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A Horse Race of Monetary Policy Regimes: An Experimental Investigation

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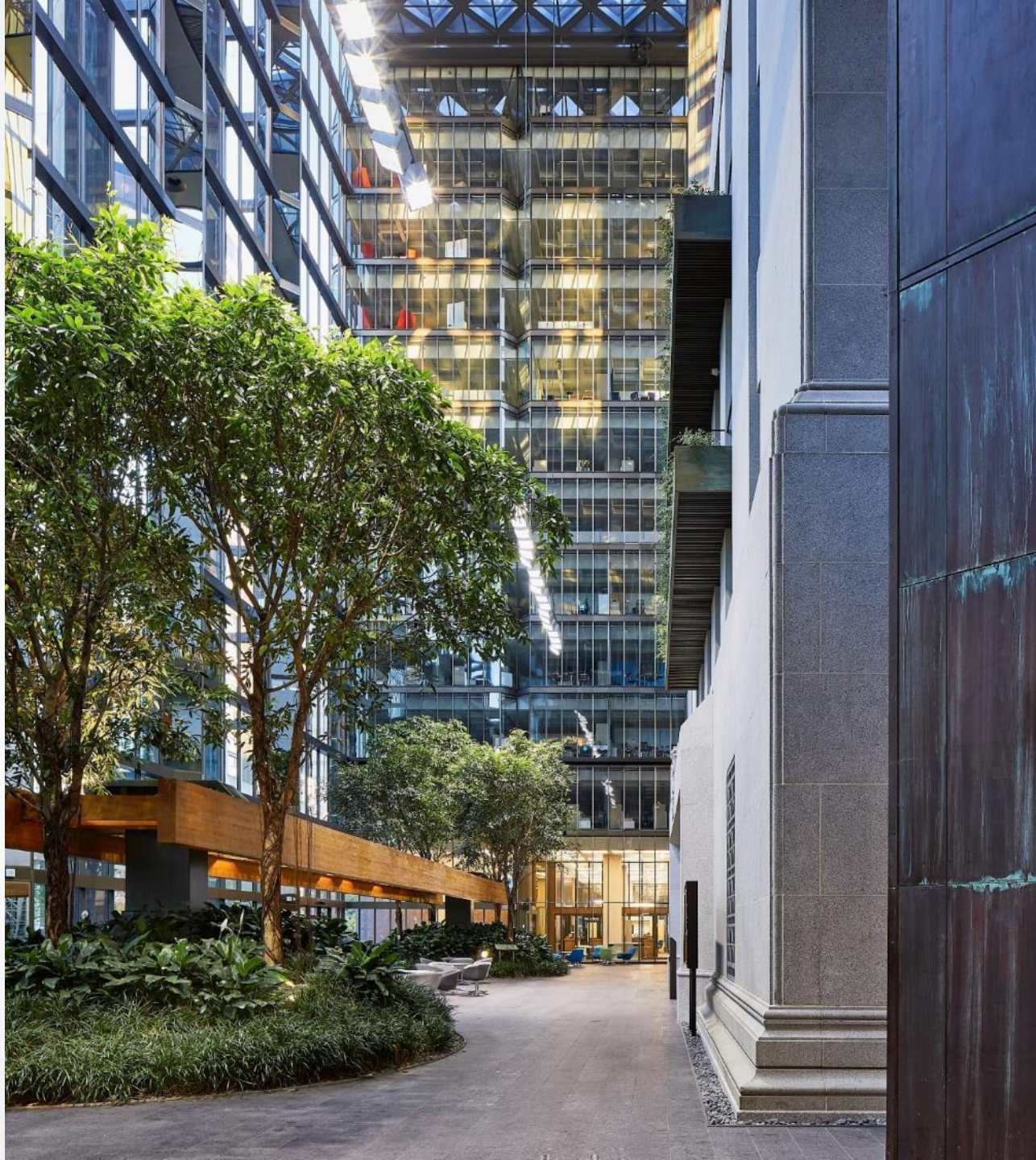
BANK OF CANADA; SIMON FRASER UNIVERSITY; BANK OF CANADA

Views expressed in this presentation are that of the authors and do not represent views of the Bank of Canada

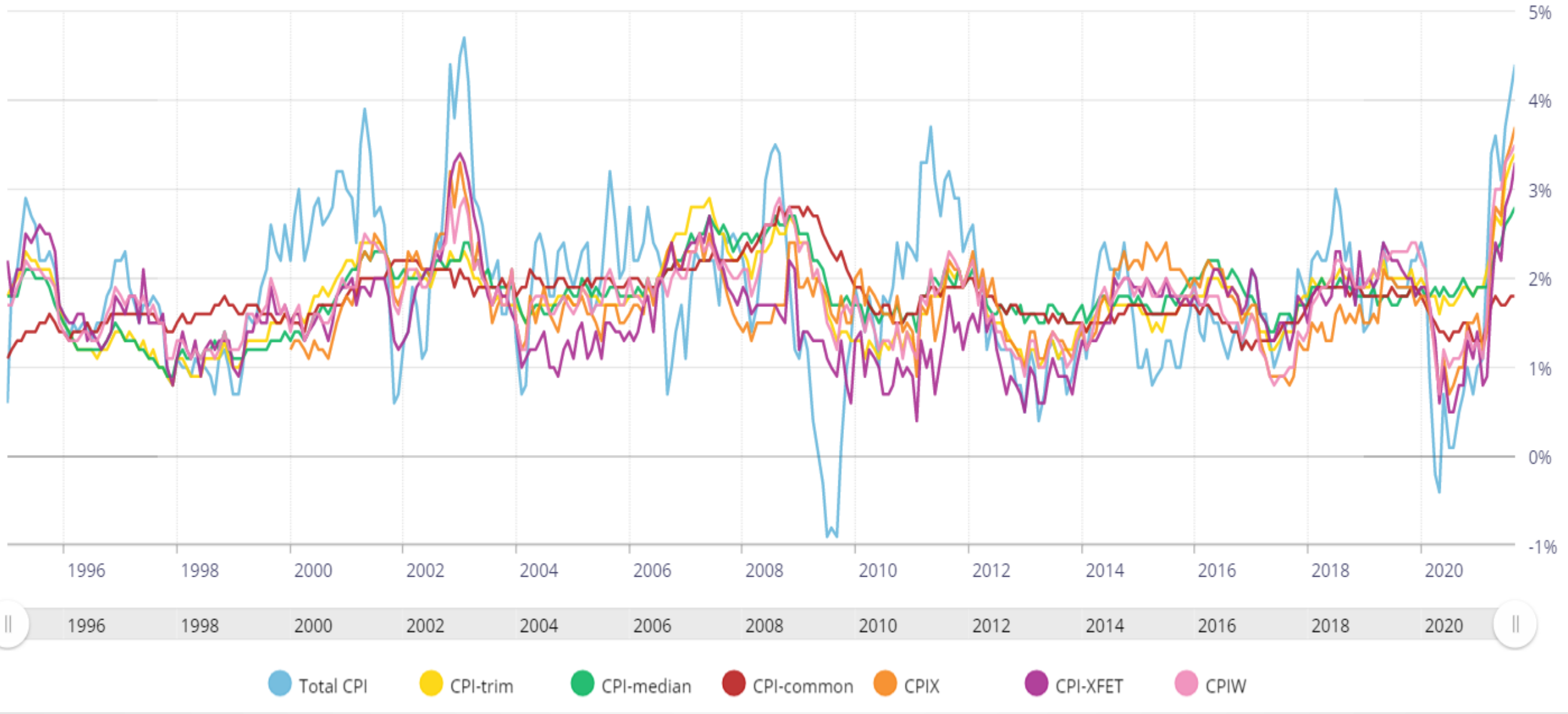


Motivation

- Inflation targeting has dominated monetary policy since the early 1990s
- Many worthwhile policy options on the table for central banks, especially at the ZLB
- Bank of Canada's mandate renewal (2021-2025)
  - Adopted inflation targeting framework in 1991 to guide monetary policy
  - Aims to keep total CPI inflation at the 2 percent midpoint of a target range of 1-3 percent over the medium term.

Consumer Price Index

Percentage change over the past 12 months



Motivation

Many worthwhile policy options on the table for central banks, especially at the ZLB

- Flexible inflation targeting (IT)
- Dual mandate (equal weight on inflation and output) (DM)
- Average inflation targeting (AIT-4, AIT-10)
- Price level targeting (PLT)
- Nominal GDP level targeting (NGDP)

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Motivation

Many worthwhile policy options on the table for central banks, especially at the ZLB

- Flexible inflation targeting (IT) – **lots of evidence**
- Dual mandate (equal weight on inflation and output) (DM) – **limited evidence**
- Average inflation targeting (AIT-4, AIT-10) - **U.S. 2020-2021**
- Price level targeting (PLT) – **Sweden 1930s**
- Nominal GDP level targeting (NGDP) – **no evidence**

Related literature

- IT vs. PLT: Evidence is mixed
  - IT outperforms PLT: Amano, Engle-Warnick, Shukayev (2011), Arifovic and Petersen (2017)
  - PLT outperforms IT: Salle (2021)
  - Depends: Hommes and Makarewicz (2021)
- IT vs. AIT: Evidence is mixed
  - Cobion et al. (2020), Hoffmann et al. (2021), Salle (2021)
- Inflation volatility can be lowered if the central bank employs a DM and responds to the output gap
  - Hommes, Massaro and Weber (2019)
- Deflationary episodes can occur at the ELB without sufficient policy intervention
  - Arifovic and Petersen (2017), Ahrens, Lustenhouwer and Tettamanzi (2017), Assenza, Heemeijer, Hommes, Massaro (2019), Hommes, Massaro and Salle (2019), Kryvtsov and Petersen (2021)

5 Policy Frameworks in the Experimental Horse Race

- Flexible inflation targeting (IT)
- Dual mandate (equal weight on inflation and output) (DM)
- Average inflation targeting (AIT-4, AIT-10)
- Price level targeting (PLT)
- Nominal GDP level targeting (NGDP)

Examine effect of policies on expectation formation during periods of stability and at the ELB.

Experimental Horserace

Main questions

Can people understand history-dependent monetary policy regimes?

Does the horizon that monetary policy respond to matters? AIT-4 vs. AIT-10

Does the framing of targets matter? AIT-10 vs. PLT

Design of experiments

- Learning-to-forecast structure with groups of participants incentivized to forecast accurately
- Macroeconomic dynamics driven by subject-supplied expectations and exogenous shocks
- Between-subject treatment variation in the policy rule

Model

Simple New Keynesian model used as part of the Bank of Canada's own horse race (Swarbrick and Zhang, 2021) :

IS curve: $$x_t = x^e_{t+1} - \frac{1}{\sigma}(i_t - \pi^e_{t+1} - r^n_t)$$

Phillips curve: $$\pi_t = \beta\pi^e_{t+1} + \kappa x_t$$

Natural rate: $$r^n_t = \rho r^n_{t-1} + \varepsilon^{rn}_t$$

Steady state and central bank's targets: $\pi^* = x^* = 0$

Policy rules / Treatments

Policy rules are parameterized to optimize loss function:

$$L = \sum (\pi_t^2 + x_t^2 + 0.5 i_t^2)$$

IT: $i_t = i^* + 3x_t + 5.5(\pi_t - \bar{\pi})$

DM: $i_t = i^* + 4.5x_t + 4.5(\pi_t - \bar{\pi})$

AIT-4: $i_t = i^* + 3x_t + 5.5\left(\frac{1}{4}\sum_{j=0}^{3} \pi_{t-j} - \bar{\pi}\right)$

AIT-10: $i_t = i^* + 3x_t + 5.5(\frac{1}{10}\sum_{j=0}^{9} \pi_{t-j} - \bar{\pi})$

PLT: $i_t = i^* + 1.3x_t + 0.8(p_t - \bar{p_t})$

NGDP Level Targeting: $i_t = i^* + 1.1\left[\left(y_t + p_t^y\right) - \left(\bar{y_t} + \overline{p_t^y}\right)\right]$

where interest rates are bounded below at zero bps.

