Online Appendix for A horse race of monetary policy regimes: An experimental investigation*

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This appendix provides the following supplementary materials.

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A. Instructions

We provide all the common instructions and indicate where the instructions differed across treatments.

1. Inflation Targeting
2. Dual Mandate
3. Average Inflation Targeting - 4 period ahead horizon
4. Average Inflation Targeting - 10 period ahead horizon
5. Price Level Targeting
6. Nominal GDP Level Targeting

Experimental Instructions

Welcome! You are participating in an economics experiment at SFU Experimental Economics Lab. In this experiment you will participate in the experimental simulation of the economy. If you read these instructions carefully and make appropriate decisions, you may earn a considerable amount of money that will be immediately paid out to you in cash at the end of the experiment.

Each participant is paid CDN$7 for attending. Throughout this experiment you will also earn points based on the decisions you make. Every point you earn is worth $0.50. We reserve the right to improve this in your favour if average payoffs are lower than expected.

During the experiment you are not allowed to communicate with other participants. If you have any questions, the experimenter will be glad to answer them privately. If you do not comply with these instructions, you will be excluded from the experiment and deprived of all payments aside from the minimum payment of CDN $7 for attending.

The experiment is based on a simple simulation that approximates fluctuations in the real economy. Your task is to serve as private forecasters and provide real-time forecasts about future output and inflation in this simulated economy. The instructions will explain what output, inflation, and the interest rate are and how they move around in this economy, as well as how they depend on forecasts. We will allow you to practice making forecasts for several unpaid periods before we begin paid periods in this experiment. You will then participate in 50 paid periods.

In this simulation, households and firms (whose decisions are automated by the computer) will form forecasts identically to yours. So to some degree, outcomes that you will see in the game will depend on the way in which you form your forecasts. Your earnings in this experiment will depend on the accuracy of your individual forecasts.

On the next page we will discuss what inflation and output are, and how to predict them. All values will be given in basis points, a measurement often used in descriptions of the economy. All values can be positive, negative, or zero at any point in time.

Your task

Your task in this experiment is to forecast future output and inflation as correctly as possible. You will submit forecasts for the next period's inflation and output, measured in basis points:

- 1% = 100 basis points
- 3.25% = 325 basis points
- -0.5% = -50 basis points
- -4.8% = -480 basis points

These are just a handful of examples of how basis points work. You can submit any forecast you wish, positive or negative or zero, but please only submit integers.

How the economy evolves

We will now explain the factors that influence output and inflation and the relationships between the different variables in the economy.

The economy consists of six main variables: shocks, inflation, output, interest rate, price level and nominal output. Each period, you will receive the following information that will help you make forecasts.

Current Shock

A shock is a random "event" that directly affects how much people want to spend, and consequently, how much will be produced.

The shocks change every period and are influenced by a random component and past shocks.

More precisely, the shocks that you observe will follow the process specified in your instructions.

At any time period *t*, the shock is calculated as follows:

$$Shock_t = 60 + 0.8(Shock_{t-1}) + Random\ Component_t$$

- The random component is 0 on average, and has a standard deviation of 93 basis points.
- Roughly 2/3rds of the time, the shock is between -155 and +155 basis points
- 95% of the time, the shock will be between -310 and +310 basis points

Intuitively, you can think of the shocks as weather shocks. Over the long run, the weather has no effect on how much consumers want to buy. However, from day to day, there may be random changes to the weather. You can think of a positive shock as unexpectedly nice weather. When the weather is especially nice, consumers are spending more time out of their homes and increasing their expenditures (for example, buying ice cream, going out for a nice dinner, going to the beach). A negative shock can be thought of unexpectedly terrible weather, where no one wants to leave their homes, causing expenditures to be relatively low. Gradually, the shocks, like weather, will revert back to their long-run levels. As the shocks dissipate, new random events occur that will make consumers want to increase or decrease their expenditures.

Consider the following examples:

$Shock_1 = 30$

$Shock_2 = 60 + 30 * 0.8 + Random\ Component_2$

$= 60+24 + Random\ Component_2$

$Shock_2 = 84 + (-150)$

$= -66$

$Shock_3 = \ldots$

Each period, you and the other forecasters will be submitting your beliefs about the following period's output and inflation. The median of each of the forecasts will be employed as the aggregate forecast in the given period and play an important role in determining the current level of output and inflation. The median, rather than the average forecast, is used so that a small number of subjects cannot have a significant effect on the economy.

Output

Output refers to a measure of the quantity of goods the economy is over- or under producing in a given period.

At any time period *t*, output is calculated as follows:

$$Output_t = Median\ Forecast\ of\ output_{t+1} + Median\ Forecast\ of\ inflation_{t+1} - Interest\ Rate_t + Shock_t$$

The value of today's output is determined by the median expectations (forecasts) of tomorrow's output and inflation, as well as today's shock and interest rate. If you, the forecasters, predict that the future economy will be producing more output and there will be more inflation, consumers will want to spend more in the current period. Firms will then produce more to meet consumer demand.

Likewise, positive shocks to consumer demand will have a positive effect on how much will be produced.

Increases in the nominal interest rate will make it more expensive for consumers to borrow and will create more incentive for them to save. With higher interest rates, consumers will decrease their demand for goods, leading to lower production, which will indirectly reduce inflation.

Inflation

Inflation is the rate at which overall prices change between two periods.

At any time period *t*, inflation is calculated as follows:

$$Inflation_t = 0.998(Median\ Forecast\ of\ Inflation_{t+1}) + 0.125(Output_t)$$

Inflation is determined largely by your forecast about future inflation. The idea behind this is simple: If you, the professional forecasters, communicate to the public that inflation is likely to rise in the future, consumers will spend more immediately to avoid paying relatively higher prices (positive inflation) in the future. This increase in demand will cause prices to start rising, i.e. current inflation will increase.

Current output will also have a small positive effect on current inflation. Importantly, variables that affect output will also have a small positive effect on inflation.

You will also have information about other macroeconomic variables that evolve over time.

Price level

The price level is an index measuring the price of output in the economy. The price level evolves with the rate of inflation:

$$Price\ Level_t = Price\ Level_{t-1} + Inflation_t$$

When inflation is positive, the price level increases. When inflation is negative, the price level declines. The price level is shown as an index with a starting value of 1000.

Example 1. Suppose the price level in the previous period is 1000. The inflation rate in the current period is 200 basis points. The price level in the current period is:
Price level = 1000 + 200 = 1200.

Example 2. Instead, suppose the inflation rate in the current period is -200 basis points. The price level in the current period is
Price level = 1000 – 200 = 800.

Nominal output level

The nominal output level is the nominal value of output in the experimental economy. The nominal output level evolves with both output and inflation over time:

$$Nominal\ Output\ Level_t = Output_t + Price\ Level_t$$

The nominal output level is higher when output (production) and the price level are higher, and vice versa. Nominal output is shown as an index with a starting value of 1000.

INFLATION TARGETING TREATMENT

Central Bank Policy

The main objective of the central bank in this experiment is to keep the nominal output level at its target level. The target for nominal output is 1000. The central bank sets the interest rate to bring nominal output to its target.

Interest Rate

The interest rate is the rate at which consumers and firms borrow and save in this experimental economy.

The interest rate responds to the distance between the current inflation rate and its target zero. The interest rate also responds to deviations of output from 0 as they are linked to deviations of inflation from its target. The response to output is much weaker than the response to inflation as output is not the principal target of the Central Bank's policy

At any time period *t*, the interest rate is calculated as follows:

$$\begin{aligned} \textit{Interest Rate}_t &= 60 + 1.5(\textit{Inflation}_t - 0) + 0.125(\textit{Output}_t - 0) && \textit{if Interest Rate}_t > 0 \\ &= 0 && \textit{otherwise} \end{aligned}$$

When inflation is high and above its target of 0 basis points, the central bank will increase interest rates more than one-for-one with inflation. The central bank will also increase interest rate, though less aggressively, in response to positive output. When inflation is further above its target, the increase in the interest rate is larger.

The increase in the interest rate has a direct negative effect on consumer demand and output, and an indirect negative effect on inflation. *When inflation is above target, a higher interest rate leads to lower inflation and thus helps bring it back towards its target.*

When inflation is below the target of 0 basis points, the central bank will decrease interest rates more than one-for-one with negative inflation. The central bank will also decrease the interest rate in response to negative output, though less aggressively. When inflation is further below its target, the decrease in the interest rate is larger.

Lower interest rates have a direct positive effect on consumer demand and output, and an indirect positive effect on inflation. *When inflation is below target, a lower interest rate leads to higher inflation and thus helps bring it back towards its target.*

It is also important for you to realize that, even though the central bank is aiming for inflation at its target of zero, it may not be able to accomplish this every period because of the persistent random shocks that are occurring each period and the public's (your) expectations. However, the economy will be kept relatively more stable as a consequence of the central bank's reaction to inflation and output.

Note that the central bank cannot lower interest rates below zero. For large negative values of inflation and output, the central bank will simply set the interest rate at zero.

You will not observe the current interest rate when you are forming your forecast about the following period's inflation and output. After you submit your forecasts, the computer will simultaneously solve for the current period's inflation, output and interest rate taking into consideration the forecasts and the realized shock.

DUAL MANDATE TREATMENT

Central Bank Policy

The main objective of the central bank in this experiment is to keep the inflation rate and output at their targets. The inflation target is equal to 0 basis points. The target for output is 0 basis points as well. The central bank sets the interest rate to bring the inflation rate and output to their targets.

Interest Rate

The interest rate is the rate at which consumers and firms borrow and save in this experimental economy.

