Escaping Expectations-Driven Liquidity Traps: Experimental Evidence

Jasmina Arifovic* Luba Petersen†

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Abstract

We explore the ability of monetary policy and central bank communication to stabilize expectations and alleviate the duration and severity of liquidity traps in learning-to-forecast macroeconomic laboratory experiments. Economic crises are generated by exogenous aggregate demand shocks that gradually dissipate over time. Monetary policy is set via a Taylor rule that either targets inflation around a constant or state-dependent inflation target. Expectations significantly over-react to the shock leading many economies to experience inescapable deflationary traps. State-dependent inflation targets, expressed either quantitatively or qualitatively, do not reduce the duration or severity of economic crises, and in many cases worsen the crisis. Past realized inflation and output are consistently used across all treatments in forming forecasts. Expectations are significantly more correlated with aggregate shocks when fundamentals improve faster following the crisis, suggesting an important role for fiscal policy to create demand and reverse adaptive deflationary traps. Combining a constant inflation target monetary policy with anticipated expansionary fiscal policy is highly effective at stabilizing economic activity and increasing the speed of recovery.

*Department of Economics, Simon Fraser University, e-mail: arifovic@sfu.ca

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1 Introduction

How should monetary policy be conducted when nominal interest rates are close to zero? This question is important as, once interest rates reach zero and cannot be reduced further (often referred to as the zero lower bound (ZLB)), a central bank loses an important tool through which it stimulates the economy. The situation may become dire if a negative shock to demand were to occur because, close to the ZLB, a central bank may not be able to lower interest rates sufficiently to stimulate the economy during a recession. If the recession is persistent, households and firms will anticipate that the central bank will be unable to provide additional stimulation in future. Rationally, they form pessimistic expectations of the future that influence their decisions. The existence of the ZLB thus has the potential to generate a long self-fulfilling macroeconomic crisis.

The consensus among macroeconomists and policy makers has been that policies that create inflationary expectations would alleviate the severity and duration of liquidity traps. In one of many proposals, Eggertson and Woodford (2006) show that creating inflationary expectations by promising to keep the nominal interest rates low through increased inflation targets even after the economy has recovered can reduce the length of a liquidity trap. The state-dependent inflation target would be adjusted upward so long as the economy fails to achieve past targets to reinforce the central bank's commitment to higher future inflation. A critical requirement to the success of such a policy is that agents form rational expectations and that the central bank credibly commits to a long-run price level target. But, if agents are not rational, specifically constant gain learners (Evans, Guse and Honkapohja, 2005), accommodative monetary policy must be combined with significant fiscal stimulus to stabilize expectations and economic activity at the zero lower bound. Essential to the success of policies in general is that private agents understand the intentions of the policy maker and that they are credible. However, central banks that have been perceived as credible in stable times have found it difficult to anchor expectations at the ZLB. Since 2007, central bank forward guidance has been significantly more effective when policy makers communicate qualitative rather than quantitative targets (Filardo and Hofmann, 2014). As such qualitative inflation targets may prove to be more effective at stabilizing inflation targets.

Our overall goal is thus to examine the effectiveness of both the monetary policies and communication strategies of central banks near the ZLB. Is additional communication of a policy goal a necessary requirement for economic stability? Or is it

sufficient to simply conduct policy without providing further explanation as to what is occurring? What should a central bank communicate? Does the effectiveness of central bank announcements wear off with frequent communication?

We design a series of learning-to-forecast laboratory experiments in order to gain insight into the relative effectiveness of state-dependent inflation targeting in alleviating crises at the zero lower bound (ZLB). In groups, participants play the role of professional forecasters that submit forecasts for inflation and output. The forecasts are aggregated and used in the data-generating process driving the economic dynamics. We consider the effect of state-dependent inflation target that communicated either quantitatively or qualitatively relative to the baseline where the central bank (CB) follows the conventional Taylor rule with a constant inflation target.

Compared to a constant inflation target, we find that neither form of state-dependent inflation targeting leads to a significant reduction in the severity or duration of liquidity traps. In fact, in many of our sessions we observe that the traps are considerably worsened by the central bank's promise of future inflation. Expectations are significantly better anchored on the central bank's inflation target when the target remains constant than when it is a time-varying quantitatively announced target. At the individual level, we find that there is significant heterogeneity in how participants form their forecasts, making it difficult to identify a single forecasting heuristic. We observe mixed evidence that participants condition sufficiently on the aggregate shocks and inflation targets when forming their forecast. Instead, they appear to consistently rely on historical values and trends to base their expectations on. Such adaptive heuristics can be tempered, however, if the aggregate shocks are quicker to recover. Indeed, if the aggregate shocks generating the initial crisis quickly recover back to the steady state, adaptive behaviour is largely mitigated and the economies are more likely to recover.

We then consider whether anticipated fiscal policy would facilitate economic recovery. Positive government expenditures that creates demand should provide a positive signal to forecasters that the economy is rebounding. Moreover, the expenditures, if done with minimal lag following the crisis, should work to minimize the trend-chasing behavior observed in our earlier experiments and more effectively reverse expectations in the direction toward the steady state. When we introduce fiscal expenditures following the economic crisis, we find that expectations are much less likely to become trend-chasing. Expectations become very focused on the aggregate shock and recovery of the economy.

2 Relation to the existing literature

There are a handful of theoretical models that explicitly discuss communication of the central bank (Woodford, 2005; Eggertson and Woodford, 2006; Baeriswyl and Cornand, 2010; Eusepi and Preston, 2010), but these models typically assume rational agents that are, by construction, capable of incorporating whatever information is communicated to them into their beliefs about the future. Thus, the assumption in these models is that the central bank can control or alter expectations if the policy is appropriately communicated. Woodford (2005) shows how liquidity traps can be avoided at the ZLB through central bank communication. However, questions regarding how the communication is conducted by the central bank, interpreted and understood by the public and how it impacts their behaviour has not been addressed. This is a critical issue that then-Deputy Governor Jean Boivin (2011) addressed in a recent Bank of Canada speech.

The public's understanding of the central bank's objectives and policy rules *in the future* is a critical component of the effectiveness of monetary policy (Woodford, 2005; Eusepi and Preston, 2010). The most important channel through which central banks can influence spending decisions and pricing is through market expectations regarding the future path of overnight interest rates. If agents form rational expectations, they should correctly infer the policy rule that the central bank is following. However, if agents have to adapt, learn, or possess imperfect information or understanding, a need for communication of the policies arise.

But do central banks actually communicate effectively? The empirical results are mixed. In some cases central bank announcements about their policy objectives have created more stability in financial markets and private sector forecasts (Connolly and Kohler, 2004; Fujiwara, 2005; Swanson, 2006) in countries that pursue inflation-targeting policies. Others find announcements generate significant and undesirable volatility in U.S. asset prices (Kohn and Sack, 2004; Ehrmann and Fratzscher, 2007). Importantly, communication may not be that effective once we control for pre-existing policies of a central bank. Gurkaynak et al. (2006) show that long-term inflation expectations derived from index-linked bonds are significantly less responsive to central bank announcements in inflation-targeting (IT) countries like Sweden and the U.S. that they are in the U.S., which has no explicit inflation objective. Indeed, Siklos (2002), Johnson (2002) and Corbo et al. (2002) finds in a series of cross-country

studies that the adoption of IT has led to lower forecast errors, suggesting greater macroeconomic stability without the need for communication.

Central banks face risks when they communicate to the public. As Woodford (2005) points out, communication of a central bank *goal* may be misperceived by the public as a *promise*. If a central bank fails to live up to its stated *goals* or *promises*, it will lose credibility and the public will stop conditioning their forecasts and behaviour on the announced goals. It is for this reason that many central banks, including the Federal Reserve, have historically communicated very little to the public. In December 2012, the Federal Reserve made an unusual announcement that it would keep interest rates low at least as long as the unemployment rate remains below 6.5 percent, the outlook for inflation one-to-two years ahead remains at or below 2.5%, and longer-term inflation expectations remain well anchored. The purpose of this forward guidance in terms of economic conditions was to create long-run inflation expectations within an economy that is perceived to be stuck in a liquidity trap. The communication has yet to show any signs of influencing aggregate activity.

The success of central bank communication of monetary policy depends crucially on how it is perceived and understood by the public, and what kind of expectations they will form. If there is no instant adjustment of rational expectations, i.e. if agents need time to process and adapt their behavior, the question arises as to what the appropriate model of aggregate expectations is. In other words, what is a reasonable class of expectations that we can work with when analyzing the impact of central bank communication? Surveys of households and professional forecasters are widely used sources of direct evidence on expectation formation (Mankiw et al., 2004; Coibion and Gorodnichenko, 2012 discuss recent studies of expectations using survey for forecaster data. These studies lack the ability to control for the information sets of agents and the economy's true underlying data generating process, so are limited in their ability to inform us on how individuals form their expectations. In the absence of empirical studies that would identify the process of expectation formation, experiments are an invaluable tool that we can use to identify this 'reasonable' class of expectations. This identification will certainly have an impact on the types of communication (e.g. macroeconomic targets, forecasted path of future interest rates, central bank outlooks) and the formulation of monetary policies a central bank would find optimal to pursue. Laboratory experiments benefit from more precise control of conditions under which participants form their expectations (see for example, Arifovic and Sargent, 2003; Arifovic, et al. 2013a,b; Duffy, 2008, 2012; Adam, 2007; Hommes et al, 2008; Pfajfar and Zakelj (2014), Hommes, 2011, 2013 reviews the lit-

erature on the evidence of heterogenous expectations hypothesis in the experimental economies; Chakravarty et al., 2011, review the growing literature on experimental macroeconomics; and Cornand and Heinemann (2014) survey experiments on monetary policy.)

Indeed, laboratory experiments have become an increasingly important tool in the macroeconomists toolbox. The Bank of Canada has been pursuing a research agenda focused on expectation formation. Amano et al. (2011) study the ability of subjects to make rational forecasts under a price-level targeting regime. Kryvtsov and Petersen (2013) investigate the robustness of the expectations channel of monetary policy. They observe a relatively weak expectations channel that is strengthened with more aggressive monetary policy. In follow-up work, Petersen (2015) shows that central bank communication initially works to coordinate expectations, but over time participants stop conditioning on the information and expectations become more volatile. Expectation rules can be influenced significantly in the short-run by the presentation of information. Petersen (2014) finds that increasing the salience of forecast error information results in significantly greater usage of the information in forecasts and more pronounced constant-gain learning. In a similar learning-to-forecast experimental design, Cornand and M'Baye (2014) find that communicating an explicit inflation target is not essential to maintain economic stability when the central bank has a strict inflation target. However, if the central bank has a dual mandate to stabilize inflation and output, communicating to private agents the central bank's inflation target leads to significant improvements in stability and convergence to the target.

3 Theoretical Framework

Our theoretical model is based on a dynamic general equilibrium business cycle model by Woodford (2011), where private expectations of future economic outcomes and policy play an important role for determining current outcomes. Each period, a unit measure of forward looking households purchases and consumes a basket of differentiated goods, C_t, supplies working hours, N_t,productive firms for which it earns an hourly wage of W_t, and saves and borrows in the form of one-period nominal bonds, B_t that pay interest i_t. The household's optimization problem is to $\max_{C_t,N_t,B_t}\{E_t\sum\beta^t\left(\frac{C_t^{1-\sigma}}{1-\sigma}-\frac{N_t^{1+\eta}}{1+\eta}\right)\}$subject budget constraint $W_tN_t+B_{t-1}(1+i_{t-1}) = P_tC_t + B_t$. The forward-looking assumption implies that agents take their expectations about future outcomes into consideration when making optimal decisions for

the current period.

A continuum of monopolistic firms employ the labour supplied by households to produce differentiated varieties according to the production technology $y_{it} = ZN_t$ where Z is a productivity parameter. Each period, firms face a constant positive probability $1 - \omega$ of being able to update their prices which imposes nominal rigidities on the aggregate price level. The firms first complete a cost minimizing problem: $\min_{N_{it}} W_t N_{it} + \phi(Y_{it} - ZN_{it})$ where they must satisfy all demand for their variety at the price that they have set at that point in time. As a result, profit-maximizing firms must take into consideration their expected future marginal costs when given the opportunity to update their prices. They select p_{it} to maximize $E_t \sum_{k=0}^{\infty} \omega^k \beta^k (C_{t+k}/C_t)^{-\sigma} \left[(p_{it}/P_{t+k})^{1-\theta} - W_t (p_{it}/P_{t+k})^{-\theta}/Z_t \right] C_t$. The solutions to these equations can be log-linearized around the model"s steady state and written as an equation describing the evolution of the output gap, $x_t = E_t x_{t+1} - \sigma^{-1}(i_t - E_t \pi_{t+1} - r_t^n)$, and inflation $\pi_t = \beta E_t \pi_{t+1} + \kappa x_t$. Both household and firms expectations are self-fulfilling: expectations of higher future demand or prices leads to immediate changes in demand and prices. Monetary policy is set by a central bank that adjusts the nominal interest rate,i_t , to maintain stability. In particular, it will increase (decrease) interest rates when inflation and output increases (decreases) below the central bank's target. For example, a central bank may follow a rule such as $(1+i_t) = (1+i_{t-1})^{\gamma} \left[(1+\rho)(1+\pi_t - \pi^*)^{\delta} \right]^{1-\gamma}$ where ρ is the natural nominal interest rate, π_t is the inflation rate, and π^* is the central bank's inflation target.

4 Experimental Design and Implementation

Our experimental environment is constructed around the theoretical model discussed in the earlier section. Subjects played the role of professional forecasters who submit daily forecasts for future inflation and output. Each session consisted of nine subjects. At the beginning of each session, subjects participated in a 45 minute instruction and practice phase. During the instructions we first explained the data generating process qualitatively. We then provided subjects with a quantitative description of the model and explain in careful detail the shock process and monetary policy rule. We walked subjects through the software in four practice periods to familiarize them with the interface and provided them with an opportunity to ask questions. The computer interface is highly graphical and presented the Appendix. Subjects learned their fore-

cast accuracy by observing changes in their points between rounds and by comparing visually (and by mousing over) the distance between their forecast and the realized values.

The experimental economy was based on a standard reduced-form version of the New Keynesian framework where the aggregate dynamics are driven by aggregate expectations, exogenous disturbances, and monetary policy. Specifically, the environment followed a data-generating process of the form:

$$x_t = E_t^* x_{t+1} - \sigma^{-1}\left(i_t - i^* - E_t^* \pi_{t+1} - r_t^n\right) \ , \tag{1}$$

$$\pi_t = \beta E_t^* \pi_{t+1} + \kappa x_t \ , \tag{2}$$

$$i_t = \begin{cases} i^* + \phi_\pi(\pi_t - \pi_t^*) + \phi_x x_t & \text{if } i_t \geq 0 \\ 0, & \text{otherwise,} \end{cases} \tag{3}$$

$$r_t^n = \rho r_{t-1}^n + \epsilon_t \ . \tag{4}$$

Equation 1 refers to the Investment-Saving equation and describes the dynamics of aggregate demand relative to its flexible-price level, or the output gap.[1] As aggregate expectations of future output ($E_t^* x_{t+1}$) and inflation ($E_t^* \pi_{t+1}$) increase, current output will also increase. Exogenous changes in the natural rate of interest, r_t^n, will have a positive effect on demand. Deviations of the nominal interest rate, i_t, from its steady state value, i^*, have a stabilizing effect on output so long as $i_t \geq 0$ and will stimulate (contract) demand as interest rates fall (increase). We parameterize $\sigma = 1$ and $i^* = 75$ basis points.

Equation 2 describes the evolution of aggregate supply or inflation. Inflation depends primarily on expectations of future inflation ($E_t^* \pi_{t+1}$) and, to a lesser extent, on aggregate demand, x_t. The parameters are assigned values of $\beta = 0.995$ and $\kappa = 0.13$.

Equation 3 is the central bank's response function and describes how nominal interest rates are set. The central bank responds to positive deviations of inflation from its steady state, $\pi_t - \pi_t^*$, and positive output gaps by adjusting nominal interest rates upward, and vice versa. The central bank responds aggressively to deviations of inflation and output from its targets with a $\phi_\pi = 1.5$ and $\phi_x = 0.5$. The monetary

[1] Throughout the paper, we refer to the output gap as simply "output".

transmission operates by influencing the real rate of interest through movements in the nominal interest rate. Monetary policy would generally be able to stabilize real output at its potential level for any fluctuation in r_t^n so long as it can adjust the policy rate such that $i_t - E_t\pi_{t+1} - r_t^n$ can be stabilized to zero. However, in this environment, the presence of a zero lower bound on nominal interest rates prevents the central bank from lowering interest rates sufficiently in the presence of very low or negative inflation and output. In other words, the central bank is unable to stabilize output at its steady state, and thus inflation, under sufficiently negative realizations of r_t^n.

Finally, Equation 4 describes the evolution of the natural rate of interest or, as we will refer to it throughout the paper, the *shock*. The shock follows an AR(1) process where $\rho = 0.8$, and ϵ_t is drawn randomly from a normal distribution with mean zero and standard deviation of -93 basis points.

Subjects had access to the following information before submitting their forecast of next period's inflation and output. They observed all historical information including the previous period's realized inflation, output, and nominal interest rate, as well as their forecast accuracy. Subjects also observed the current period's shock. Subjects had 65 seconds to submit forecasts. Forecasts were submitted in basis point measurements (i.e. 1% is inputed as 100 basis points) and could be positive or negative. After all subjects submitted their forecasts or time ran out, the median forecasts for inflation and output were used as the aggregate forecast in the calculation of the current period's realized output and inflation.

Participants' score, and subsequently their earnings in the game, depended on the accuracy of their forecasts each period:

$$Score_{i,t} = 0.3(e^{-0.01|E^*_{i,t-1}\pi_t - \pi_t|} + e^{-0.01|E^*_{t-1}x_{i,t} - x_t|}) \ , \tag{5}$$

where $E^*_{i,t-1}\pi_t - \pi_t$ and $E^*_{i,t-1}x_t - x_t$ were subject i's forecast errors associated with forecasts submitted in period $t-1$ for period t variables. The scoring rule incentivized subjects to form accurate forecasts. This scoring rule is very similar to that used in the previous experimental literature in that scores decrease monotonically with the forecast errors and the minimum score a subject can earn in any period is zero.[2]

[2]In the scoring rules used by Assenza et al. (2013) and Pfajfar and Zakelj (2014), there is diminishing marginal loss from forecast errors. Under our rule, the per-period score reduces by 50% for every 100 basis point forecast error for both inflation and output, continually incentivizing subjects to make the most accurate forecasts possible.

Every session consisted of two repetitions of 40 periods each. To reinforce the steady state values, we initialize each sequence at the steady state and show five pre-sequence periods where the economy is in the steady state. That is, output, inflation, and the shock were initialized at zero while the nominal interest rate was initialized at 75 basis points. We conducted two sequences on the same group of subjects to observe the effects of additional learning on their forecasting behaviour. Our experiment consisted of three initial treatments in a between-subject design. Subjects only participated in only one session.

This experiment focuses on the ability of policy to alleviate the duration and magnitude of liquidity traps. As such, we were interested in focusing on economies that would experience a liquidity trap and stay in it for some number of periods. To generate such an environment, we imposed a negative natural rate of interest shock of -400 basis points (± 2 basis points) in periods 20 and 15 of the first and second repetitions, respectively. We chose different periods to shock the economies across the repetition so that the subjects would not be anticipating the shock in the second repetition. We chose approximately the same size shock (between -398 and -402) in both repetitions to be consistent for comparison purposes.

We employed *social evolutionary learning*, SEL (Arifovic and Karaivanov, 2010), to explore the parameter space when designing our experiment. Hundreds of shock sequences were drawn to observe the behaviour of our social evolutionary learning agents in those environments. We selected shock sequences that met a number of our criteria: 1) The economies did not reach the zero lower bound prior to us imposing the liquidity trap shock, 2) the shock remained negative for 3-8 periods, 3) the economy rebounded in the later periods with few if any returns to the zero lower bound.

4.1 Treatments

We conducted three treatments that relate to either the type of inflation targeting or the communication of the target. Each treatment consists of six independent sessions, where each session consisted of a different pair of shock sequences. Across treatments, the set of shock sequences was identical. Thus, for any given pair of shock sequences, we can observe how behaviour may differ across treatments. Screen shots for each of the three treatments can be found in the Appendix in Figures 12-14.