Experimental Timeline

Information:

- Period t shock
- Historical information up to period t-1
- DGP

Simultaneous Decisions:

- Inflation forecast for t+1
- Output forecast for t+1

Median forecasts selected

Outcome for Period t:

- Inflation
- Output
- Nominal interest rate

Design of experiments

IS curve: $y_t = median\,(x_{t+1}^{i,e}) - \frac{1}{\sigma}\left(i_t - median\,(\pi_{t+1}^{i,e}) - r_t^n\right)$

Phillips curve: $\pi_t = \beta\, median(\,\pi_{t+1}^{i,e}) + \kappa x_t$

Natural rate: $r_t^n = \rho r_{t-1}^n + \varepsilon_t^{rn}$

Policy rule: $i_t = f(\pi_t, x_t\,)$ with a ZLB

- Each experimental session lasts 50 periods.
  - Periods 1-19: Pre-shock phase
  - Periods 20-50: Large negative demand shock followed by recovery

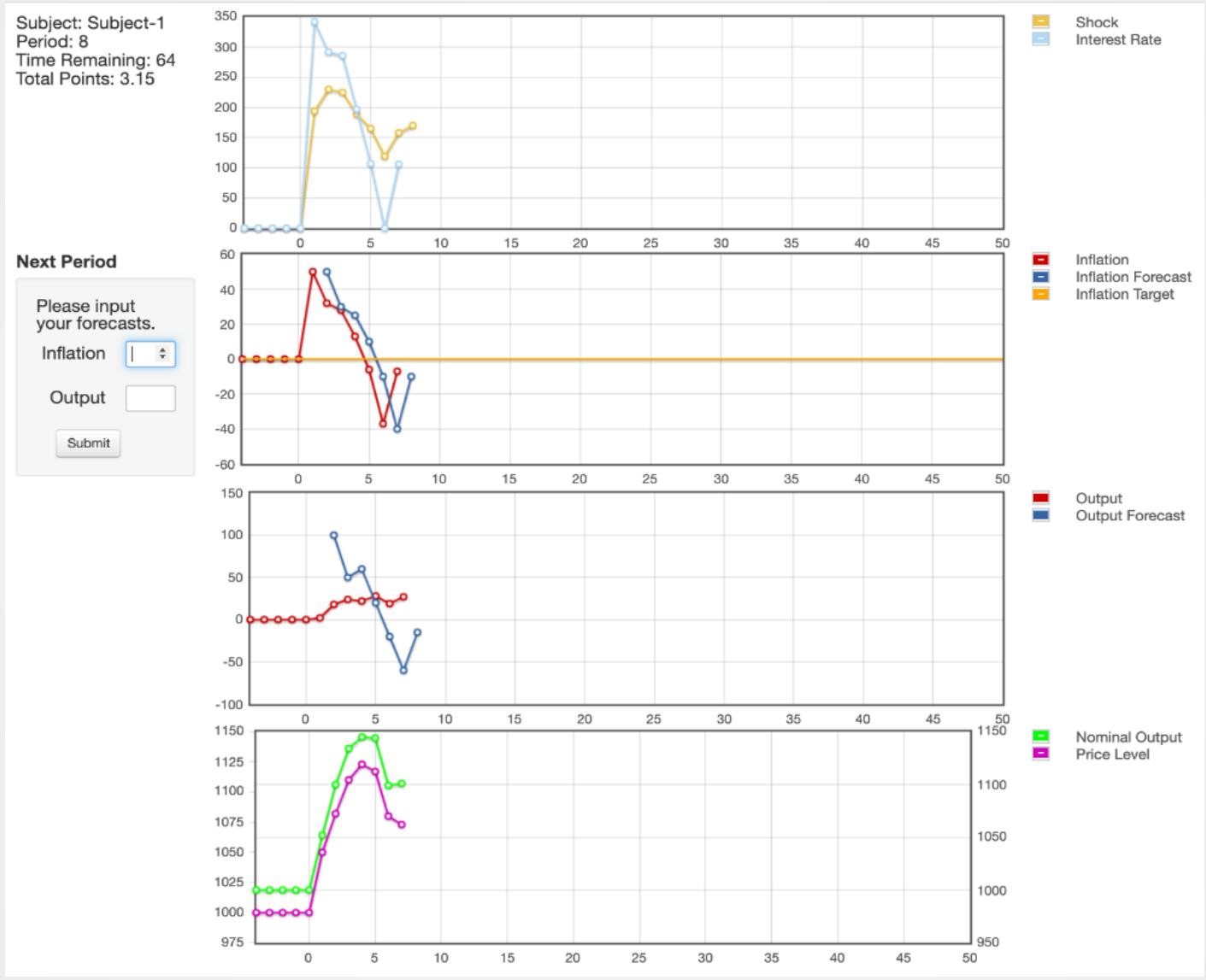
Design of experiments (2)

- Experiments were conducted online with students from Simon Fraser University and Texas A&M University
- 6 sessions for each monetary policy regime.

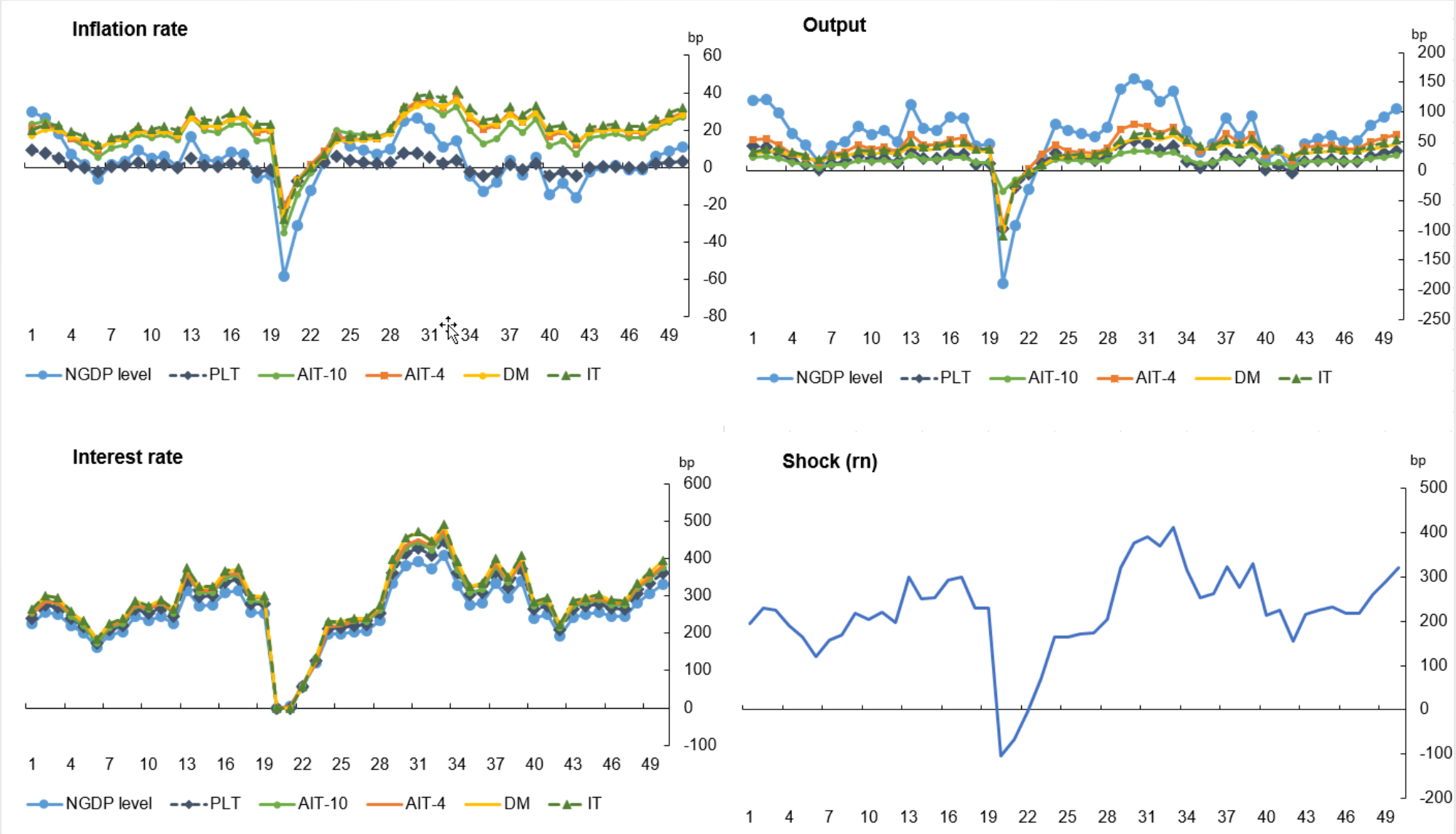
7 subjects x 6 sessions x 6 treatments = 252 participants

With 50 periods = 12,600 observations

Screenshot

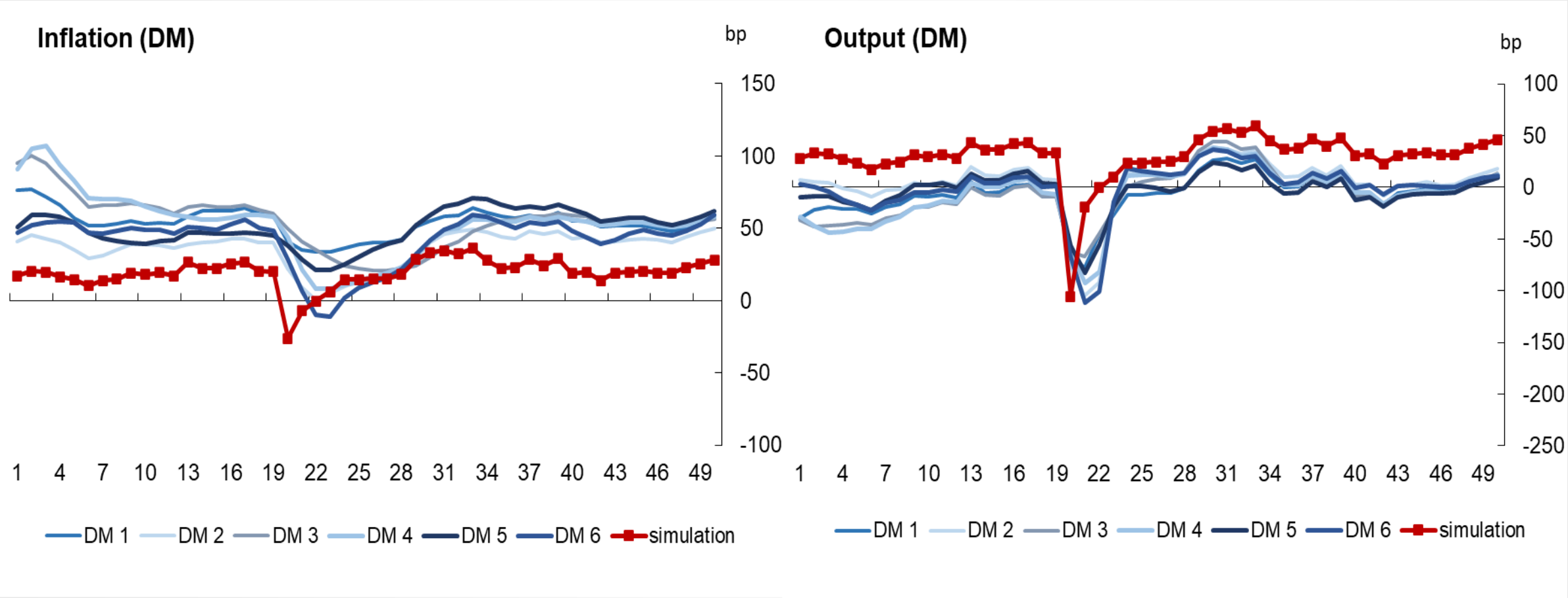

Subject: Subject-1
Period: 8
Time Remaining: 64
Total Points: 3.15
Next Period
Please input your forecasts.
Inflation
Output
Submit
Shock
Interest Rate
Inflation
Inflation Forecast
Inflation Target
Output
Output Forecast
Nominal Output
Price Level

