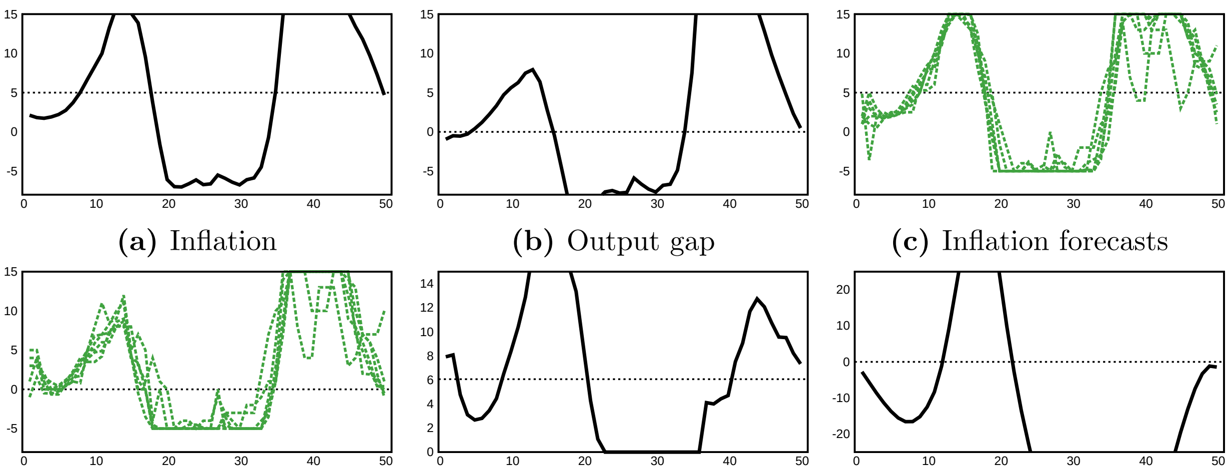
(a) Inflation **(b)** Output gap **(c)** Inflation forecasts
(d) Output gap forecasts **(e)** Interest rate **(f)** Price Deviation

Figure B.3.3: Group number 3 (PLT: Unstable with Guidance).



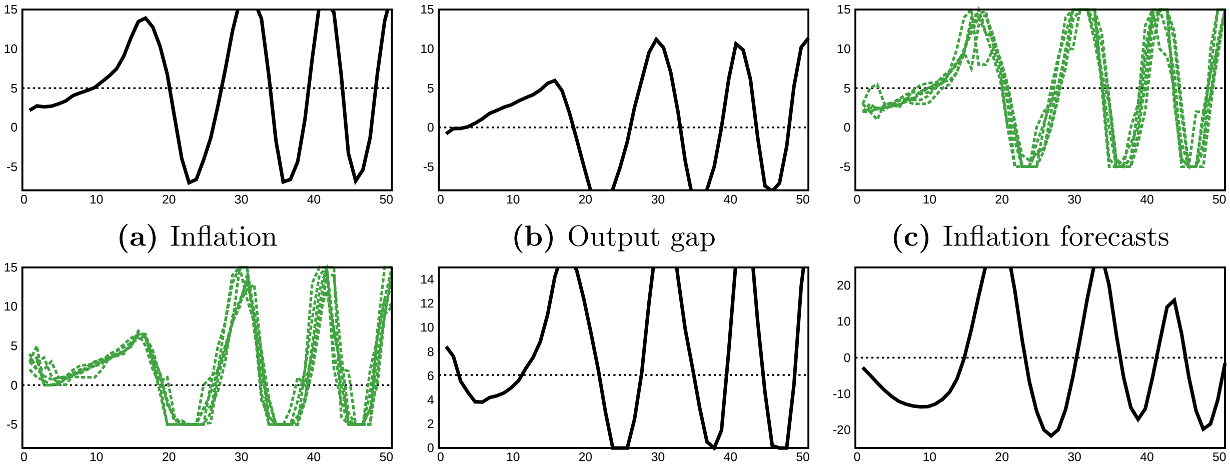
(a) Inflation **(b)** Output gap **(c)** Inflation forecasts
(d) Output gap forecasts **(e)** Interest rate **(f)** Price Deviation

Figure B.3.4: Group number 4 (PLT: Unstable with Guidance).



(a) Inflation **(b)** Output gap **(c)** Inflation forecasts
(d) Output gap forecasts **(e)** Interest rate **(f)** Price Deviation

Figure B.3.5: Group number 5 (PLT: Unstable with Guidance).

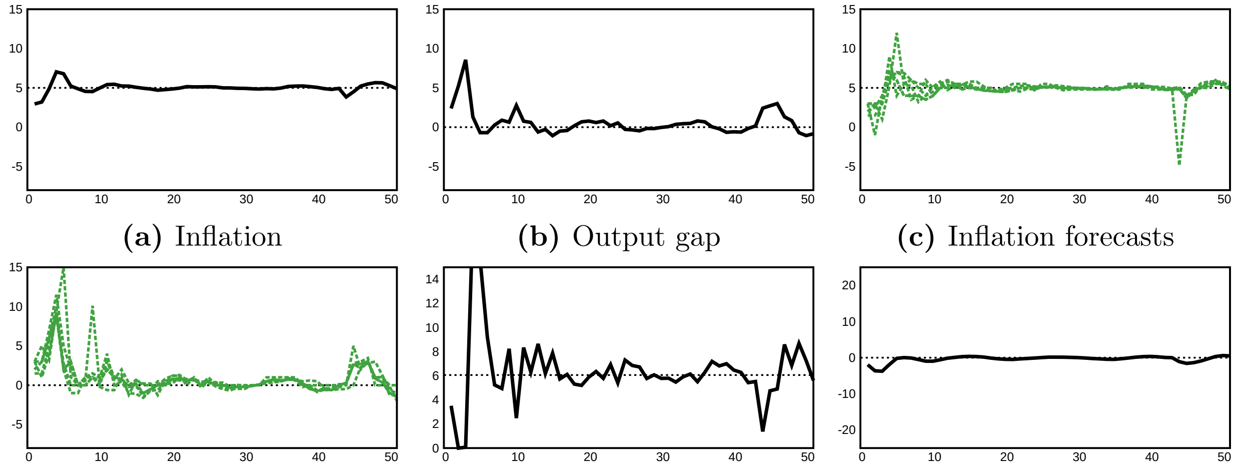


(a) Inflation **(b)** Output gap **(c)** Inflation forecasts

(d) Output gap forecasts **(e)** Interest rate **(f)** Price Deviation

Figure B.3.6: Group number 6 (PLT: Unstable with Guidance).

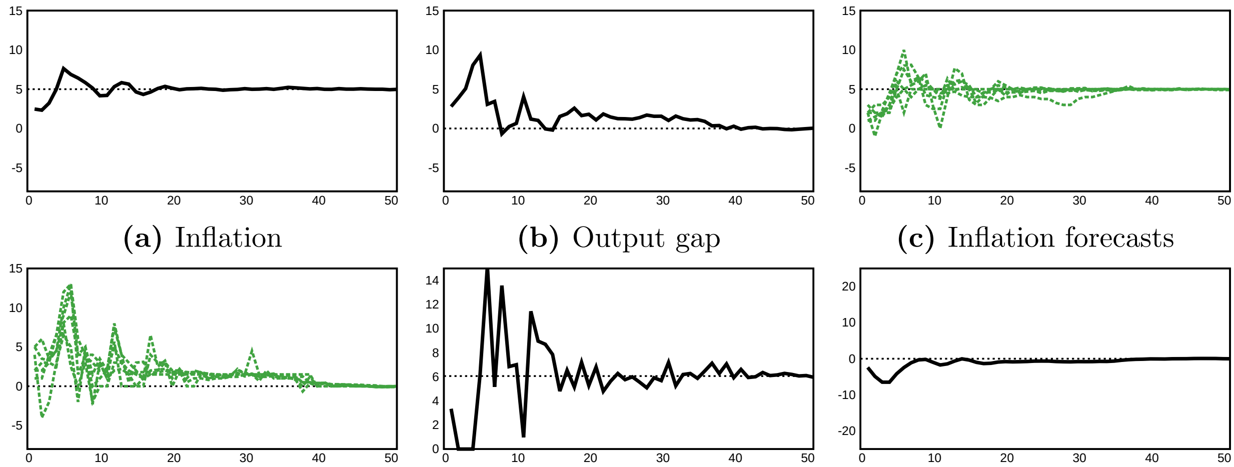
B.4 PLT: Stable with No Guidance



(a) Inflation (b) Output gap (c) Inflation forecasts

(d) Output gap forecasts (e) Interest rate (f) Price Deviation

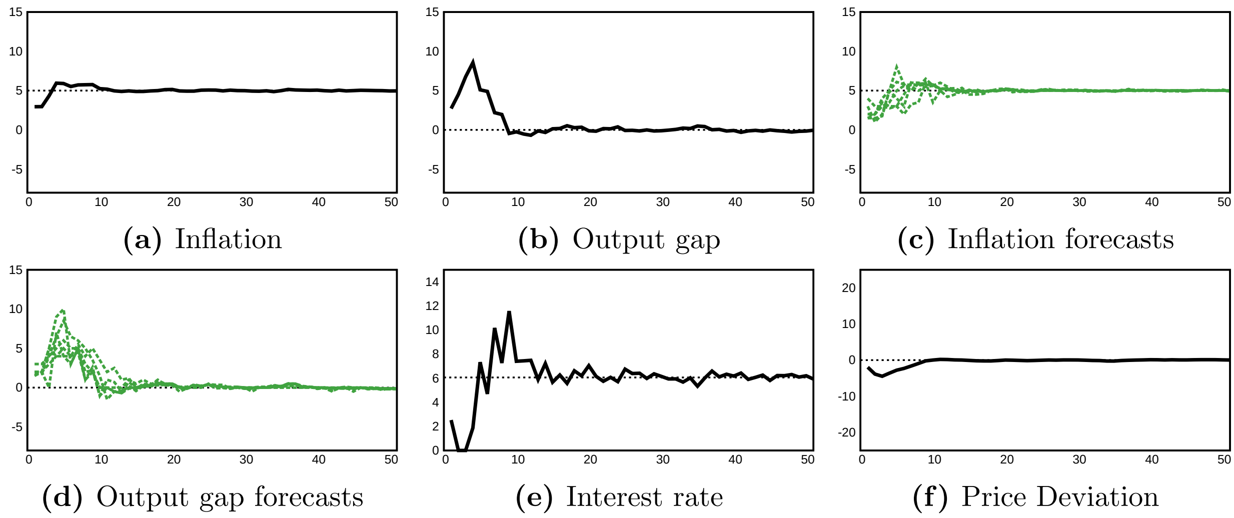
Figure B.4.1: Group number 1 (PLT: Stable with No Guidance).