The interest rate responds to the distance between the current inflation rate and its target zero. The interest rate also responds to the distance between the current output and its target zero.

At any time period *t*, the interest rate is calculated as follows:

$$\begin{aligned} \textit{Interest Rate}_t &= 60 + 4.5(\textit{Inflation}_t - 0) + 4.5(\textit{Output}_t - 0) && \textit{if Interest Rate}_t > 0 \\ &= 0 && \textit{otherwise} \end{aligned}$$

When inflation and output are high and above their targets of 0 basis points, the central bank will increase interest rates more than one-for-one with inflation and output. When inflation and output are further above their targets, the increase in the interest rate is larger.

The increase in the interest rate has a direct negative effect on consumer demand and output, and an indirect negative effect on inflation. *When inflation and output are above target, a higher interest rate leads to lower inflation and output and thus helps bring both back towards their targets.*

When inflation and output are low and below their targets of 0 basis points, the central bank will decrease interest rates more than one-for-one with negative inflation and output. When inflation and output are further below their target, the decrease in the interest rate is larger.

Lower interest rates have a direct positive effect on consumer demand and output, and an indirect positive effect on inflation. *When inflation and output are below target, a lower interest rate leads to higher inflation and output and thus helps bring both back towards their targets.*

It is also important for you to realize that, even though the central bank is aiming for inflation at its target of zero, it may not be able to accomplish this every period because of the persistent random shocks that are occurring each period and the public's (your) expectations. However, the economy will be kept relatively more stable as a consequence of the central bank's reaction to inflation and output.

Note that the central bank cannot lower interest rates below zero. For large negative values of inflation and output, the central bank will simply set the interest rate at zero.

You will not observe the current interest rate when you are forming your forecast about the following period's inflation and output. After you submit your forecasts, the computer will simultaneously solve for the current period's inflation, output and interest rate taking into consideration the forecasts and the realized shock.

AVERAGE INFLATION TARGETING – 4 PERIOD AND 10 PERIOD HORIZON TREATMENTs

Central Bank Policy

The main objective of the central bank in this experiment is to keep the average inflation rate over 4 (10) periods at its target. The average inflation target is equal to 0 basis points. The central bank sets the interest rate to bring the average inflation rate to its target.

Interest Rate

The interest rate is the rate at which consumers and firms borrow and save in this experimental economy.

The interest rate responds to the distance between the average inflation rate over the current and past 3 (10) periods and its target zero. The interest rate also responds to deviations of output from 0 as they are linked to deviations of inflation from its target. The response to output is much weaker than the response to inflation as output is not the principal target of the Central Bank's policy.

At any time period *t*, the interest rate is calculated as follows:

$$\begin{aligned} \textit{Interest Rate}_t &= 60 + 5.5(\textit{Average Inflation}_t - 0) + 3(\textit{Output}_t - 0) \quad \textit{if Interest Rate}_t > 0 \\ &= 0 \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad \textit{otherwise} \end{aligned}$$

where

$\textit{Average Inflation}_1 = \textit{Inflation}_1$ in Period 1

$\textit{Average Inflation}_2 = (\textit{Inflation}_1 + \textit{Inflation}_2)/2$ in Period 2

$\textit{Average Inflation}_t = (\textit{Inflation}_1 + \textit{Inflation}_2 + \textit{Inflation}_3)/3$ in Period 3

$\textit{Average Inflation}_t = (\textit{Inflation}_t + \textit{Inflation}_{t-1} + \textit{Inflation}_{t-2} + \textit{Inflation}_{t-3}) / 4$ in Periods 4+

$(\textit{Average Inflation}_t = (\textit{Inflation}_t + \textit{Inflation}_{t-1} + \textit{Inflation}_{t-2} + \ldots + \textit{Inflation}_{t-9}) / 4$ in Periods 10+)

When average inflation is high and above its target of 0 basis points, the central bank will increase interest rates more than one-for-one with average inflation. The central bank will also increase interest rate, though less aggressively, in response to positive output. When average inflation is further above its target, the increase in the interest rate is larger.

The increase in the interest rate has a direct negative effect on consumer demand and output, and an indirect negative effect on inflation. *When inflation is above target, a higher interest rate leads to lower inflation and thus helps bring average inflation back towards its target.*

When average inflation is below the target of 0 basis points, the central bank will decrease interest rates more than one-for-one with negative average inflation. The central bank will also decrease the interest rate in response to negative output, though less aggressively. When average inflation is further below its target, the decrease in the interest rate is larger.

Lower interest rates have a direct positive effect on consumer demand and output, and an indirect positive effect on inflation. *When average inflation is below target, a lower interest rate leads to higher inflation and thus helps bring average inflation back towards its target.*

It is also important for you to realize that, even though the central bank is aiming for average inflation at its target of zero, it may not be able to accomplish this every period because of the persistent random shocks that are occurring each period and the public's (your) expectations. However, the economy will be kept relatively more stable as a consequence of the central bank's reaction to inflation and output.

Note that the central bank cannot lower interest rates below zero. For large negative values of average inflation and output, the central bank will simply set the interest rate at zero.

You will not observe the current interest rate when you are forming your forecast about the following period's inflation and output. After you submit your forecasts, the computer will simultaneously solve for the current period's inflation, output and interest rate taking into consideration the forecasts and the realized shock.

PRICE LEVEL TARGETING TREATMENT

Central Bank Policy

The main objective of the central bank in this experiment is to keep the price level at its target level. The target for the price level is 1000. The central bank sets the interest rate to bring nominal output to its target.

Interest Rate

The interest rate is the rate at which consumers and firms borrow and save in this experimental economy.

The interest rate responds to the distance between the price level and its target level of 1000. The interest rate also responds to deviations of output from 0 as they are linked to deviations of the price level from its target.

At any time period *t*, the interest rate is calculated as follows:

$$\begin{aligned} \textit{Interest Rate}_t &= 60 + 0.8(\textit{Price Level}_t - 1000) + 1.3(\textit{Output}_t - 0) \quad \textit{if Interest Rate}_t > 0 \\ &= 0 \quad \textit{otherwise} \end{aligned}$$

When the price level is high and above its target of 1000 basis points, the central bank will increase interest rates. The central bank will also increase interest rate in response to positive output. When the price level is further above its target, the increase in the interest rate is larger.

The increase in the interest rate has a direct negative effect on consumer demand and output, and an indirect negative effect on inflation, and thus the price level. *When the price level is above target, a higher interest rate leads to lower inflation and thus helps bring the price level back towards its target.*

When the price level is below the target of 1000 basis points, the central bank will decrease interest rates. The central bank will also decrease the interest rate in response to negative output. When the price level is further below its target, the decrease in the interest rate is larger.

Lower interest rates have a direct positive effect on consumer demand and output, and an indirect positive effect on inflation, and thus the price level. *When the price level is below target, a lower interest rate leads to higher inflation and thus helps bring the price level back towards its target.*

It is also important for you to realize that, even though the central bank is aiming for the price level to be at its target of 1000, it may not be able to accomplish this every period because of the persistent random shocks that are occurring each period and the public's (your) expectations. However, the economy will be kept relatively more stable as a consequence of the central bank's reaction to the price level and output.

Note that the central bank cannot lower interest rates below zero. For low price levels and large negative values of output, the central bank will simply set the interest rate at zero.

You will not observe the current interest rate when you are forming your forecast about the following period's inflation and output. After you submit your forecasts, the computer will simultaneously solve for the current period's inflation, output and interest rate taking into consideration the forecasts and the realized shock.

NOMINAL GDP LEVEL TARGETING TREATMENT

Central Bank Policy

The main objective of the central bank in this experiment is to keep the nominal output level at its target level. The target for nominal output is 1000. The central bank sets the interest rate to bring nominal output to its target.

Interest Rate

The interest rate is the rate at which consumers and firms borrow and save in this experimental economy.

The interest rate responds to the distance between nominal output level and its target level of 1000.

At any time period *t*, the interest rate is calculated as follows:

$$\begin{aligned} \textit{Interest Rate}_t &= 60 + 1.1(\textit{Nominal Output}_t - 1000) && \textit{if Interest Rate}_t > 0 \\ &= 0 && \textit{otherwise} \end{aligned}$$

When the level of nominal output is above its target level of 1000, the central bank will increase interest rates more than one-for-one in response to this discrepancy. When nominal output is further above its target, the increase in the interest rate is larger.

The increase in the interest rate has a direct negative effect on consumer demand and output, and an indirect negative effect on inflation. When inflation decreases, the price level decreases. As output and the price level decrease, nominal output decreases. Thus, *when nominal output is above its target, higher interest rate leads to lower nominal output and thus helps bring it back towards its target.*

When the level of nominal output is below its target level of 1000, the central bank will decrease interest rates more than one-for-one in response to this discrepancy. When nominal output is further below its target, the decrease in the interest rate is larger.

The decrease in the interest rate has a direct positive effect on consumer demand and output, and an indirect positive effect on inflation. When inflation increases, the price level increases. As output and price level increase, nominal output increases. *Thus, when nominal output is below its target, lower interest rate leads to higher nominal output and thus helps bring it back towards its target.*

Lower interest rates have a direct positive effect on consumer demand and output, and an indirect positive effect on inflation, and thus the price level. *When the price level is below target, a lower interest rate leads to higher inflation and thus helps bring the price level back towards its target.*

It is also important for you to realize that, even though the central bank is aiming for a stable level of nominal output at its target of 1000, it may not be able to accomplish this every period because of the persistent random shocks that are occurring each period and the public's (your) expectations. However, the economy will be kept relatively more stable as a consequence of the central bank's reaction to the nominal output from its target.