Simulations under RE

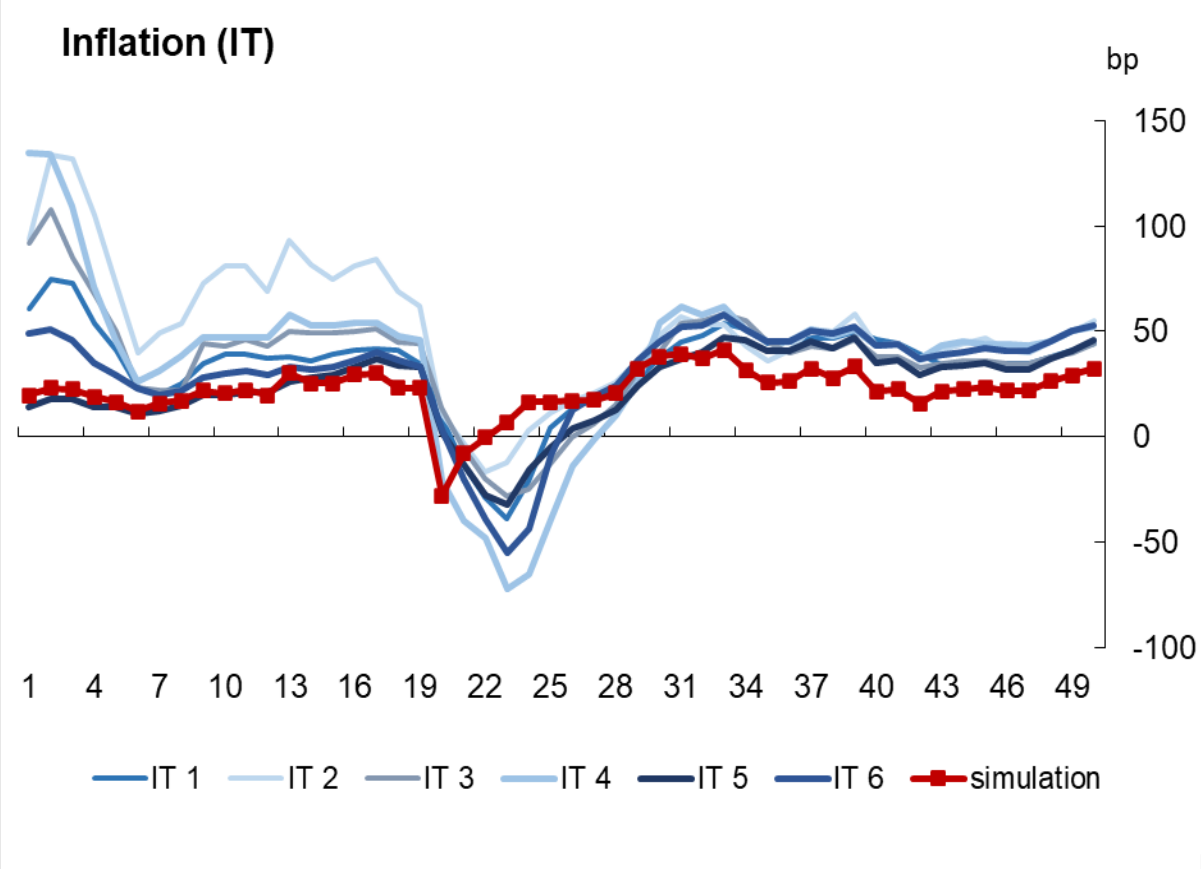


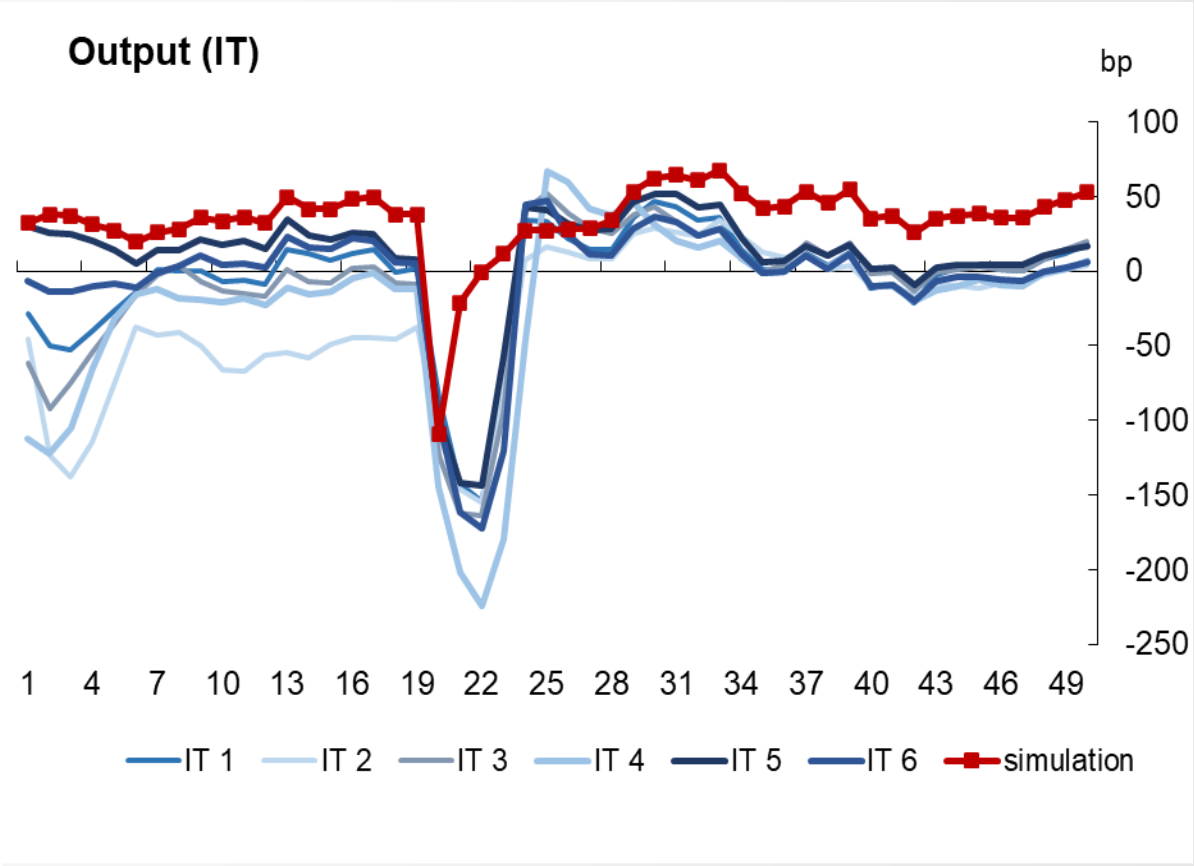
Results

Dual mandate

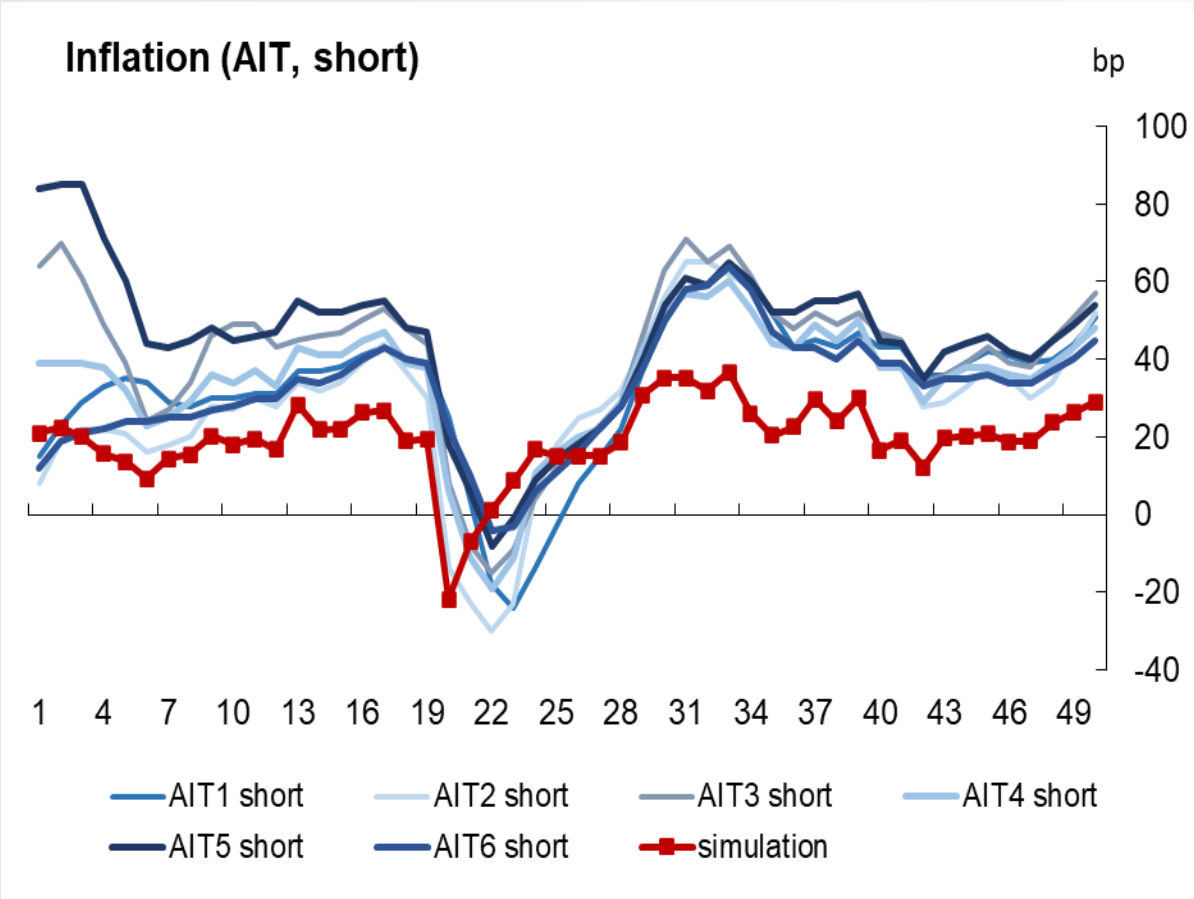


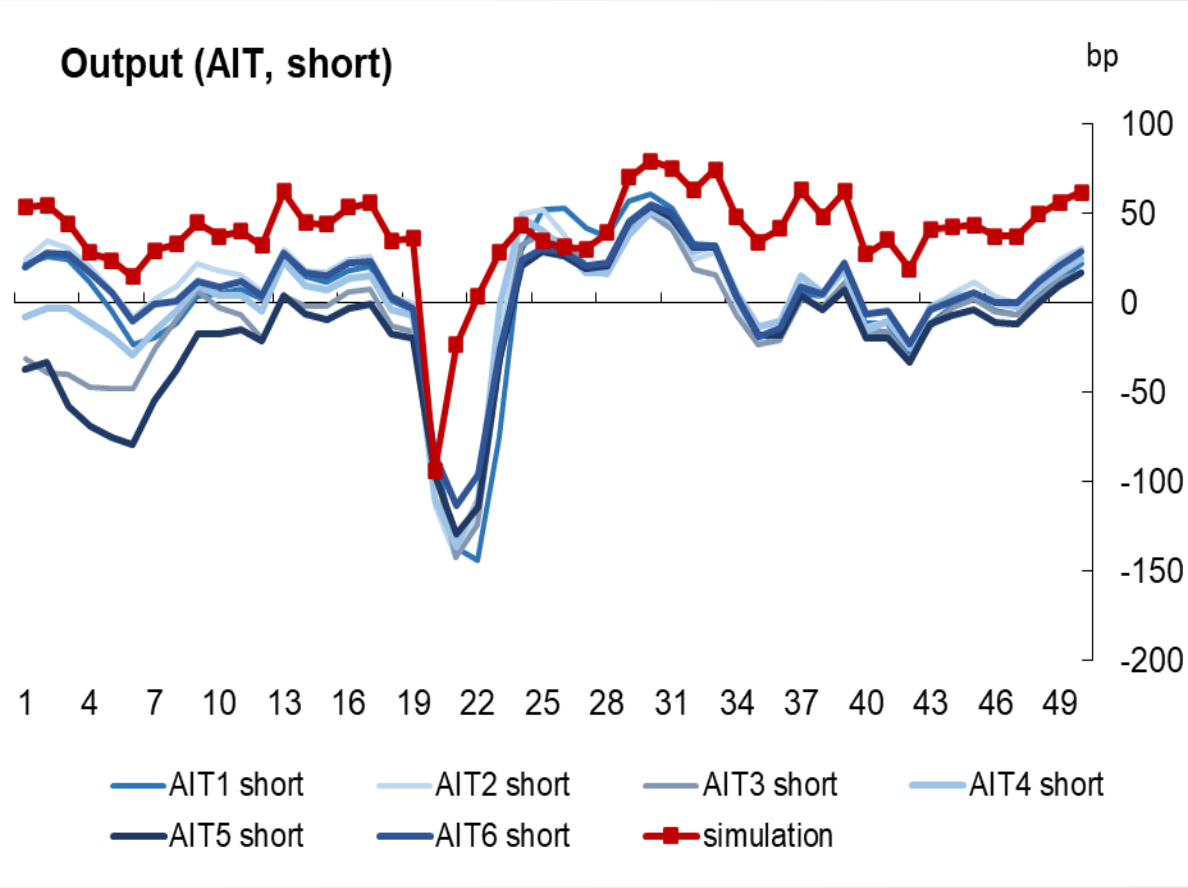
Inflation targeting



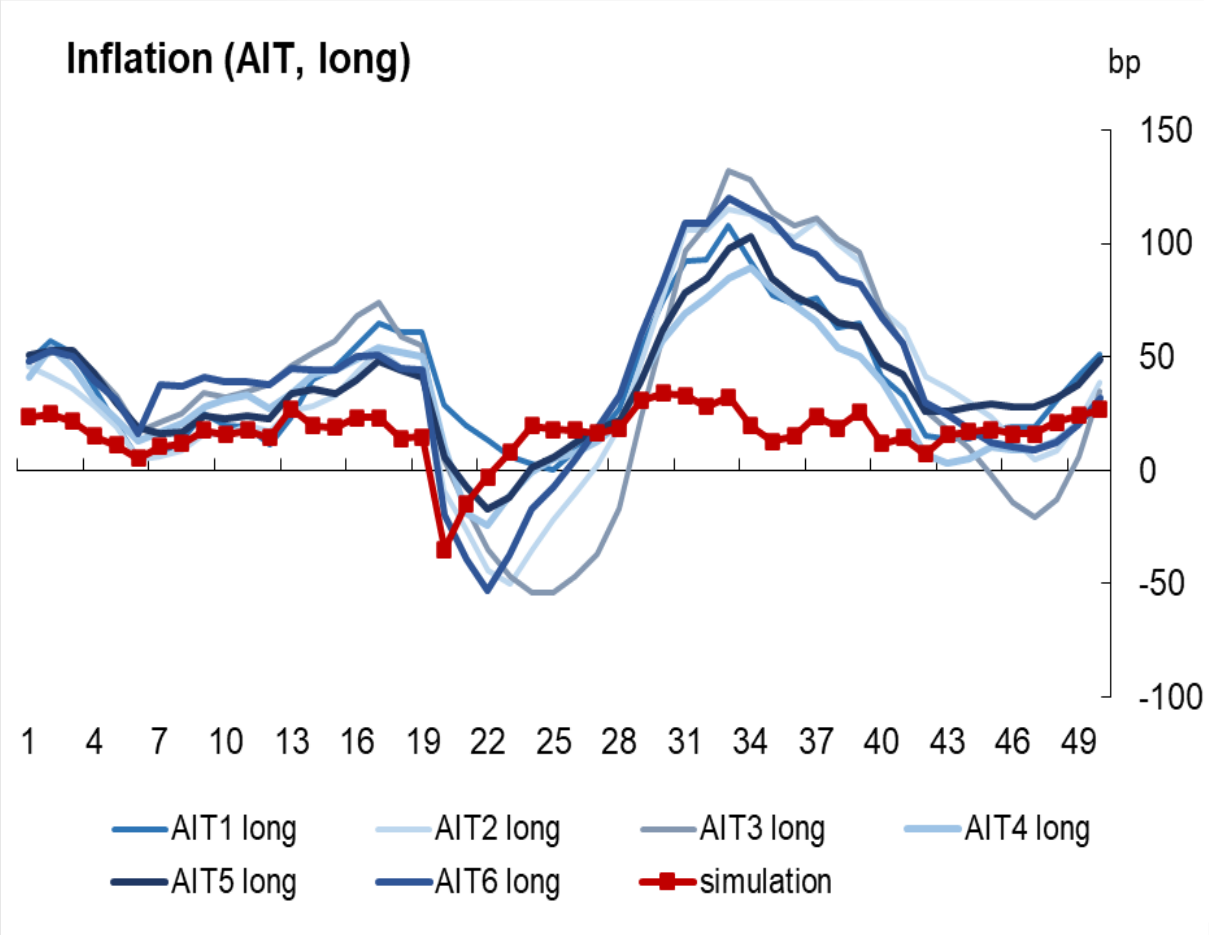


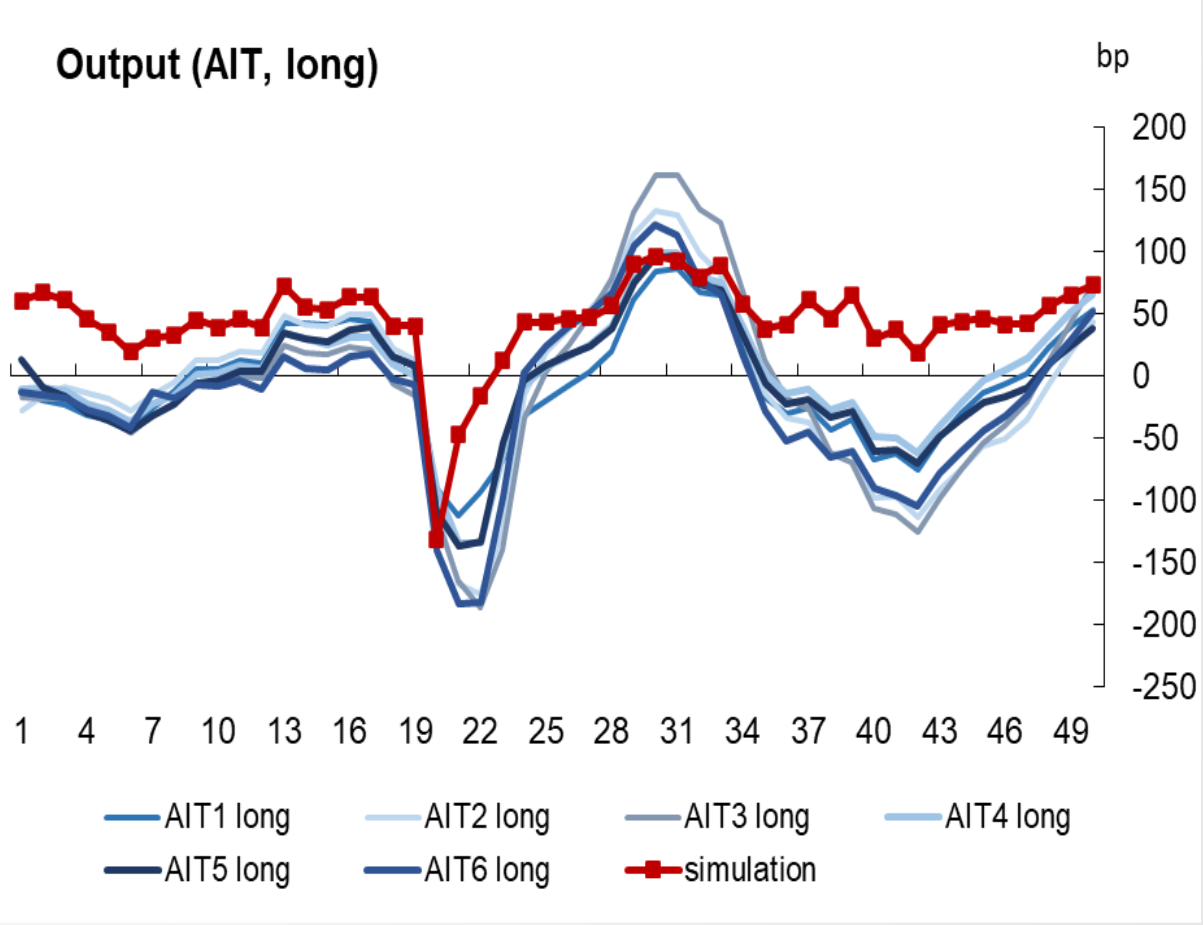
AIT short horizon, IT policy coefficients