(a) Inflation (b) Output gap (c) Inflation forecasts

(d) Output gap forecasts (e) Interest rate (f) Price Deviation

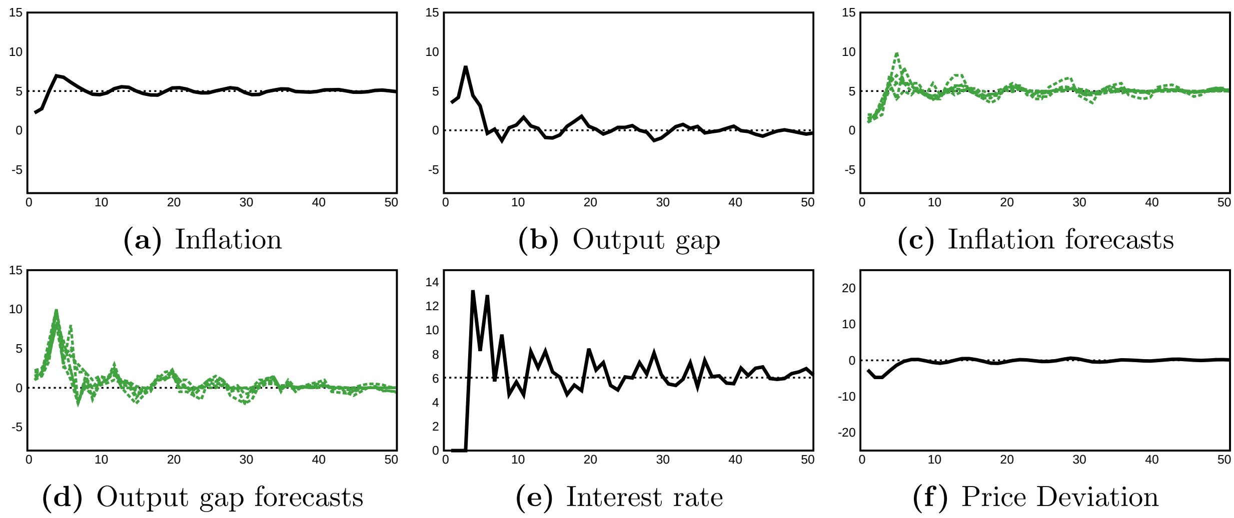
Figure B.4.2: Group number 2 (PLT: Stable with No Guidance).



(a) Inflation **(b)** Output gap **(c)** Inflation forecasts

(d) Output gap forecasts **(e)** Interest rate **(f)** Price Deviation

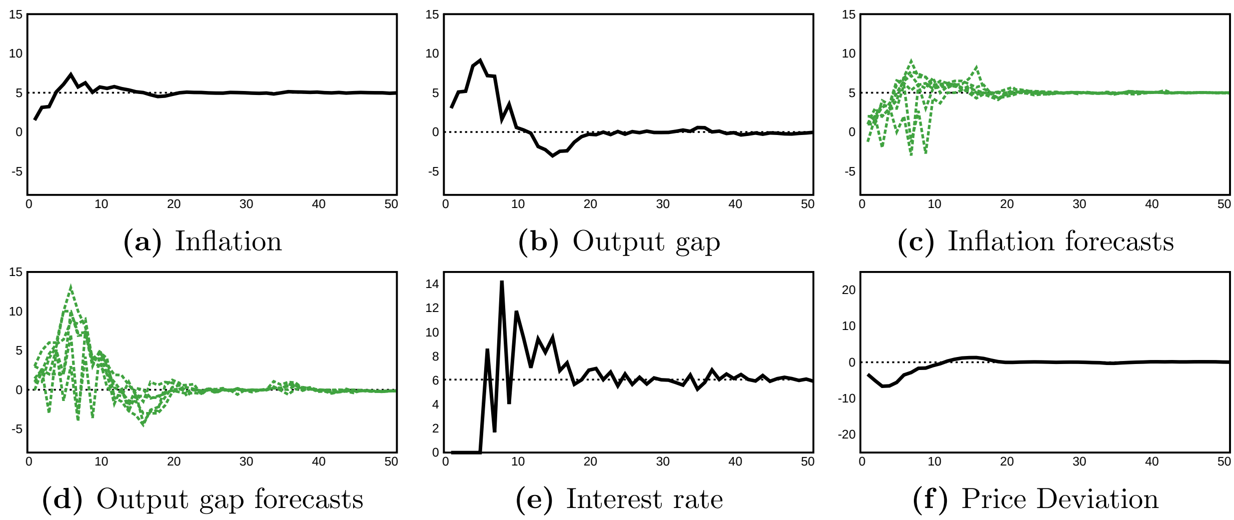
Figure B.4.3: Group number 3 (PLT: Stable with No Guidance).



(a) Inflation **(b)** Output gap **(c)** Inflation forecasts

(d) Output gap forecasts **(e)** Interest rate **(f)** Price Deviation

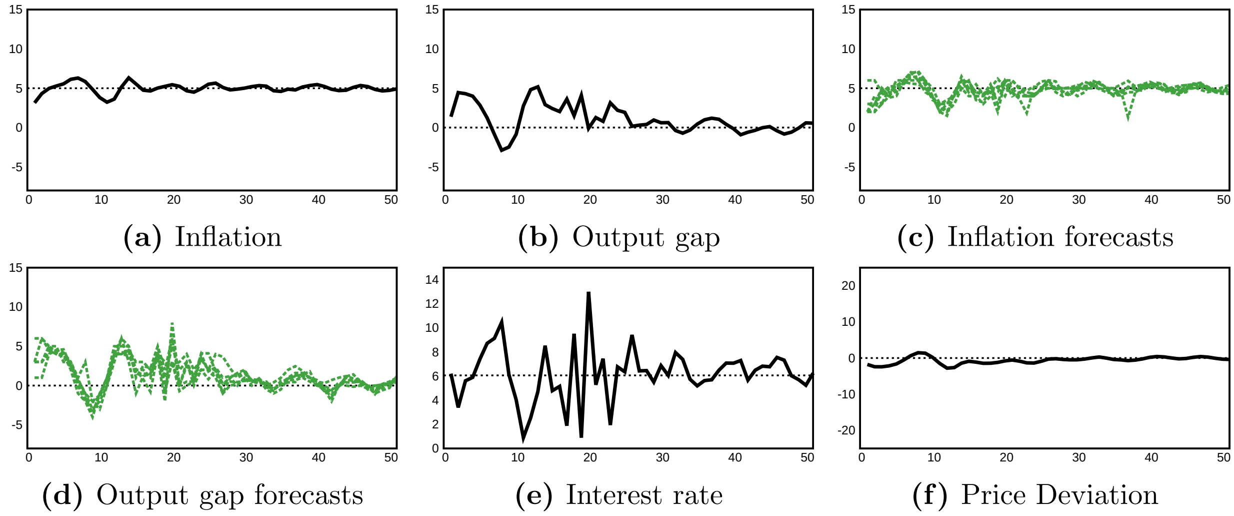
Figure B.4.4: Group number 4 (PLT: Stable with No Guidance).



(a) Inflation **(b)** Output gap **(c)** Inflation forecasts

(d) Output gap forecasts **(e)** Interest rate **(f)** Price Deviation

Figure B.4.5: Group number 5 (PLT: Stable with No Guidance).



(a) Inflation

(b) Output gap

(c) Inflation forecasts

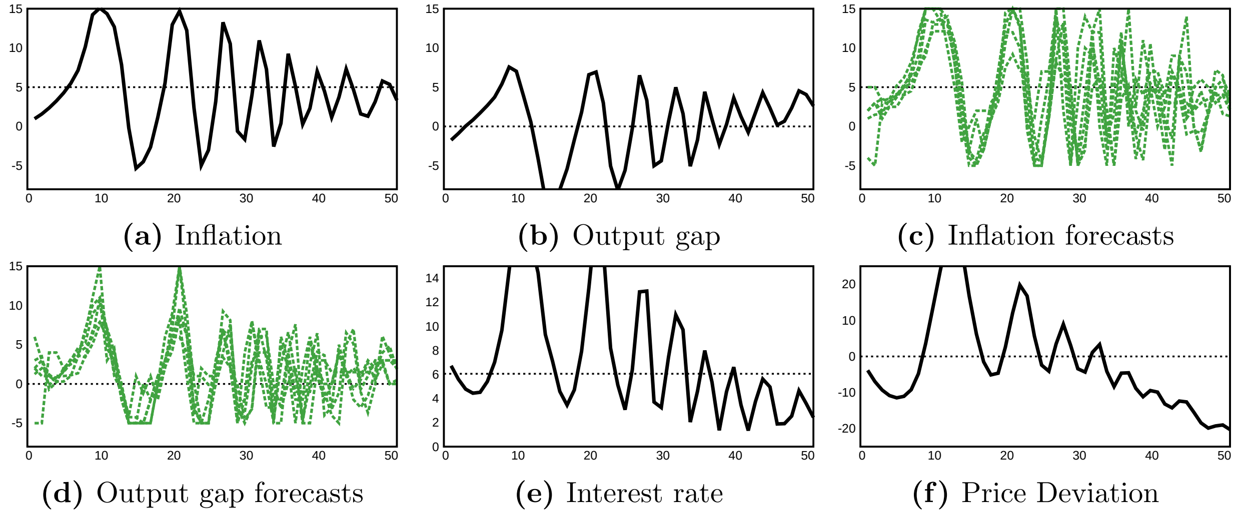
(d) Output gap forecasts

(e) Interest rate

(f) Price Deviation

Figure B.4.6: Group number 6 (PLT: Stable with No Guidance).