Note that the central bank cannot lower interest rates below zero. For low nominal outputs, the central bank will simply set the interest rate at zero.

You will not observe the current interest rate when you are forming your forecast about the following period's inflation and output. After you submit your forecasts, the computer will simultaneously solve for the current period's inflation, output and interest rate taking into consideration the forecasts and the realized shock.

Score

Your score will depend on the accuracy of your inflation and output forecasts. The absolute difference between your forecasts and the actual values for output and inflation are your absolute forecast errors.

Absolute Forecast Error = absolute (Your Forecast – Actual Value)
Total Score = 0.30(2^-0.01(Absolute Forecast Error for Output)) + 0.30(2^-0.01 (Absolute Forecast Error for Inflation))

The maximum score you can earn each period is 0.6 points.
Your score will decrease as your forecast error increases. Suppose your forecast errors for each of output and inflation are:

0	-Your score will be 0.6	300	-Your score will be 0.075
50	-Your score will be 0.42	500	-Your score will be 0.02
100	-Your score will be 0.3	1000	-Your score will be 0
200	-Your score will be 0.15	2000	-Your score will be 0

Information about the Interface, Actions, and Payoffs

During the experiment, your main screen will display information that will help you make forecasts and earn more points.

At the top left of the screen, you will see your subject number, the current period, time remaining, and the total number of points earned. You will also see four history plots.

The top history plot displays past interest rates and past and current shocks.

The second plot displays your past forecasts of inflation and realized inflation levels. (*IT/DM/AIT Treatments:* You will also be shown the central bank's inflation target of 0 in orange.)

The third plot displays your past forecast of output and realized output levels.

Your forecasts will always be shown in blue while the realized value will be shown in red. You can see the exact value for each point on a graph by placing your mouse at that point. The difference between your forecasts and the actual realized levels constitutes your forecast errors.

The fourth plot will show price level and nominal output. The price level will be presented on the left axis in purple while the nominal output will be presented on the right axis in green. (*PLT Treatment:* You will also be shown the central bank's nominal output level target of 1000 in orange.) (*NGDP Treatment:* You will also be shown the central bank's nominal output level target of 1000 in orange.)

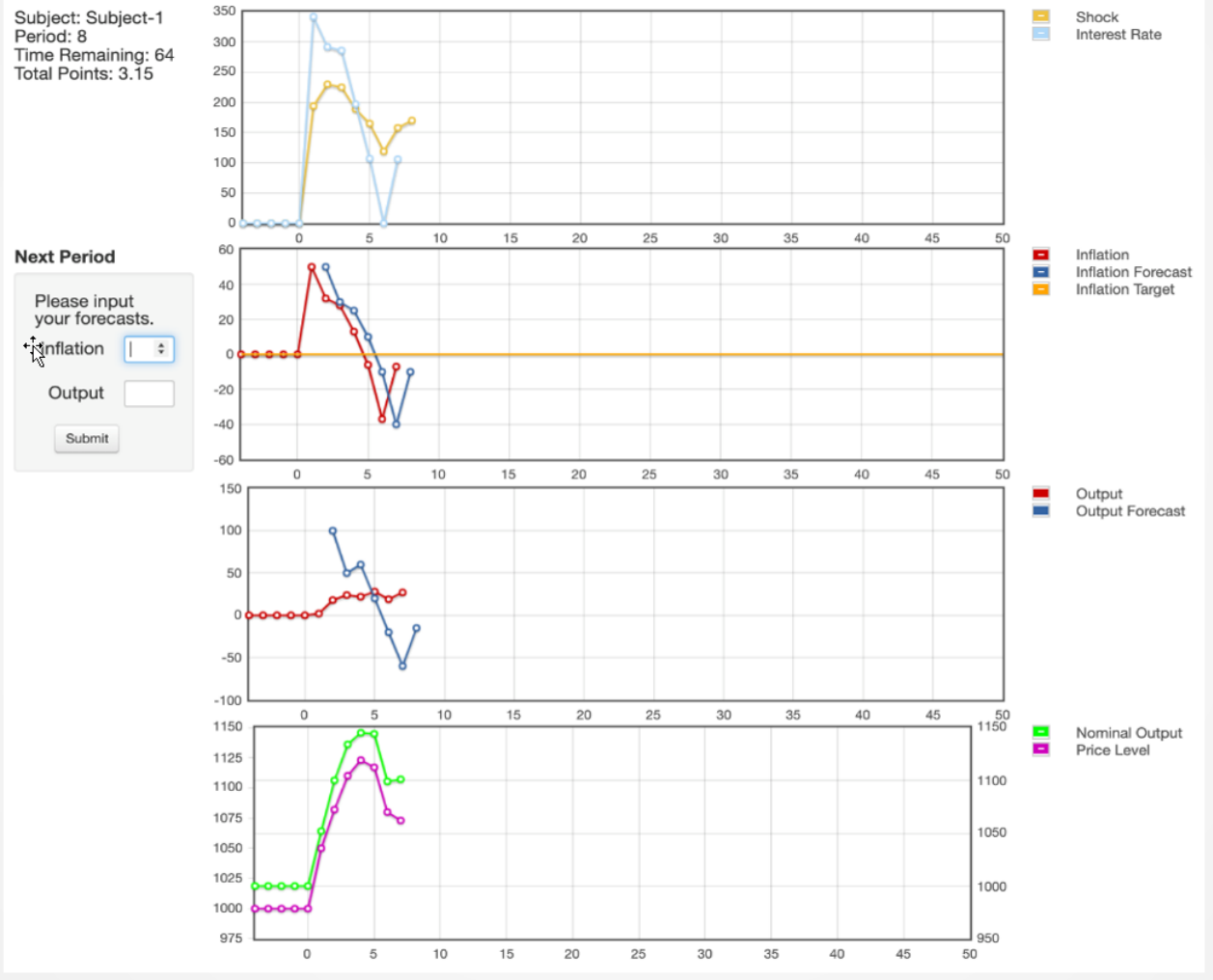
You may submit positive, negative or zero forecasts. Please use whole numbers. Please review your forecasts before pressing the SUBMIT button. Once the SUBMIT button has been clicked, you will not be able to revise your forecasts until the next period. You will earn zero points if you do not submit both forecasts.

You will have 75 seconds to submit forecasts for output and inflation for the first 10 rounds, and 60 seconds for the remaining 40 periods. Your score converted into Canadian dollars ($0.50 per point) plus the show up fee will be paid to you in cash at the end of the experiment.

B. Experimental interface

Participants interacted in an online interface where they repeatedly made inflation and output forecasts. Figure B1 presents a sample screenshot from the inflation targeting treatment.

Figure B1: Screenshot of participants' screens during the experiment



C. Simulations with rational and naive expectations

Table C1 presents the breakdown of losses associated with deviations of inflation, output, and nominal interest rates from target, for each phase and treatment. Simulations are conducted under the assumption that expectations are rational/model-consistent.

Table C1: Losses associated with inflation, output, and interest rate in REE

	$\sqrt{\text{total loss}/T}$	$\sqrt{\sum^T(\pi-\pi^*)^2/T}$	$\sqrt{\sum^T(x-x^*)^2/T}$	$\sqrt{\sum^T(i-i^*)^2/T}$
periods 1-50				
NGDP	168.2	14.8	82.8	206
PLT	169.8	9.3	40.4	232.8
AIT-10	179.7	20.2	56.5	239.6
AIT-4	180.8	22	47.4	244.8
DM	184.4	21.7	38.1	253.4
IT	186.9	24.8	43	254.8
periods 1-19				
NGDP	153.8	11.8	75.5	188.8
PLT	155.9	7.5	34.3	214.8
AIT-10	164	18.2	49.8	219.5
AIT-4	165.3	20	42.1	224.2
DM	168.5	19.6	32.1	232.4
IT	170.8	22.4	36.8	233.7
periods 20-50				
NGDP	176.4	16.4	87	215.8
PLT	177.7	10.2	43.7	243.2
AIT-10	188.7	21.3	60.2	251.2
AIT-4	189.7	23.1	50.3	256.6
DM	193.5	22.8	41.3	265.4
IT	196.2	26.1	46.5	267

Loss and standard deviations of inflation, output, and interest rate were computed from simulations with rational expectations and are expressed in basis points.