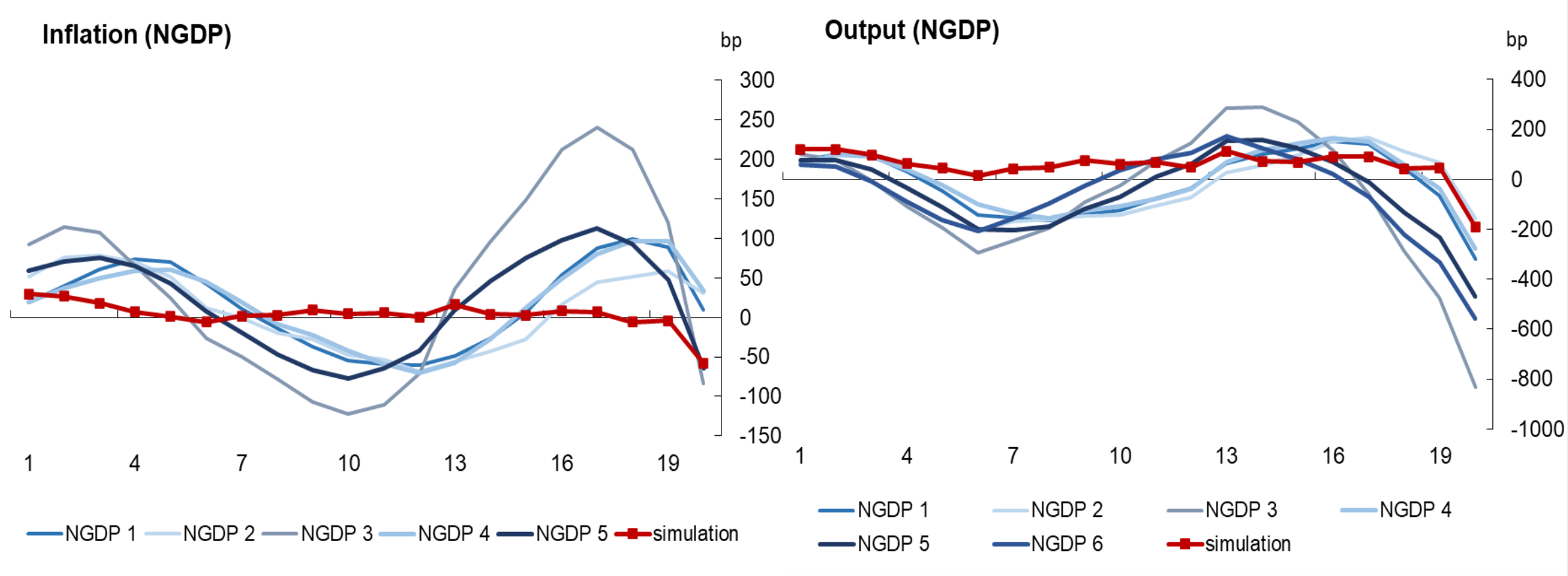


AIT long horizon, IT policy coefficients

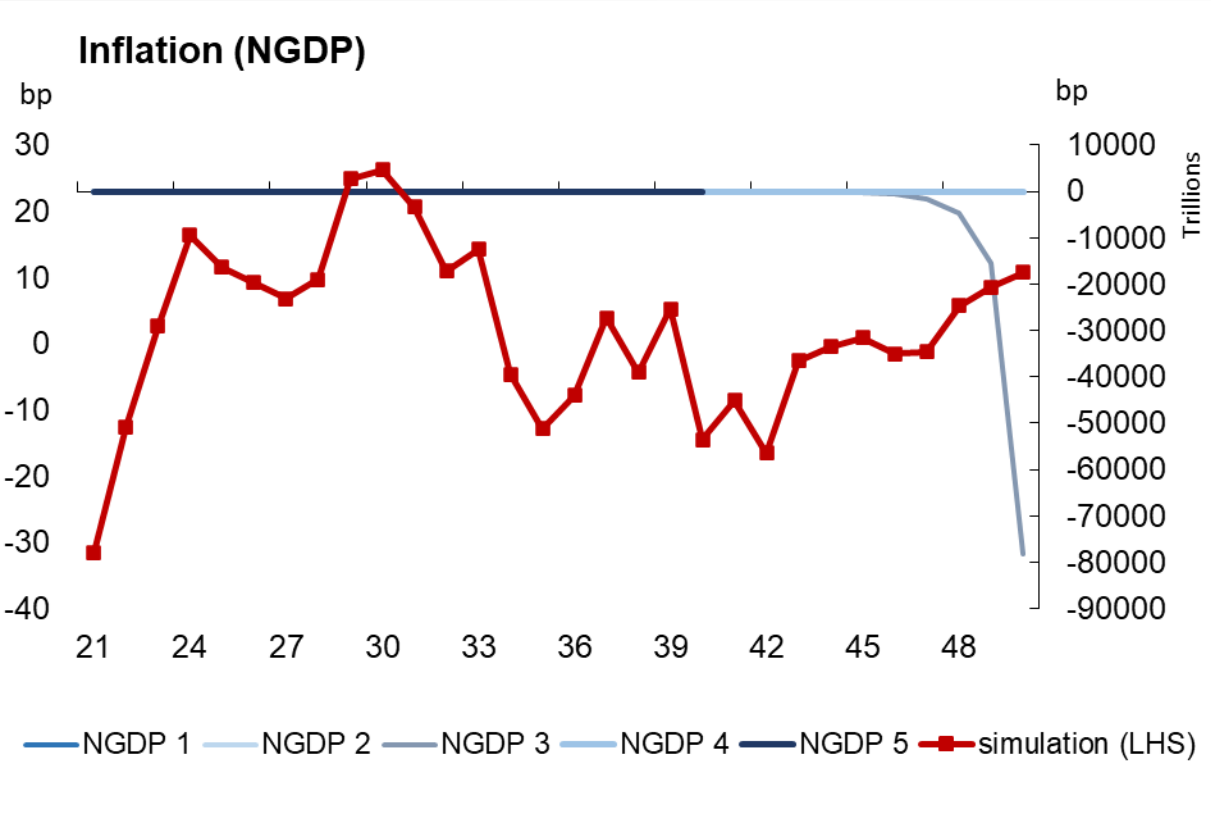


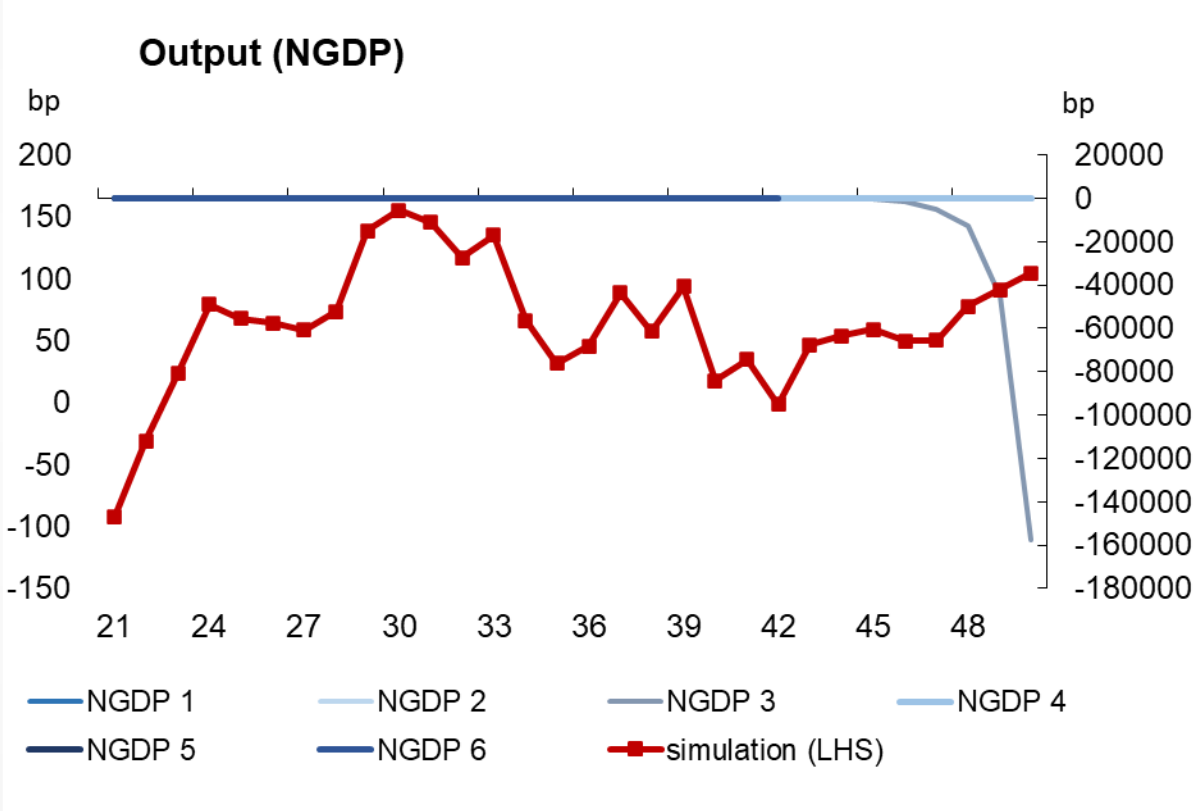


Nominal GDP level targeting

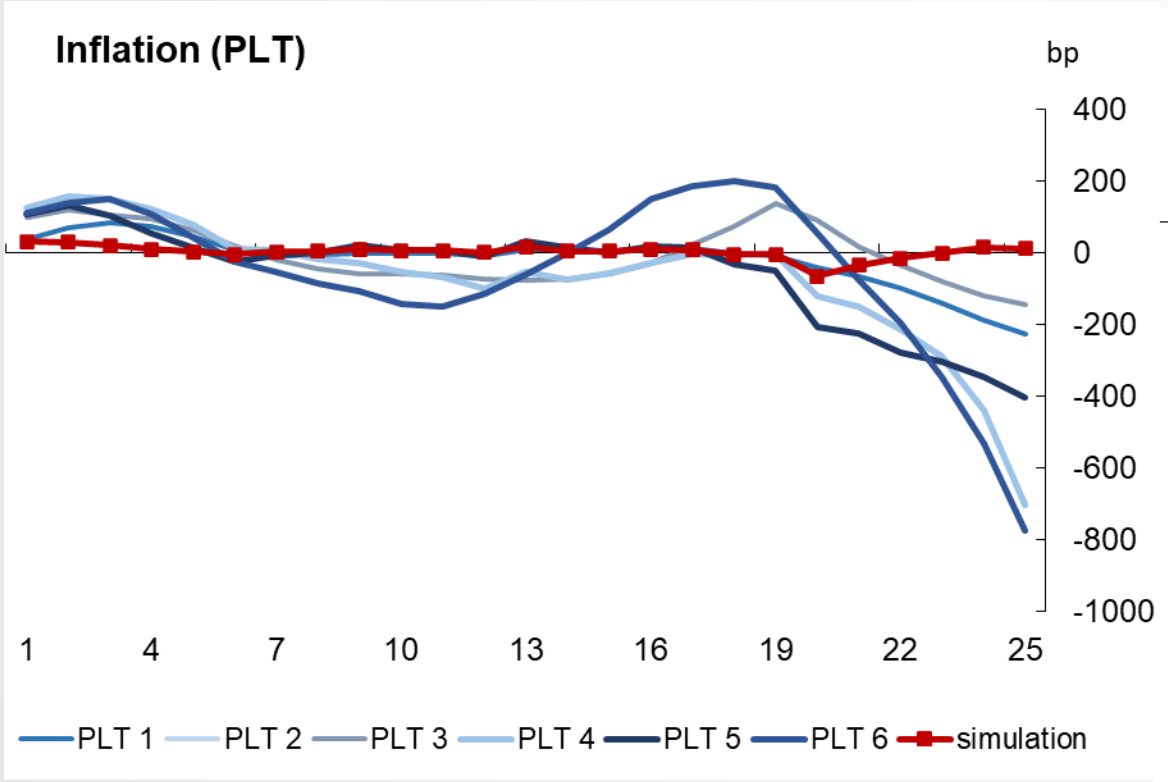


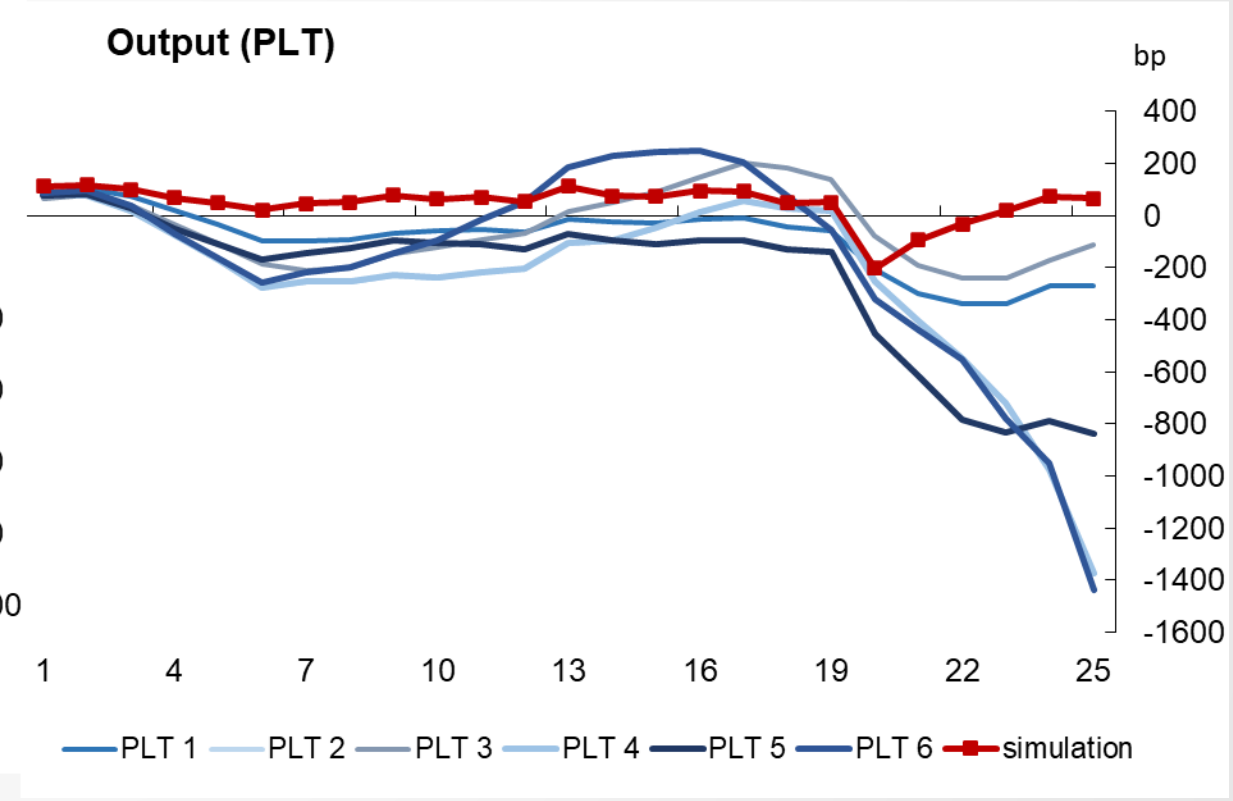
NGDP level targeting: remaining periods



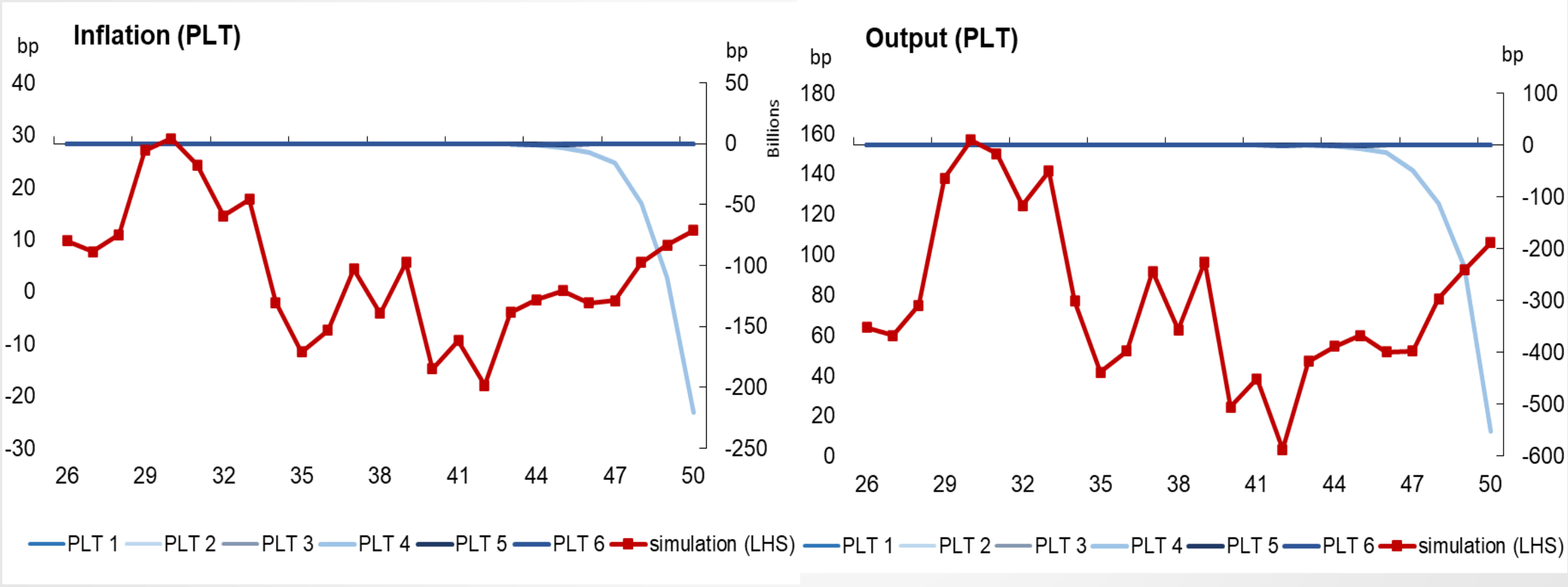


Price level targeting



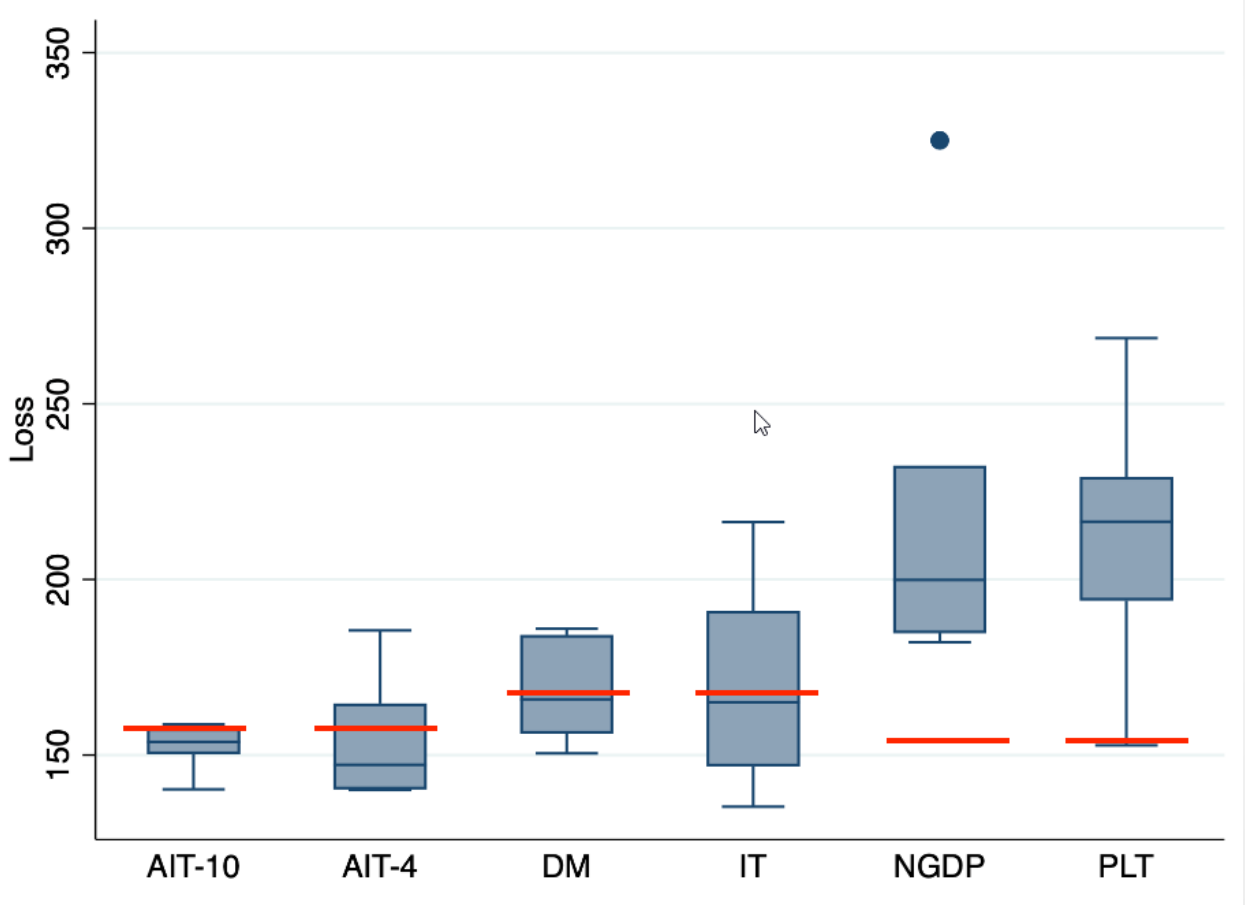


PLT: remaining periods



Ranking of policy regimes – Pre-shock

$$L = \sum(\pi_t^2 + x_t^2 + 0.5i_t^2)$$



Ranking of policy regimes – Post-shock

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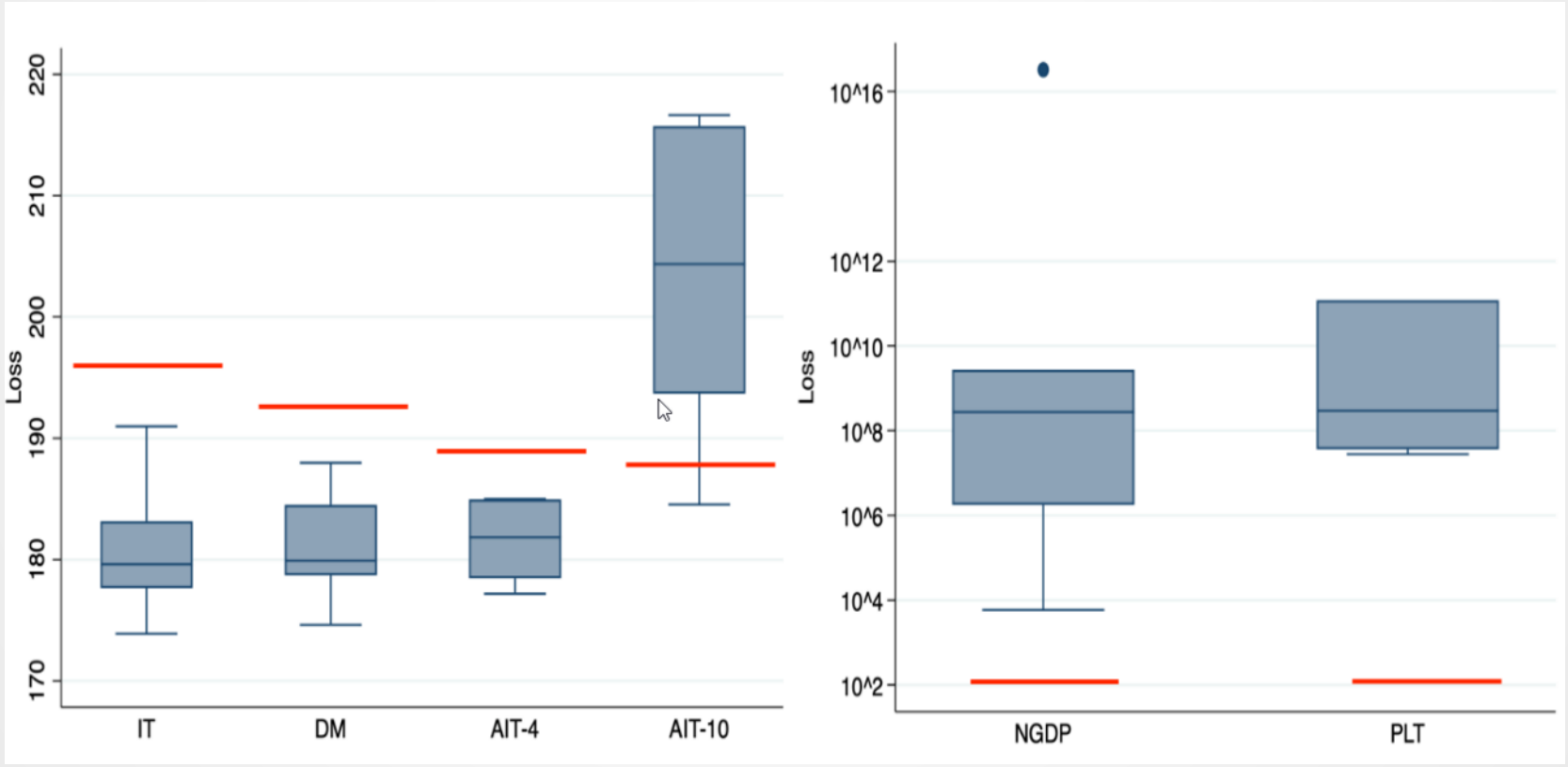


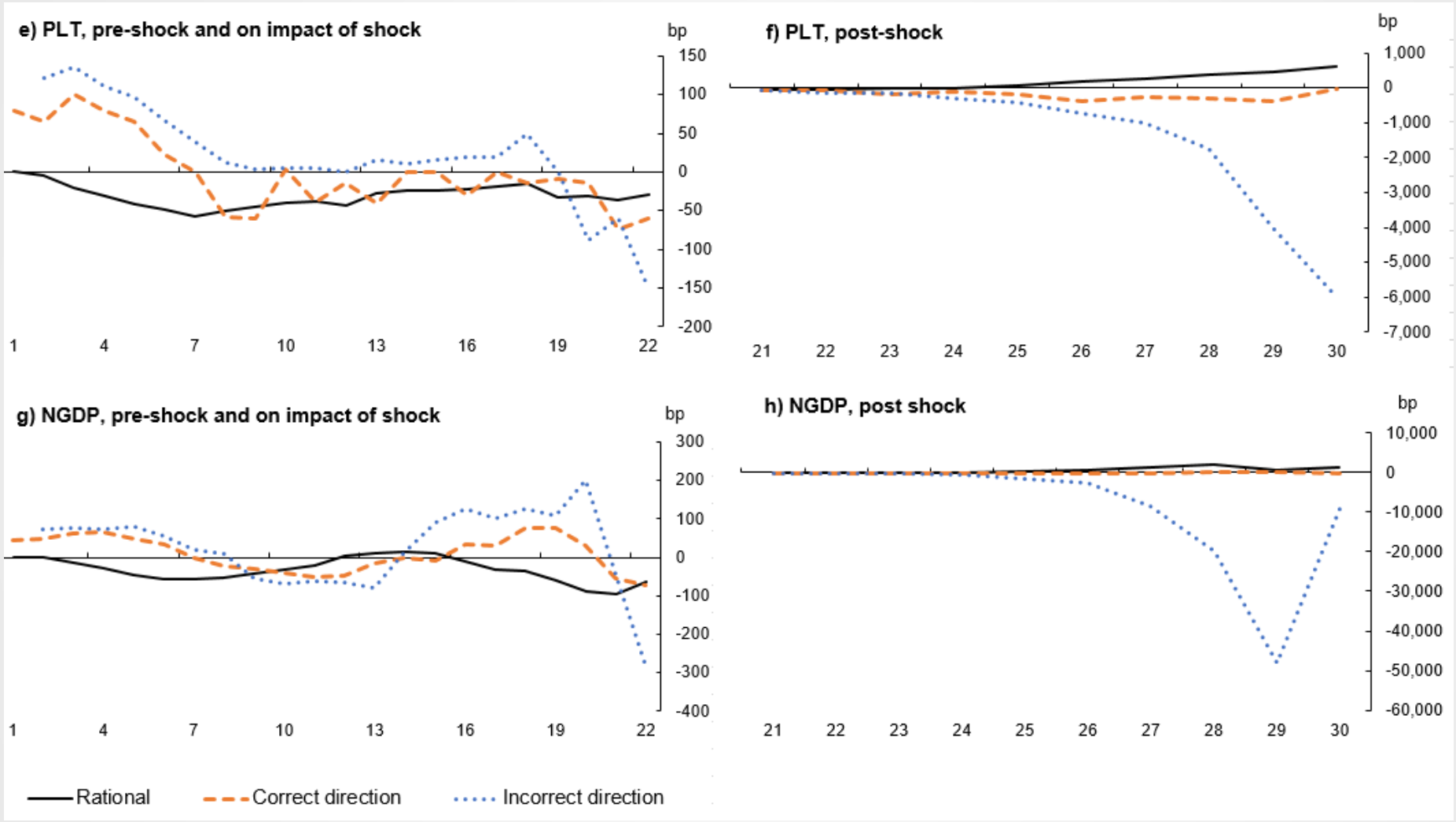