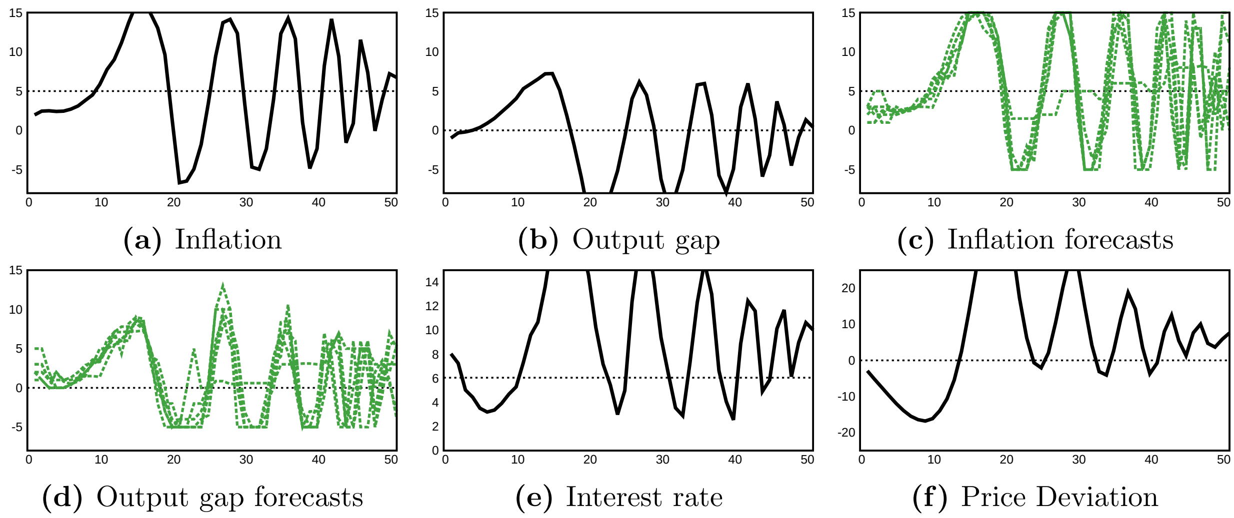
B.5 PLT: Unstable with No Guidance



(a) Inflation (b) Output gap (c) Inflation forecasts

(d) Output gap forecasts (e) Interest rate (f) Price Deviation

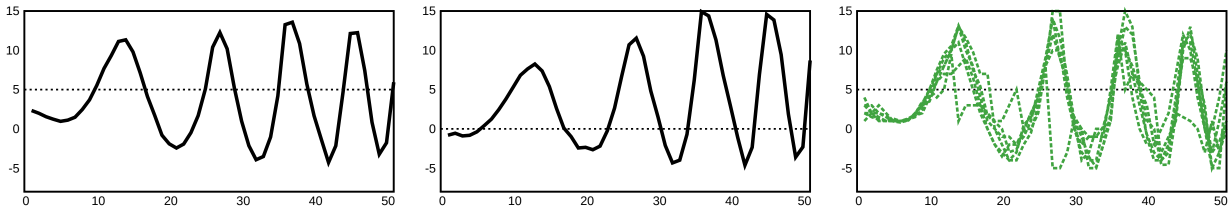
Figure B.5.1: Group number 1 (PLT: Unstable with No Guidance).



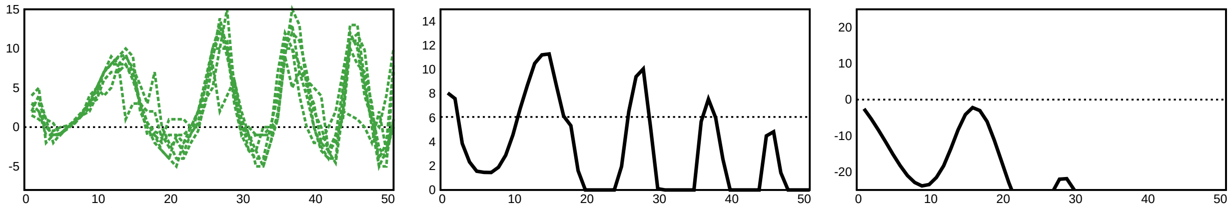
(a) Inflation (b) Output gap (c) Inflation forecasts

(d) Output gap forecasts (e) Interest rate (f) Price Deviation

Figure B.5.2: Group number 2 (PLT: Unstable with No Guidance).

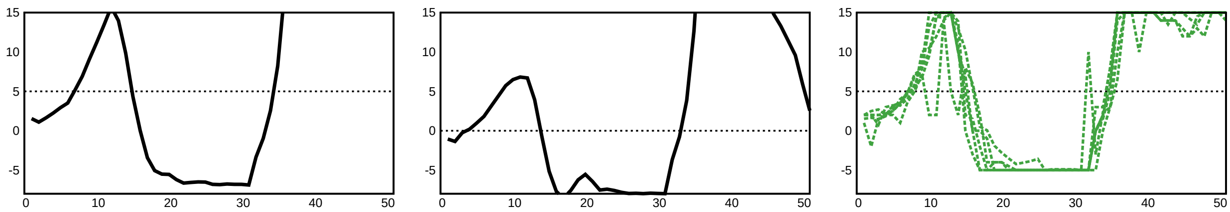


(a) Inflation (b) Output gap (c) Inflation forecasts

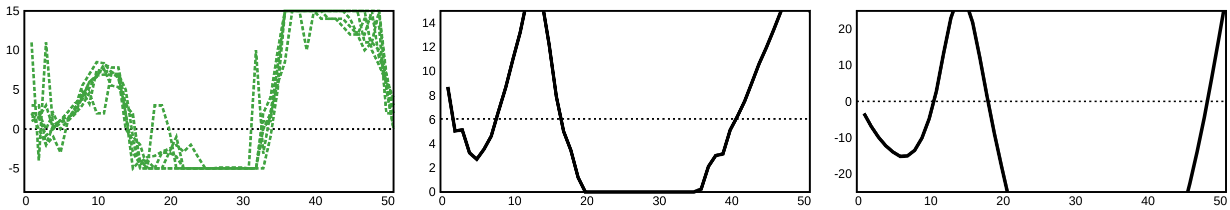


(d) Output gap forecasts (e) Interest rate (f) Price Deviation

Figure B.5.3: Group number 3 (PLT: Unstable with No Guidance).

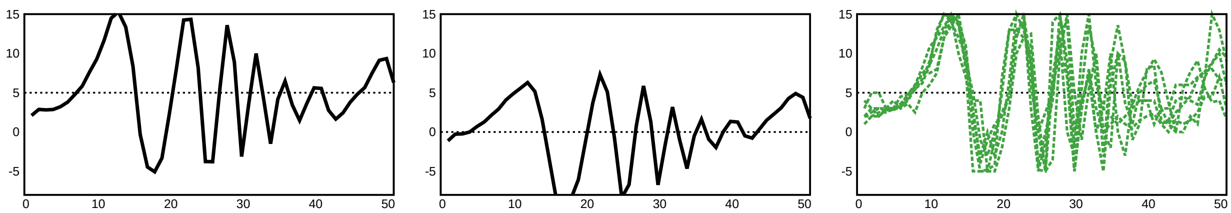


(a) Inflation (b) Output gap (c) Inflation forecasts

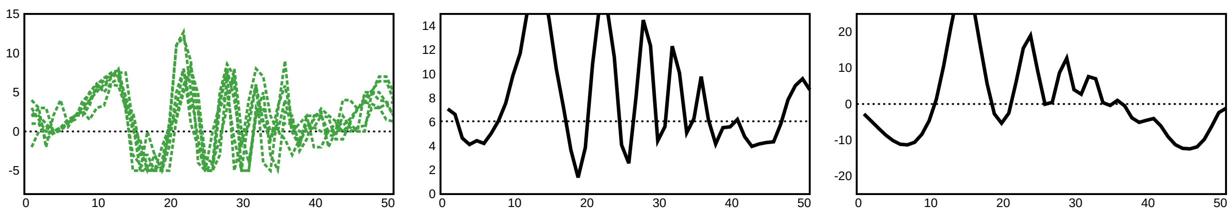


(d) Output gap forecasts (e) Interest rate (f) Price Deviation

Figure B.5.4: Group number 4 (PLT: Unstable with No Guidance).

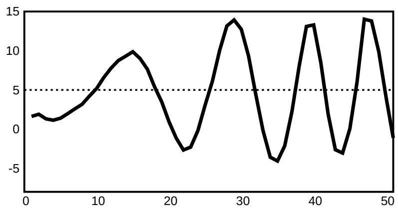


(a) Inflation (b) Output gap (c) Inflation forecasts

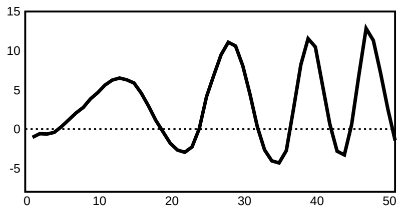


(d) Output gap forecasts (e) Interest rate (f) Price Deviation

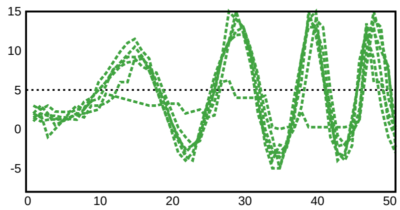
Figure B.5.5: Group number 5 (PLT: Unstable with No Guidance).