Simulations with naive agents

Other experimental studies of monetary policy regimes illustrate that participants' expectations are mostly non-rational [Anufriev et al., 2013, Assenza et al., 2019]. Given this evidence, we introduce a very simple form of bounded rationality – naive expectations – into our model to understand the implications for stabilization properties of different monetary policy regimes. Naive expectations are set as $E_t\pi_{t+1} = \pi_{t-1}$ and $E_t x_{t+1} = x_{t-1}$. We find that the presence of naive agents can be disruptive to economies with certain monetary policy regimes. Level-targeting regimes such as PLT and NGDP can break down at certain shares of naive agents. The threshold share of naive agents is 33% in the PLT regime and 45% in NGDP; economies become unstable with shares of naive agents above the threshold level. IT, DM, and AIT tolerate 100% of

Table C2: Ranking of regimes in the simulations with RE, naive expectations and in the data from laboratory experiments

ranking	REE Table C1	naive =33% Table C3	lab data Table 2
Periods 1-19			
1	NGDP	NGDP	AIT-10
2	PLT	PLT	AIT-4
3	AIT-10	AIT-10	DM
4	AIT-4	IT	IT
5	DM	DM	PLT
6	IT	AIT-4	NGDP
Periods 20-50			
1	NGDP	NGDP	IT
2	PLT	IT	DM
3	AIT-10	DM	AIT-4
4	AIT-4	AIT-4	AIT-10
5	DM	PLT	PLT
6	IT	AIT-10	NGDP
All Periods			
1	NGDP	NGDP	AIT-4
2	PLT	IT	DM
3	AIT-10	DM	IT
4	AIT-4	AIT-4	AIT-10
5	DM	PLT	PLT
6	IT	AIT-10	NGDP

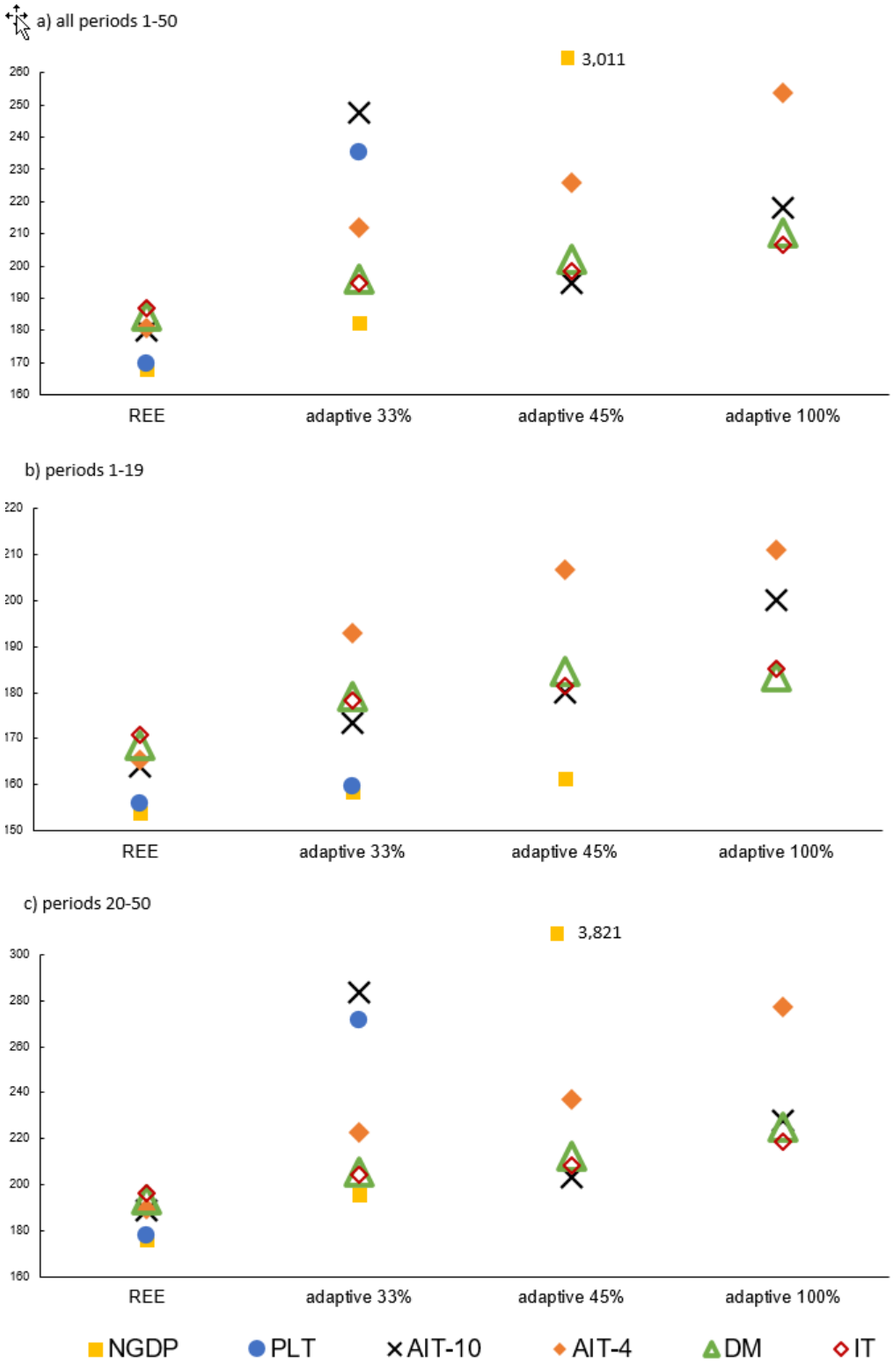
Note: Ranking in column "naive=33%" is based on simulations with 33% of naive agents in all regimes. For details on losses for these simulations, see Table C3.

naive agents, remaining stable. In other words, PLT and NGDP are the least robust to the presence of naive expectations.

We have simulated our model with different shares of naive expectations using a sequence of demand shocks implemented in the experiment. Figure C1 presents losses from the simulations with rational expectations and simulations with different shares of naive agents – 33%, 45%, and 100%. Table C3 reports results from simulation with 33% of naive agents in all regimes, Table C4 reports results from simulation with 33% in PLT regime and 45% in the rest of the regimes, and Table C5 reports simulations with 33% in PLT, 45% in NGDP, and 100% in IT, DM and AIT.

The results presented in Figure C1 lead to the following interesting observations. First, the presence of naive agents leads to higher losses across all regimes. Second, the increase of the share of naive agents leads to the increase of the losses for all regimes (except for AIT-10 following the shock). Third, the ranking of monetary policy regimes changes with an increase of the share of naive agents: performance of history-dependent regimes (AIT, PLT, NGDP) deteriorates relative to regimes responding to current inflation and output gap (IT and DM). We would like to note that AIT performs better than level-targeting regimes PLT and NGDP. These simple simulations with naive expectations illustrate the important role expectations play in the ability of different policy regimes to stabilize the economy.

Figure C1: Summary of losses from simulations



This figure shows results from simulations of New Keynesian model with rational expectations and simulations with naive agents. We vary the shares of naive agents from 0% (REE) to 33% (threshold in PLT), 45% (threshold in NGDP) and 100%.

Table C3: Losses associated with inflation, output, and interest rate from simulations with both rational and naive agents

	$\sqrt{\text{total loss}/T}$	$\sqrt{\sum^T(\pi-\pi^*)^2/T}$	$\sqrt{\sum^T(x-x^*)^2/T}$	$\sqrt{\sum^T(i-i^*)^2/T}$
periods 1-50				
NGDP	182.5	29.5	87.9	222.3
IT	194.8	34.8	27.5	268.3
DM	195.8	35.3	25.6	270
AIT-4	212	54.9	53.8	279.5
PLT	235.3	63.3	144.3	247.1
AIT-10	247.8	68.5	154.9	255.8
periods 1-19				
NGDP	158.5	17.4	63	204.2
PLT	159.6	11.6	29.2	221.2
AIT-10	173.4	27.8	44	233.9
IT	178.3	31.3	25	245.7
DM	179.2	31.8	23.4	247.2
AIT-4	193.1	48.9	45.9	256
periods 20-50				
NGDP	195.8	34.9	100.2	232.7
IT	204.3	36.8	28.9	281.2
DM	205.3	37.3	26.9	283
AIT-4	222.9	58.2	58	293
PLT	271.4	79.9	181.8	261.6
AIT-10	283.9	84.3	193.7	268.4

Losses are computed from simulations with combination of rational expectations (67%) and naive expectations (33%) and are expressed in basis points.

Next, we discuss the mechanism through which naive expectations weaken the performance of history-dependent regimes. As described above, naive agents form their expectations for the next period based on the realization in the previous period. These expectations are purely backward-looking and do not incorporate an understanding of what a monetary policy regime aims to achieve (stabilize inflation and output) and how it works to achieve it. In other words, naive expectations do not have a forward-looking aspect and, as a result, they weaken the expectations channel on which history-dependent regimes rely for their superior performance in models with rational expectations. In addition, in the economy with naive agents, rational agents account for the non-rationality of naive agents and adjust their expectations relative to expectations in the model with only rational agents. Thus, the presence of naive agents diminishes the effectiveness of the expectations channel. Given that history-dependent regimes such as AIT, PLT, and NGDP rely heavily on the expectations channel, the performance of these regimes deteriorates as the expectations channel weakens.

The simulations with naive agents suggest that IT and DM may be more robust to the presence of non-rational expectations in their ability to stabilize the economy. And these simulations may be indicative of

how these regimes may perform in the laboratory, where expectations are likely to deviate from rationality.

Table C4: Losses associated with inflation, output, and interest rate from simulations with both rational and naive agents

	$\sqrt{\text{total loss}/T}$	$\sqrt{\sum^T(\pi-\pi^*)^2/T}$	$\sqrt{\sum^T(x-x^*)^2/T}$	$\sqrt{\sum^T(i-i^*)^2/T}$
periods 1-50				
AIT-10	194.7	37	43.6	263.2
IT	198.4	38.5	23.8	273.2
DM	202.2	42.6	21.1	278
AIT-4	226	69	44.8	297.7
PLT	235.3	63.3	144.3	247.1
NGDP	3010.6	1285.2	2691.2	581.7
periods 1-19				
PLT	159.6	11.6	29.2	221.2
NGDP	161.4	21.6	58	210.9
AIT-10	180.1	35.3	41	242.9
IT	181.4	34.7	21.1	250
DM	184.5	37.7	19.6	253.9
AIT-4	206.8	63	41	272.4
periods 20-50				
AIT-10	203.1	38	45.1	274.9
IT	208.2	40.7	25.3	286.5
DM	212.3	45.3	22	291.7
AIT-4	237	72.5	47	312.2
PLT	271.4	79.9	181.8	261.6
NGDP	3821.4	1632.2	3417.5	720.1

Losses are computed from simulations with a combination of rational expectations and naive expectations and are expressed in basis points. Shares of naive expectations: 33% in PLT and 45% in all other regimes.