Monetary Policy Rules

Our nominal interest rate generally takes the form depicted in Equation 3. We consider two variations of this rule. First, we consider an inflation target that is set to a constant value, $\pi_t^* = 0$. In this *Constant Target (CT)* treatment, we convey to subjects that the central bank's objective is to keep inflation and output as close to zero as possible. Under this environment, when the crisis shock of -400 basis points occurs, forecasters should react by significantly reducing their output and inflation forecasts

As a comparison, we conduct a *State-Dependent Target (SD)* treatment where the inflation target evolves based on the past realized inflation and output. The time-varying inflation target is computed as follows:

$$\pi_{t+1}^* = \frac{1}{\beta}\left(\pi_t^* - \pi_t\right) - \frac{\lambda}{\kappa\beta}\left(x_t - x_{t-1}\right) - \frac{\lambda\sigma}{\beta}x_t \tag{6}$$

This inflation targeting rule consists of two components: the inflation and the output gap component. In the cases, when the economy is in the liquidity trap, the central bank will find it difficult to meet higher inflation targets due to the zero lower bound on the nominal interest rates. In such cases, the first component of this rule will cause the central bank to increase its inflation target for the subsequent period. This situation will continue as long as the economy is in the liquidity trap (and the longer this situation prevails, everything else being equal, the greater the inflation target would become).

Once the economy exits the liquidity trap (either due to the improving expectations or due to the increasing natural interest rate r_t^n), the central bank would be able to achieve its inflation target. However, the inflation target will not immediately drop to zero when the economy exits the liquidity trap. Instead, there will be a gradual decline in the inflation target due to the improvement in output gap. Essentially, during this time the central bank will keep the nominal interest rates at 0, generating higher than usual inflation.

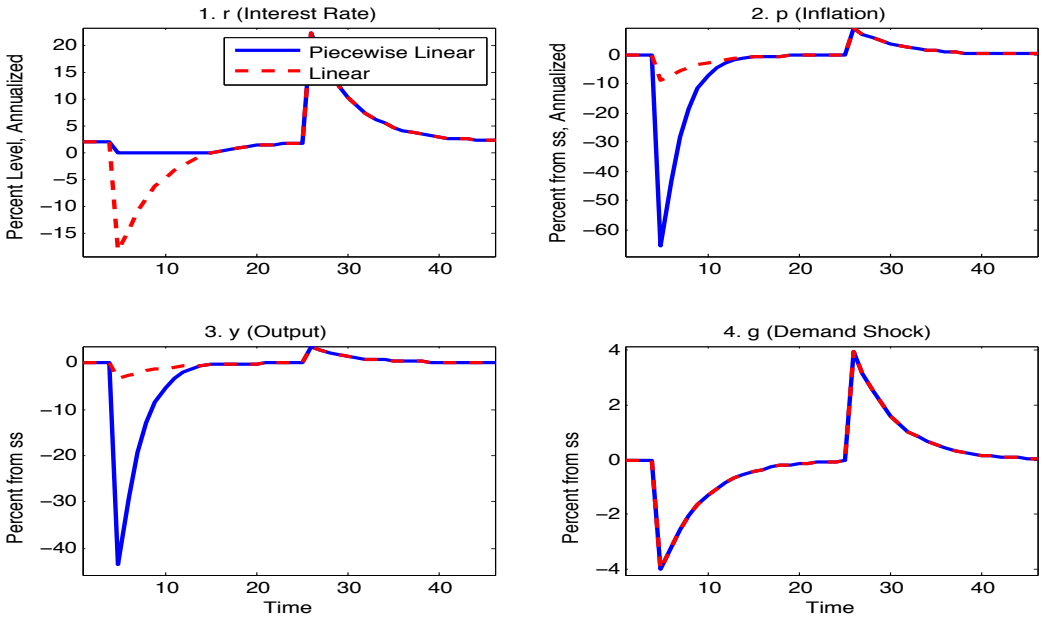
Simulation of the rational expectations equilibrium solution under constant and state-dependent inflation targets are presented in Figure 1. The simulations were conducted using OccBin developed by Guerrieri and Iacoviello (2015). OccBin solves

dynamics models with occasionally binding constraints by solving for the piece-wise linear non-explosive solution. The same approach was applied by Eggertson and Woodford (2003). The simulations presented show the linear solution that ignores the zero lower bound as a red dashed line. The solid blue line is the piece-wise linear solution that takes into consideration the zero lower bound. The first 30 periods refer to the dynamics associated with a negative natural rate of interest shock of 400 basis points while the following periods refer to dynamics under a positive shock. As can be seen in the figures, when the economy experiences positive shocks, the piecewise linear and the linear impulse responses coincide. The simulations indicate that economic recovery is considerably faster and the severity of the crisis significantly lower under a state-dependent inflation target. Output and inflation are four and seven times more reactive to the negative shock when the central bank implements a constant inflation target.

During the experiment, the central bank's inflation target is communicated each period on participants' screens in the same graphical panel as forecast and realized inflation. We also provide an announcement on the right side of the screen.

We also consider the possibility that qualitative evidence may be easier for participants to comprehend. In the *Directional State Dependent Target (Dir. SD)* treatment, the central bank sets monetary policy to stabilize inflation around a state-dependent inflation target (as in the SD treatment), but only communicates to participants the direction of the target. The direction is presented as either "positive" or "negative". As such, we remove the time series graph of the target.

(a) Constant Inflation Target



(b) State-Dependent Inflation Target

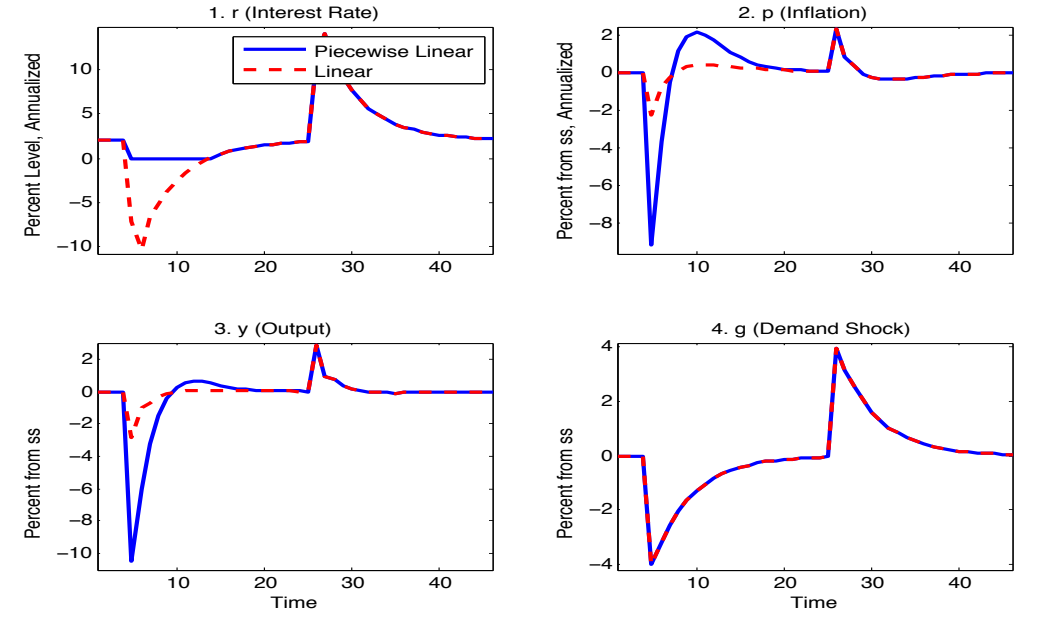


Figure 1: Simulations of parameterized environment with a constant and state-dependent inflation targets

The experiments were conducted at the CRABE Lab at Simon Fraser University. The subject pool consisted of undergraduate students recruited from a wide variety of disciplines. Subjects were invited to participate in sessions that involved 30 minutes of instructions and 60 or 90 minutes of game participation. Only one group participated in any session. We have conducted six sessions of each treatment. Earnings, including a $7 show up fee, ranged from $20 to $33.50, and averaged $26 for two hours of participation.

5 Results

5.1 An Overview of the Data

After 20 periods in Repetition 1 or 15 periods in Repetition 2, the experimental economies experience a *crisis* shock of -400 basis points. Thereafter, the shock begins trending back to zero and surpasses zero. Across different shock sequences we vary the number of periods it takes for the shock to reach zero. We define *BadShockLength* as the number of periods, including the period of the initial shock, before the natural interest rate shock reaches zero.

On impact of the crisis shock, expectations drop significantly and drive the economy down to the ZLB. All economies reach the ZLB on impact of the *crisis* shock in both repetitions. However, some economies escape the ZLB and trend up back to the steady state, while others experience persistent deflationary spirals. We define a *liquidity trap* as a situation where the expectations remain pessimistic in the presence of the expansionary monetary policy. In all treatments, we observe liquidity traps that subjects are not able to escape from.

We present two representative examples of shock sequences where the economies, regardless of treatment, either escape or remain trapped at the ZLB.[3] In Figures 2 and 3, times series of output and inflation in blue and green, respectively. The nominal interest rate is presented in orange, while the shock is presented in bold red. Figure 2 refers to sequence 3 where the BadShockLength is three (five) periods in Repetition 1 (Repetition 2). PRE and POST refers to the preshock and postshock phases of each repetition, respectively. Across all treatments, expectations, and thus output and

[3]All time series graphs of inflation, output, and interest rates can be found in the Appendix in Figures **??** to **??**.

inflation, track the shock well. On impact of the shock, expectations drop and even trend downwards one period after the crisis shock. However, median expectations are quickly reversed and the economies all successfully return back to the steady state relatively quickly in both repetitions. By contrast, sequence 2 presented in Figure 3 has a BadShockLength of 8 periods in both repetitions. Again, median expectations do fall significantly on the impact of the shock. However, in all treatments, they never return to the steady state, and instead, reach very large negative levels resulting in deep liquidity traps.

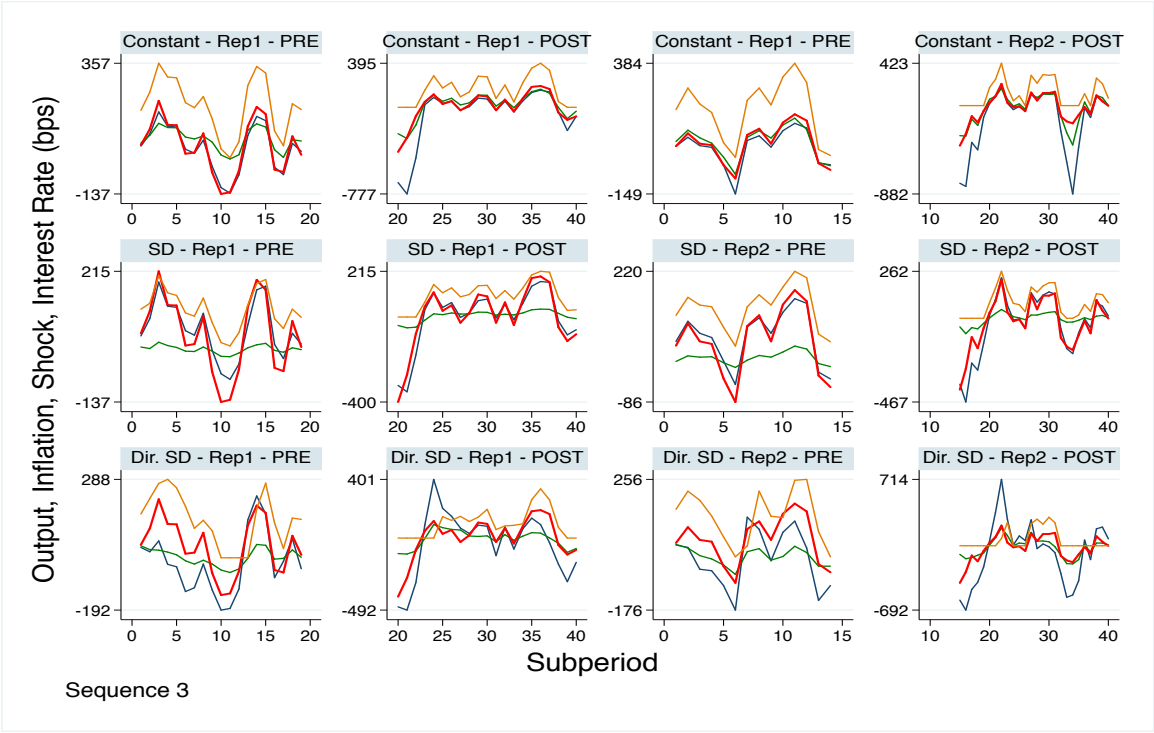


Figure 2: An Example of a Stable Shock Sequence

We consider two measures of policy effectiveness. The first is related to how successful the policy is in reducing the duration of a liquidity trap, while the second addresses the policies success in reducing the severity (or standard deviation) of output gap and inflation. We begin with the duration of the liquidity trap. Because each shock sequence in a given treatment has a different BadShockLength, we normalize the number of periods before expectations are reversed by the BadShockLength.

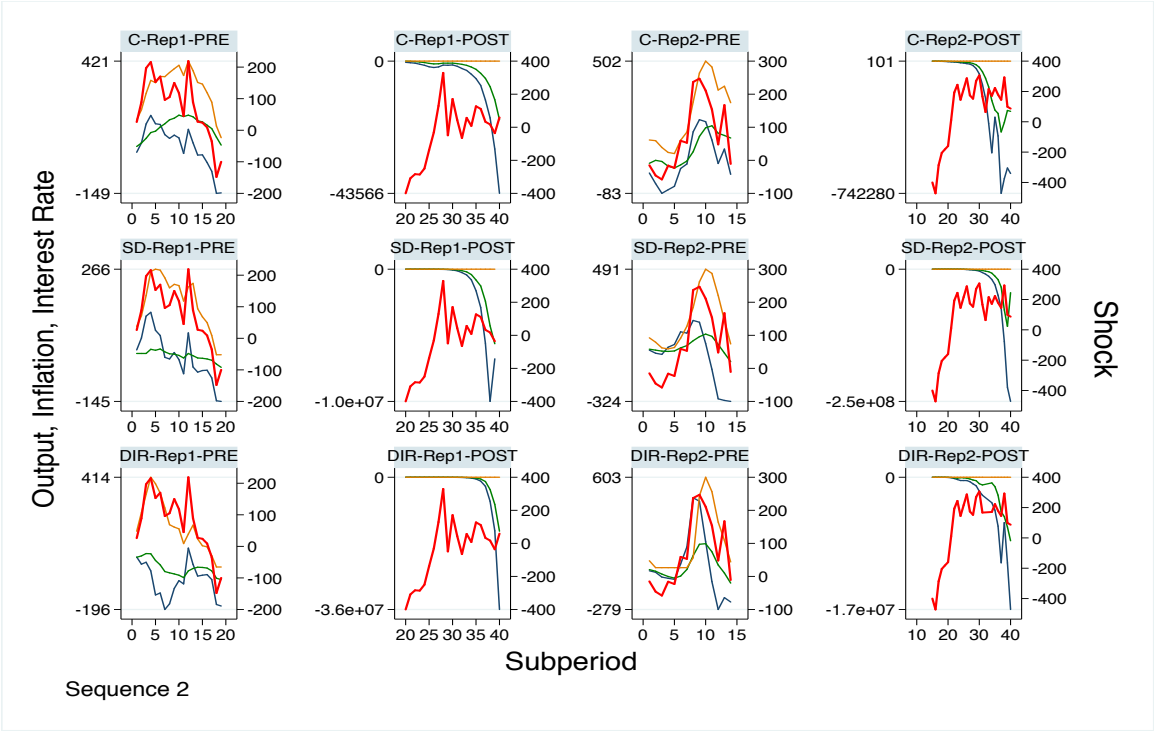


Figure 3: An Example of an Unstable Shock Sequence

Specifically , we measure the duration of the liquidity trap at the session-repetition level using *Relative Trap Length*:

$$\text{Relative Trap Length} = \frac{\text{Number of periods before expectations are reversed}}{\text{Number of periods before shock becomes nonnegative}}$$

The results are aggregated in box plots in Figure 4. Among inexperienced subjects (Repetition 1), the relative traps are, on average, the lowest in the Constant treatment where it takes an average of 9.5 periods for subjects to reverse their expectations. By contrast, In treatments SD and Dir. SD, it takes an average of 15.2 and 13.8 periods, respectively. However, the differences across treatments are not statistically significant. Two-sided Wilcoxon rank sum tests failed to reject the null hypothesis that the distributions of the relative trap lengths across all pairwise treatment combinations (with $p > 0.42$ in all cases). With experienced subjects (Repetition 2), the average relative trap length increases in the Constant treatment with subjects taking an average of 12.9 periods to reverse their expectations, while the average relative trap

length decreases only modestly in the SD treatments (with an average of 18 periods to reverse the expectations) and decreases considerably in Dir. SD (with an average of 11 periods to reverse the expectations. Again, none of these are statistically significant (with $p > 0.173$ in all cases).

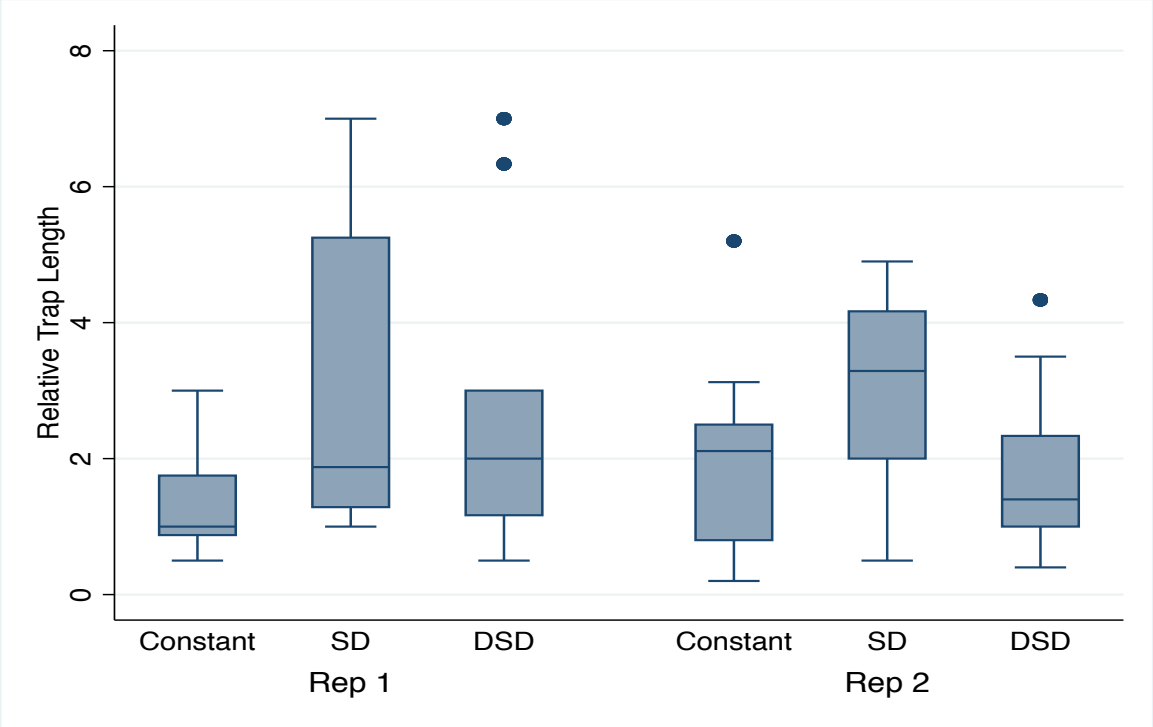


Figure 4: Relative trap length

Figure 5 presents standard deviations of inflation across treatments and repetitions (log scale on the y-axis). The standard deviation of inflation is significantly lower in the Constant treatment relative to SD treatment ($p = 0.055$). However, because of the considerable variability of inflation across sessions of Dir. SD treatment, we do not observe any statistically significant differences with respect to either the Constant or SD treatments. As subjects become experienced, the standard deviation of inflation worsens in the Constant and SD treatments, and we do not observe any statistically significant differences between the two. However, the qualitative communication in the Dir. SD treatment is more effective at reducing inflation variability relative to quantitative communication in the SD treatment (where the difference is statistically

significant with $p = 0.055$). The results for the output gap follow an identical pattern.