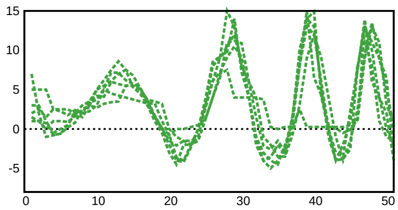
(a) Inflation



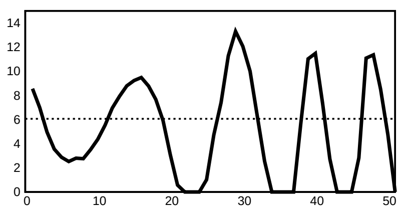
(b) Output gap



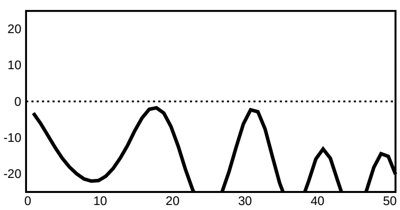
(c) Inflation forecasts



(d) Output gap forecasts



(e) Interest rate



(f) Price Deviation

Figure B.5.6: Group number 6 (PLT: Unstable with No Guidance).

C Estimated individual behavior

For every subject, we independently estimate the two-dimensional forecasting rule (7) with the algorithm discussed below. All the estimations are base on a straightforward two-dimensional ML approach (with BFGS maximization algorithm), while test are performed with LR test on 5% significance level. We wrote the econometrics code in matrix algebra language Ox. The code is available on request.

Variable selection algorithm **Start** with all coefficients in the coefficient pool.

1. Test significance of each individual coefficient, which was not yet thrown out of the coefficient pool. If all are significant, **stop**. Otherwise, go to the next point.

2. Test the joined significance of all coefficients, which were found insignificant in the previous step. If test rejects their joint significance, throw them all out of the pool and repeat the previous point. Otherwise go to the next point.

3. From the coefficients, which were found insignificant in point 1, select exactly one to be thrown out of the pool according to this criterion:

   - If no coefficient was so far thrown out from the pool at point 3; or if the last coefficient that was thrown out of the pool at point 3 was a coefficient from the output gap rule, select a coefficient from the inflation rule;
   - Otherwise, select a coefficient from the output gap rule;
   - For the relevant rule, throw one coefficient out of the pool which was deemed insiginificant in point 1, and which appears as first in the following enumeration (superscripts have been suppressed for the sake of brevity): α_3, β, γ (only if one of the two guidance treatments), δ, α_2, α_1, constant.

   Afterward, go back to point 1.

Remark that at no stage one throws out higher lags of the explained variables, as to make sure that there is no autocorrelation in the data. See also Table 4 for the average coefficients.

C.1 Treatment INF

	Inflation forecasting rule						Output gap forecasting rule					
Subject	c^{π}	α_1^{π}	α_2^{π}	α_3^{π}	β^{π}	δ^{π}	c^{υ}	α_1^{υ}	α_2^{υ}	α_3^{υ}	β^{υ}	δ^{υ}
Group 1												
11		0.553	0.43		0.995		2.41	0.305				−0.403
12		0.292				0.551	1.94	0.28			−0.601	−0.286
13			0.972		1.38				1.01		1.16	
14	0.528	0.874			1.24		1.06	−0.0197	0.693			−0.163
15	0.465	0.888			1.16		1.02	0.241	0.403			−0.159
16			0.994						1.02			
Mean	0.165	0.434	0.399	0	0.796	0.0918	1.07	0.134	0.521	0	0.0932	−0.168
(SD)	(0.235)	(0.368)	(0.44)	(0)	(0.575)	(0.205)	(0.9)	(0.142)	(0.423)	(0)	(0.525)	(0.145)
Group 2												
21	4.44				1.04		−0.958	0.201	0.528		1.23	0.205
22			1.01		1.01		−2.12		1.36		1.08	0.365
23	2.25	0.478			1.37		−0.098	0.264	0.532		1.29	0.0238
24	4.24				1.4		0.777	0.0913	0.00873		1.53	−0.102
25			0.997		0.642				0.964		0.742	
26	−0.898		−0.837			1.59	0.0146	0.00215	1.15		0.783	0.0255
Mean	1.67	0.0797	0.195	0	0.91	0.265	−0.397	0.0931	0.757	0	1.11	0.0863
(SD)	(2.11)	(0.178)	(0.644)	(0)	(0.479)	(0.594)	(0.92)	(0.105)	(0.451)	(0)	(0.278)	(0.154)
Group 3												

Table 5: Estimated individual rules for Treatment 1 (Inflation forecasting).

Subject	c^{π}	α_1^{π}	α_2^{π}	α_3^{π}	β^{π}	δ^{π}	c^{v}	α_1^{v}	α_2^{v}	α_3^{v}	β^{v}	δ^{v}
31			1.01						1.04			
32	0.335	0.929			1.26		1.24	0.182	0.486			−0.219
33			0.976				−0.113		0.99		1.03	
34			1.01				3.37					−0.558
35		0.995			1.18				1.11			
36			1						1.02			
Mean	0.0559	0.321	0.667	0	0.408	0	0.75	0.0304	0.774	0	0.172	−0.13
(SD)	(0.125)	(0.454)	(0.472)	(0)	(0.577)	(0)	(1.26)	(0.068)	(0.402)	(0)	(0.384)	(0.208)
						Group 4						
41		1.01							0.95			
42		1.01						0.932				
43		1.01							0.907			
44		1.01						0.947				
45		1						0.977				
46		1.01						0.941				
Mean	0	1.01	0	0	0	0	0	0.633	0.309	0	0	0
(SD)	(0)	(0.00242)	(0)	(0)	(0)	(0)	(0)	(0.448)	(0.438)	(0)	(0)	(0)
						Group 5						
51			1.03		1.08		6.29		−1.24	−1.08	0.814	
52			0.94		0.688			0.283	0.612		0.788	
53			0.992		1.63				0.849		2.01	
54			0.974		0.649		1.27		0.526		0.565	−0.159
55	1.59		0.998		1.63	−0.243	3.37	−0.0395	−0.422	−1.21	1.57	0.459

Table 5: Estimated individual rules for Treatment 1 (Inflation forecasting).

Subject	c^π	α_1^π	α_2^π	α_3^π	β^π	δ^π	c^v	α_1^v	α_2^v	α_3^v	β^v	δ^v
56			1		0.607				1.02		0.868	
Mean	0.265	0	0.989	0	1.05	−0.0405	1.82	0.0405	0.223	−0.383	1.1	0.05
(SD)	(0.592)	(0)	(0.0277)	(0)	(0.44)	(0.0905)	(2.33)	(0.109)	(0.798)	(0.543)	(0.511)	(0.192)
						Group 6						
61		1.01							1.25			
62			0.997									
63	1.5	0.675			2.11		−1.06	0.417	0.899			0.179
64			0.998									
65	4.64						0.031		0.85			
66	1.37	0.701					−0.0455	0.349	0.9			
Mean	1.25	0.397	0.333	0	0.352	0	−0.178	0.128	0.65	0	0	0.0298
(SD)	(1.64)	(0.411)	(0.47)	(0)	(0.787)	(0)	(0.393)	(0.182)	(0.478)	(0)	(0)	(0.0667)

Table 5: (Cont.) Estimated individual rules for Treatment 1 (Inflation forecasting).

C.2 Treatment StrongNo

	Inflation forecasting rule						**Output gap forecasting rule**					
Subject	c^π	α_1^π	α_2^π	α_3^π	β^π	δ^π	c^v	α_1^v	α_2^v	α_3^v	β^v	δ^v
						Group 1						
11			1.11			−0.0882	2.2		0.735			−0.286
12			1.18			−0.15			0.719			
13			0.992						0.944			

Table 6: Estimated individual rules for Treatment 2 (Stable price level targeting (no guidance)).

Subject	c^π	α_1^π	α_2^π	α_3^π	β^π	δ^π	c^v	α_1^v	α_2^v	α_3^v	β^v	δ^v
14			0.993						0.941			
15	1.03	0.796			1.17		1.58	0.209	0.736			−0.259
16			0.953				−8.72		1.28	0.699	1.02	0.847
Mean	0.171	0.133	0.87	0	0.195	−0.0397	−0.823	0.0349	0.892	0.117	0.17	0.0503
(SD)	(0.382)	(0.296)	(0.397)	(0)	(0.436)	(0.0589)	(3.64)	(0.0781)	(0.197)	(0.261)	(0.38)	(0.377)
Group 2												
21	3.35	0.308			2.5		0.0945	0.215	0.646		0.856	
22	4.96				0.89		7.62	0.136	1.08	−1.63	−0.0981	0.0959
23	6.06				1.03	−0.174	−3.53	−0.129	1.62	−0.84	1.76	1.26
24	2.43	0.818			1.2	−0.237	0.486	0.584	0.479		0.134	−0.0675
25		0.997						0.511	0.489			
26	5						0.452	0.569				
Mean	3.63	0.354	0	0	0.936	−0.0686	0.854	0.314	0.719	−0.411	0.443	0.214
(SD)	(2.01)	(0.41)	(0)	(0)	(0.844)	(0.0987)	(3.33)	(0.263)	(0.513)	(0.624)	(0.67)	(0.468)
Group 3												
31	5							−0.106	1.13			
32	5						0.105		1.05			
33			1									
34	1.72	0.171	0.473				3.49	0.812	0.0597			−0.562
35			0.999									
36	5.01						0.0569	0.541	0.234			
Mean	2.79	0.0285	0.412	0	0	0	0.608	0.208	0.413	0	0	−0.0937
(SD)	(2.29)	(0.0638)	(0.448)	(0)	(0)	(0)	(1.29)	(0.343)	(0.486)	(0)	(0)	(0.21)

Table 6: Estimated individual rules for Treatment 2 (Stable price level targeting (no guidance)).