Why do level targeting policy rules not work better?

- Lack of basic rationality? Don't get it? Don't get it enough?
- Lack of credibility? Don't believe it?
- Different forecasting heuristics?

Why do level targeting policy rules not work as well as rate targeting rules?

- Lack of basic rationality? Don't get it? **COMPARABLE**
- Don't get it *enough*? **YES**
- Lack of credibility? Don't believe it?
- Different forecasting heuristics?

Median Inflation Forecasts and Basic Rationality



Large deviations from rationality pre-shock (75-200 bps)

Insufficiently positive expectations in post-shock for those with basic rationality

"Too little, too late"

Why do level targeting policy rules not work as well as rate targeting rules?

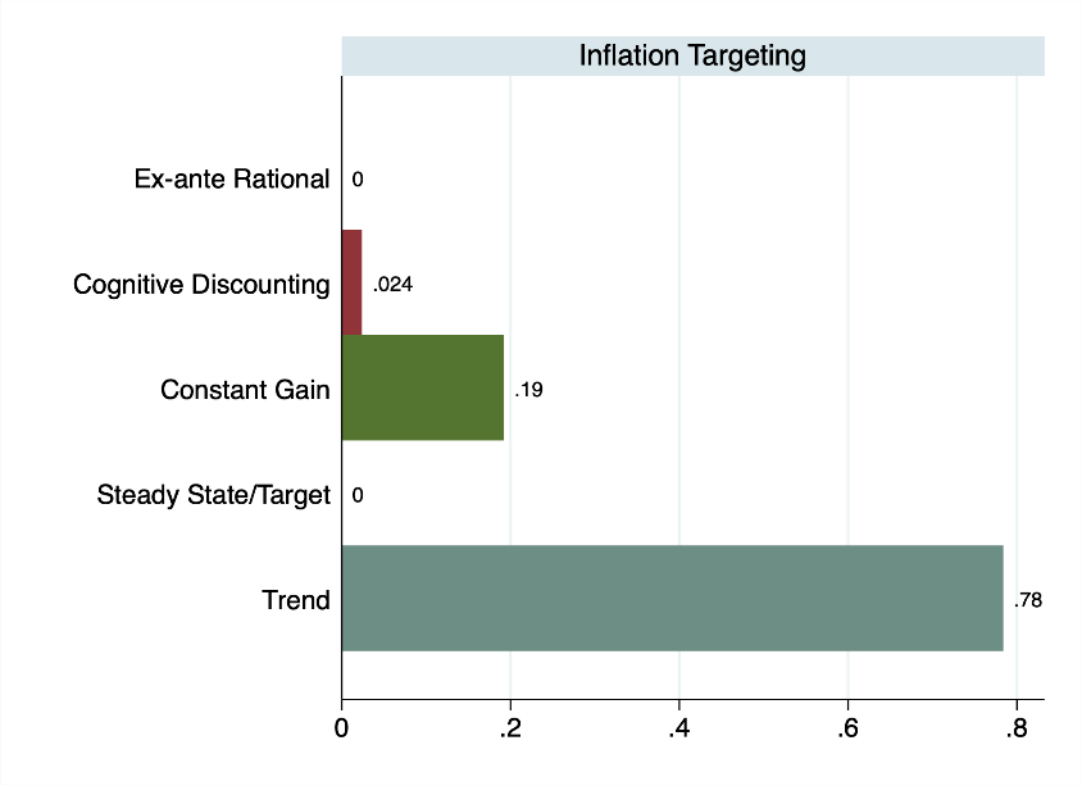
- Lack of basic rationality? Don't get it? **COMPARABLE**
- Don't get it *enough*? **YES**
- Lack of credibility? Don't believe it? **YES**
- Different forecasting heuristics?

Why do level targeting policy rules not work as well as rate targeting rules?

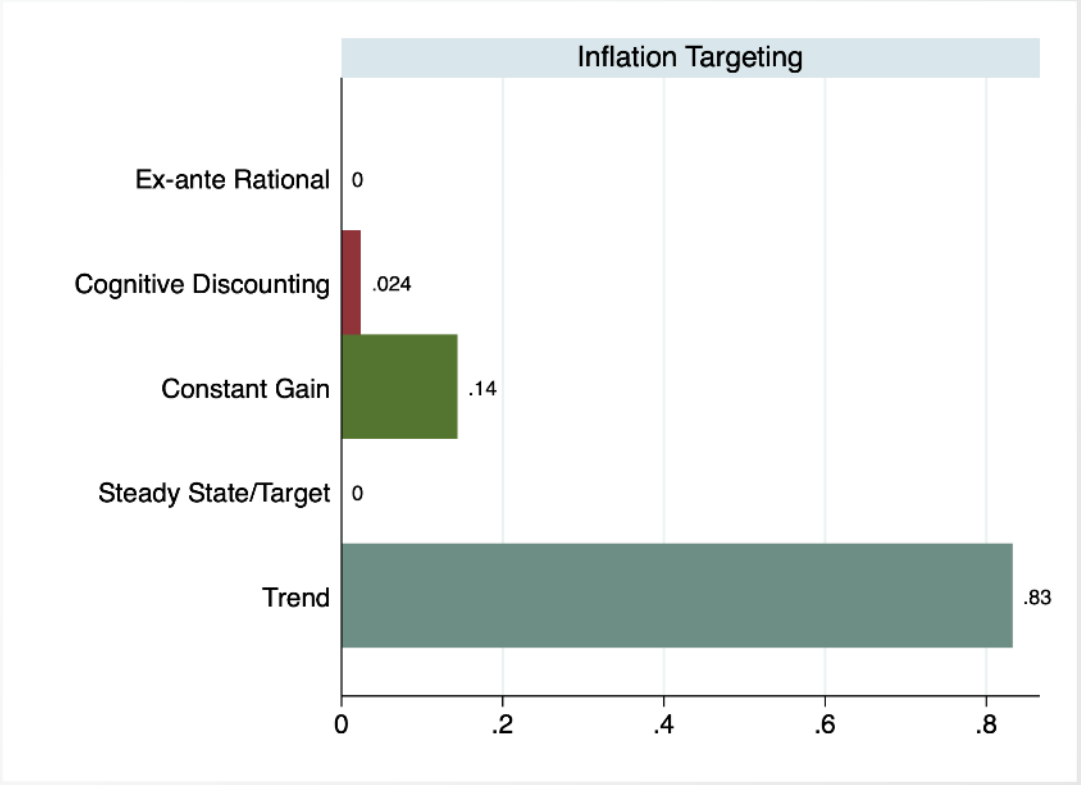
- Lack of basic rationality? Don't get it? **COMPARABLE**
- Don't get it *enough*? **YES**
- Lack of credibility? Don't believe it? **YES**
- Different forecasting heuristics? **ONLY AFTER ENTERING THE ELB**
  - Level targets encourage more heterogeneity, stronger trend-extrapolation, and larger deviations from rationality AT THE ELB