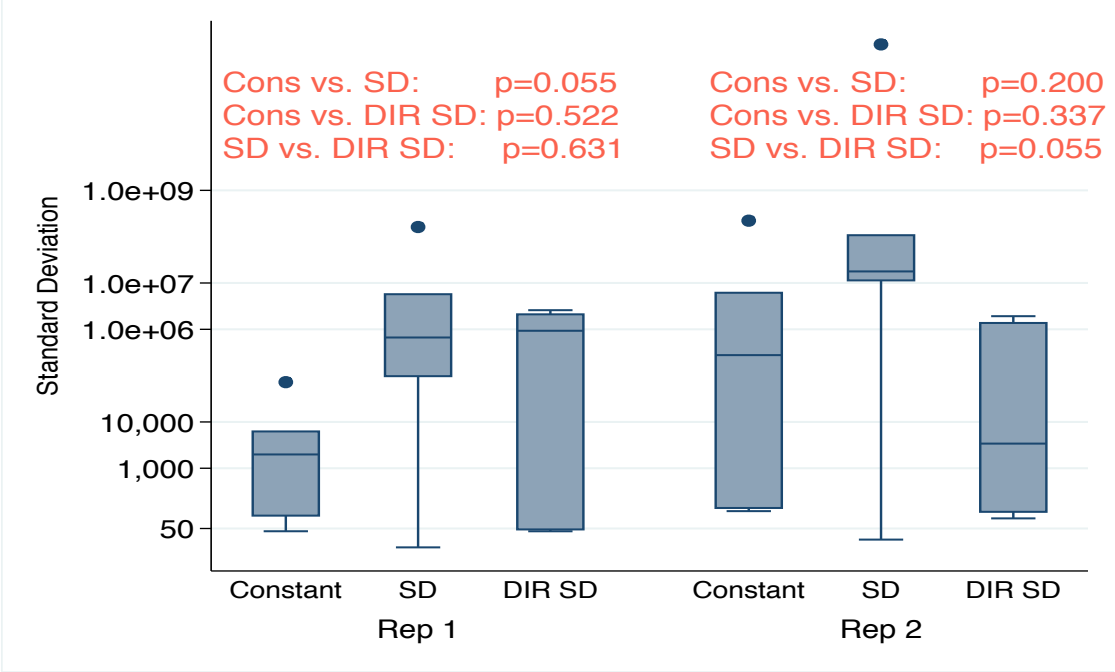


Figure 5: Standard Deviation of Inflation

6 Fiscal Policy

Our results in the previous sections suggest that faster recoveries of fundamentals increases the probability and speed of recovery, and reduces the severity of economic crises. We next consider whether economic crises can be effectively ameliorated by anticipated expansionary fiscal policy. Anticipated productive government spending should create more optimistic expectations about future demand and inflation. To determine whether this is the case, we conduct a fourth treatment that introduces fiscal spending into our baseline constant inflation targeting environment.

In the Fiscal Policy (FP) treatment, participants are informed that the government

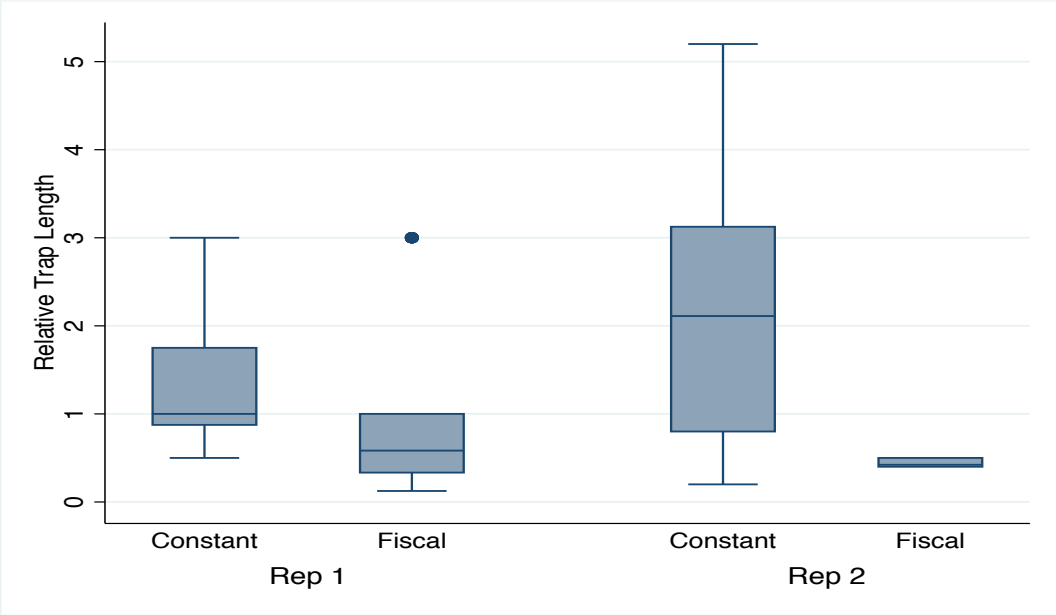
is able to conduct discretionary expansionary and contractionary fiscal policy. The government does not follow a specified rule, nor is it required to balance its budget over the horizon of the game. Government expenditures or taxation, denoted as g_t, has a direct effect on aggregate demand, resulting in a modified I-S curve:

$$x_t = E_t^* x_{t+1} - \sigma^{-1} \left(i_t - i^* - E_t^* \pi_{t+1} - r_t^n \right) + g_t \ , \tag{7}$$

Participants were informed each period of the government's planned expenditures in the following period and understand that the expenditures occur with certainty. They were informed that the government's spending was discretionary and was not required to be balanced. The planned expenditures were displayed to them on their screen in the form of a time series graph in the same panel as the nominal interest rate and the natural rate of interest shock. A screenshot of the interface is presented in Figure 15. During the practice phase, participants encounter both positive and negative government expenditures to ensure that they understand both are possible.

During the actual game, government spending is exogenously set to zero until the crisis occurs. On impact of the crisis, the government announces it will engage in fiscal spending equal to 200 basis points, which is 50% of the size of the aggregate demand shock. Importantly, we do not try to offset the shock entirely. We do, however, explore whether we can minimize the pessimistic reaction to the crisis by creating optimistic expectations through fiscal spending. To capture the fact it often takes time for a fiscal authority to have new expenditures approved, we only introduce the fiscal spending in the period following the initial crisis shock. The positive government spending announcements lasted for as long as the current natural rate of interest shock was trending back up to the steady state. Thus, the last period of positive government spending occurred in the period when the shock first became positive. The decision to keep spending positive until the shock returned to zero seemed to be a simple rule to follow and not overly generous, especially since in our previous treatments we found that expectations would take nearly twice as long to reverse and begin trending back to the steady state. Six sessions of the FP treatment were conducted following the same procedures and shock sequences as in the other treatments.

(a) Relative Trap Length



(b) Standard Deviation of Inflation

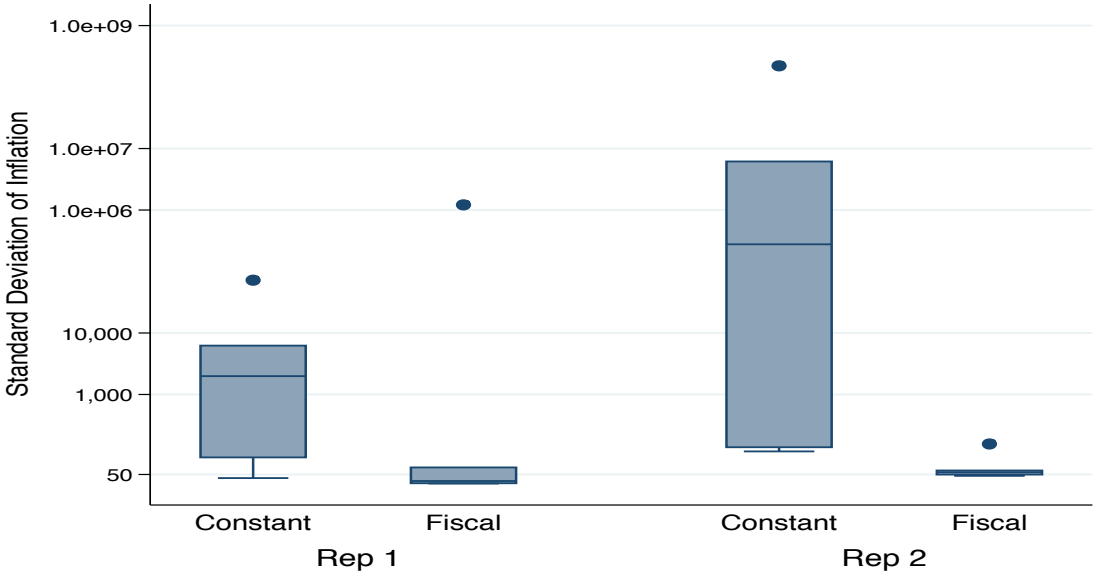


Figure 6: Duration and Severity of Crises, Constant Inflation Target vs. Fiscal Policy

Combining a constant inflation-targeting monetary policy with fiscal stimulus is effective at stabilizing expectations during an economic crisis. The mean relative trap length under the fiscal policy treatment is 0.937 (s.d. 1.053) in the first repetition and 0.441 (s.d. 0.049) in the second repetition. This is considerably smaller than the relative trap lengths observed in the Constant Target treatment (means of 1.652 (s.d. 0.977) and 2.536 (s.d. 1.903) in Repetitions 1 and 2, respectively). Two-sided Wilcoxon rank sum tests reject the null hypothesis of equal distributions ($p - value = 0.025$) in the second repetition, but fail to in the first repetition ($p - value = 0.126$). Only one economy in the fiscal policy treatment experienced a severe liquidity trap (shock sequence 2, repetition 1). If we exclude that repetition from our analysis, we find that the differences between the constant and fiscal treatment are again highly significant ($p - value = 0.028$).

The standard deviations of inflation and output are also considerably reduced with the introduction of fiscal policy. Figure 6 b. presents a comparison of standard deviations at the session-level in the Constant Target and Fiscal Policy treatments. The differences across treatments are visually dramatic. Two-sided Wilcoxon rank sum tests indicate that the differences across treatments are stark. In the first repetition, we obtain a $p-value = 0.078$ for inflation and $p-value = 0.109$ for output, and when exclude the outlier session, the significance increases considerably to $p-value = 0.011$ for inflation and $p - value = 0.018$ for output. With experience in the second repetition, the differences are more significant: the $p - value = 0.010$ for inflation and $p - value = 0.004$ for output.

7 Individual-Level Analysis

In this section, we consider how alternative forecasting strategies are influenced by the impact of the shock and the amount of time it takes for fundamentals to recover. Expectations are pooled across repetitions, differentiating between preshock and postshock forecasting behaviour.

We consider how expectations might evolve under five different forecasting heuristics: *rational*, where forecasts condition solely on the fundamental shock, *naive*, where forecasts condition solely on past realized output or inflation, and *trend-chasing* where forecasts condition on the change in output or inflation over the past two periods. We regress forecasts on each of these pieces of information at the individual level, pre- and postshock. Specifically, we run the following OLS regressions for each individual

i: $E_{i,t}x_{t+1} = \beta r_t^n + \epsilon_t$, $E_{i,t}x_{t+1} = \beta x_{t-1} + \epsilon_t$, and $E_{i,t}x_{t+1} = \beta(x_{t-1} - x_{t-2}) + \epsilon_t$. For the state-dependent inflation targeting treatments, we estimate each individual's responsiveness to the the central bank's evolving inflation target using the following regression equation: $E_{i,t}x_{t+1} = \beta\pi_t^* + \epsilon_t$. Finally, for the fiscal policy treatments, we estimate participants' responsiveness to fiscal policy: $E_{i,t}x_{t+1} = \beta g_t + \epsilon_t$. Inflation expectation regressions are similar. The cumulative distribution functions of estimated βs are plotted in Figures 7 - 11. The solid blue and dashed red lines denote the pre- and postshock distributions, respectively. For additional reference, we provide the distribution and standard deviation of inflation forecasts, by period, for each session in the Appendix in Figures **??** to 29.

An initial visual inspection of the distributions suggests that the postshock behaviour - irrespective of forecasting type and treatment - is considerably more heterogeneous than in the preshock phase. The standard deviation in estimated coefficients increases the least in the Fiscal Policy treatment and quite dramatically in the other treatments.

Participants reduce their weight of the aggregate shock in their forecasts in the postshock phase. In terms of output forecasts, median[4] estimated $\beta_{r_t^n}$ falls from 0.72 to 0.49 in the CT treatment, from 0.26 to -267.63 in the SD treatment, from 0.08 to -1.06 in the DSD treatment, and from 0.65 to 0.47 in the FP treatment. A similar pattern occurs for inflation forecasts. The number of subjects whose expectations respond positively to the aggregate demand shock decreases after the crisis occurs.[5]

In the CT treatment, the post-shock estimated coefficients are significantly negatively correlated with the bad shock length ($\rho_x = -0.38$ and $\rho_\pi = -0.30$, with the p-value 0.01 in both cases)[6]. Similarly, participants' inflation forecasts respond more positively to aggregate demand shocks following the crisis in the DSD treatment ($\rho_\pi = -0.27$, p-value < 0.01) and FP treatment ($\rho_\pi = -0.43$, p-value < 0.01). In the SD treatment, the post-shock correlation is very small and not statistically significant.

The extent to which the median participant utilizes lagged output in forming their output forecasts decreases in all treatments. Median estimated β_{t-1} falls from 0.86 to

[4]When referring to median estimated values, we are referring to the median individual in the entire set of participants for a given treatment and phase.

[5]We have a total of 108 individual observations. The number of participants responding positively to an increase in the aggregate demand shock in the pre and postshock phases adjusts as follows. CT Output: 107 to 59; CT Inflation: 100 to 59; SD Output: 86 to 38; SD Inflation: 78 to 40; DSD Output: 67 to 51; DSD Inflation: 85 to 46; FP Output: 106 to 95; FP Inflation: 104 to 88.

[6]Spearman rank correlations reported throughout

0.63 in CT, 0.70 to 0.61 in SD, 0.60 to 0.54 in DSD and 0.83 to 0.67 in FP. Similarly, inflation forecasts respond less to lagged inflation in the postshock phase of the CT, with the estimated median coefficient falling from 0.88 to 0.7. While there is minimal change in how the median participants utilizes past inflation in forming their inflation forecast in the DSD and FP treatments, the median SD participant becomes increasingly naive in the postshock phase. In the SD treatment, the estimated weight on past inflation increases from 0.81 to 0.94. As the bad shock length increases, the weight participants place on lagged inflation in the postshock phase increases in the CT treatment ($\rho_\pi = 0.30$, p-value < 0.01) and in the DSD treatment (($\rho_\pi = 0.21$, p-value $= 0.03$). FP participants respond more strongly to lagged output information when forming their output gap forecasts (($\rho = 0.18$, p-value $= 0.05$).

The median participant reduces their trend-chasing behaviour when forming their output forecasts after the large shock occurs. The estimated weights placed on the past output trend decreases from 0.55 to 0.41 in CT, 0.62 to 0.41 in SD, 0.44 to 0.31 in DSD, and 0.53 to 0.45 in FP. Similarly, median inflation forecasts become less trend-chasing in the CT, where the estimated coefficient on trend inflation decreases from 0.79 to 0.57, and in FP where the coefficient decreases 0.60 to 0.45. Median inflation forecasts become increasing more trend-chasing in the SD and DSD treatments following the large shock. The estimated coefficients on trend inflation increase from 0.66 to 0.85 in SD and 0.52 to 0.88 in DSD. Postshock, as the bad shock length increases, trend-chasing behavior becomes more prevalent for CT inflation forecasts ($\rho_\pi = 0.30$, p-value 0.01) and DSD inflation forecasts ($\rho_\pi = 0.34$, p-value 0.01).

Participants do not generally condition on the inflation target in the anticipated direction. The majority of participants respond to higher inflation targets by decreasing their output and inflation forecasts. In the SD treatment, the estimated $\beta_{pi_t^*}$ decreases from -0.16 to -0.32 for output and from -0.11 to -0.14 for inflation, suggesting that the target becomes increasingly ineffective in the postshock phase. Preshock, 41% (44 out of 108) and 18.5% (20 out of 108) of participants increased their output and inflation forecasts, respectively, in response to a higher inflation target. Postshock, only 7% (8 subjects) and 14% (15 subjects) continued to do so. Thus, on impact to the large shock, not only is the median participant responding less to the inflation target when forming its forecasts, but fewer participants are forming inflation targets in the predicted direction. Reactions to the inflation target are not significantly correlated with the bad shock length (associated p-values > 0.27).

In the DSD treatment, we observe a different pattern where the qualitatively com-

municated inflation target has a small positive effect on output forecasts, with the estimated $\beta_{pi_t^*}$ is 0.09 preshock. However, postshock, the median reaction decreases to -0.17. Inflation forecasts respond negatively to higher inflation targets both pre and postshock, with the estimate increasing from -0.13 to -0.07. Preshock, 61% (66 subjects) and 10% (11 subjects) increased their output and inflation forecasts in response to higher inflation targets. Postshock, 22% (24 subjects) and 19% (21 subjects) increase their output and inflation forecasts. Interesting, the number of participants who positively condition their output forecasts on the target is considerably higher - both pre and postshock - in the DSD treatment compared to the SD treatment. Postshock, the number of participants responding to the inflation target when forming output forecasts drops dramatically but increases modestly for inflation forecasts. Inflation forecasts also respond less to the inflation target as the bad shock length increases ($\rho_\pi = -0.23$, p-value $= 0.02$).

In response to an additional 100 basis points of government spending, median output and inflation forecasts decrease by 31 and 0.5 basis points, respectively. This alone would suggest that fiscal policy has a contractionary effect on expectations and the economy, which is inconsistent with what we have observed in our FP sessions. When we alternatively control for the effect of the aggregate shock on expectations[7], we find that expansionary fiscal policy creates more optimistic expectations in the majority of participants. Median output and inflation forecasts increase by 41 and 37 basis points, respectively, in response to a 100 basis point increase in government spending. Postshock inflation forecasts also respond significantly less to fiscal policy as the bad shock length increases ($\rho_\pi = -0.28$, p-value 0.01).

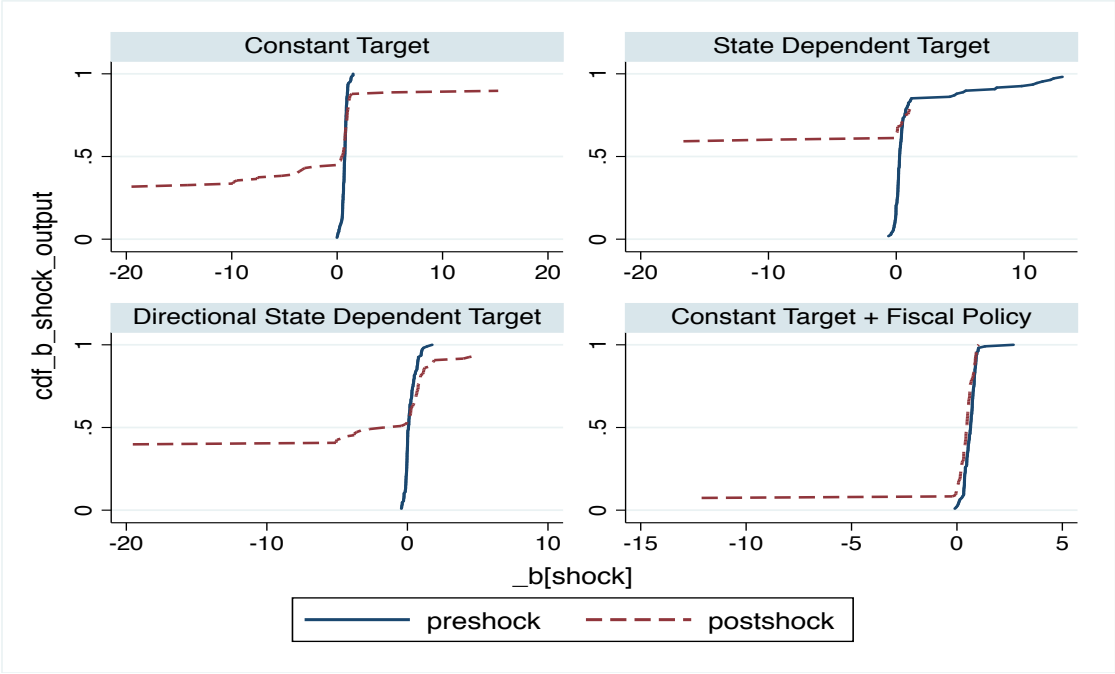
We further conduct a series of probit regressions to identify the effects of the BadShockLength on the likelihood of coordinating expectations in the direction of the inflation target. The results for each treatment are presented in the first three columns of Table 1, where the data is pooled across repetitions and standard errors are clustered at the session-level. The results indicate that the longer is the BadShockLength, the lower is the probability that individuals will coordinate their expectation in the direction of the inflation target. The estimate is large and statistically significant in the Constant treatment, but not precisely estimated in the two state-dependent treatments. We also consider the possibility that larger adjustments in the aggregate shock in the period after the crisis has occurred may appear more focal and serve to effectively coordinate expectations in line with the target. The

[7]Specifically, we estimate the following regression: $E_{i,t}x_{t+1} = \beta_0 r_t^n + \beta_1 g_t + \epsilon_t$. The associated cumulative density function is plotted in Figure 11 b.

results are presented in the last three columns of the same table. Indeed, in the Constant and Dir. SD treatments, a larger recovery of the shock immediately after the crisis occurs significantly increases the probability that participants coordinate their expectations in that given period in the direction of the target. In the SD treatment, larger recoveries in the shocks has no effect on the likelihood of coordinating expectations on the central bank's target.