Post-shock dynamics in the presence of naive agents

We highlight two additional observations from Figure C1, both about the performance of monetary policy regimes following the ELB shock. First, in the presence of naive agents (33%), NGDP performs better than other regimes, and notably better than PLT, another level-targeting regime. Second, the performance of AIT-10 does not deteriorate monotonically with the increase in the share of naive agents in the post-shock period.

Post-shock dynamics in NGDP and PLT with naive agents

During a stable period, with the share of naive agents at 33%, NGDP performs somewhat better than PLT, and these two regimes outperform other regimes. However, following the ELB shock, the performance of NGDP remains better than that of other regimes, while PLT performs much worse. In other words, during stable times, PLT can handle the presence of naive agents as well as NGDP does, but after ELB shock, PLT deteriorates substantially relative to NGDP and other regimes. Why can NGDP handle the period after ELB shock better than PLT? And why does PLT deteriorate so much?

Table C5: Losses associated with inflation, output, and interest rate from simulations with both rational and naive agents

	$\sqrt{\text{total loss}/T}$	$\sqrt{\sum^T(\pi-\pi^*)^2/T}$	$\sqrt{\sum^T(x-x^*)^2/T}$	$\sqrt{\sum^T(i-i^*)^2/T}$
periods 1-50				
IT	206.7	44.5	28.5	282.6
DM	210.1	49.9	23.5	286.7
AIT-10	217.9	54.1	52	289.3
PLT	235.3	63.3	144.3	247.1
AIT-4	254	95.6	42	327.4
NGDP	3010.6	1285.2	2691.2	581.7
periods 1-19				
PLT	159.6	11.6	29.2	221.2
NGDP	161.4	21.6	58	210.9
DM	183.4	34.2	25	252.3
IT	185.1	35.2	26.4	254.3
AIT-10	200	50	35.8	269.2
AIT-4	211	63.2	46.1	277.1
periods 20-50				
IT	218.9	49.4	29.7	298.6
DM	224.9	57.4	22.6	305.9
AIT-10	228.2	56.5	59.8	301
PLT	271.4	79.9	181.8	261.6
AIT-4	277.1	110.8	39.3	354.8
NGDP	3821.4	1632.2	3417.5	720.1

Losses are computed from simulations with combination of rational expectations and naive expectations and are expressed in basis points. Shares of naive expectations: 33% in PLT, 45% in NGDP, and 100% in IT, DM, AIT-4, and AIT-10.

The deterioration of PLT's performance after ELB shock is mostly due to higher volatility of output (Table C3). The focus of PLT is on the stabilization of price level and making up for all past misses from the price-level target; therefore, price-level stability comes at a price of higher output volatility. In contrast, NGDP aims at the stability of nominal output where deviations of price level can be compensated with deviations in output level, keeping nominal output stable. Indeed, NGDP has lower volatility of output than PLT during post-shock periods 20-50. And so, after ELB shock, PLT overreacts to deviations of the price level from the target, leading to higher output volatility, thus reducing its stabilization performance. Such a focus on price level also reduces the performance of PLT relative to IT and DM. This result is related to the finding in Hommes et al. [2019] who shows that in the presence of backward-looking expectations responding to output is important for stabilizing inflation and output.

It is worth noting that with an increase in the share of naive agents to the 45% threshold level (the threshold level for NGDP), the performance of NGDP declines below that of all other regimes. A larger presence of naive agents further weakens the expectations channel and consequently, NGDP can no longer outperform

other regimes.

Post-shock dynamics in AIT-10 with naive agents

The relationship between the presence of naive agents and the performance of AIT-10 is non-monotonic during the post-shock period: losses increase when the share rises from 0 to 33%, then decline when the share is 45% and increase when the share increases further to 100% (Figure C1, panel c), while during stable periods 1-19, an increase in the share of naive agents leads to the monotonic decline in the performance of AIT-10 (Figure C1, panel b).

The presence of naive agents brings two effects. First, naive expectations carry over strength in inflation and output from past periods, which leads to smaller declines in these variables after ELB shock than in the case with rational expectations. Second, expectations channels weaken directly because of naive agents and indirectly because rational agents adjust their expectations to account for the presence of naive agents.

AIT-10 performs worse at 33% than at 0% because the presence of naive agents weakens the expectations channel (the second effect dominates). When the share of naive agents increases from 33% to 45%, the first effect becomes more pronounced. As a higher share of backward-looking expectations carries over some of the past strength in economic variables, the ELB episode is less severe and shorter with AIT-10 than in other regimes, resulting in its better performance. However, when the share of naive agents reaches 100%, the complete absence of rational agents destroys forward-looking expectations and the expectations channel necessary for AIT-10 to work. As a result, at 100% AIT-10 performed worse than at 45%.

D. Classification of forecasting heuristics

We use experimental data on participants' forecasts to determine how participants form their forecasts. We consider several types of expectation formation and assign a type to each participant that best fits their forecasting behaviour. Table D1 summarizes all mechanisms we have considered. As we discussed above, the experimental economies significantly deviate from rational expectations equilibrium paths. Therefore, we need to consider other types of forecasting mechanisms in addition to rational expectations. We study several heuristics that have been previously used in the literature on the formation of expectations in macroeconomic models. The simplest deviation from rational expectations is cognitive discounting à la Gabaix [2020], with expectations that are somewhat short (a share α) of a rational expectations solution. Cognitive discounting weakens the expectations channel and makes history-dependent rules less successful than rational expectations. We also consider a heuristic in which participants forecasts' are based on steady state/target.

We also consider backward-looking mechanisms in which the formation of expectations is history driven. Constant-gain learning has been widely used in the literature on the role of learning in macroeconomics [Evans and Honkapohja, 2001] and implications for monetary policy [Bullard and Mitra, 2002] and is supported by the evidence of such expectations in the survey data [Branch, 2004]. We also consider trend-chasing expectations that have been shown to be used in the experimental data [Hommes et al., 2019, Anufriev et al., 2013, Assenza et al., 2019]. Trend-chasing expectations nest naive expectations $E_{i,t}x_{t+1} = x_{t-1}$ under a trend-chasing parameter $\tau = 0$, and survey data provides empirical evidence of the use of naive expectations [Branch, 2004].

Table D1: Forecasting heuristics: models of expectations as functions of exogenous or historical data.

Model	Heuristic Name	Model
M1	Ex–Ante Rational	$E_{i,t}x_{t+1} = f(r^n_{t-1}, \epsilon_t)$
		$E_{i,t}\pi_{t+1} = f(r^n_{t-1}, \epsilon_t)$
M2	Cognitive Discounting	$E_{i,t}x_{t+1} = \alpha f(r^n_{t-1}, \epsilon_t)$
		$E_{i,t}\pi_{t+1} = \alpha f(r^n_{t-1}, \epsilon_t)$
M3	Constant Gain	$E_{i,t}x_{t+1} = E_{i,t-1}x_t - \gamma(E_{i,t-2}x_{t-1} - x_{t-1})$
		$E_{i,t}\pi_{t+1} = E_{i,t-1}\pi_t - \gamma(E_{i,t-2}\pi_{t-1} - \pi_{t-1})$
M4	Steady State/Target	$E_{i,t}x_{t+1} = 0$
		$E_{i,t}\pi_{t+1} = 0$
M5	Trend Chasing	$E_{i,t}x_{t+1} = x_{t-1} + \tau(x_{t-1} - x_{t-2})$
		$E_{i,t}\pi_{t+1} = \pi_{t-1} + \tau(\pi_{t-1} - \pi_{t-2})$

$\alpha \in [0.1, 0.9]$, γ and $\tau \in [0, 1.5]$ in increments of 0.1.

We determine the forecasting heuristic for each participant that best fits their forecasting behavior during each of the phases of the experiment. To do so, we compute the mean absolute error of each participant's expectations for each of the heuristics presented in Table D1. For some heuristics such as M2 Cognitive Discounting, M4 Constant Gain, and M5 Trend-Chasing, we consider a wide range of parameterizations. The cognitive discounting parameter α can take values in the range of $[0.1, 0.9]$. Constant gain parameter γ and trend-chasing parameter τ are in the range of $[0, 1.5]$. We consider values of these parameters from

these ranges with an increment of 0.1. We assign each participant the heuristic and its parameter value (if applicable) that produces the lowest mean absolute error. Participants' forecasts can be classified under different heuristics for two different phases of the experiment. The prevalence of the assigned heuristics, by treatment and phase, are presented in Figure D1 for inflation forecasts and Figure D2 for output forecasts.