Subject	c^π	α_1^π	α_2^π	α_3^π	β^π	δ^π	c^v	α_1^v	α_2^v	α_3^v	β^v	δ^v
						Group 4						
41	2.16		0.565				2.25	0.223	0.534			−0.333
42			0.992						1.19			
43			1.01				0.411		0.66			
44	3.38	0.32			1.3		2.39	0.437	0.24			−0.343
45	3.11	0.383			2.72		4.44	0.37	0.307			−0.702
46	2.83	0.431					0.136	−0.0313	0.72			
Mean	1.91	0.189	0.428	0	0.671	0	1.61	0.167	0.608	0	0	−0.23
(SD)	(1.4)	(0.192)	(0.452)	(0)	(1.03)	(0)	(1.59)	(0.188)	(0.311)	(0)	(0)	(0.26)
						Group 5						
51	1.48	0.347				0.293	−0.547	0.259	0.308			0.0807
52		0.63	0.382						0.267			
53	2.11	0.579			1.34		−0.104	−0.231	1.28			0.0364
54			1.01					0.357	0.71			
55			1.25		−1.21	−0.206	9.42		1.64	−2.52		0.53
56		−0.462	1.47					0.589				
Mean	0.599	0.182	0.685	0	0.021	0.0144	1.46	0.162	0.702	−0.419	0	0.108
(SD)	(0.867)	(0.38)	(0.587)	(0)	(0.736)	(0.145)	(3.57)	(0.27)	(0.585)	(0.937)	(0)	(0.191)
						Group 6						
61	3.27	0.318			1.38		−3.24	0.0223	0.55	0.255	1.14	0.427
62	2.23	0.344			0.698	0.155	3	0.271	0.348		−0.0979	−0.435
63	1.8	0.612			0.908		−1.8	0.394	0.592		0.593	0.355
64			1.16		0.372	−0.176		0.398	0.401	0.253	0.662	−0.136

Table 6: Estimated individual rules for Treatment 2 (Stable price level targeting (no guidance)).

Subject	c^π	α_1^π	α_2^π	α_3^π	β^π	δ^π	c^v	α_1^v	α_2^v	α_3^v	β^v	δ^v
65			0.964						0.971		0.151	
66		0.359	0.923			−0.239	2.61		0.657			−0.386
Mean	1.22	0.272	0.507	0	0.559	−0.0433	0.0955	0.181	0.586	0.0847	0.408	−0.0291
(SD)	(1.29)	(0.215)	(0.513)	(0)	(0.495)	(0.13)	(2.22)	(0.179)	(0.202)	(0.12)	(0.432)	(0.332)

Table 6: (Cont.) Estimated individual rules for Treatment 2 (Stable price level targeting (no guidance)).

C.3 Treatment WeakNo

	Inflation forecasting rule						Output gap forecasting rule					
Subject	c^π	α_1^π	α_2^π	α_3^π	β^π	δ^π	c^v	α_1^v	α_2^v	α_3^v	β^v	δ^v
Group 1												
11			0.361		0.855	0.427	−0.958	−0.109	0.993	−0.585	0.683	0.614
12			0.284		0.445	0.256		−0.0777	0.748	−0.647	0.359	0.591
13	2.37			0.315	0.648	0.262	1.93	0.25	0.394	−0.183	0.515	−0.0118
14			−0.695	0.747	0.5	0.907		−0.255	0.898	−0.715	0.647	0.585
15	5.75		−2	1.76		1.14	3.08	−0.103	1.38	−1.43	−0.0866	0.634
16	4.95	0.181	−0.247	0.471			3.11	0.0278	0.414	−0.186	0.0468	−0.203
Mean	2.18	0.0301	−0.383	0.549	0.408	0.498	1.19	−0.0446	0.804	−0.624	0.361	0.368
(SD)	(2.41)	(0.0674)	(0.805)	(0.602)	(0.316)	(0.396)	(1.59)	(0.155)	(0.341)	(0.417)	(0.291)	(0.341)
Group 2												
21	2.14	−0.295	0.172	0.855		0.513	1.53	−0.355	1.65	−0.927	0.204	0.66
22	4.81	−0.372		0.859	0.65	0.437	3.37	0.292	0.544	−0.264	0.461	−0.0281

Table 7: Estimated individual rules for Treatment 3 (Unstable price level targeting (no guidance)).

Subject	c^{π}	α_1^{π}	α_2^{π}	α_3^{π}	β^{π}	δ^{π}	c^{v}	α_1^{v}	α_2^{v}	α_3^{v}	β^{v}	δ^{v}
23	2.24			0.645	0.348	0.623	2.01	0.0601	1.3	−0.825	0.289	0.466
24	4.69	0.544	−1.26	1.4		0.612	2.11	−0.0336	1.96	−1.95	−0.00253	1.17
25	2.16	0.694		0.226			3.57	0.627	0.291	−0.0239	−0.0589	−0.224
26	2.67	−0.368		0.615	1.09	0.611	2.43	−0.231	1.24	−0.62	0.675	0.368
Mean	3.12	0.0339	−0.181	0.767	0.348	0.466	2.5	0.06	1.16	−0.769	0.261	0.402
(SD)	(1.17)	(0.434)	(0.485)	(0.354)	(0.41)	(0.219)	(0.737)	(0.327)	(0.584)	(0.614)	(0.254)	(0.455)
						Group 3						
31	2.12	0.532			0.564		2.1	0.604	0.2	−0.276	0.503	−0.0353
32	0.592	−0.4	1.03		0.56	0.251	−0.314	−0.374	1.57	−0.911	0.483	0.779
33	1.15	0.165	0.18		0.776	0.241	1.21	0.169	0.18	0.0631	0.856	0.182
34	0.745	0.473					0.103	0.341	0.618	−0.716	0.0799	0.486
35	1.32	0.586			0.728		1.12	0.361	0.53	−0.459	0.712	0.218
36		−0.179	0.687		0.683	0.559	−0.474		0.698	−0.396	0.553	0.78
Mean	0.987	0.196	0.316	0	0.552	0.175	0.623	0.184	0.633	−0.449	0.531	0.402
(SD)	(0.658)	(0.374)	(0.401)	(0)	(0.259)	(0.204)	(0.923)	(0.31)	(0.464)	(0.311)	(0.24)	(0.307)
						Group 4						
41		0.32	0.47		0.587	0.118	−1.27	0.214	1.14	−0.953	0.367	0.761
42	0.66		0.589		0.268	0.258	−0.542	0.0292	1.46	−1.34	0.109	0.971
43		0.223	0.607				−0.419	0.334	0.801	−0.586	0.272	0.508
44			0.724		0.747	0.163	−1.3	−0.376	1.55	−1.05	0.418	1.02
45		0.26	0.522		0.748	0.142	0.57	0.793	0.134		0.317	−0.101
46		0.511	0.361		0.782			0.3	0.435		0.399	0.0399
Mean	0.11	0.219	0.546	0	0.522	0.114	−0.493	0.216	0.922	−0.655	0.314	0.534

Table 7: Estimated individual rules for Treatment 3 (Unstable price level targeting (no guidance)).

Subject	c^{π}	α_1^{π}	α_2^{π}	α_3^{π}	β^{π}	δ^{π}	c^{υ}	α_1^{υ}	α_2^{υ}	α_3^{υ}	β^{υ}	δ^{υ}
(SD)	(0.246)	(0.179)	(0.114)	(0)	(0.292)	(0.0912)	(0.662)	(0.351)	(0.518)	(0.513)	(0.104)	(0.434)
						Group 5						
51	5.5	0.352	−1.82	1.61	0.476	0.85	2.3	0.268	0.779	−0.578	0.6	0.159
52			−0.584	0.522	0.524	0.79		−0.141	0.371		0.417	0.088
53	6.69	−0.301	0.887		0.575	−0.459	4.45	−0.128	0.513	−0.0205	0.737	−0.247
54	3.58	0.229	−1.81	1.73	0.253	1.23	2.39	0.31	0.607	−0.531	0.37	0.198
55	1.31		0.759		0.347		0.605	0.0133	0.765	−0.137	0.3	0.177
56	4.55	0.251			0.45		2.78	−0.0786	0.595	−0.321	0.312	0.098
Mean	3.6	0.0884	−0.428	0.645	0.437	0.401	2.09	0.0405	0.605	−0.265	0.456	0.0789
(SD)	(2.32)	(0.217)	(1.1)	(0.752)	(0.108)	(0.591)	(1.46)	(0.183)	(0.141)	(0.23)	(0.16)	(0.151)
						Group 6						
61	1.76	0.586			0.892		1.53	0.278	0.519	−0.0833	0.854	−0.135
62	0.58		0.802		0.414		−0.00439	0.0818	0.624		0.486	0.18
63	1.54		0.575		0.905		0.949	−0.224	1.19	−0.543	1.08	0.338
64	1.34		0.741		0.738		1.75	−0.086	1.15	−0.225	0.541	−0.0832
65	0.811	0.731			0.31		1.14	0.659	0.218		0.228	−0.184
66	1.66		0.543		1.01		1.4	0.201	0.383	0.215	0.977	−0.266
Mean	1.28	0.219	0.443	0	0.711	0	1.13	0.152	0.68	−0.106	0.694	−0.0252
(SD)	(0.44)	(0.313)	(0.326)	(0)	(0.261)	(0)	(0.568)	(0.282)	(0.367)	(0.235)	(0.299)	(0.213)

Table 7: (Cont.) Estimated individual rules for Treatment 3 (Unstable price level targeting (no guidance)).