Taken together, these results suggest the importance of a speedy recovery on impact of a demand-driven crisis. The greater is the initial speed of recovery of shocks, the higher is the likelihood that the central bank is able to anchor inflation expectations. However, if recovery is slow to occur, pessimistic and adaptive expectations quickly form leading to extreme liquidity traps.

(a) Fundamentals-Driven Expectations - Output Forecasts



(b) Fundamentals-Driven Expectations - Inflation Forecasts

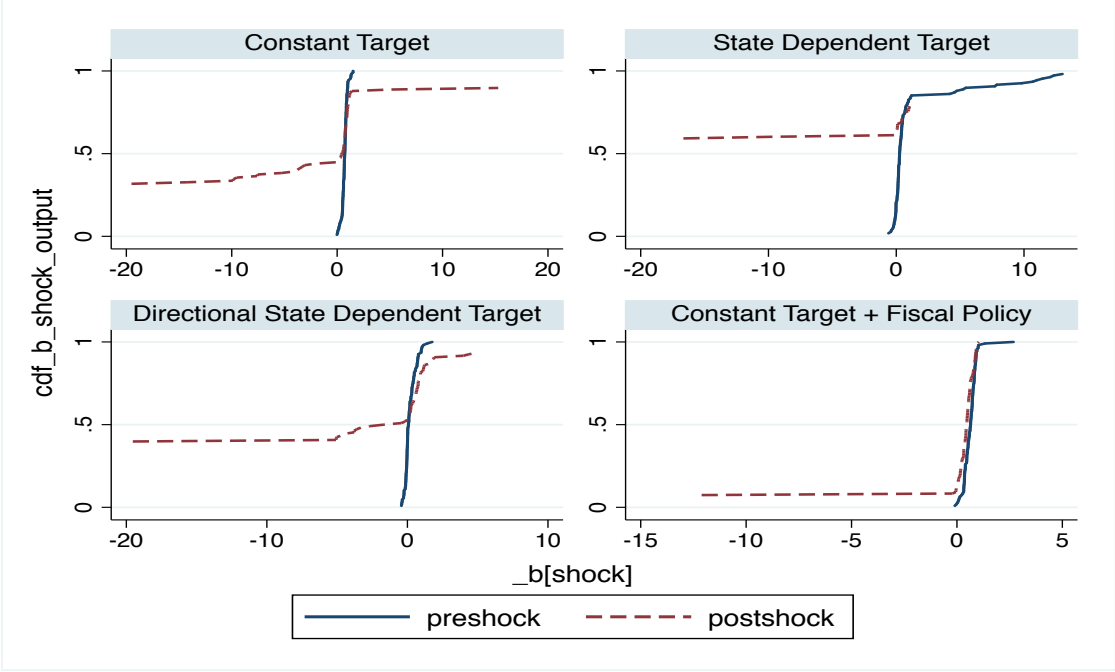
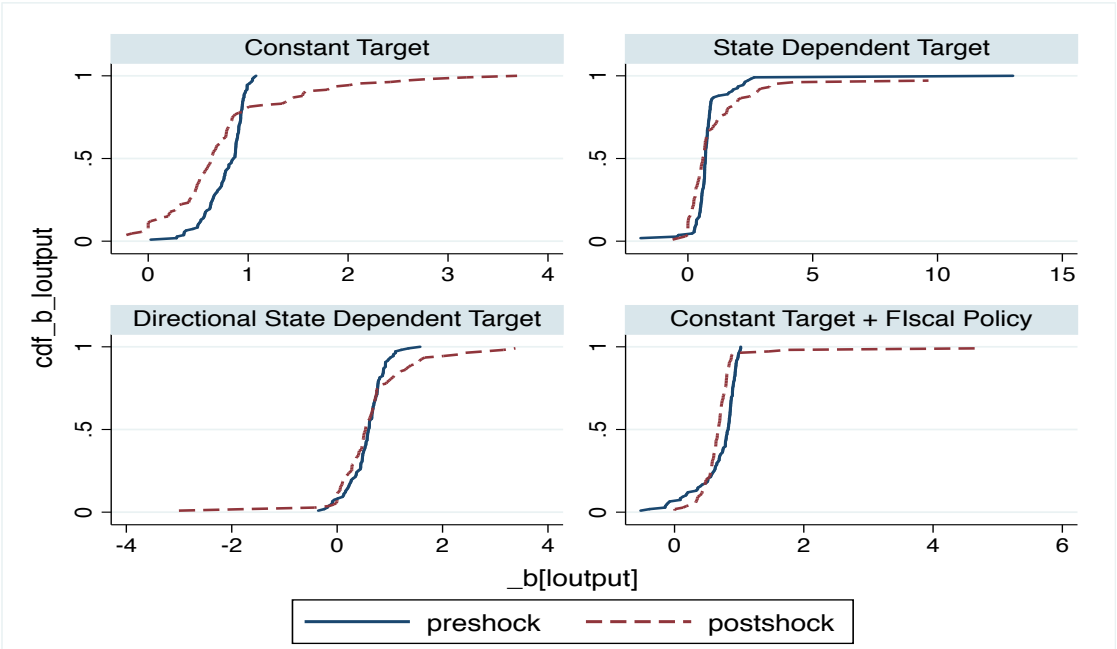


Figure 7: Distribution of Rational Types Across Treatments and Shock Phases

(a) Naive Expectations - Output Forecasts



(b) Naive Expectations - Inflation Forecasts

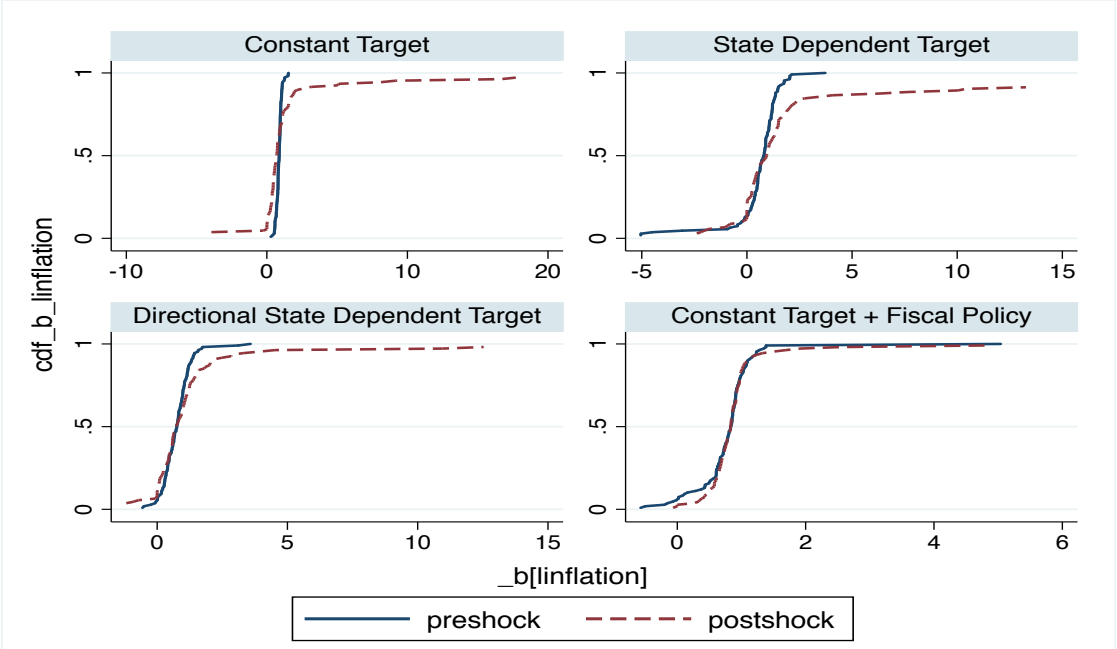
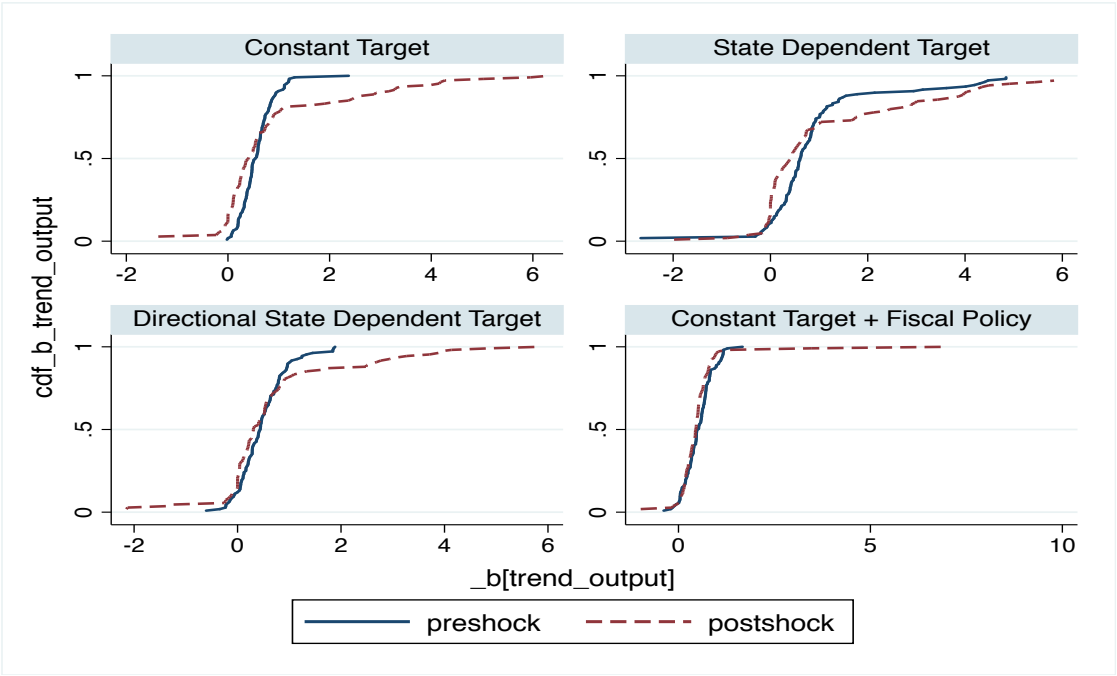


Figure 8: Distribution of Naive Types Across Treatments and Shock Phases

(a) Trend-chasing & Contrarian Expectations - Output Forecasts



(b) Trend-chasing & Contrarian - Inflation Forecasts

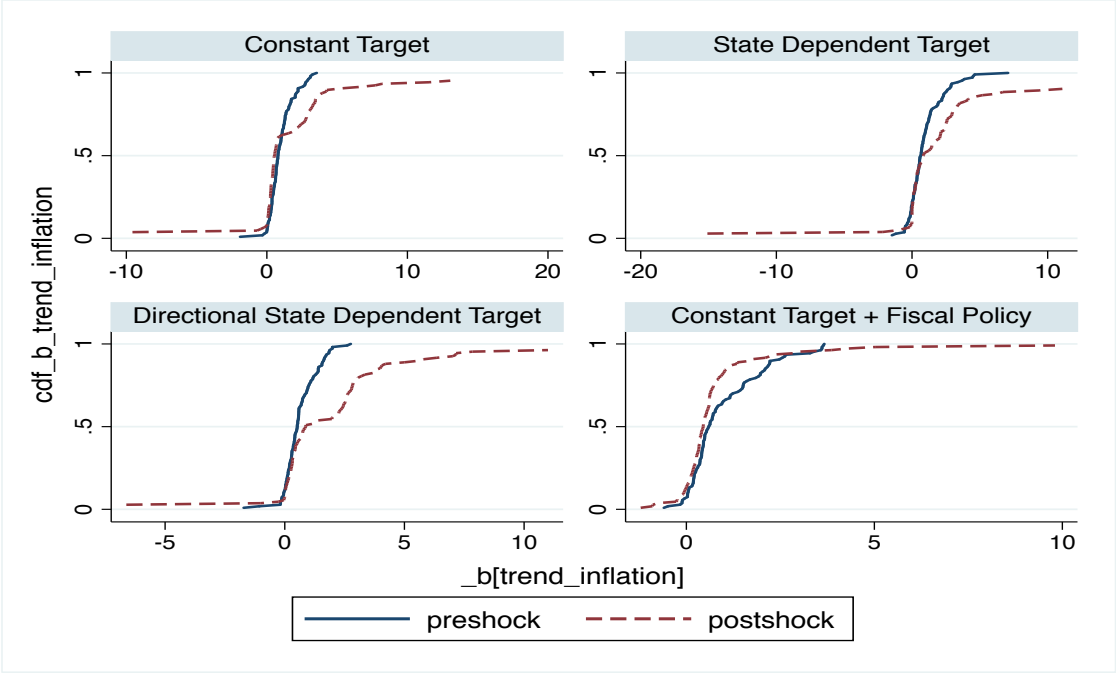
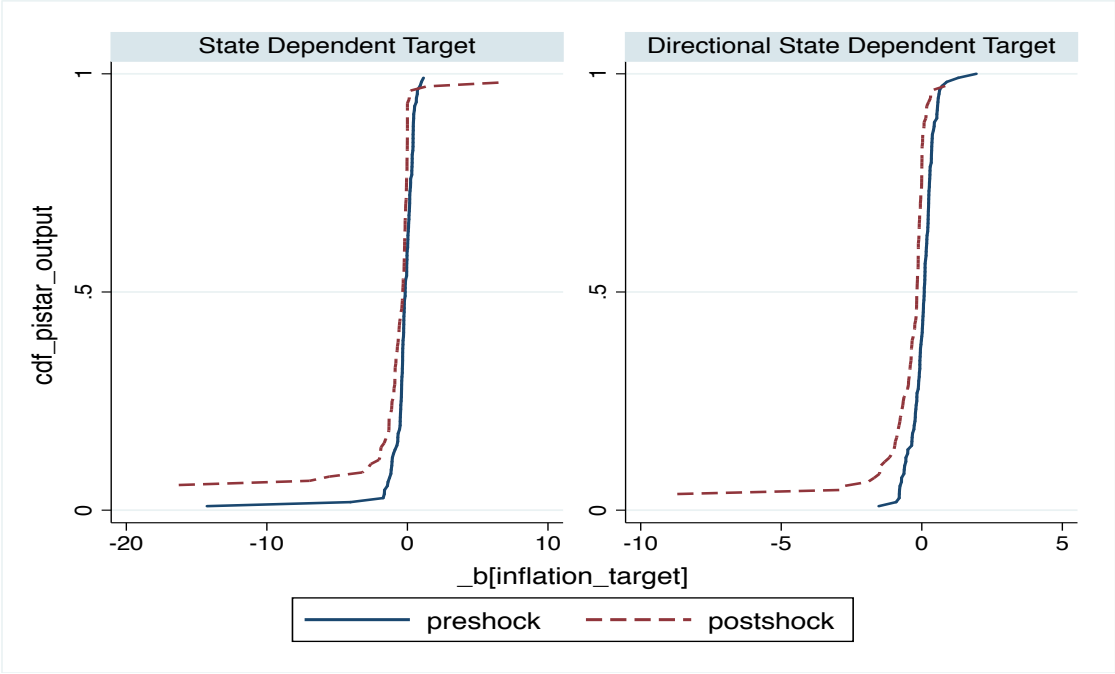


Figure 9: Distribution of Naive Types Across Treatments and Shock Phases

(a) Inflation Target - Output Forecasts



(b) Inflation Target - Inflation Forecasts

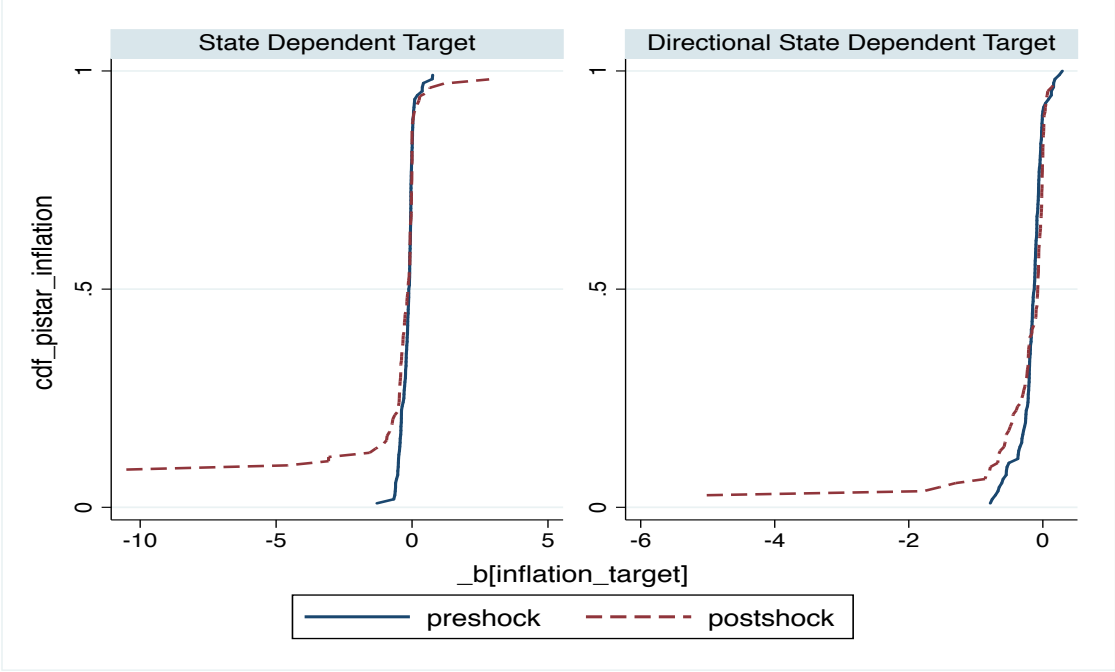
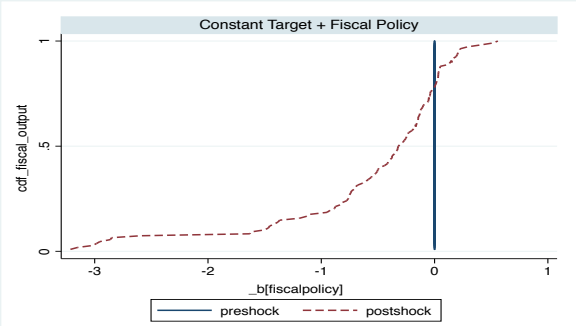
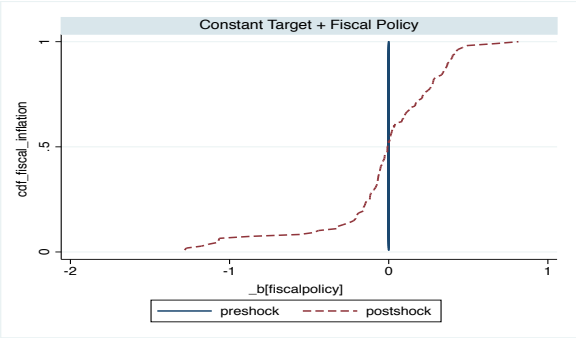


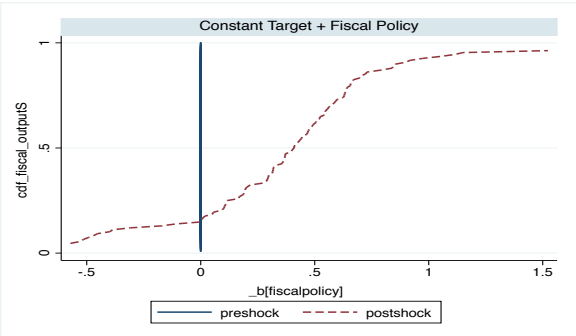
Figure 10: Distribution of Responses to State Dependent Inflation Target Across Treatments and Shock Phases

(a) Fiscal Policy - Output and Inflation Forecasts





(b) Fiscal Policy Controlling for Aggregate Shock - Output and Inflation Forecasts



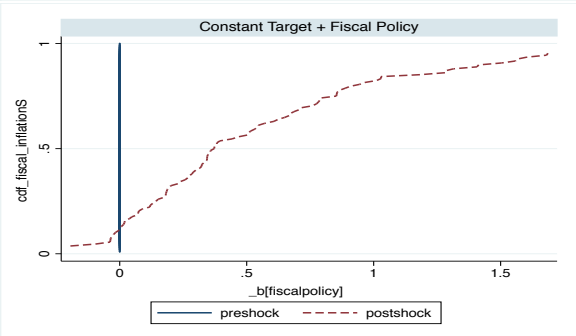


Figure 11: Distribution of Responses to State Dependent Inflation Target Across Treatments and Shock Phases

Table 1: Probit Analysis of BadShockLength and Adjustment on Anchoring of Expectations [I]

	Forecast in Target Direction				Increase Inflation Forecast Rel. Past Inflation			
	Constant	SD	Dir. SD	Fiscal	Constant	SD	Dir. SD	Fiscal
BadShockLength	-0.076***	-0.019	-0.006	0.035				
	(0.03)	(0.06)	(0.05)	(0.04)				
$r_t^n - r_{t-1}^n$					0.006**	0.000	0.007***	0.008 ***
					(0.00)	(0.00)	(0.00)	(0.00)
α	0.651***	0.091	0.181	-0.065	0.029	0.003	-0.482	-0.131
	(0.17)	(0.48)	(0.38)	(0.25)	(0.41)	(0.32)	(0.36)	(0.34)
N	2494	2373	2502	2446	108	106	107	106
χ^2	7.67	0.12	0.01	0.53	4.873	0.0101	10.62	14.07

Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Standard errors are presented in parentheses and clustered at the session-level.