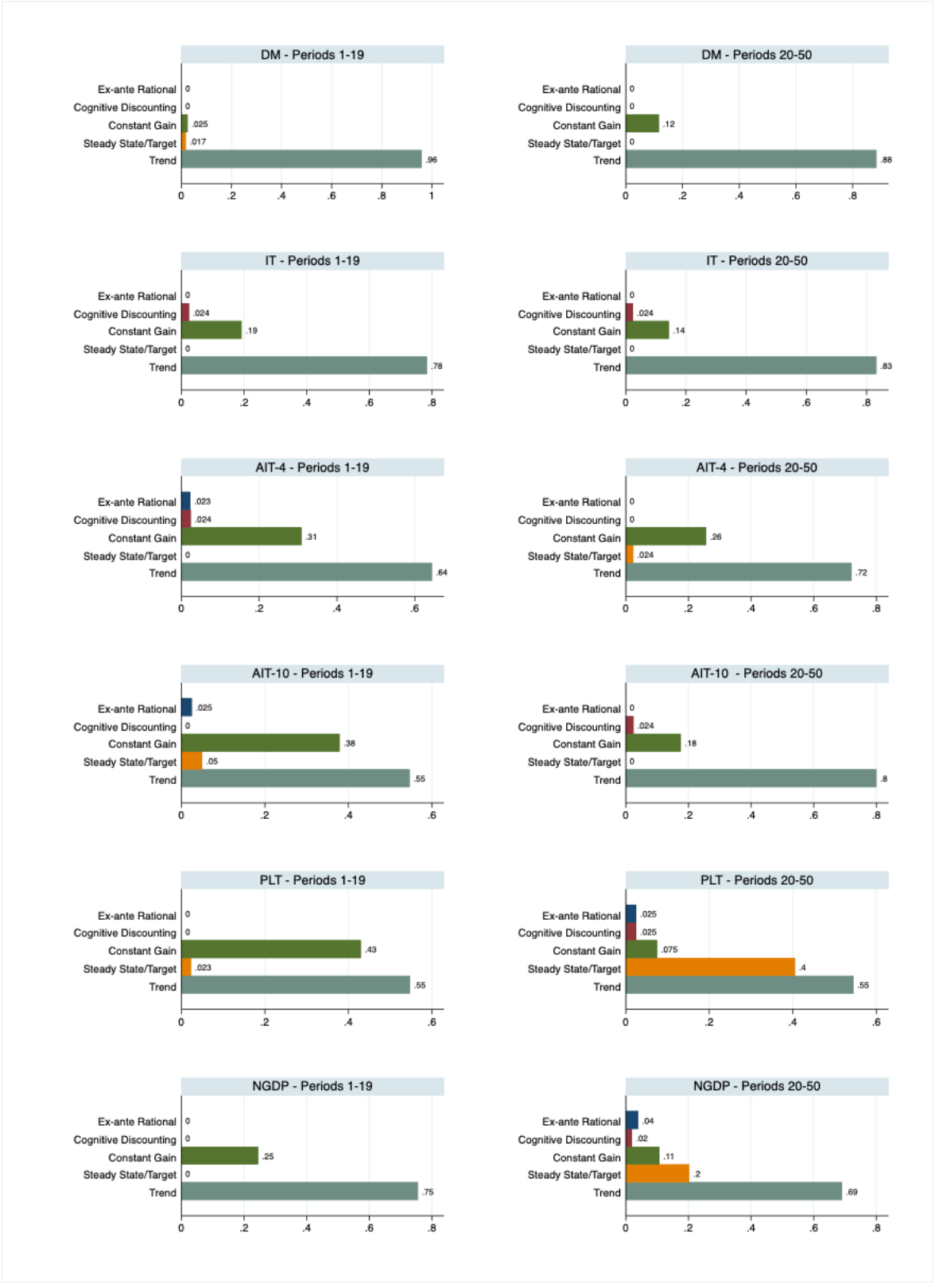
The most striking result is the rarity of the rational expectations in the experimental data. Fewer than 5% of participants in any treatment can be classified as rational or *model consistent*, and in some cases, this share is close to zero. The consistent lack of rational expectations suggests that participants do not broadly appreciate how economic fundamentals influence aggregate dynamics. Participants' elicited expectations show little evidence that they made their forecasts in a forward-looking way responding to the dynamics of shocks and internalizing the stabilizing role of monetary policy. There remains a possibility that participants may understand these elements but not fully, i.e. they may use cognitive discounting, which, like rational expectations, assumes agents are forward-looking and respond solely to aggregate demand shocks, albeit in a more muted manner. However, we observe very little use of the cognitive discounting model. In most treatments, we observe under 5% of participants using cognitive discounting, and frequently this share is close to zero. We observe the highest incidence of cognitive discounting in the post-shock phase of the NGDP treatment, with 11% of participants. While this small minority of participants tried to use their understanding of this policy regime, their forecasts were insufficiently rational and their share was too small to pull NGDP economies out of deflationary spiral in the post-shock phase.

We emphasize that although participants in the rate-targeting treatments are not especially model consistent in their forecasting, their beliefs are not wildly different from rational expectations. They are relatively well anchored on the inflation target. Moreover, the consistency in aggregate dynamics across sessions in rate-targeting treatments suggests a consistent aggregate forecasting heuristic and not just random or confused expectations.

Backward-looking expectations – trend-chasing and constant gain learning – are the dominant forecasting heuristics in most of our treatments. Together, these backward-looking heuristics make up the majority of participants' forecasts. In inflation forecasts, the largest share of participants use trend-chasing during both pre-shock and post-shock phases, with trend-chasing becoming more prevalent post-shock with a decline of constant gain learning. We observe similar composition and evolution of heuristics in output forecasts across all treatments, except for AIT-4 and DM. AIT-4 and DM stand out among the treatments: the share of constant-gain learning is considerably larger than the share of trend-chasing in the pre-shock phase, although it declines below that of trend-chasing post-shock.

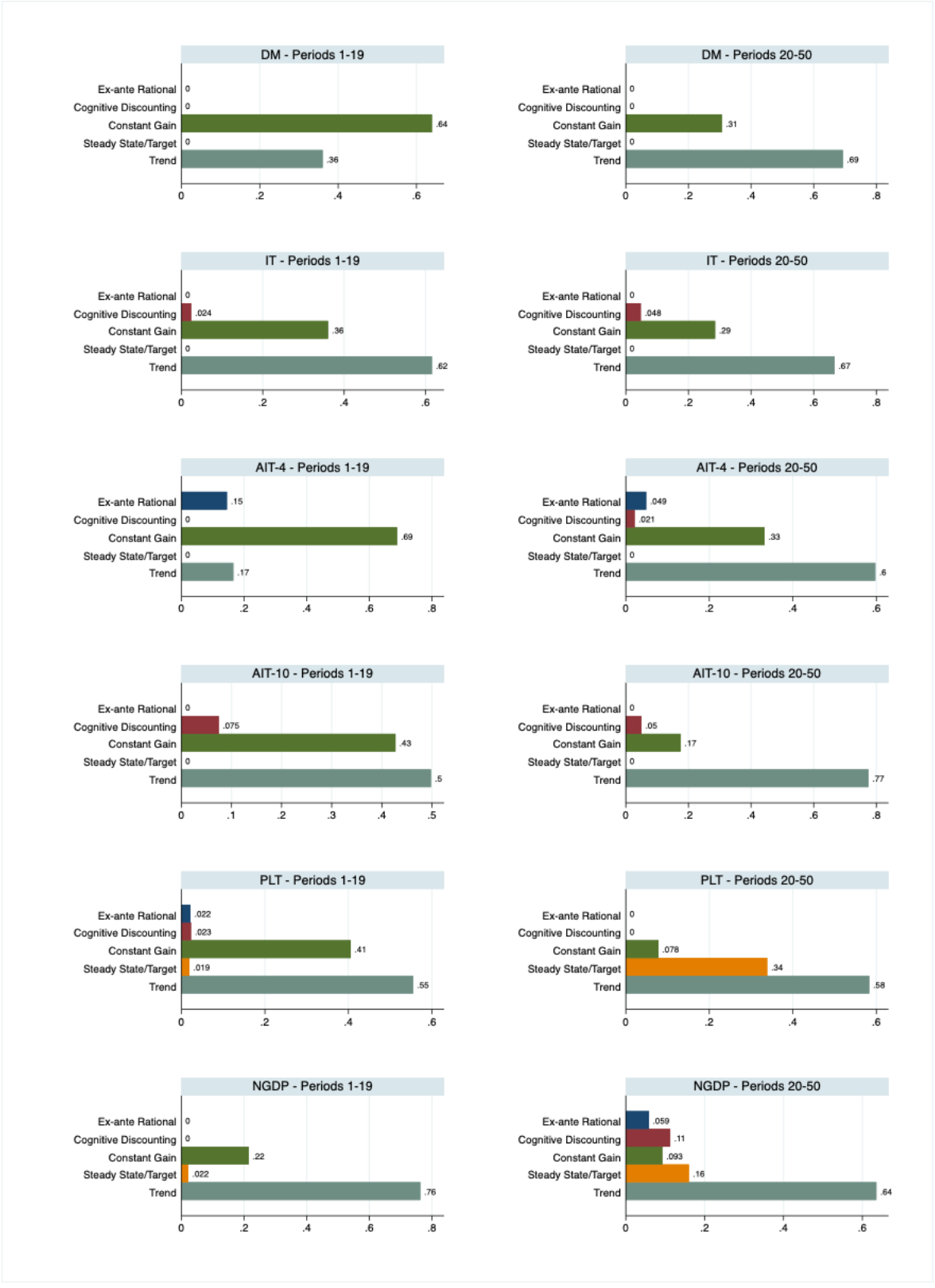
Also noteworthy is the large minority of participants in the NGDP and PLT treatments classified as using steady-state/target forecasting during the post-shock phase. A detailed analysis of individual forecasts shows that only a small minority of these participants actually forecast the steady-state values of zero. Rather, they submit forecasts closer to the steady-state value of zero than to values implied by other heuristics, but their values are negative. This behavior is certainly not rational, as an ex-ante rational agent would anticipate very high levels of inflation and output gap given the observed deflation and negative output gaps.

Figure D1: Distribution of forecasting heuristics for inflation forecasts, by treatment and phase



This figure presents the share of participants in each treatment and phase classified into a given heuristic.

Figure D2: Distribution of forecasting heuristics for output forecasts, by treatment and phase



This figure presents the share of participants in each treatment and phase classified into a given heuristic.