C.4 Treatment StrongGuid

Subject	Inflation forecasting rule							Output gap forecasting rule						
	c^π	α_1^π	α_2^π	α_3^π	β^π	δ^π	γ^π	c^υ	α_1^υ	α_2^υ	α_3^υ	β^υ	δ^υ	γ^υ
Group 1														
11	−1.61		1.3				−0.44	4.53	0.5	−1.36		−0.618	−0.704	−2.63
12	0.973		0.798					−1.17	0.399	0.236		1.26	0.247	
13	4.93				0.936			8.71	0.119	0.933	−1.77	−0.179	0.032	0.497
14	−4.14		1.76				−1	5.23	0.475	−1.65		−0.365	−0.84	−2.89
15			0.977					2.26		−0.728			−0.377	−2.17
16		0.626	0.355				−0.365		−0.268					−2.06
Mean	0.0255	0.104	0.865	0	0.156	0	−0.301	3.26	0.204	−0.428	−0.294	0.0158	−0.274	−1.54
(SD)	(2.74)	(0.233)	(0.58)	(0)	(0.349)	(0)	(0.361)	(3.33)	(0.28)	(0.906)	(0.658)	(0.595)	(0.399)	(1.3)
Group 2														
21	2.07	0.507					−0.632	2.41	0.329	−0.665		0.041	−0.268	−1.4
22	4.28							0.609	0.577					
23		0.917					−0.684		0.901					
24			0.876				−0.574		0.467	0.276		0.61	0.0544	
25		0.314	0.663		0.874			−0.765		0.265			0.126	−1.61
26		0.833					−1.24		0.626					−0.821
Mean	1.06	0.429	0.257	0	0.146	0	−0.521	0.376	0.483	−0.0207	0	0.109	−0.0147	−0.638
(SD)	(1.63)	(0.363)	(0.368)	(0)	(0.326)	(0)	(0.427)	(0.994)	(0.277)	(0.312)	(0)	(0.225)	(0.122)	(0.68)
Group 3														
31			1.01					0.568	0.229	0.48			−0.0745	0.379
32	6.89	−0.213			1.08	−0.138	−0.986	1.35	−0.105	1.12		−0.446	−0.18	1.25
33	6.83				1.28	−0.29		−12.4	−0.293	2.39	1.41	1.05	0.909	0.387
34	2.63	0.499						0.0161	0.491	0.477				
35		0.995			0.573			−2.51		1.12			0.426	

Table 8: Estimated individual rules for Treatment 4 (Stable price level targeting with guidance).

Subject	c^π	α_1^π	α_2^π	α_3^π	β^π	δ^π	γ^π	c^v	α_1^v	α_2^v	α_3^v	β^v	δ^v	γ^v
$36^!$	4.95				1.08				0.0954	−0.769		1.36	0.00826	−2.78
Mean	3.55	0.214	0.168	0	0.669	−0.0715	−0.164	−2.16	0.0695	0.802	0.235	0.328	0.181	−0.126
(SD)	(2.88)	(0.411)	(0.375)	(0)	(0.519)	(0.11)	(0.367)	(4.71)	(0.249)	(0.947)	(0.526)	(0.648)	(0.376)	(1.26)
							Group 4							
41		0.241	0.644		0.767	0.0835				0.551				−1.2
42	2.88	0.358			1.43			9.54		3.84	−3.13	0.886	1.07	5.35
43^*		0.477				0.358	−0.332		−0.271	−2.25	1.57		−1.1	−5.12
44	−5		3.13	−3.48	0.603	−0.904	−5.99	13	0.244	5.35	−4.19	0.628	1.44	8.94
45	4.08				1.18	0.137		2.77	0.429	−0.546	0.426	−0.0214	−0.677	−1.27
46	1.43	−0.381	0.977		0.47	0.0886		3.88	0.0909	1.73	−0.796	0.507	0.0931	2.01
Mean	0.565	0.116	0.792	−0.58	0.74	−0.0395	−1.05	4.86	0.082	1.45	−1.02	0.333	0.138	1.45
(SD)	(2.89)	(0.282)	(1.11)	(1.3)	(0.466)	(0.402)	(2.21)	(4.83)	(0.218)	(2.56)	(2.01)	(0.358)	(0.893)	(4.64)
							Group 5							
51		0.629	0.365							0.828				
52			0.976							0.844				
53	4.94				1.5			−0.802	0.251	−0.923	0.592	1.63	−0.355	−2.83
54			1.01							0.828		0.25		
$55^!$	3.66					0.195			−0.267	1.91	−1.07	0.534	0.855	0.961
56	1.27	0.303	0.429				−0.479	0.293	0.212	−0.0945		0.665		−1.12
Mean	1.64	0.155	0.464	0	0.251	0.0325	−0.0798	−0.0849	0.0325	0.565	−0.0797	0.514	0.0834	−0.498
(SD)	(1.97)	(0.239)	(0.409)	(0)	(0.561)	(0.0727)	(0.178)	(0.338)	(0.17)	(0.882)	(0.493)	(0.559)	(0.369)	(1.2)
							Group 6							
61	5							0.0388	0.0711	0.692				
62			0.996							1				
63			0.994						0.969					
64		0.986					−0.815	0.147	0.402	0.755				

Table 8: Estimated individual rules for Treatment 4 (Stable price level targeting with guidance).

Subject	c^π	α_1^π	α_2^π	α_3^π	β^π	δ^π	γ^π	c^v	α_1^v	α_2^v	α_3^v	β^v	δ^v	γ^v
65			0.989				−0.65	1.9	0.35	0.406			−0.277	
66	5.12	0.547			−0.998	−0.427		2.48	0.379	−0.648		−0.00864	−0.37	−1.82
Mean	1.69	0.256	0.496	0	−0.166	−0.0712	−0.244	0.762	0.362	0.368	0	−0.00144	−0.108	−0.304
(SD)	(2.39)	(0.383)	(0.496)	(0)	(0.372)	(0.159)	(0.349)	(1.03)	(0.313)	(0.552)	(0)	(0.00322)	(0.155)	(0.68)

Table 8: (Cont.) Estimated individual rules for Treatment 4 (Stable price level targeting with guidance).

C.5 Treatment WeakGuid

	Inflation forecasting rule							Output gap forecasting rule						
Subject	c^π	α_1^π	α_2^π	α_3^π	β^π	δ^π	γ^π	c^v	α_1^v	α_2^v	α_3^v	β^v	δ^v	γ^v
							Group 1							
11*		0.487	0.457			0.589	−0.0781	−5.73				0.554	0.937	−0.258
12*!		0.491	0.384	−0.308	0.258	0.39	−0.203		0.405			0.493	0.214	−0.158
13*!		−0.478	1.31	−0.28	0.592	0.181				0.517		1.02	0.232	
14!	13.7	0.258	−1.95	3.09	0.456		0.674		−0.000506	1.19	−0.81	0.56	0.716	0.000803
15!		−0.186	0.698		0.313	0.196	−0.0579		−0.213	0.937	−0.565	0.549	0.535	
16		0.501	0.189		−0.109	0.266	−0.19	−0.852	0.444	−0.156			0.404	−0.234
Mean	2.28	0.179	0.182	0.417	0.252	0.27	0.0243	−1.1	0.106	0.415	−0.229	0.529	0.506	−0.108
(SD)	(5.11)	(0.38)	(1.02)	(1.2)	(0.243)	(0.184)	(0.299)	(2.09)	(0.238)	(0.509)	(0.332)	(0.295)	(0.259)	(0.113)
							Group 2							
21*!		0.106	0.906	−0.2	1.15	−0.0797			0.448	0.432	−0.157	0.356	0.0823	
22	2.56	0.639	0.205				−0.0583	−11.1	0.102	−2.21	1.31	−0.144	1.19	−0.75
23*!		−0.368	1.59		0.758	−0.696	0.337		0.462	2.28	−1.09			0.486
24	1.3		0.765		1.07			7.72	0.374	2.21	−1.28	0.441	−0.364	0.402

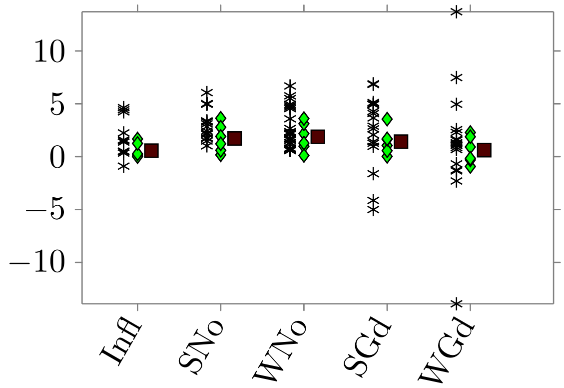
Table 9: Estimated individual rules for Treatment 5 (Unstable price level targeting with guidance).