8 Discussion

We have demonstrated that severe, long-lasting expectations-driven liquidity traps can be generated in the laboratory. With an unanticipated significantly large demand shock, expectations can become extremely pessimistic and cause an economy to diverge into deep recessions. Recent research has suggested that state-dependent central bank policies that promise to keep interest rates low following a recession even after inflation has returned to its target can lead to greater economic stability and faster recovery. We conduct a series of experiments to test whether such policies live up to their predictions, and if not, identify why this is the case.

We find that state-dependent inflation targets do not lead to significantly greater stability. In fact, in many instances, recession duration and severity are made considerably worse by continually raising the central bank's inflation target. This was particularly the case when fundamentals improved slowly. We attribute the relatively poorer performance of state-dependent inflation targets to a loss of confidence in the central bank's ability to stabilize the economy. During a slower recover, the central bank's inflation target should grow quite large as the economy fails to live up to the state-dependent target. The disparity between the inflation target and actual inflation - which is largely driven by adaptive expectations - will grow rapidly. Such a policy is unlikely to be successful if agents condition their expectations on the central bank's target based on the central bank's efficacy of achieving the target. However, when fundamentals improve faster, the greater is the likelihood the inflation target is going to be achieved and individuals coordinate their expectations in the direction of the target. By contrast, anticipated fiscal policy provides considerable support when fundamentals improve slowly. Compared to our baseline of a constant inflation target, introducing fiscal policy leads to significantly faster and more stable recoveries. Unlike state-dependent monetary policies that provide a promise of future recovery in the uncertain future, anticipated expansionary fiscal policy in our environment stimulates demand with certainty.

In our study of the individual-level data, we analyze how expectations might evolve under five different forecasting heuristics: fundamental-driven, where forecasts condition solely on the fundamental shock; naive, where forecasts condition solely on past realized output or inflation; and trend-chasing, where forecasts condition on the change in output or inflation over the past two periods. Irrespective of forecasting type and treatment, the post-shock behaviour is substantially more heterogenous than in the pre-shock phase. However, the standard deviation of estimated coeffi-

cients increases the least in the Fiscal Policy treatment.

In general, participants reduce their weight on the aggregate shock in their forecasts in the postshock phase. In addition, the number of subjects whose expectations respond positively to the aggregate demand shock decreases after the crisis occurs. Participants reduce the weight that they put on lagged output in all of the treatments in the postshock phase. Regarding the utilization of lagged inflation, it also decreases in the constant-target economies. There is a minimal change in its utilization in the state-dependant inflation targeting economies and fiscal policy treatments, while the median participant in the directional treatment becomes increasingly naive in the postshock phase. The median participant reduces their trend-chasing behaviour when forming their output forecasts after the large shock occurs. Median inflation forecasts become less trend-chasing in the constant target and fiscal policy treatments. However, median inflation forecasts become more trend-chasing in the directional and state-dependant treatments, following the large shock.

We also find that participants do not generally condition on the inflation target in the anticipated direction. The majority of participants respond to higher inflation targets by decreasing their output and inflation forecasts. And, among those, who react by increasing the inflation and output forecast in response to the increase in the target, the percentage decreases in the postshock phase. In the environment in which most participants respond negatively to the increases in the inflation target, it is hard for those who want to respond in the same direction with their forecasts to maintain this sort of behaviour. They might realize that, if everyone did the same, everybody would be better off, and try to do so. But, eventually, given that the majority forecasts in the opposite direction, they give up following the target themselves.

The assumption that underlines our implementation of inflation targeting rules is that agents form rational expectations which is necessary for the inflation targeting policy to be credible and successful. However, we know that in experimental economies participants do not start out with rational expectations. The question is whether they learn to forecast as if they form rational expectations. If they do, and do so fast enough, the inflation targeting policies could turn out to be successful in mitigating the bad outcomes related to the liquidity trap. However, if they this does not happen fast enough, these policies loose their power to guide these economies out of the traps. On the other hand, the policy of government spending appears to be more successful probably because it requires a lesser degree of learning and coordination of expectations.

Our results are in line with the results obtained in the macro literature where agents learn using an econometric model. This work (see Preston, 2008) shows that in case that that agents are adaptive and the monetary authority does not have a full knowledge of the economy, in other words, operates under the assumption that agents are rational, inflation targeting policies frequently lead to divergent learning dynamics. [8] However, price-targeting policy is robust to this lack of knowledge on the part of the monetary authority and the convergence of the learning dynamics occurs for a wide range of the parameter values. In other words, stabilization policy is best implemented by controlling the path of the price level rather than the inflation rate. Our future research will focus on the price targeting policies in our experimental environments in order to see whether these policies are more successful in combating liquidity traps.

[8]Note this is not the case if the monetary authority has a complete knowledge of private agents' learning behaviour.

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Appendix

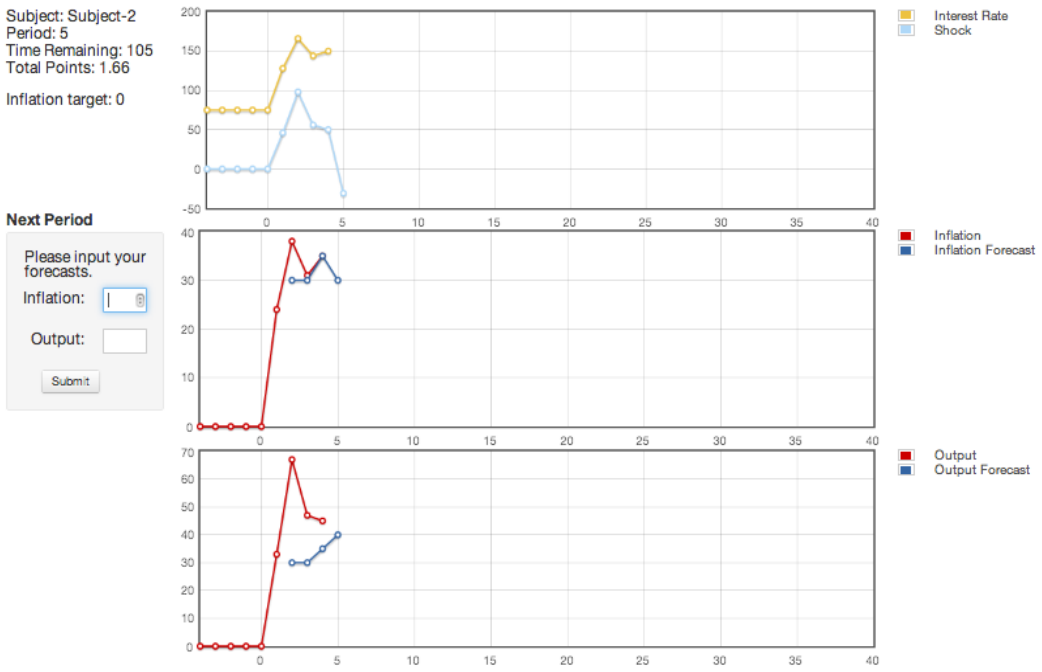


Figure 12: Constant Target Treatment Screenshot

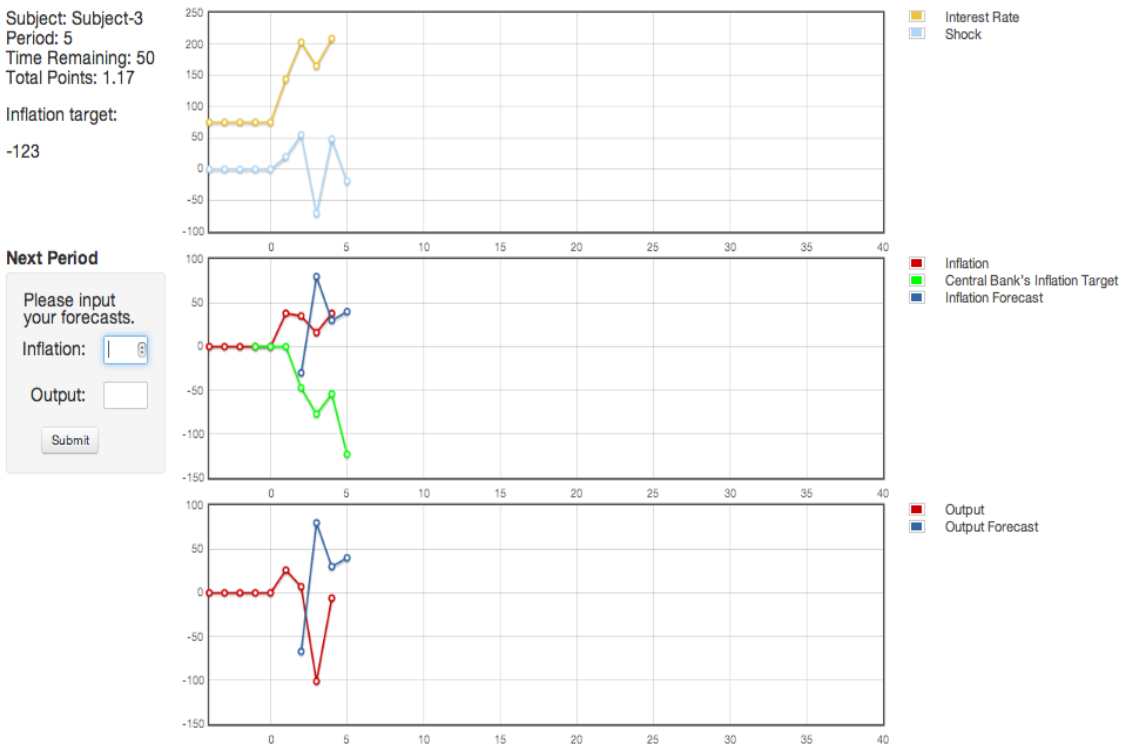


Figure 13: State Dependent Target Treatment Screenshot

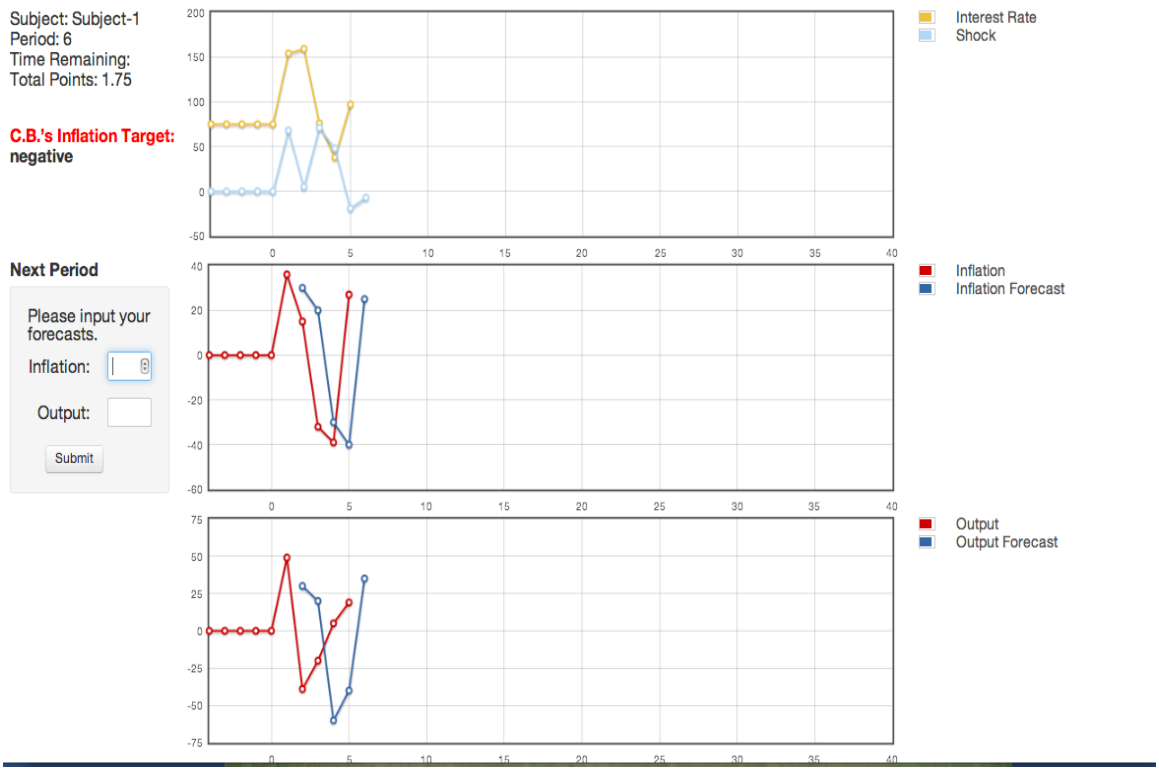


Figure 14: Directional State Dependent Target Treatment Screenshot

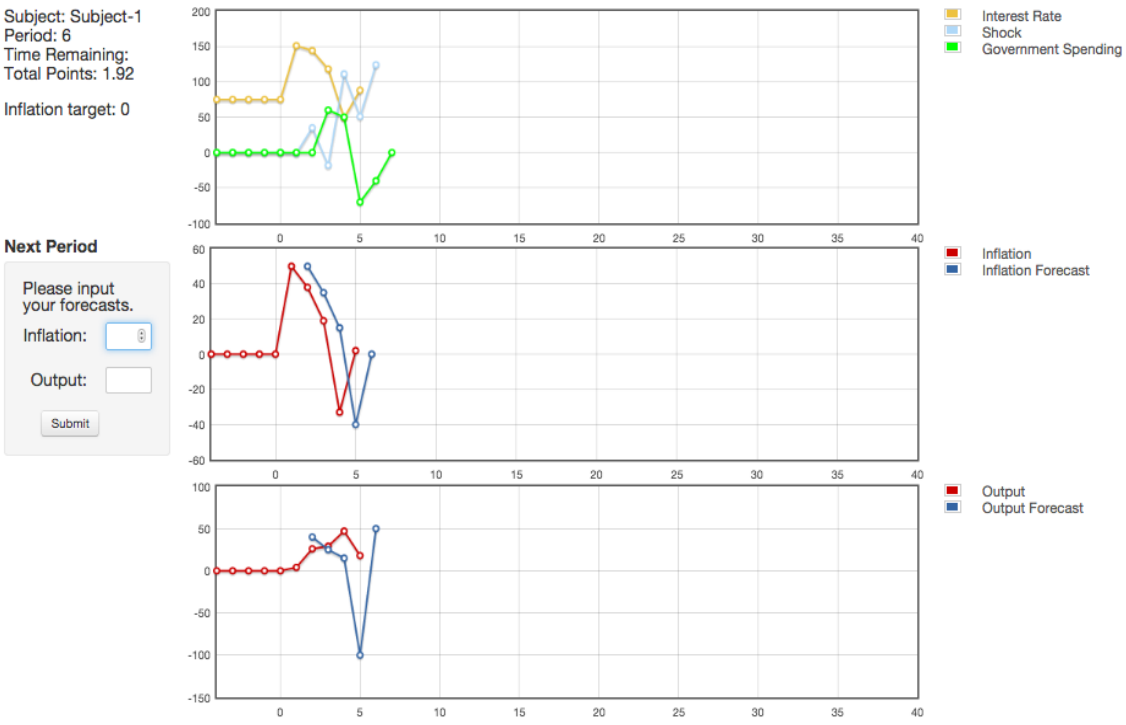
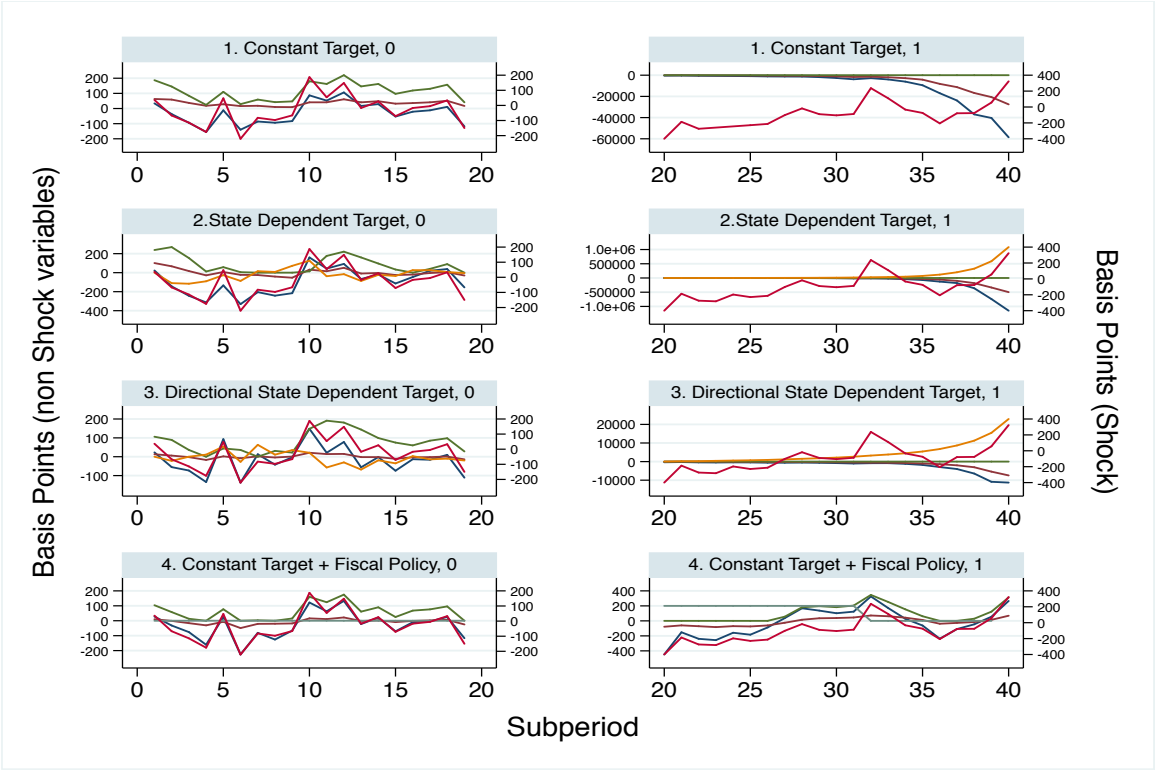