E. Additional experimental results

Table E1: Wilcoxon rank order test, statistical significance

Periods 1-19						
	NGDP	PLT	DM	IT	AIT-4	AIT-10
NGDP						
PLT	0.87					
DM	0.0163	0.037				
IT	0.0782	0.0542	0.8728			
AIT-4	0.0104	0.0103	0.1093	0.3367		
AIT-10	0.0039	0.0161	0.0547	0.4233	0.5218	
Periods 20-50						
	NGDP	PLT	DM	IT	AIT-4	AIT-10
NGDP						
PLT	0.4225					
DM	0.0039	0.0039				
IT	0.0039	0.0039	0.631			
AIT, short	0.0039	0.0039	0.7488	0.631		
AIT-4	0.0039	0.0039	0.0065	0.0065	0.0104	
AIT-10						
	NGDP	PLT	DM	IT	AIT-4	AIT-10
NGDP						
PLT	0.4225					
DM	0.0039	0.0039				
IT	0.0039	0.0039	0.8728			
AIT-4	0.0039	0.0039	0.3367	0.3367		
AIT-10	0.0039	0.0039	0.2002	0.2002	0.025	

Results from Wilcoxon rank order test based on the average losses from each of 6 sessions for all treatments. These results are for the hypothesis that losses in the treatments listed in the rows are equal to the losses in the treatments listed in the columns.

Table E2: Wilcoxon rank order test, probability that regimes in rows have lower losses than regimes in columns

Periods 1-19						
	NGDP	PLT	DM	IT	AIT-4	AIT-10
NGDP						
PLT	0.528					
DM	0.917	0.861				
IT	0.806	0.833	0.472			
AIT-4	0.944	0.944	0.778	0.667		
AIT-10	1	0.917	0.833	0.639	0.389	
Periods 20-50						
	NGDP	PLT	DM	IT	AIT-4	AIT-10
NGDP						
PLT	0.639					
DM	1	1				
IT	1	1	0.417			
AIT-4	1	1	0.444	0.417		
AIT-10	1	1	0.028	0.028	0.056	
All Periods						
	NGDP	PLT	DM	IT	AIT-4	AIT-10
NGDP						
PLT	0.639					
DM	1	1				
IT	1	1	0.472			
AIT-4	1	1	0.667	0.667		
AIT-10	1	1	0.278	0.278	0.111	

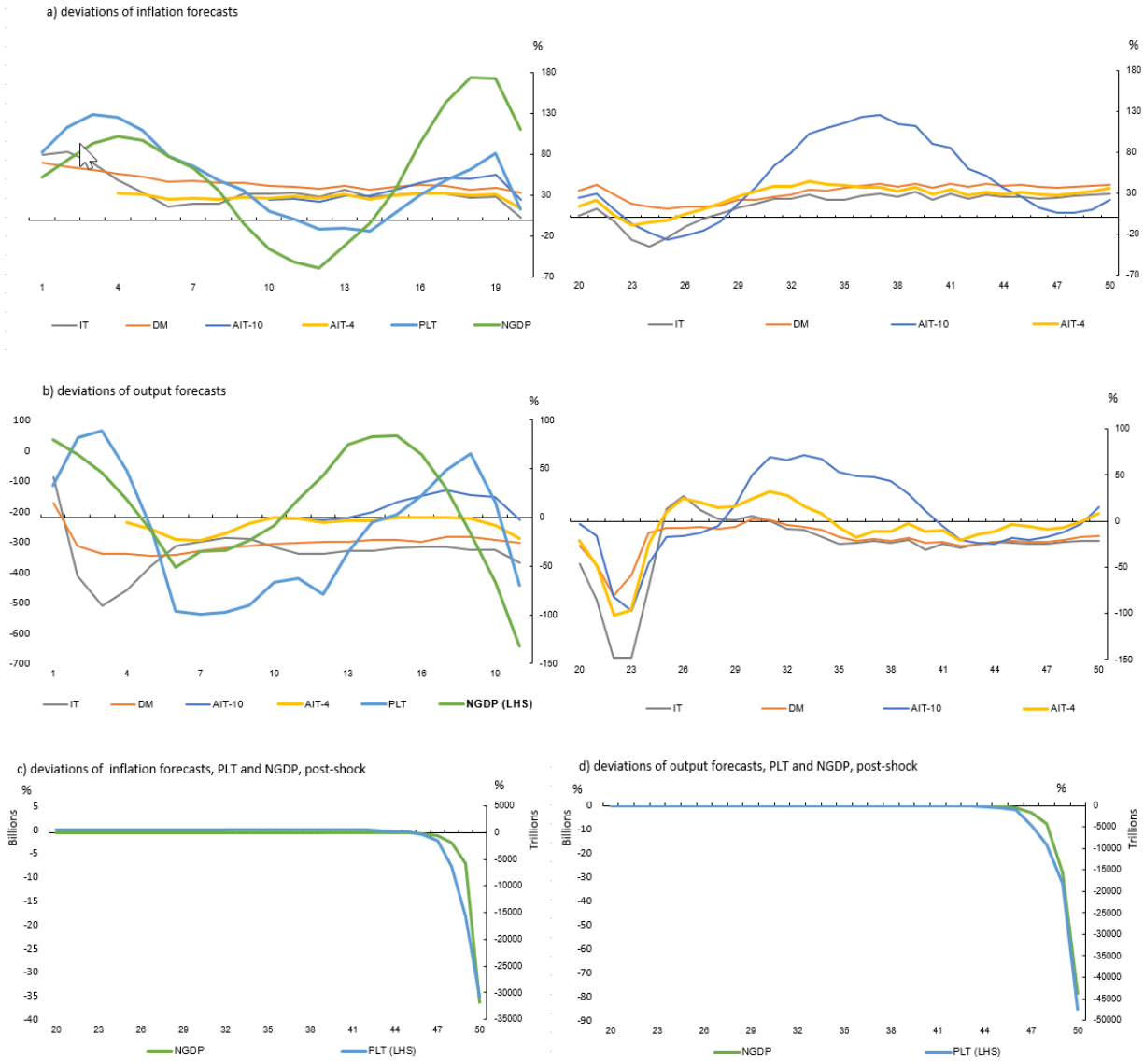
Results from Wilcoxon rank order tests based on the average losses from each of 6 sessions for all treatments. These results present the probability that losses in the treatments listed in the rows are less than the losses in the treatments listed in the columns, in accordance with hypothesis H1 presented in Section **??**.

Table E3: Summary statistics about participants' forecasts

	Deviation from REE		Interquartile Range	
	$E_{i,t}\pi_{t+1}$	$E_{i,t}x_{t+1}$	$E_{i,t}\pi_{t+1}$	$E_{i,t}x_{t+1}$
Periods 1-19				
AIT-4	29.12	-2.57	17.94	27.26
	(33.59)	(16.5t)	(30.57)	(37.76)
AIT-10	37.81	13.06	16.35	18.73
	(16.89)	(28.22)	(22.99)	(32.52)
DM	46.79	-26.53	12.15	18.76
	(17.67)	(17.33)	(18.05)	(36.20)
IT	37.11	-34.48	22.93	20.93
	(31.70)	(38.28)	(37.11)	(22.32)
NGDP	51.21	-153.5	33.97	59.54
	(84.32)	(190.2)	(28.91)	(38.90)
PLT	53.19	-16.07	49.98	63.06
	(66.38)	(87.53)	(49.4)	(51.08)
Periods 20-50				
DM	31.56	-20.21	8.483	9.906
	(13.17)	(17.91)	(17.58)	(12.65)
IT	14.89	-27.7	11.66	17.45
	(19.69)	(41.03)	(11.64)	(19.52)
AIT-4	25.71	-8.463	10.77	22.77
	(15.63)	(31.41)	(9.791)	(22.01)
AIT-10	44.55	6.18	14.74	22.6
	(49.99)	(43.14)	(10.49)	(17.28)
NGDP	-5.4e+14	-8.9e+14	1.24E+25	1.24E+25
	(5.3e+15)	(7.6e+15)	(2.14E+26)	(2.14E+26)
PLT	-1.6e+09	-3.4e+09	1.79E+09	2.75E+09
	(1.4e+10)	(3.2e+10)	(2.18E+10)	(2.23E+10)