Inflation targeting: inflation forecasting rules

Before shock



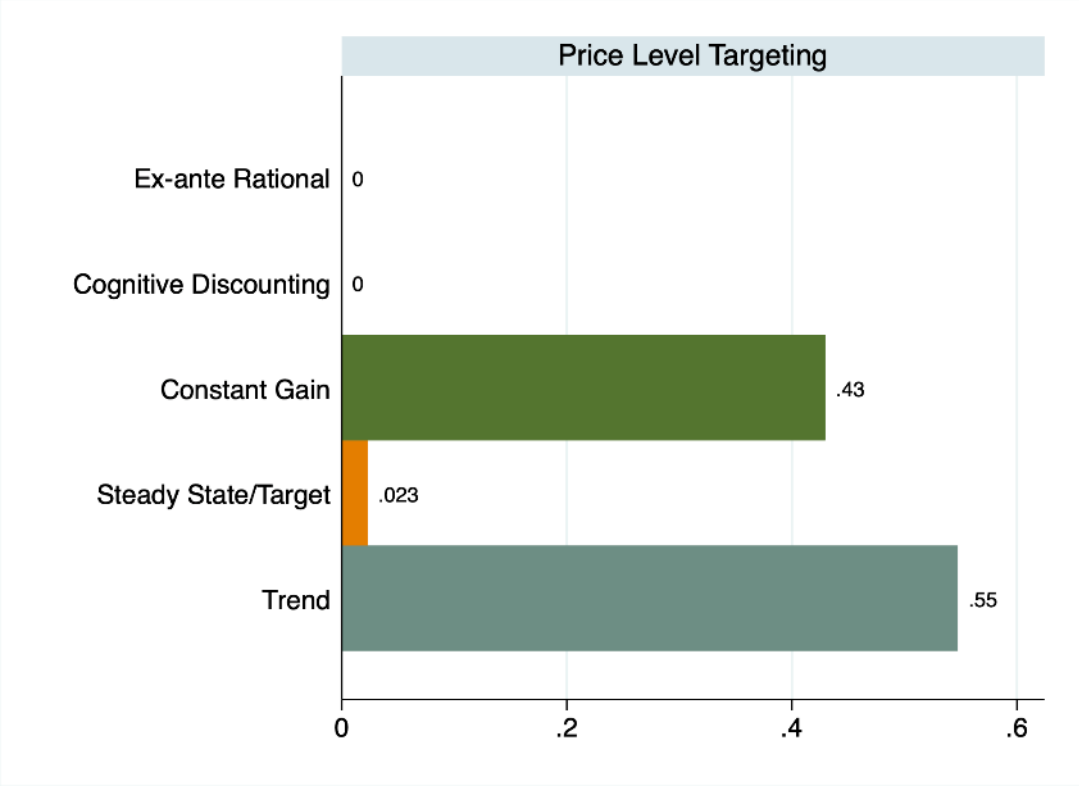
After shock



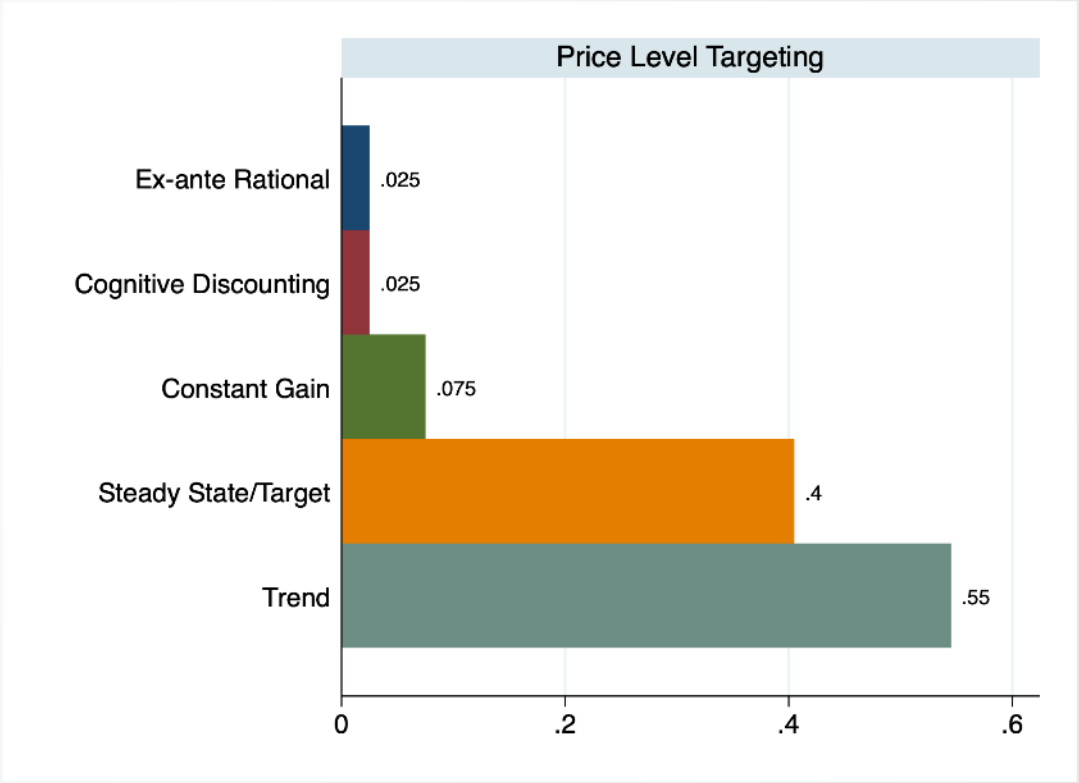
IT policy rule: $i_t = i^* + 3\tilde{x}_t + 5.5(\pi_t - \bar{\pi})$

PLT: inflation forecasting rules

Before shock



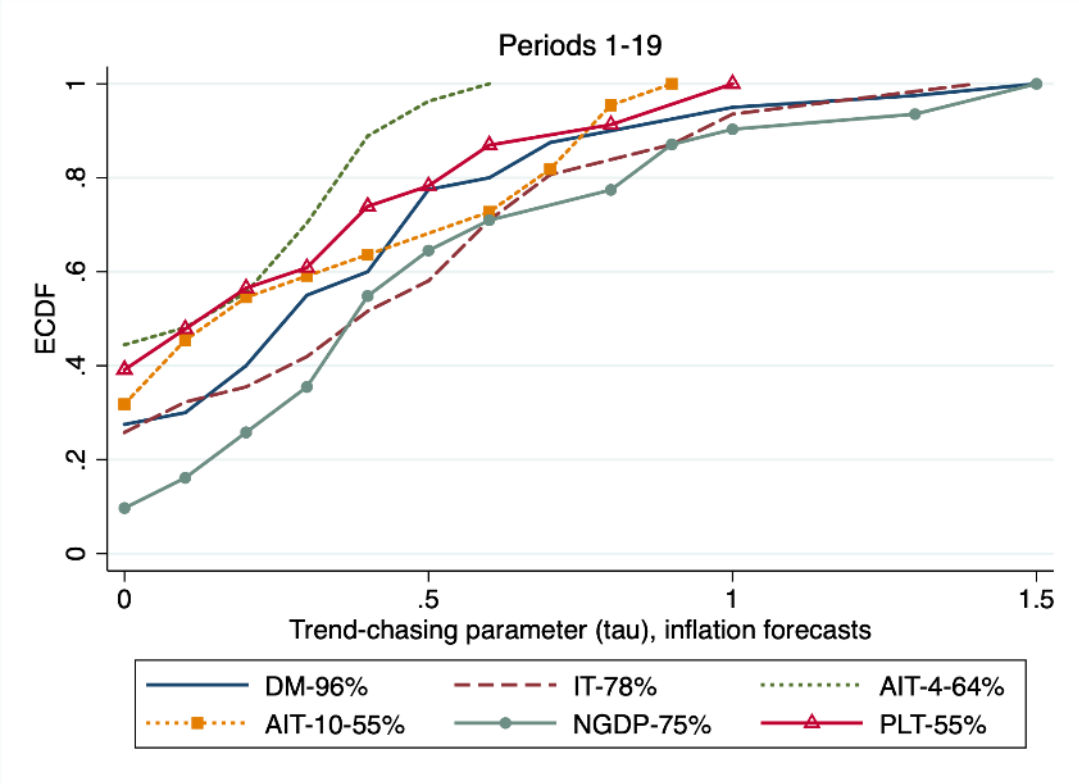
After shock



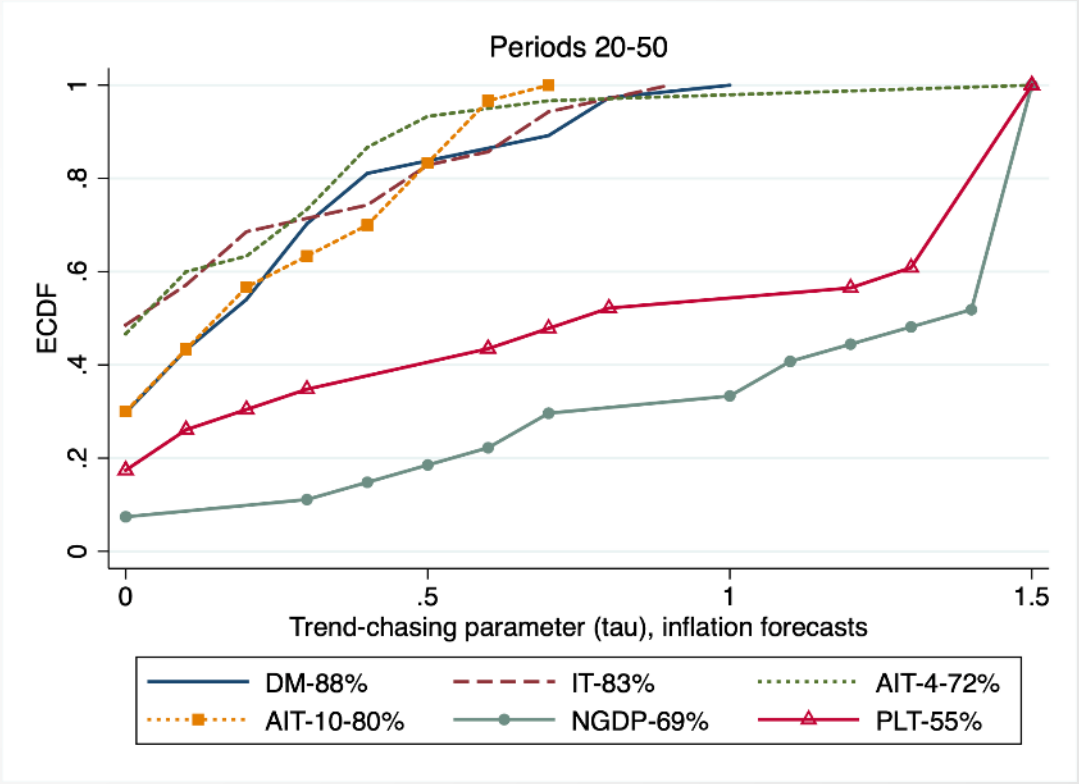
PLT policy rule: $i_t = i^* + 1.3\widetilde{x_t} + 0.8(p_t - \overline{p_t})$

Trend-chasing in inflation forecasts becomes stronger after shock in history-dependent rules

Before shock



After shock



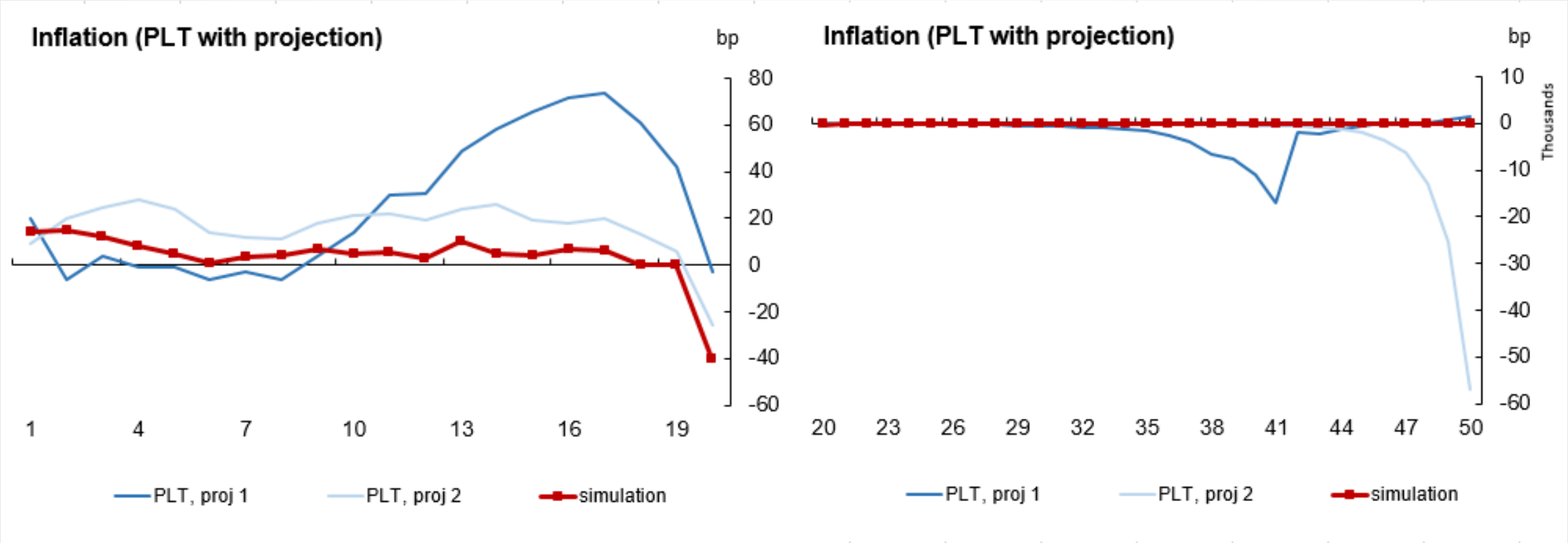
$$E_{it}\pi_{t+1} = \pi_{t-1} + \boldsymbol{\tau_i}(\pi_{t-1} - \pi_{t-2}) \quad \textit{where } \tau_i \in [0,1.5]$$

Any hope for level targeting policy rules?