Figure 15: Fiscal Policy Treatment Screenshot

(a) Sequence 1, Repetition 1



(b) Sequence 1, Repetition 2

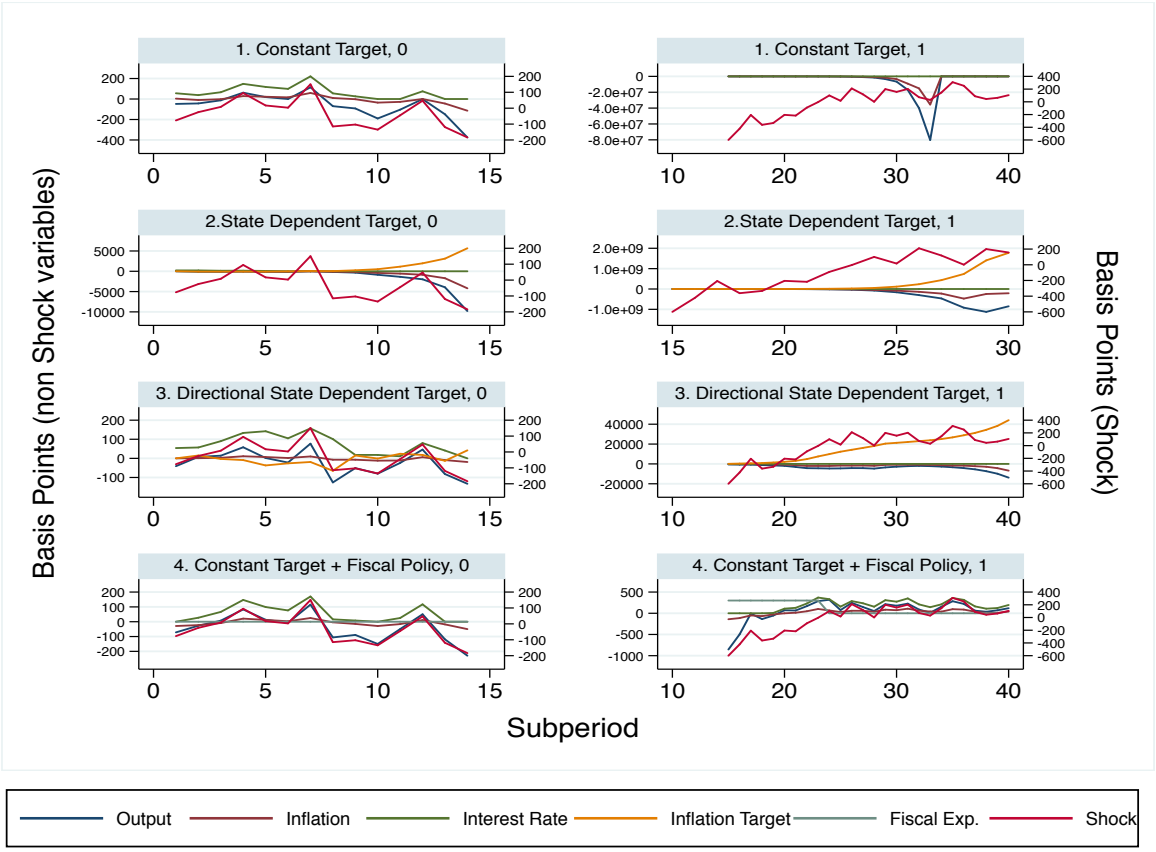
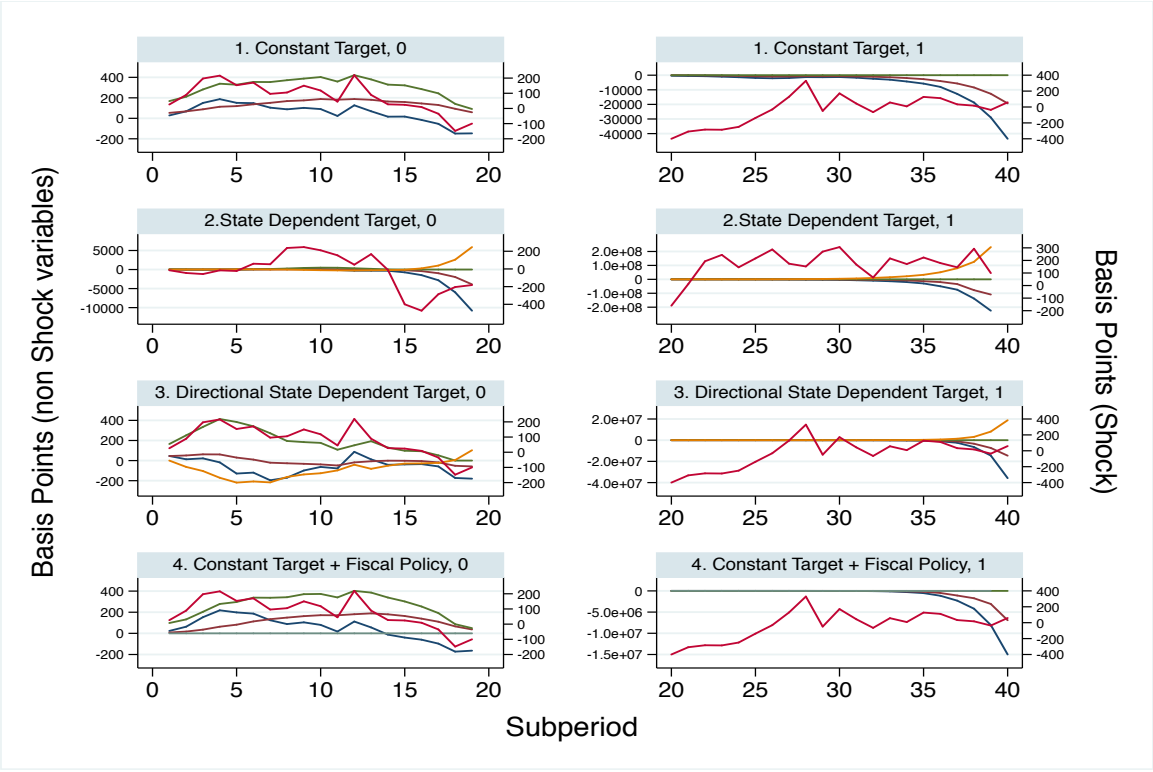


Figure 16: Time series data, Pre and Post shock

(a) Sequence 2, Repetition 1



(b) Sequence 2, Repetition 2

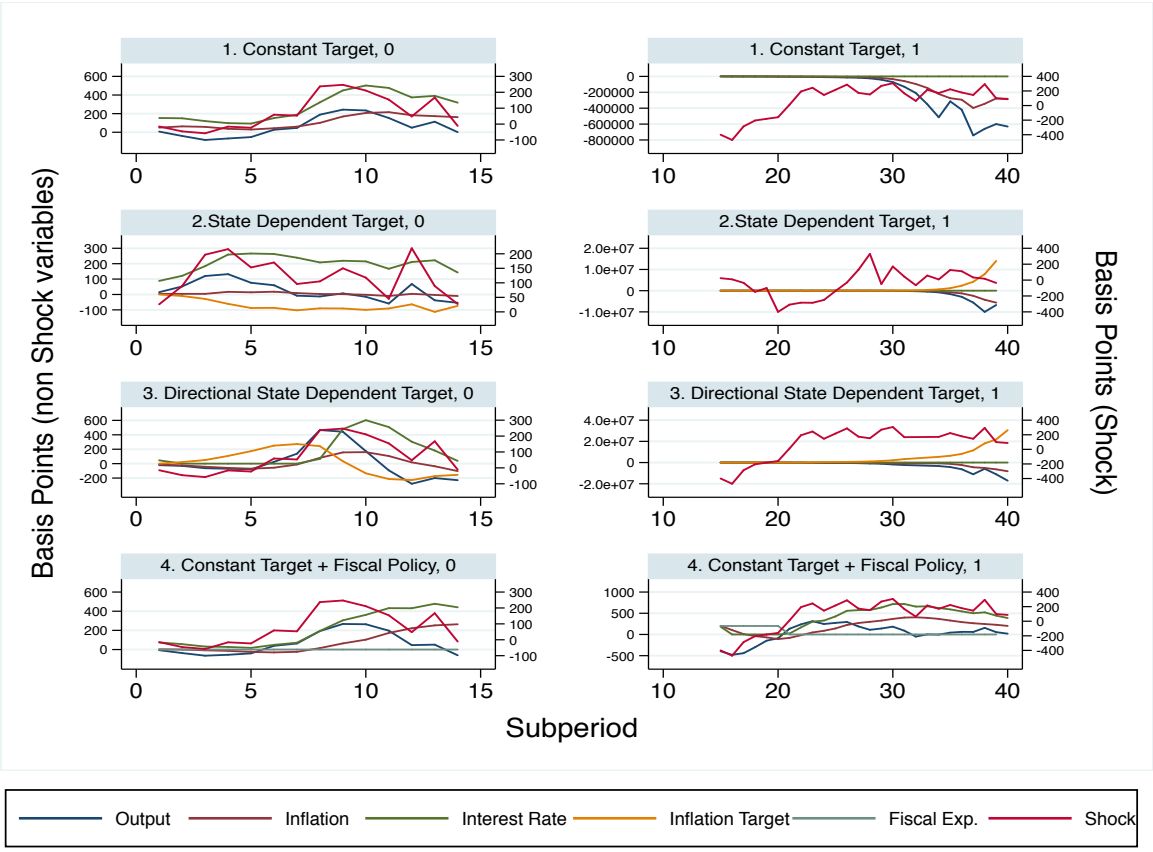
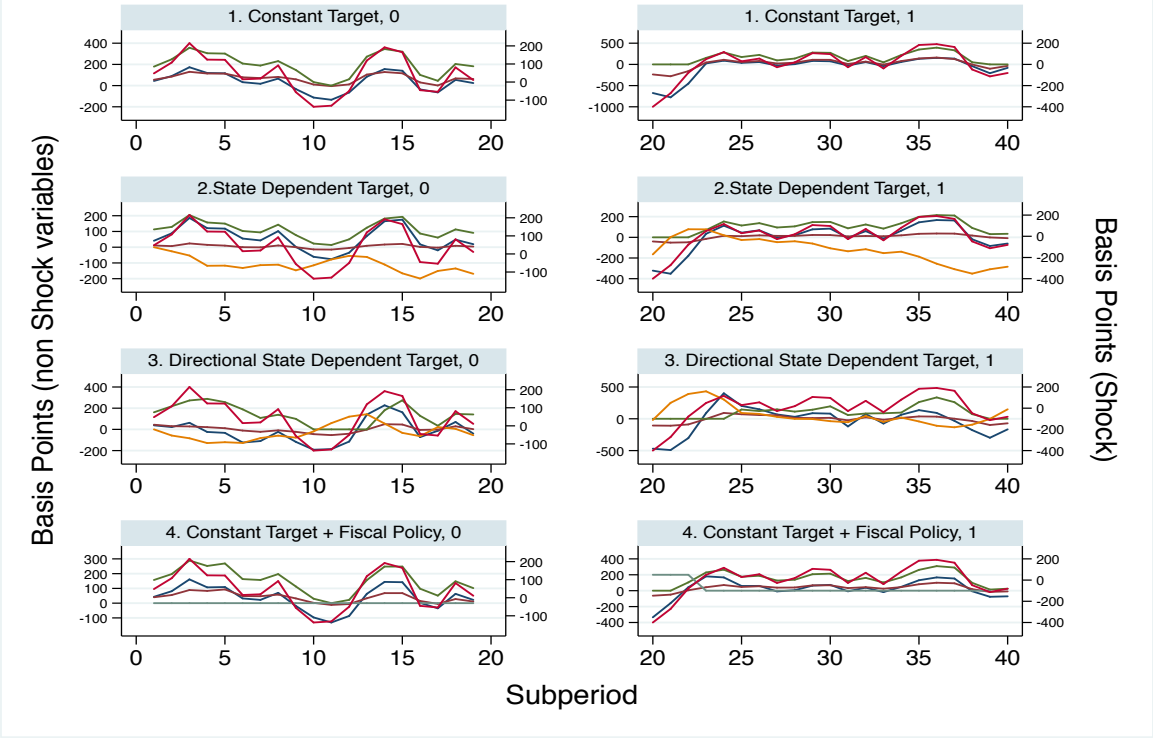


Figure 17: Time series data, Pre and Post shock

(a) Sequence 3, Repetition 1



(b) Sequence 3, Repetition 2

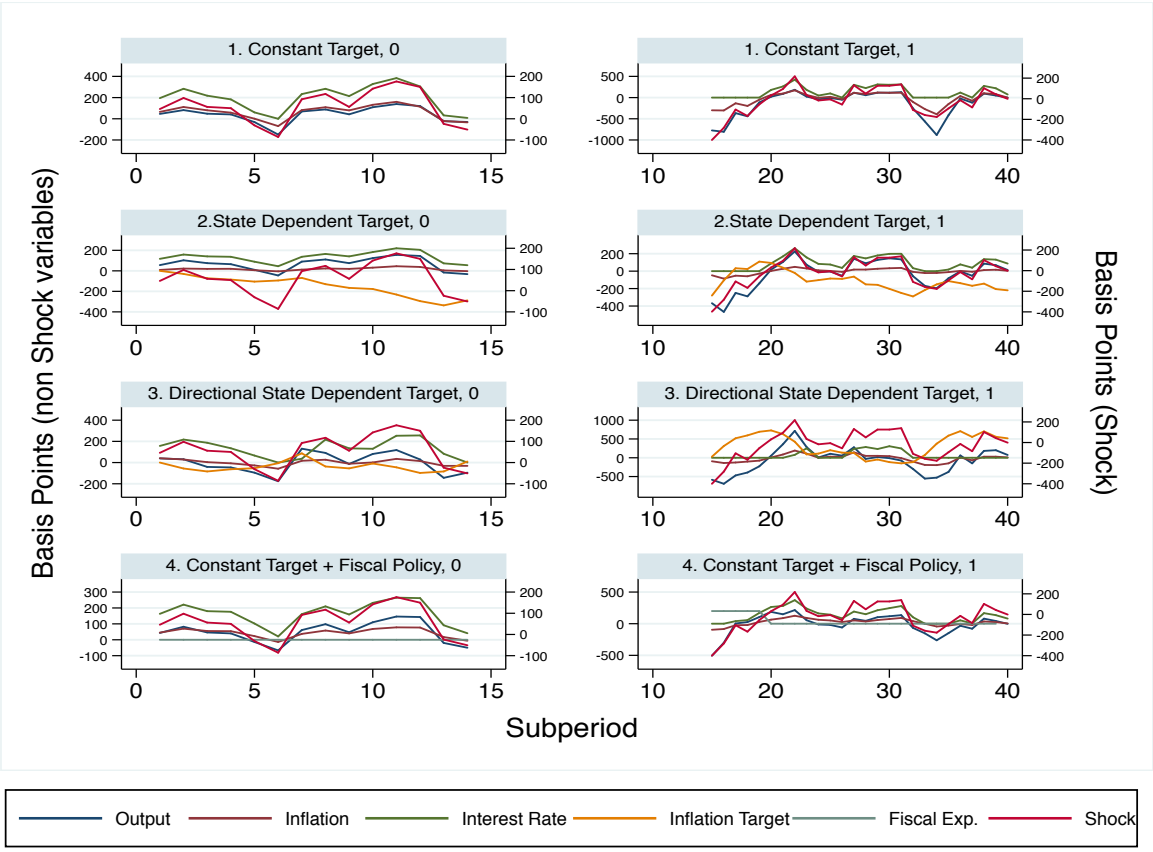
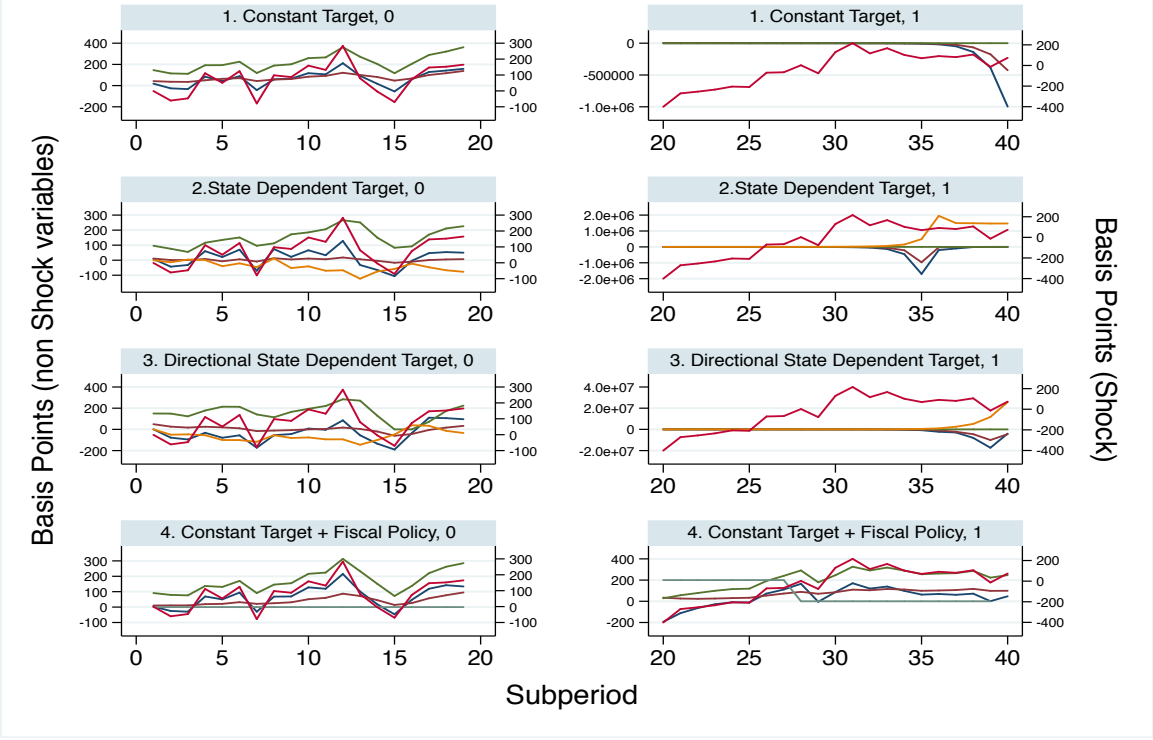


Figure 18: Time series data, Pre and Post shock

(a) Sequence 4, Repetition 1



(b) Sequence 4, Repetition 2

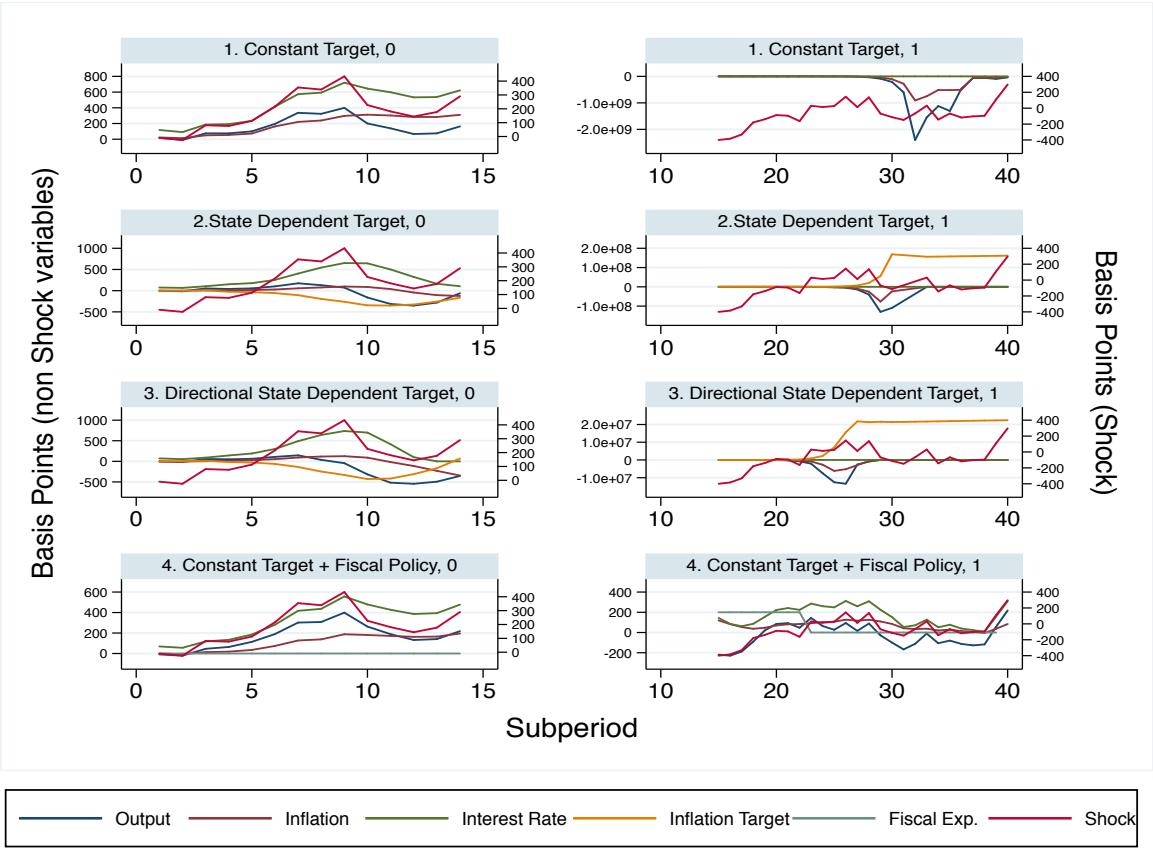
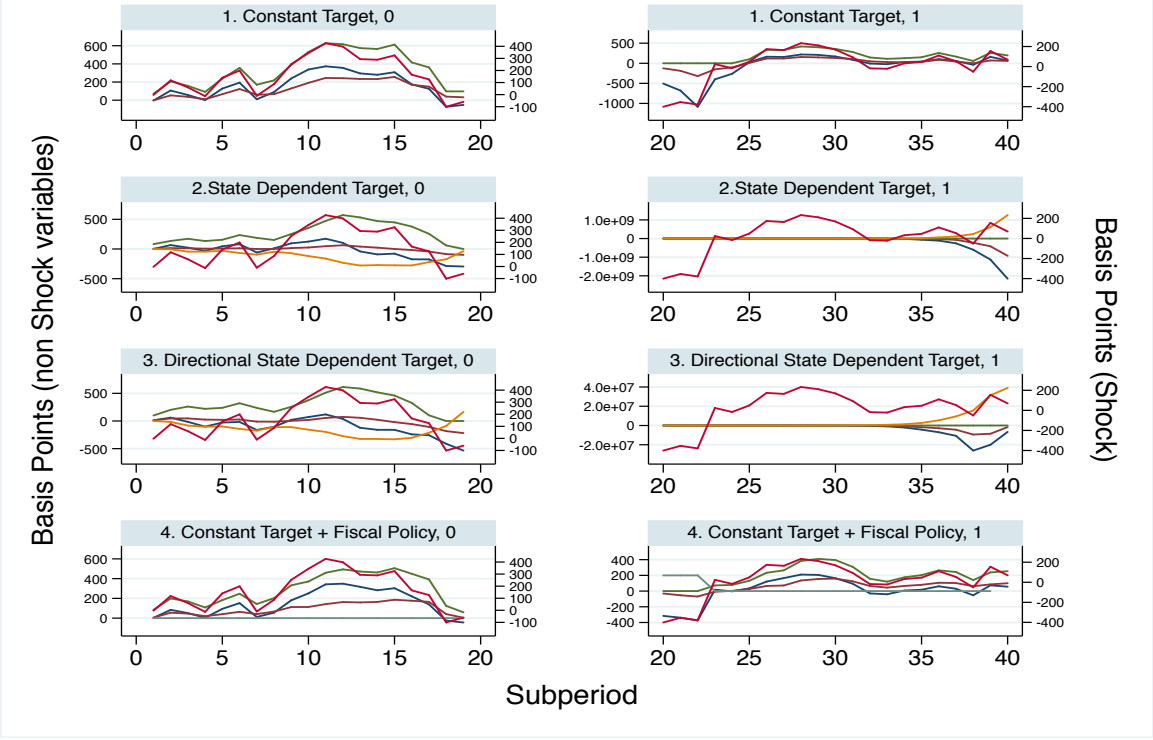