Subject	c^π	α_1^π	α_2^π	α_3^π	β^π	δ^π	γ^π	c^v	α_1^v	α_2^v	α_3^v	β^v	δ^v	γ^v
25!	1.65		0.919		0.461		−0.0334		0.183	−0.329	−0.526	−0.0641	1.2	−0.474
26*		0.544	0.876	−1.28	−0.794	0.551	−0.401	2.83	0.373	0.801			−0.403	0.264
Mean	0.917	0.154	0.877	−0.246	0.441	−0.0374	−0.026	−0.089	0.323	0.53	−0.291	0.0982	0.285	−0.0121
(SD)	(0.99)	(0.344)	(0.402)	(0.466)	(0.673)	(0.362)	(0.214)	(5.63)	(0.135)	(1.54)	(0.852)	(0.219)	(0.668)	(0.457)
							Group 3							
31*!			1.45	−0.969	1.08	−0.276	−0.0893				0.67	0.961	−0.193	−0.0591
32		−0.197	0.497		0.644	0.546		−14	−0.179	−2.83	2.3	0.524	0.835	−0.586
33!	7.48	0.484	0.721		0.564	−0.872	0.114		0.09	−0.981	1.05	0.96	−0.474	−0.137
34*!		0.324			0.362	0.447	−0.0799		0.166	0.71	−0.743	0.347	0.66	−0.0511
35	0.863	0.514	0.254		0.398			3.94	0.525	0.499		0.353	−0.435	0.102
36	−13.9	0.29	3.92	−4.69	0.723		−0.862	−1.51	0.491	−1.52	1.56	0.647	−0.595	−0.198
Mean	−0.929	0.236	1.14	−0.944	0.628	−0.0257	−0.153	−1.92	0.182	−0.687	0.805	0.632	−0.0338	−0.155
(SD)	(6.39)	(0.256)	(1.32)	(1.71)	(0.238)	(0.471)	(0.324)	(5.63)	(0.254)	(1.24)	(0.993)	(0.254)	(0.567)	(0.214)
							Group 4							
41	−1.26		0.522		0.299	0.478	−0.0491	−2.24	−0.119	1.32	−1.07	0.217	1.12	−0.0599
42			0.671		0.556	0.223		−0.488		1.15	−0.727	0.37	0.663	
43		0.647	0.192		0.462		−0.0378	−1.4	0.451		0.331	0.411		−0.0669
44	−2.3	0.577			0.659	0.417	−0.0788	−0.286	0.64	−0.3	0.632	0.266	−0.378	−0.0637
45	1.07		0.76		0.412			1.15	−0.184	1.13	−0.346		0.275	0.011
46	0.675		0.784		0.64				−0.301	1.47	−0.819	0.482	0.636	
Mean	−0.303	0.204	0.488	0	0.505	0.186	−0.0276	−0.542	0.0812	0.797	−0.333	0.291	0.386	−0.0299
(SD)	(1.15)	(0.289)	(0.295)	(0)	(0.127)	(0.202)	(0.0302)	(1.07)	(0.344)	(0.685)	(0.62)	(0.157)	(0.487)	(0.0338)
							Group 5							
51	−0.679	0.275		0.391	0.598	0.437		−0.81	0.118	1.22	−0.885	0.3	0.71	
52	−1.35		0.728		0.706	0.222	−0.0283	−1.85	−0.164	1.55	−1.11	0.233	0.91	−0.00805
53			0.589		0.469	0.315	−0.0107	−1.61		0.73	−0.358	0.288	0.651	−0.0293

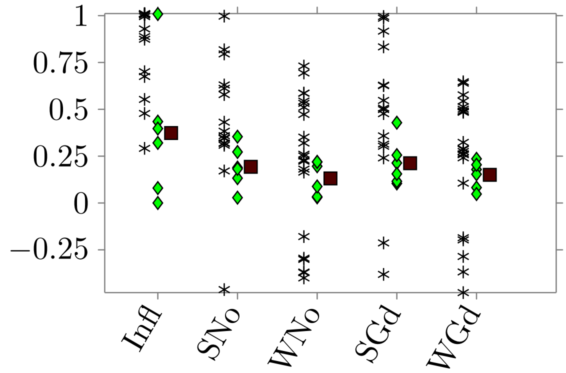
Table 9: Estimated individual rules for Treatment 5 (Unstable price level targeting with guidance).

Subject	c^{π}	α_1^{π}	α_2^{π}	α_3^{π}	β^{π}	δ^{π}	γ^{π}	c^{v}	α_1^{v}	α_2^{v}	α_3^{v}	β^{v}	δ^{v}	γ^{v}
54	1.07	0.241	1.25	−0.653	0.69	−0.424		0.956	0.182	−0.796	1.46	0.463	−0.658	−0.0348
55		−0.285	1.01		0.326	0.156				0.651		0.312	0.102	
56		0.263	0.531		0.676	0.0858	−0.0126	−0.51		1.16	−0.732	0.53	0.574	
Mean	−0.16	0.0822	0.684	−0.0437	0.577	0.132	−0.0086	−0.638	0.0227	0.753	−0.27	0.354	0.382	−0.012
(SD)	(0.738)	(0.202)	(0.393)	(0.307)	(0.138)	(0.273)	(0.0102)	(0.951)	(0.109)	(0.756)	(0.853)	(0.105)	(0.525)	(0.0145)
							Group 6							
61	1.55		0.517		0.862	0.151	−0.0771	4.23	−0.0461	1.44	−0.696	1.05	0.173	0.0849
62			0.213		0.804	0.524	−0.0684	5.36		1.61	−0.873	0.742		0.202
63	1.32		0.639		0.651			−6.28	0.0755	−0.745	0.777	0.877	0.563	−0.3
64	2.3	0.287	0.327		0.826		−0.0372	6.91	0.744	0.436	0.181	0.656	−0.895	0.149
65	4.96			0.878	0.552		0.2	7.15	−0.222	2.52	−1.42	0.26	0.132	0.272
66	1.19		0.834		0.351			−3.17	−0.255	0.708	−0.322	0.388	0.85	−0.141
Mean	1.89	0.0478	0.422	0.146	0.674	0.112	0.00291	2.37	0.0494	0.994	−0.392	0.661	0.137	0.0442
(SD)	(1.53)	(0.107)	(0.276)	(0.327)	(0.18)	(0.192)	(0.0931)	(5.18)	(0.332)	(1.03)	(0.717)	(0.27)	(0.544)	(0.201)

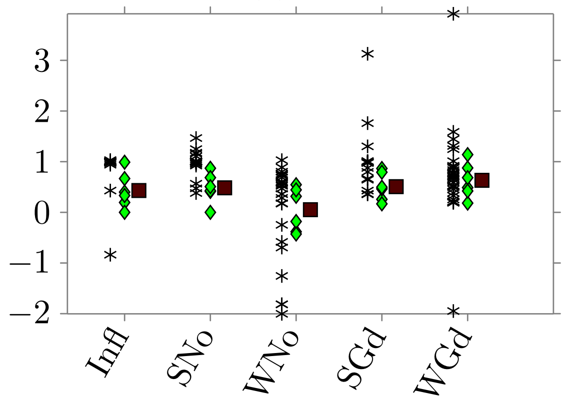
Table 9: (Cont.) Estimated individual rules for Treatment 5 (Unstable price level targeting with guidance).