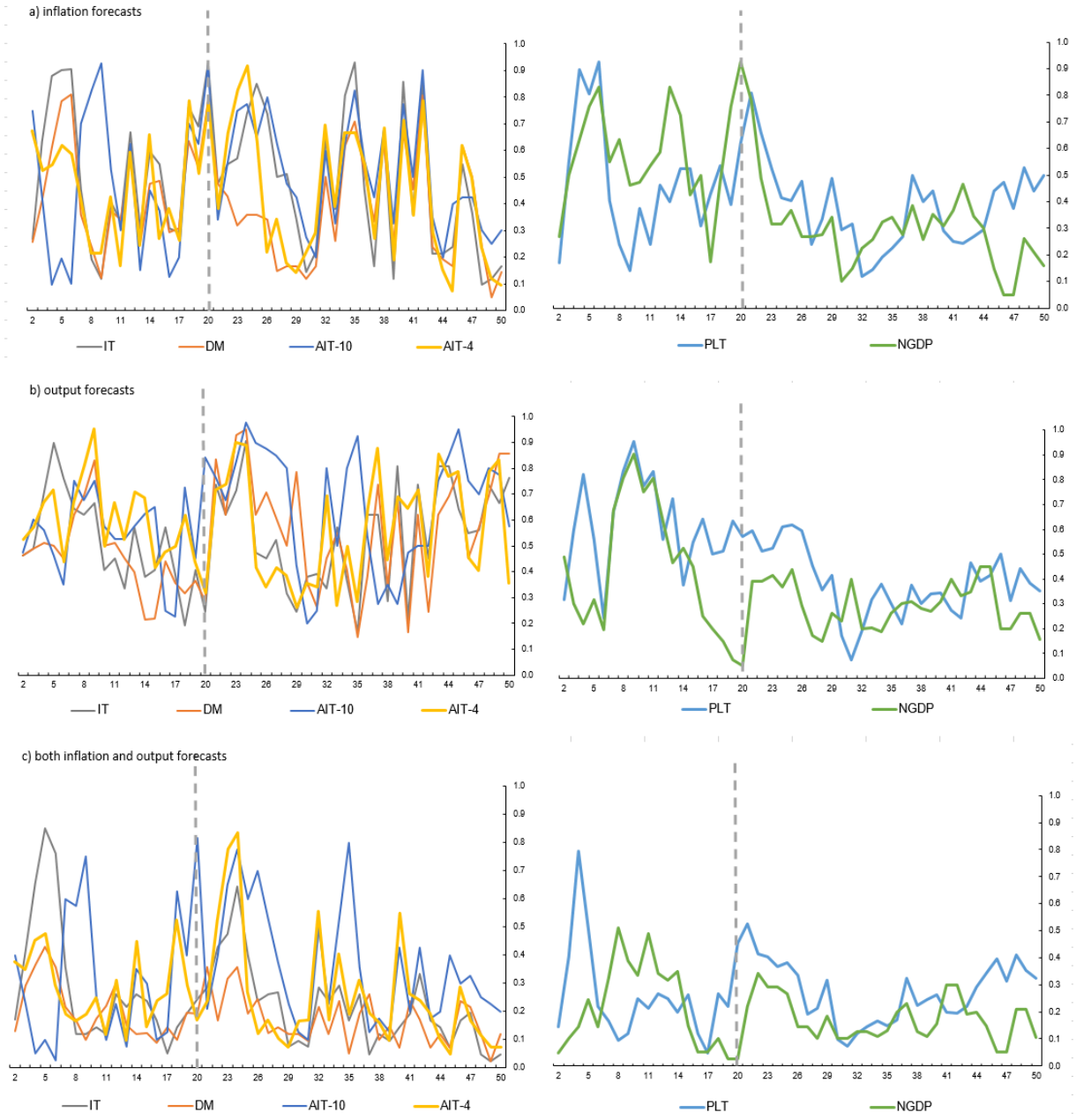
This table presents inflation and output gap forecast statistics. Columns (1) and (2) present the average across sessions of the median absolute forecast deviations from the REE solution. Columns (3) and (4) present the interquartile range of forecasts. Standard deviations are presented in parentheses.

Figure E1: Deviations of inflation and output forecasts from REE forecasts



This figure presents the median deviations of inflation and output forecasts from REE, averaged for each period across all sessions for each treatment.

Figure E2: Share of participants exhibiting basic rationality in inflation and output forecasts



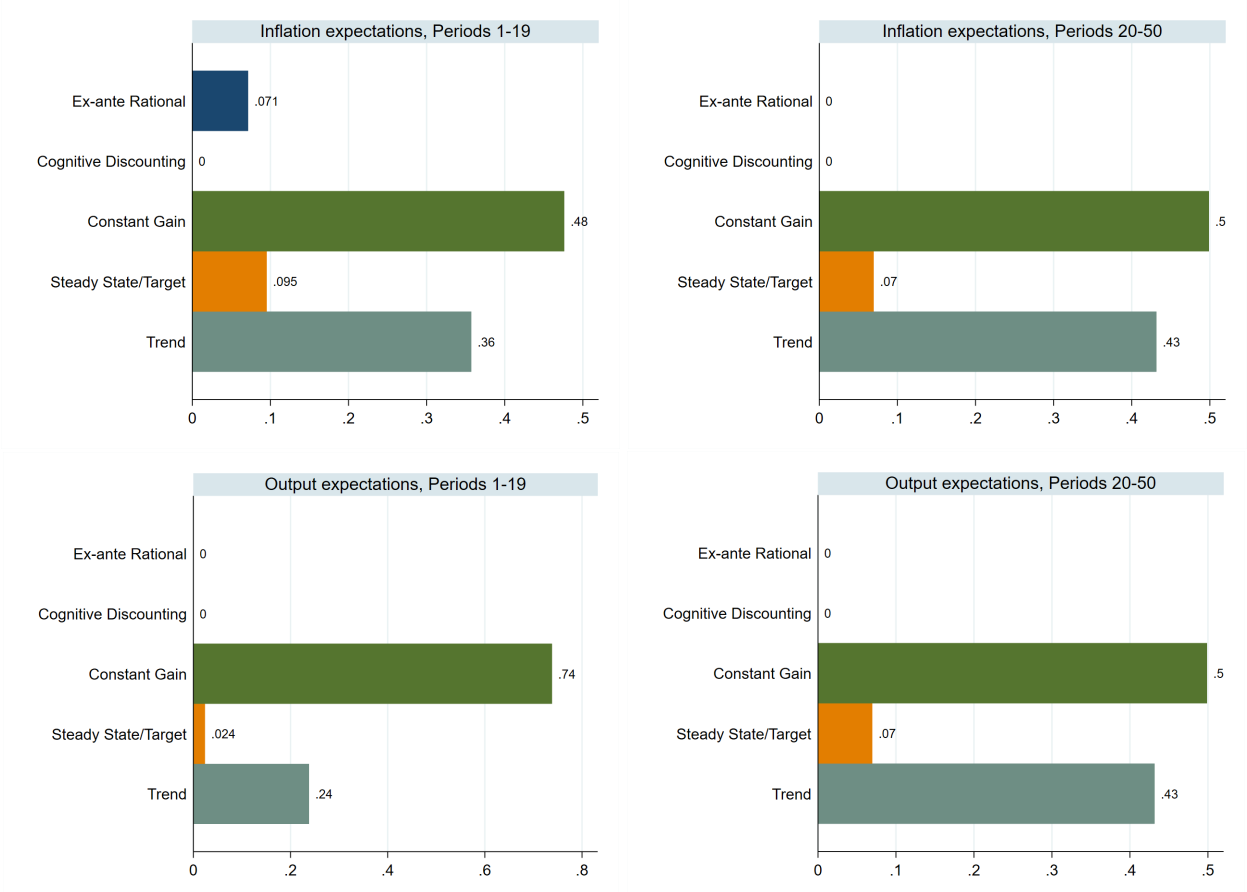
This figure presents the shares of participants whose forecasts satisfy the definition of basic rationality as forecasting in the correct direction. Panel (a) presents share for inflation forecasts, panel (b) – share for output forecasts, and panel (c) – share for both inflation and output forecasts satisfying basic rationality.

F. Additional PLT Comm experimental results

In this section, we present individual-level findings from the PLT Comm treatment.
Figure F1 presents the distribution of forecasting heuristics for inflation and output gap forecasts in PLT Comm.

Figure F2 shows the distribution of losses in the PLT Comm treatment relative to the original set of treatments. Losses in PLT Comm are significantly lower than losses in PLT in both the pre-shock and post-shock phases (Wilcoxon rank sum test, $N = 6$ for each treatment, $p < 0.001$). PLT Comm produces the lowest average losses in both phases of the experiment, excluding unstable session 5.

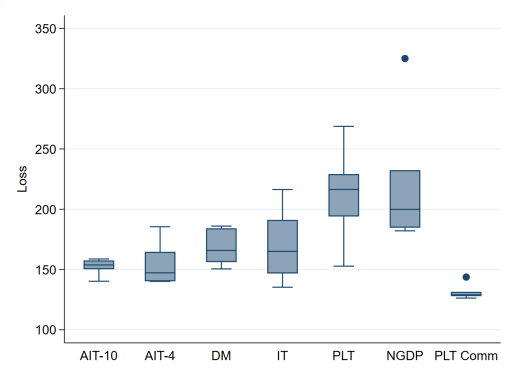
Figure F1: Distribution of forecasting heuristics for inflation and output gap forecasts in PLT Comm



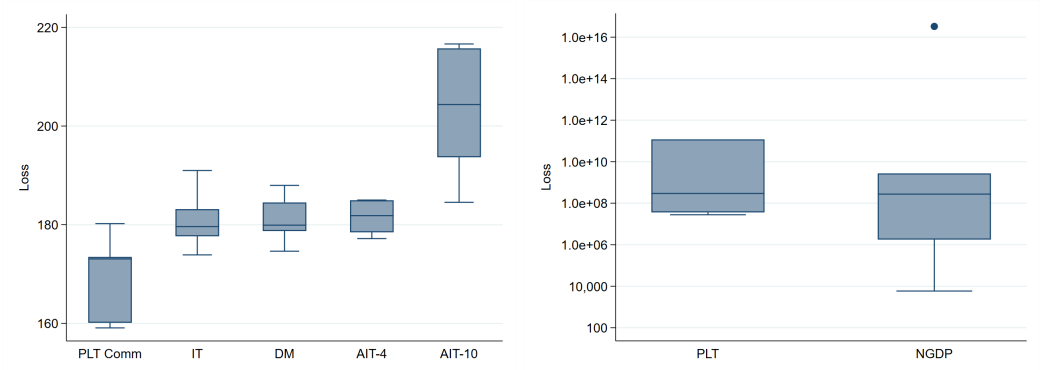
This figure presents the share of participants in each phase classified into a given heuristic.

Figure F2: Distribution of losses including PLT Comm treatment

Periods 1-19



Periods 20-50



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