Figure 19: Time series data, Pre and Post shock

(a) Sequence 5, Repetition 1



(b) Sequence 5, Repetition 2

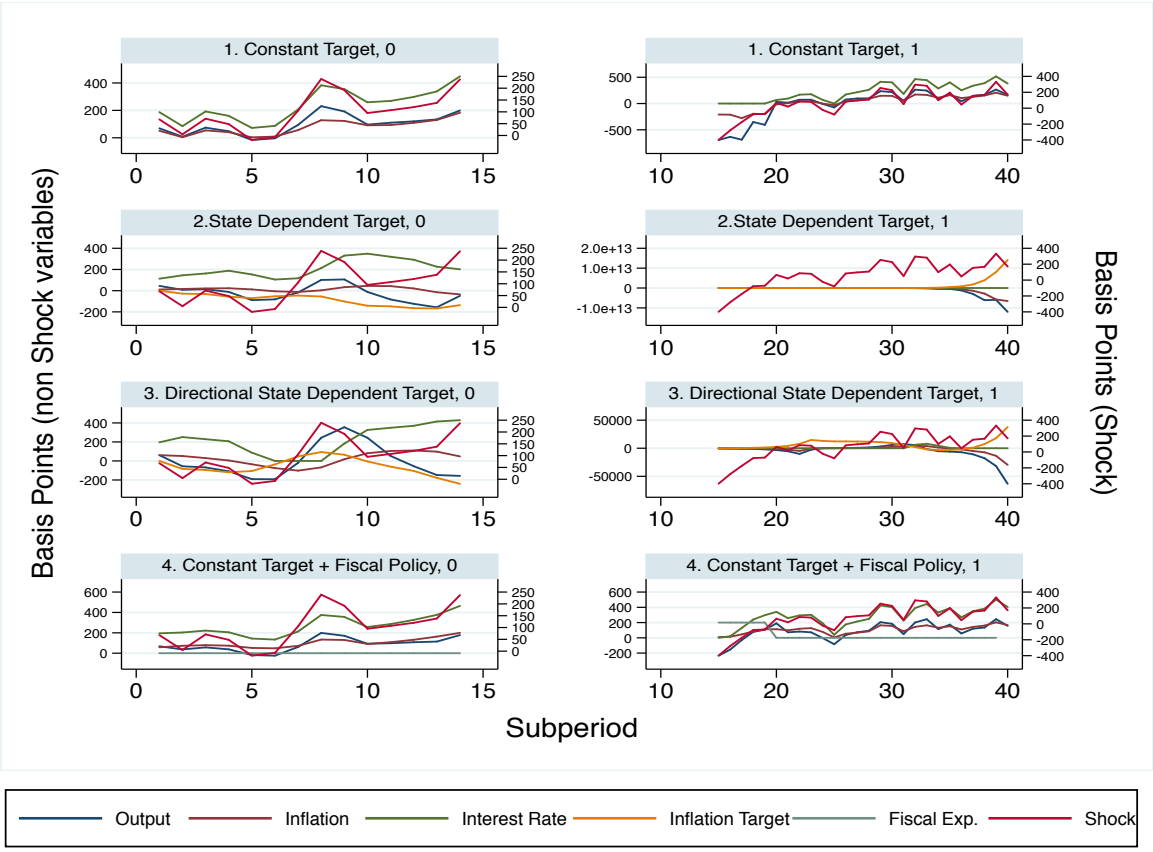
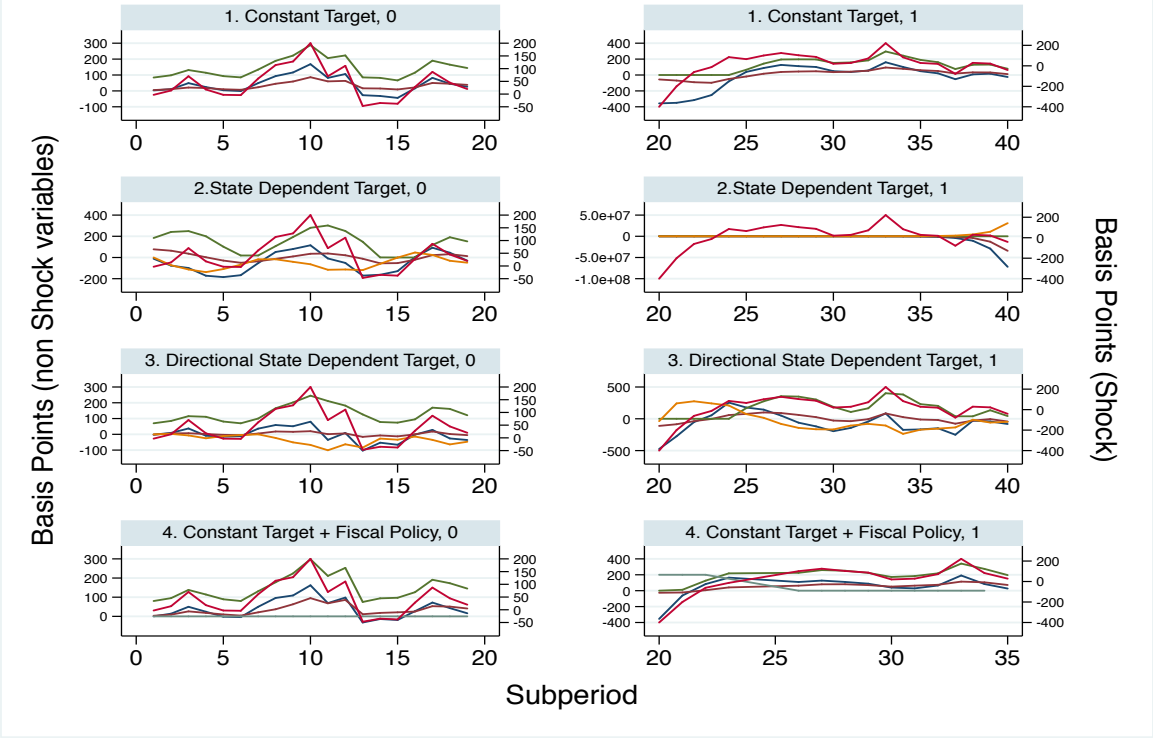


Figure 20: Time series data, Pre and Post shock

(a) Sequence 6, Repetition 1



(b) Sequence 6, Repetition 2

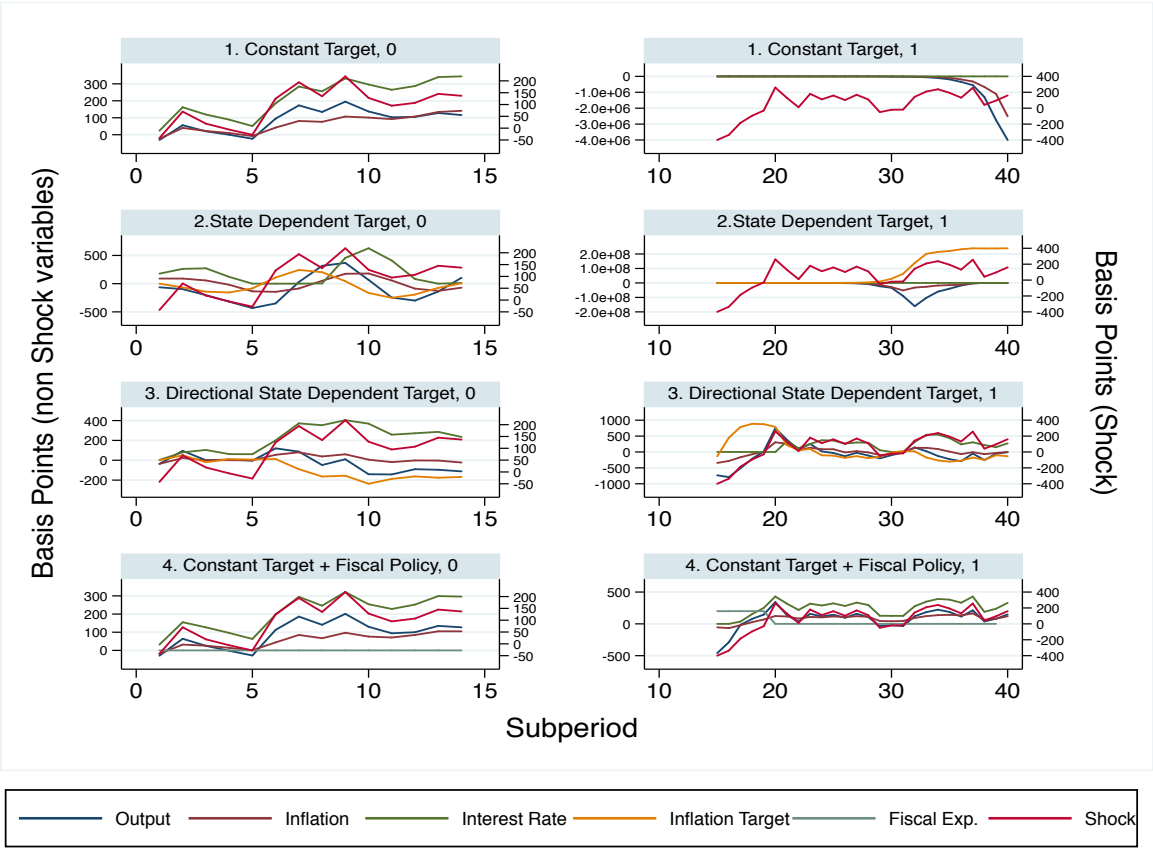


Figure 21: Time series data, Pre and Post shock

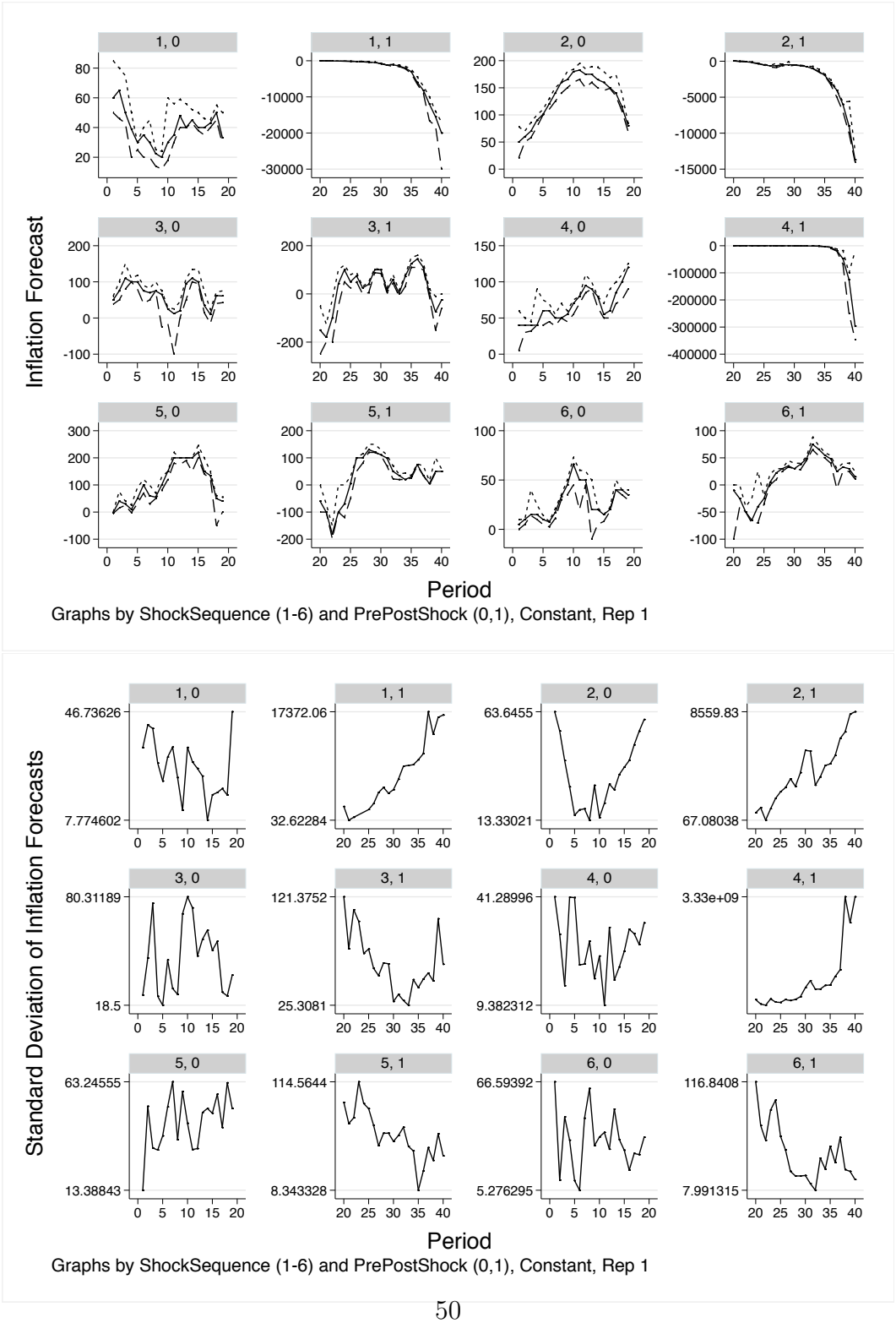


Figure 22: Distribution of Inflation Forecasts (25th, 50th, and 75th percentile and standard deviation), Constant Rep 1

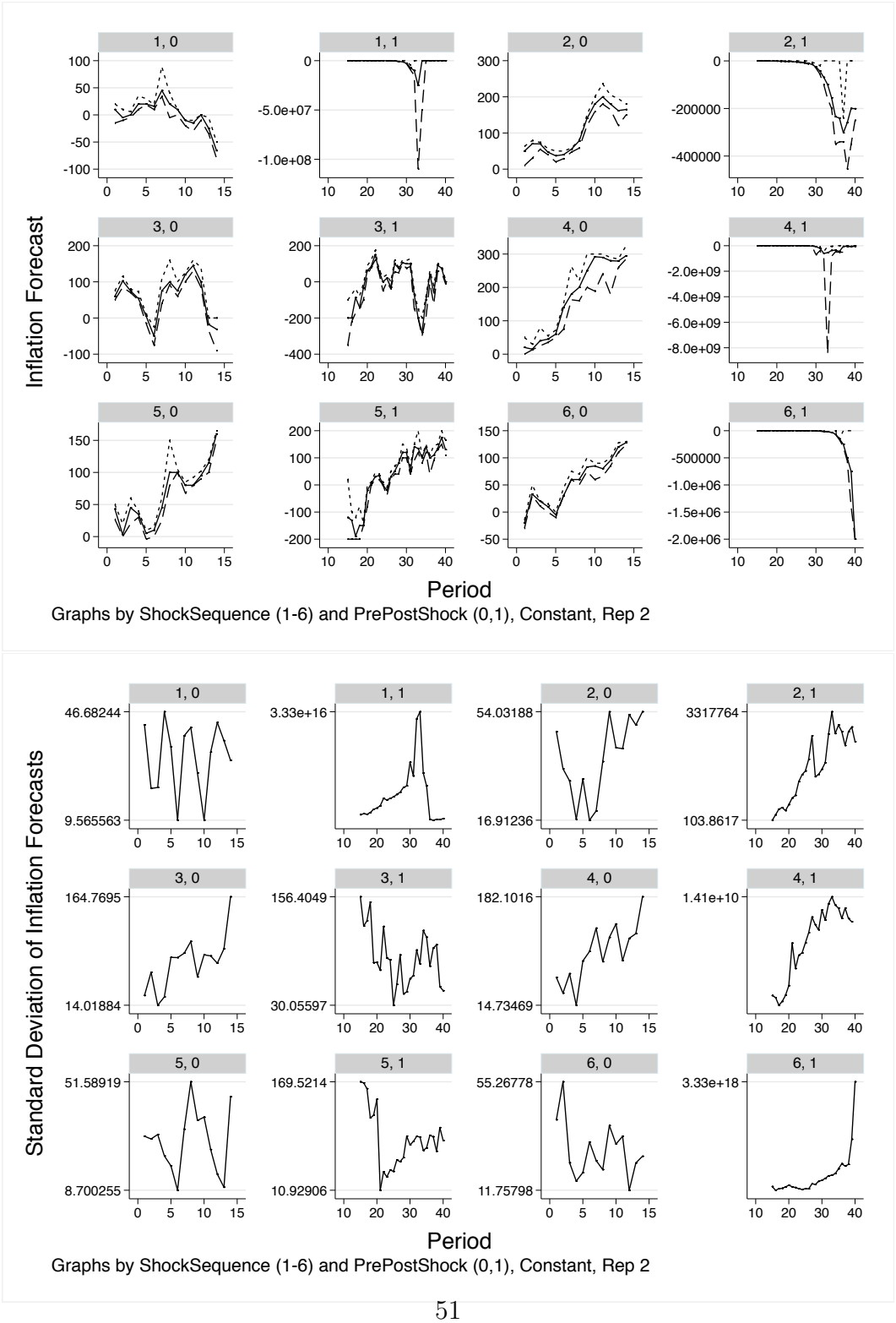


Figure 23: Distribution of Inflation Forecasts (25th, 50th, and 75th percentile and standard deviation), Constant Rep 2

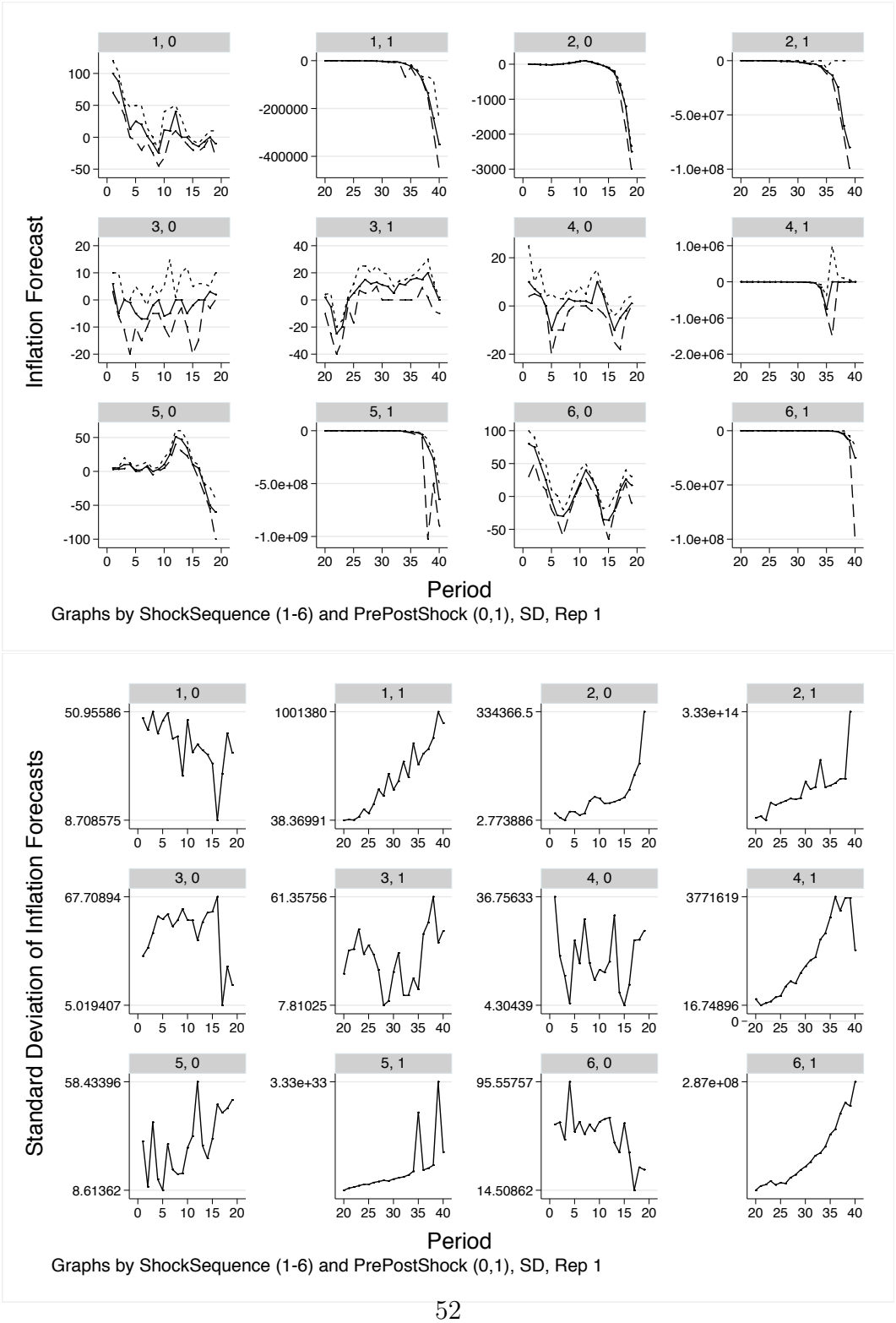


Figure 24: Distribution of Inflation Forecasts (25th, 50th, and 75th percentile and standard deviation), SD Rep 1