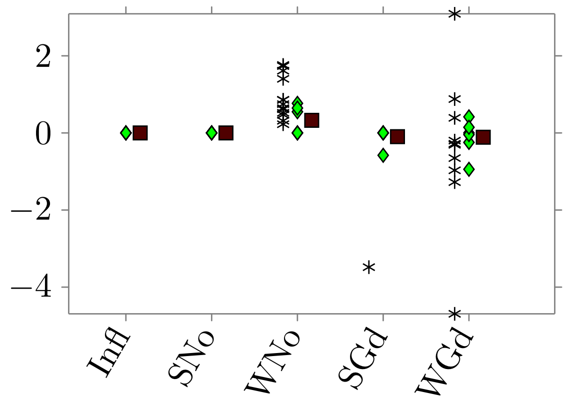
(a) c^{π}



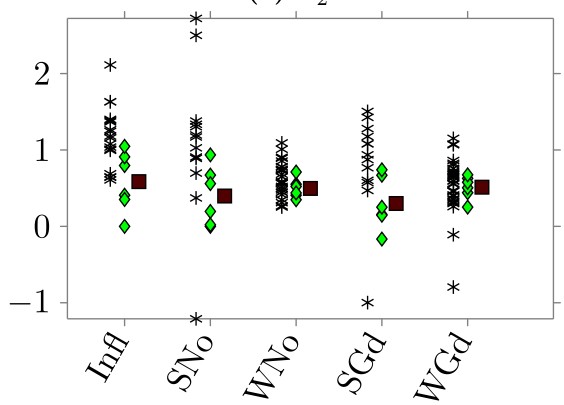
(b) α_1^{π}



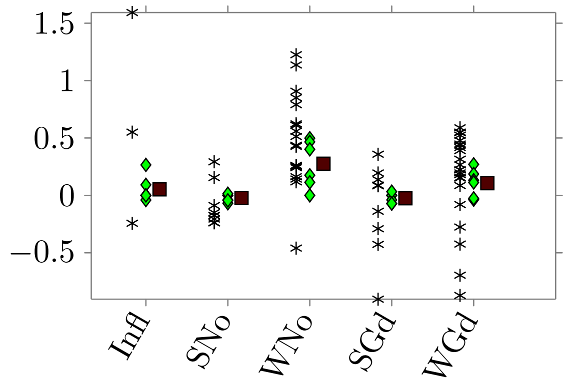
(c) α_2^{π}



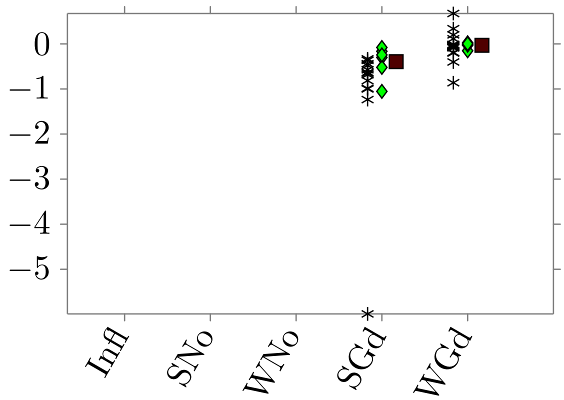
(d) α_3^{π}



(e) β^{π}

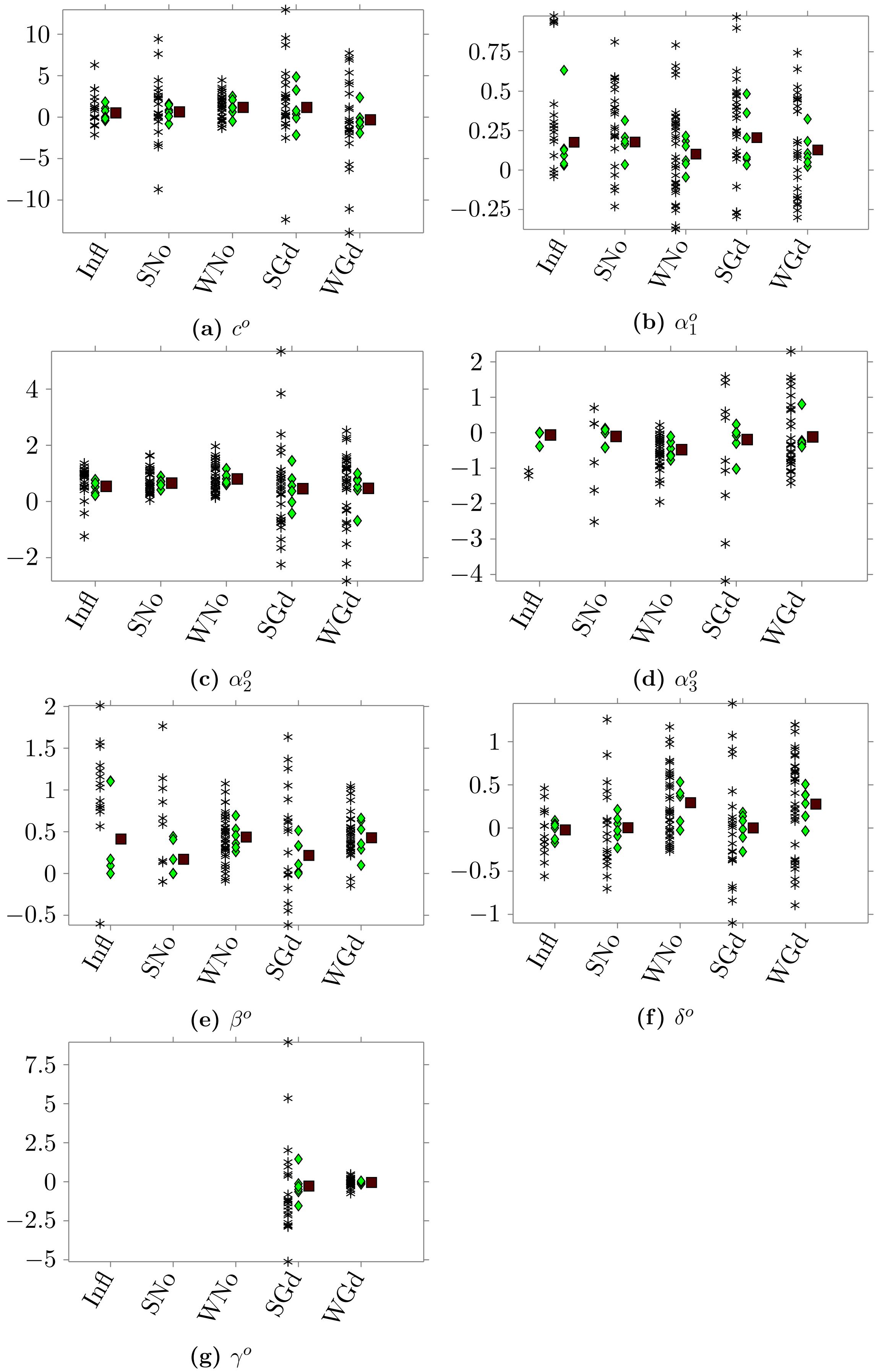


(f) δ^{π}



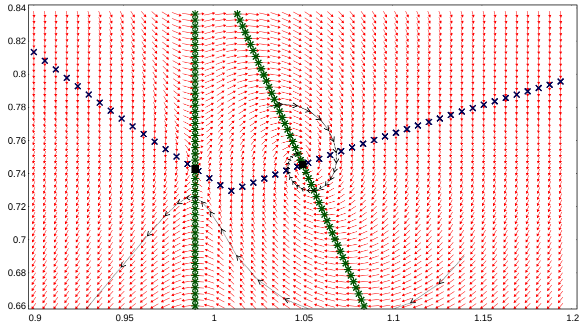
(g) γ^{π}

Figure C.1: Distribution of estimated individual inflation forecasting rules. Stars denote individual rules (if significant), diamonds indicate group averages and squares denote average in treatment.

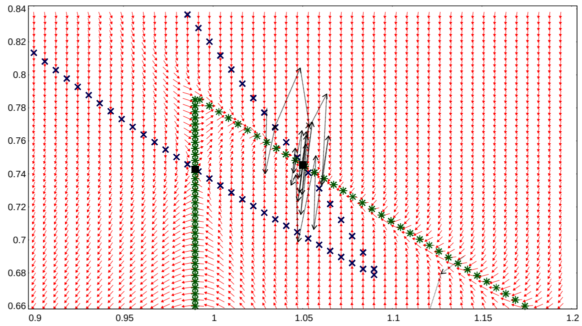


(a) c^o **(b)** α_1^o **(c)** α_2^o **(d)** α_3^o **(e)** β^o **(f)** δ^o **(g)** γ^o

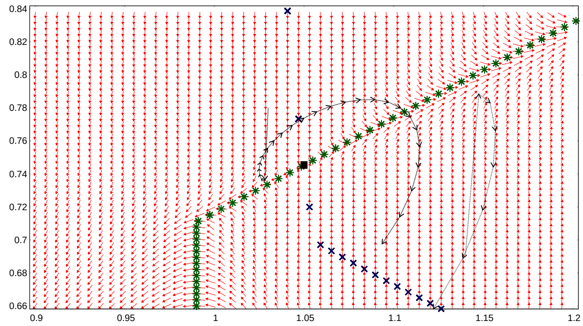
Figure C.2: Distribution of estimated individual output gap forecasting rules. Stars denote individual rules (if significant), diamonds indicate group averages and squares denote average in treatment.



(a) Inflation target Taylor rule



(b) Strong PLT Taylor rule



(c) Weak PLT Taylor rule

Figure D.1: Phase plots of the experimental economy under three different Taylor rules and naive expectations. The space is $\pi_t \times c_t$. Notice that under PLT rules the system is actually 3D, so these phase plots are projections with $P_0 = \bar{P}_0$. Red arrows denote the direction of the system at any point. Blue and green points denote manifolds with stable inflation and consumption respectively. The black points denote steady state. Finally, black arrows denote two sample paths that, for each Taylor rule, start at $(\pi_1, c_1)^1 = (1.03, 0.78)$ and $(\pi_1, c_1)^2 = (1.14, 0.69)$.

D Stability under naive expectations

With the noise switched off and under naive expectations

$$\begin{pmatrix} \pi^e_{t+1} \\ c^e_{t+1} \end{pmatrix} = \begin{pmatrix} \pi_{t-1} \\ c_{t-1} \end{pmatrix}, \tag{9}$$

the model becomes a deterministic non-linear 2D system under inflation target and 3D system under PLT Taylor rule. Since the full employment steady state can only be found numerically, and since we want to avoid log-linearization of the system, we deiced to analyze the model with numerical methods. To be specific, one can easily find the analytical expression for the relevant Jacobian matrix, and next use numerical algorithm to find the eigenvalues of the Jacobian at the steady state.[6] Please remark that, regardless of the monetary policy, the system has an additional ZLB steady state, which is always a saddle.

Inflation targeting rule Consider our DSGE model with the inflation-based Taylor rule (1). The full employment steady state is stable with real eigenvalues given by $\lambda_1^{INF} = 0.28679$ and $\lambda_2^{INF} = 0.88583$.

[6] These results were confirmed by a simple finite elements approximation algorithm.

PLT rules Consider our DSGE model with the PLT-based Taylor rule (2). If the PLT Taylor rule is parametrized with $(\psi_P, \psi_y) = (0.25, 1)$ (weak rule), the system in the full employment steady state has one real eigenvalue $\lambda_1^{PLWe} = 0.21162$ and two conjugate complex eigenvalues $\lambda_{23}^{PLWe} = 1.0770 \pm 0.20153i$ with modulus equal to $|\lambda_{23}^{PLWe}| = 1.0957$. Therefore, the full employment steady state is unstable. On the other hand, if the PLT Taylor rule is parametrized with $(\psi_P, \psi_y) = (3, 2)$, the system in the full employment steady state has one real eigenvalue $\lambda_1^{PLSt} = -0.48274$ and two complex conjugate eigenvalues $\lambda_{23}^{PLSt} = 0.85067 \pm 0.52406i$ with modulus equal to $|\lambda_{23}^{PLSt}| = 0.99914$, which means that the full employment steady state is just on the edge of stability.

These results can be visualized by phase plots (Figure D.1) and sample time paths. A clear difference between the three monetary policy treatments can observed. Under inflation targeting (Figure D.1a), smooth dynamics emerge. If the system is initialized close enough to the full employment steady state (such as in $(\pi_1, c_1)^1 = (1.03, 0.78)$), it gradually converges to this equilibrium. On the other hand, if the system starts too far away (such as in $(\pi_1, c_1)^2 = (1.14, 0.69)$), it bounces of the convergent region and falls into an inflation-output contraction spiral.

The dynamics, which appear under the two PLT Taylor rules, are only remotely similar to those from the inflation rule treatment. Under the strong PLT Taylor rule (Figure D.1b), the two initial points have the same long-run outcome as under the inflation Taylor rule. The stable initialization $(\pi_1, c_1)^1 = (1.03, 0.78)$ seems to be initially more chaotic, but it gradually converges. The unstable initialization $(\pi_1, c_1)^2 = (1.14, 0.69)$ diverges immediately, without the transitory dynamics as under the inflation rule. Finally, under the weak PLT Taylor rule (Figure D.1c), the dynamics are highly unstable and both initializations eventually diverge from the steady state.