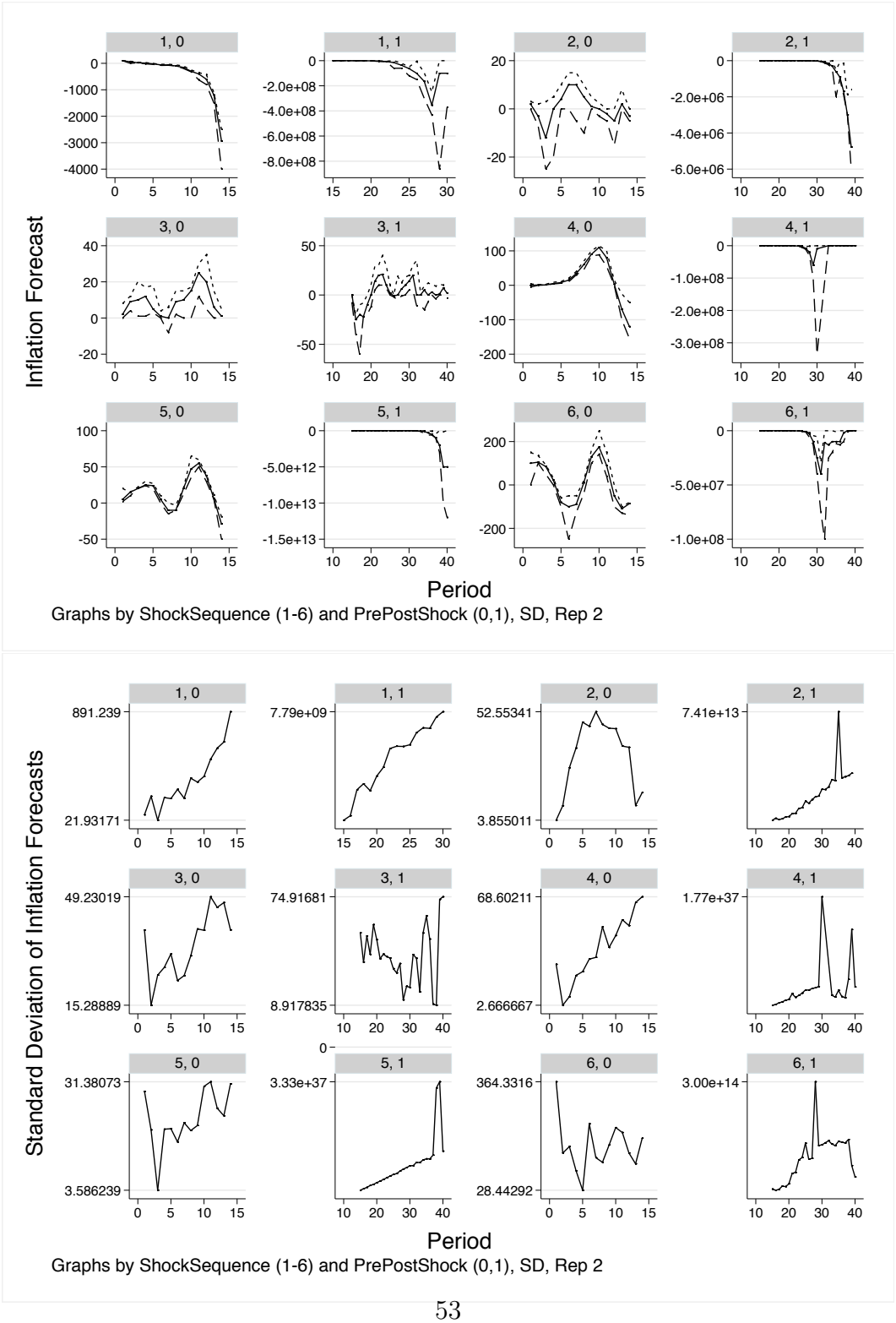


Figure 25: Distribution of Inflation Forecasts (25th, 50th, and 75th percentile and standard deviation), SD Rep 2

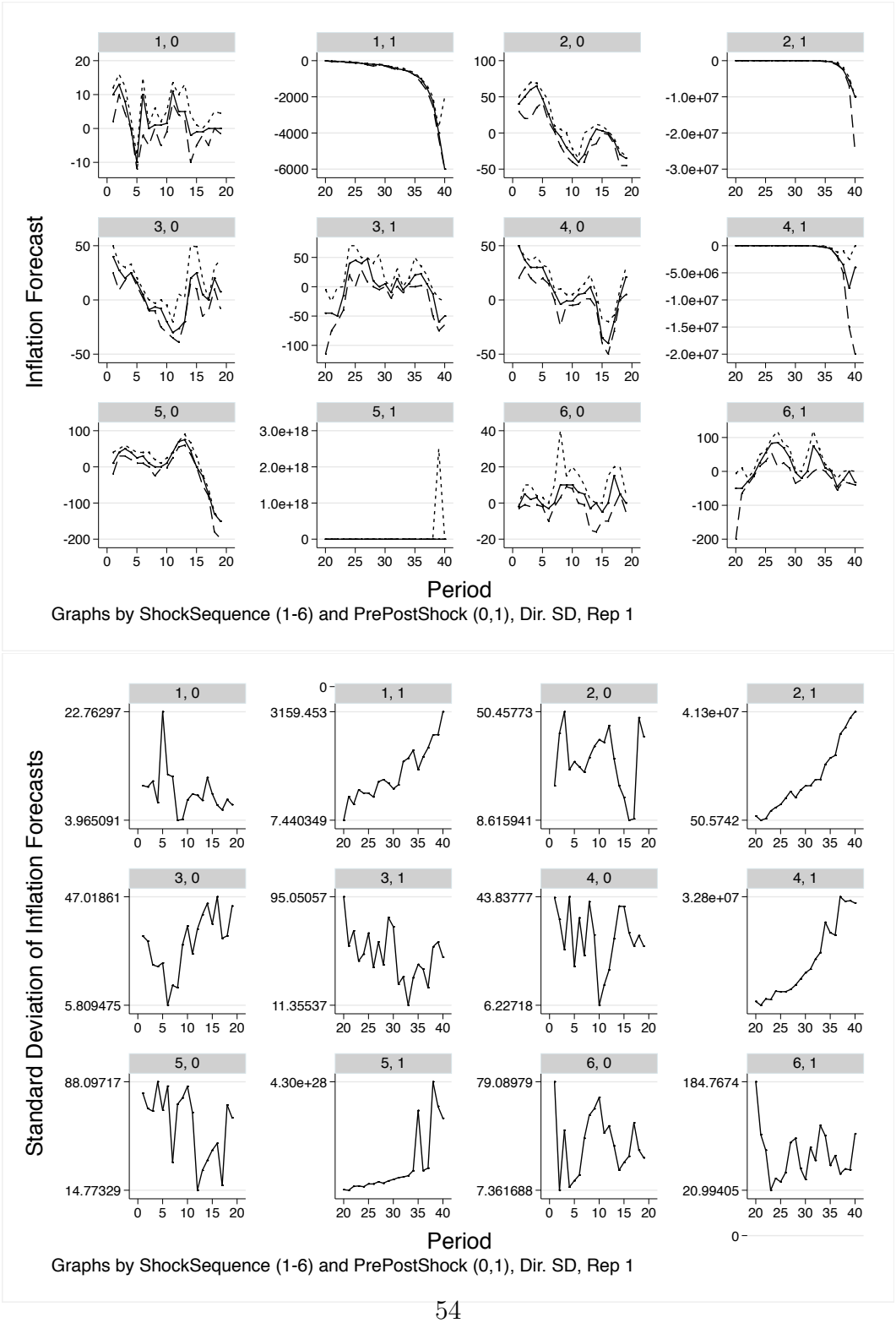


Figure 26: Distribution of Inflation Forecasts (25th, 50th, and 75th percentile and standard deviation), Dir. SD Rep 1

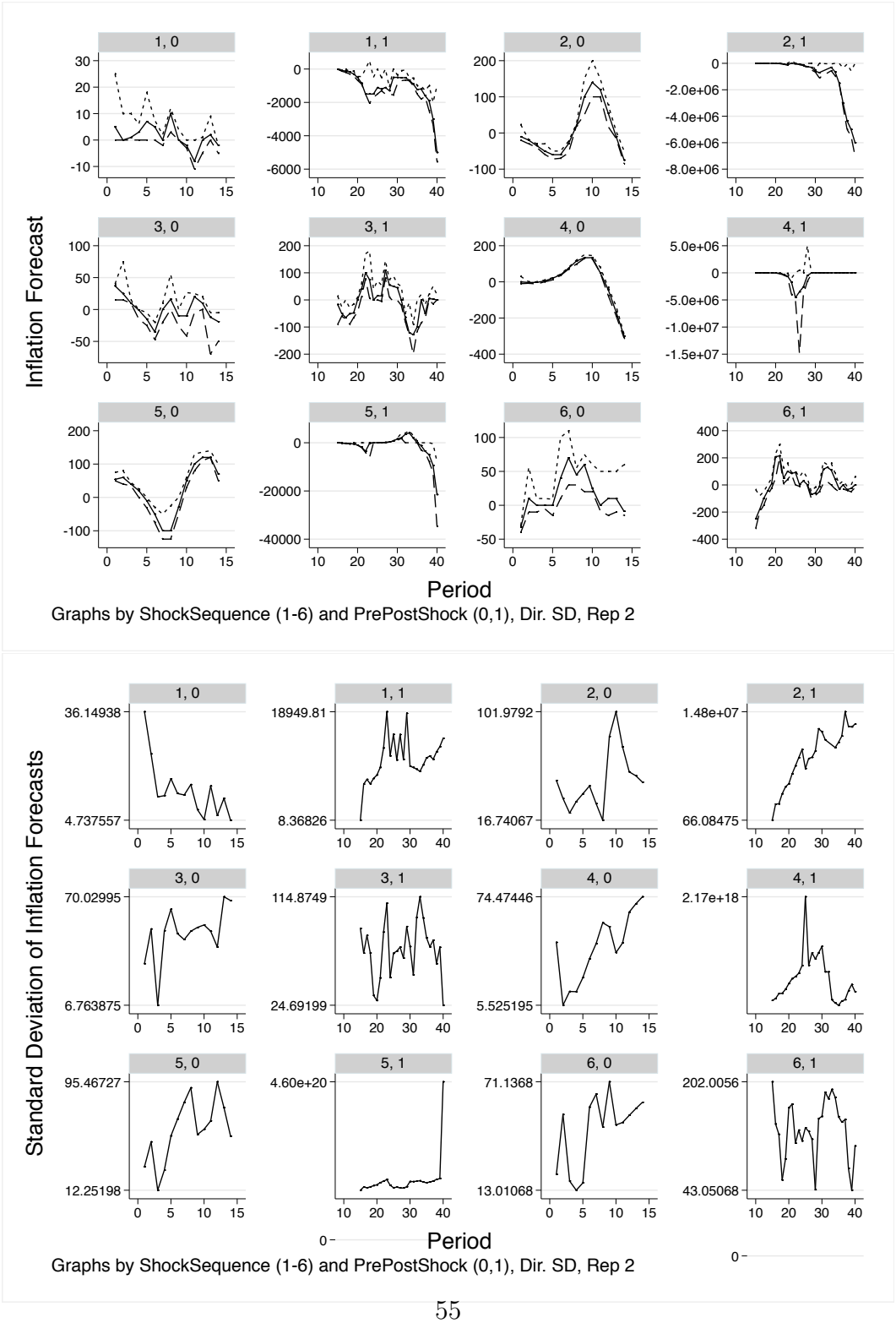


Figure 27: Distribution of Inflation Forecasts (25th, 50th, and 75th percentile and standard deviation), Dir. SD Rep 1

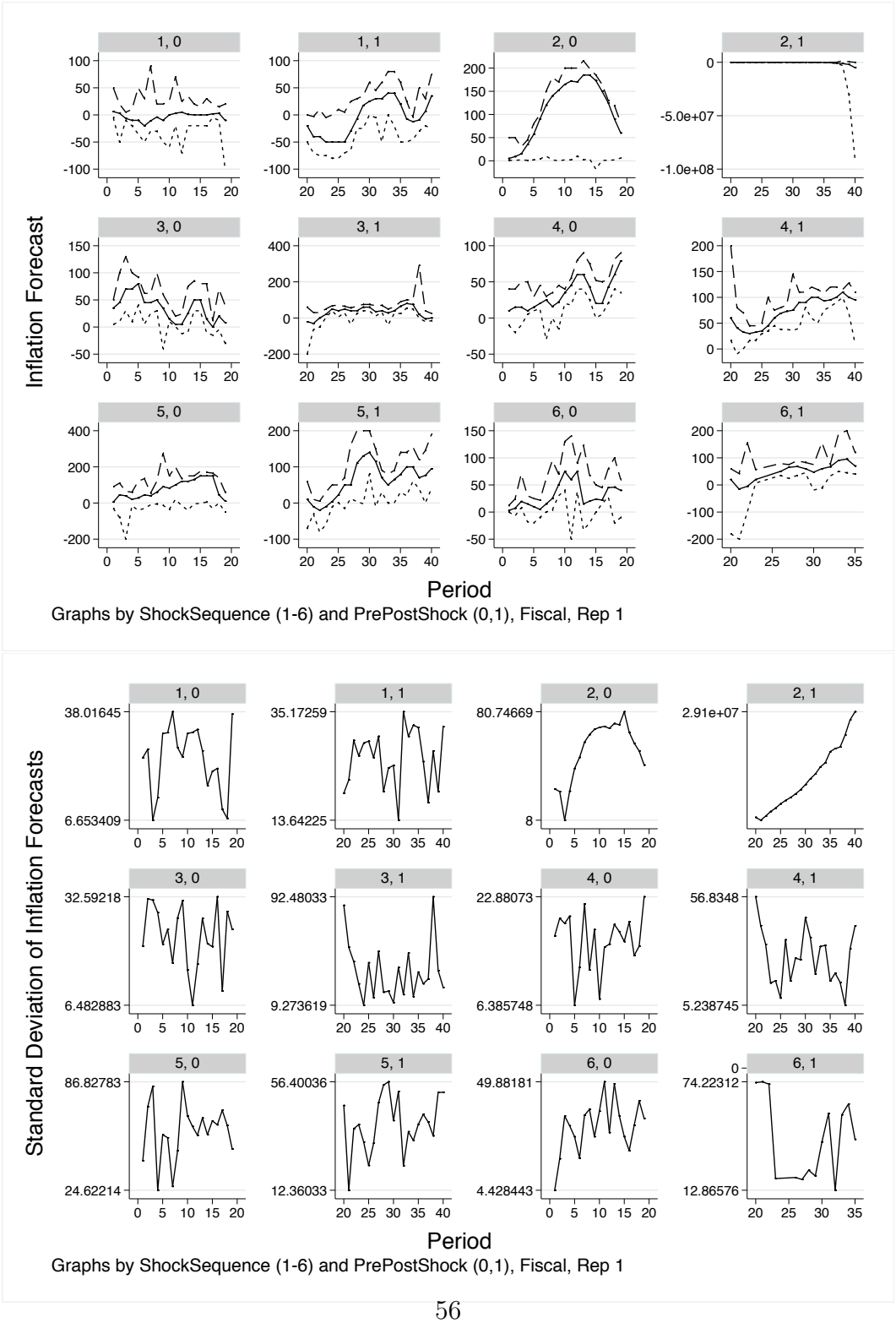


Figure 28: Distribution of Inflation Forecasts (25th, 50th, and 75th percentile and standard deviation), Fiscal Rep 1

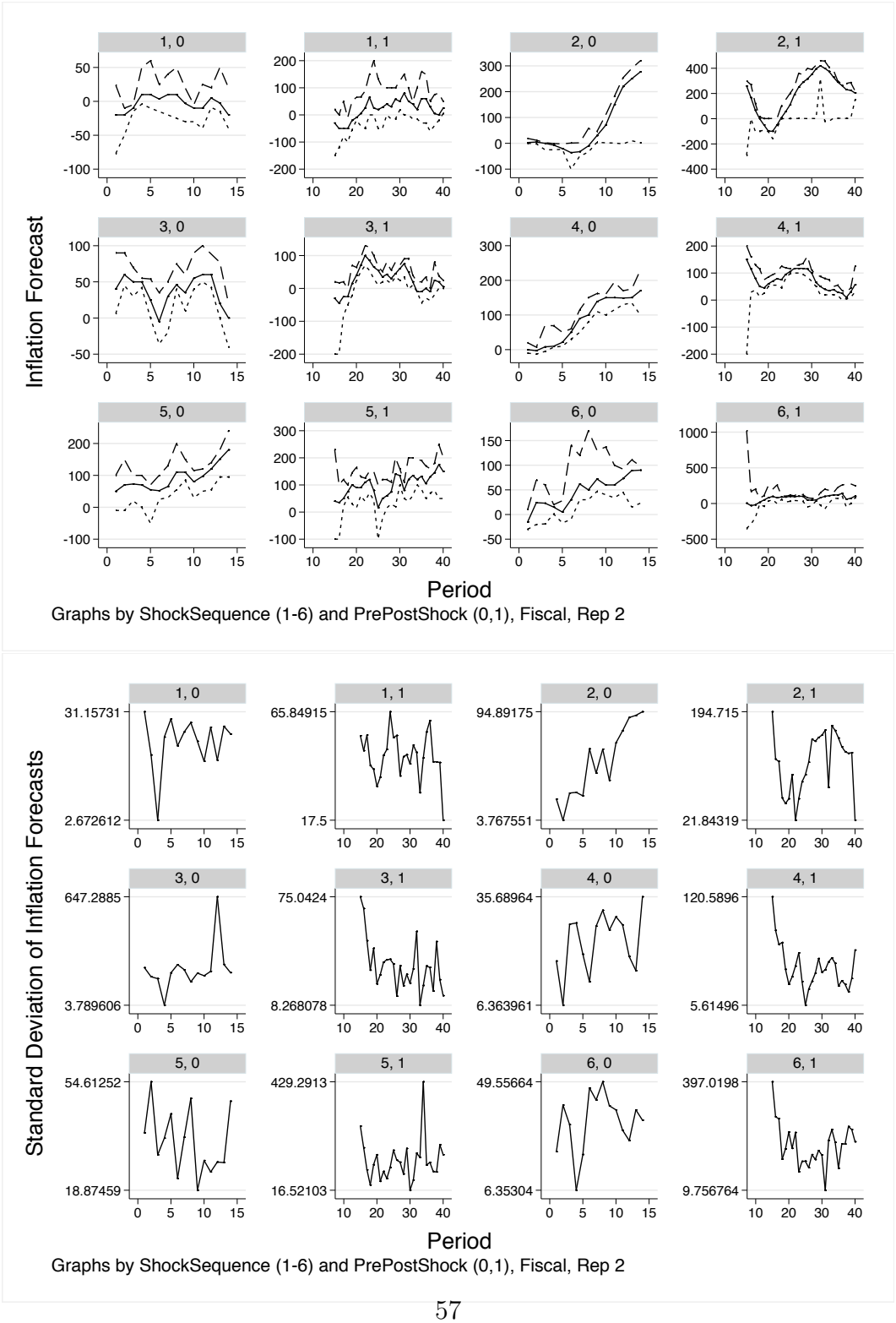


Figure 29: Distribution of Inflation Forecasts (25th, 50th, and 75th percentile and standard deviation), Fiscal Rep 2