- Increase the reaction coefficients in the policy rules to build credibility
  - Hommes & Makarewicz, 2021

- Provide precise central bank projections to guide expectations and quantitatively improve reactions
  - Mokhtarazadeh & Petersen, 2020
  - Petersen & Rholes, 2021

Price level targeting with inflation and output projections



If it ain't broke, don't fix it!

- A lot to still learn about level-targeting mandates
- Rate-targeting rules are more robust to the presence of non-rational expectations
  - Reacting to current economic conditions preserves credibility better than trying to play catch up
- Framing matters: Long horizon AIT is easier to understand the PLT


Thank you!

Forecasting heuristics

- Level-targeting regimes require a high level of forward-looking expectations
- Are participants using backward-looking heuristics more frequently in more complicated treatments?
- Do level-targets create more confusion and disagreement?

Why go to the lab?

1. Experimental methods offer an alternative approach to studying the causal effects of monetary policy on expectations and decisions

2. Laboratory experiments fill important empirical gaps

3. Can explore new policy frameworks and communication strategies with low cost

4. Avoids making assumptions about how expectations are formed

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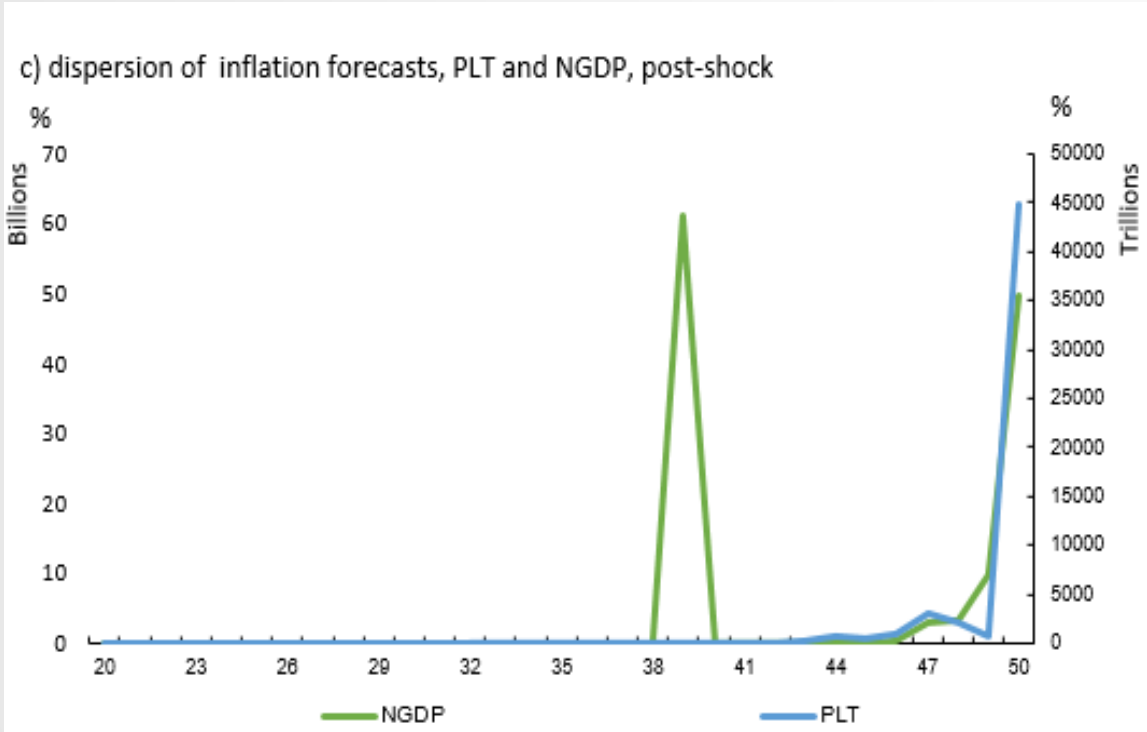
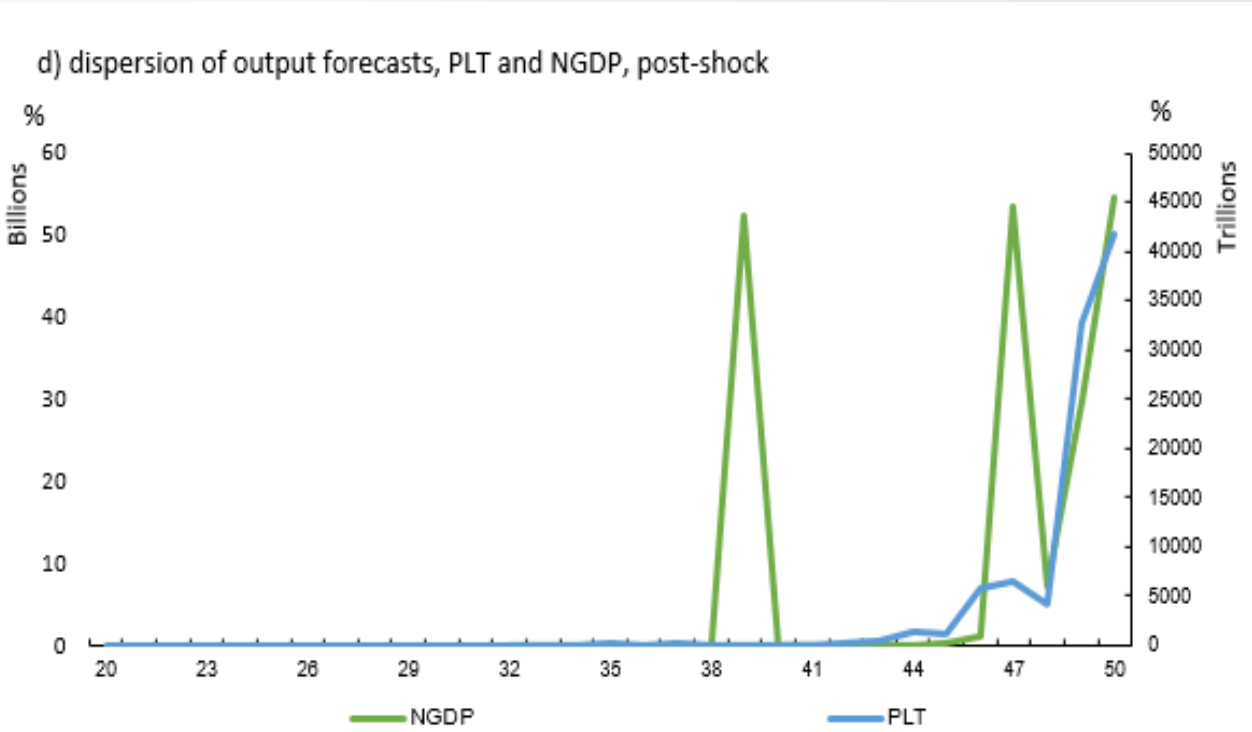
Concerns about laboratory-generated data

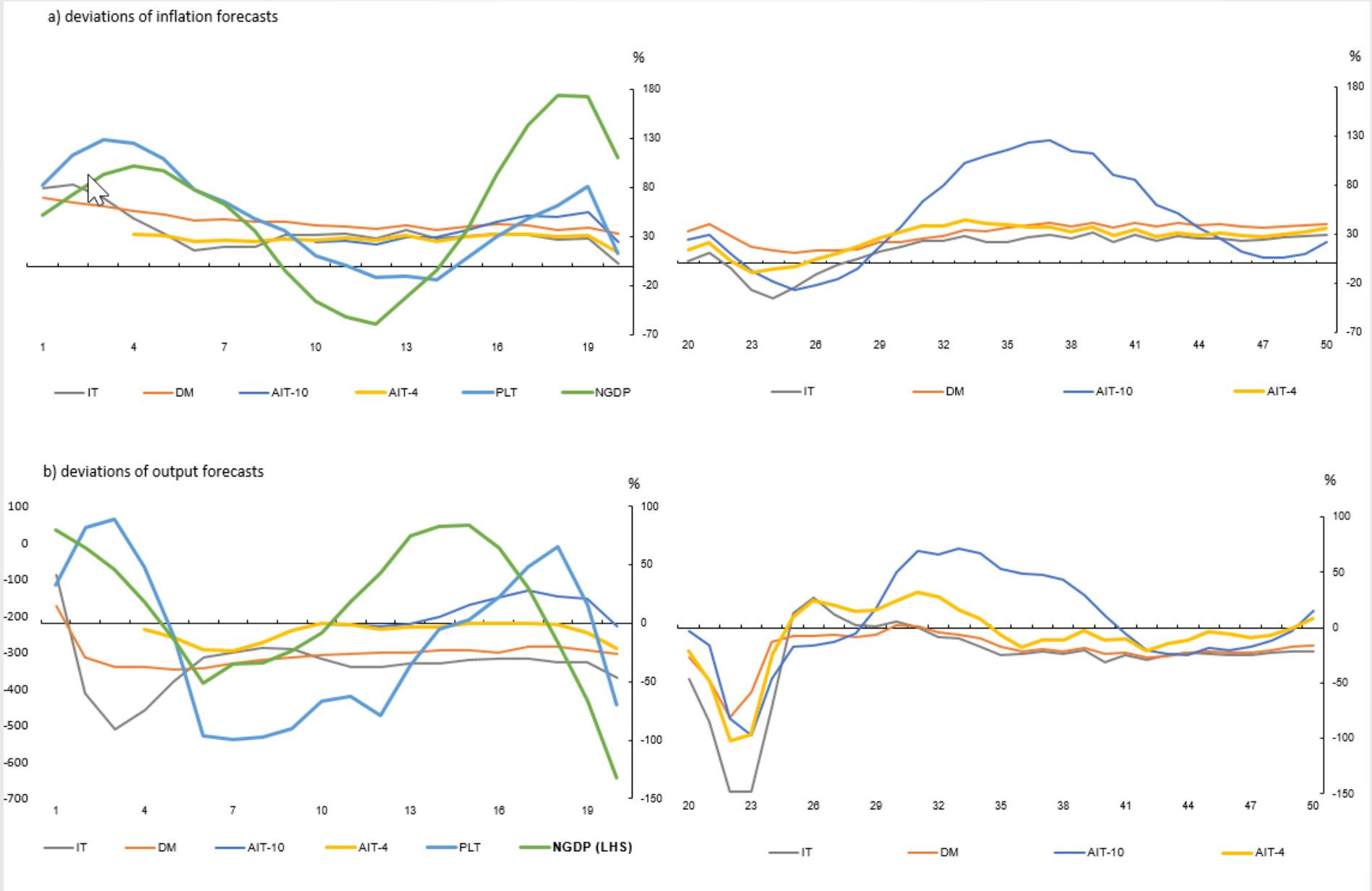
1. External validity: model and subjects

Lack of common understanding?





How far from rational?



Basic Rationality

- Do subjects even understand the basic direction in which they should be forecasting?
  - IT and DM requires reacting to current fundamentals, ignoring past history
  - AIT, PLT and NGDP would require taking into consideration both current fundamentals and recent deviations from target
- Denote a person i in period t as exhibiting basic rationality if

$$\begin{cases} E_{it}\pi_{t+1} > \pi_{t-1} \; when \; E_t^{REE}\pi_{t+1} > \pi_{t-1} \\ E_{it}\pi_{t+1} < \pi_{t-1} \; when \; E_t^{REE}\pi_{t+1} < \pi_{t-1} \end{cases}$$

Basic Rationality

	Preshock (Periods 1-19)		
	Inflation	Output	Both
NGDP	0.59	0.49	0.26
PLT	0.49	0.64	0.29
DM	0.47	0.49	0.25
IT	0.54	0.54	0.33
AIT-4	0.48	0.62	0.32
AIT-10	0.48	0.57	0.33

Pre-shock,

- PLT and NGDP are not significantly less rational than DM and IT
- Roughly 50% of inflation and output forecasts are in the correct direction, but only ¼ to 1/3 of subjects forecast *both* correctly

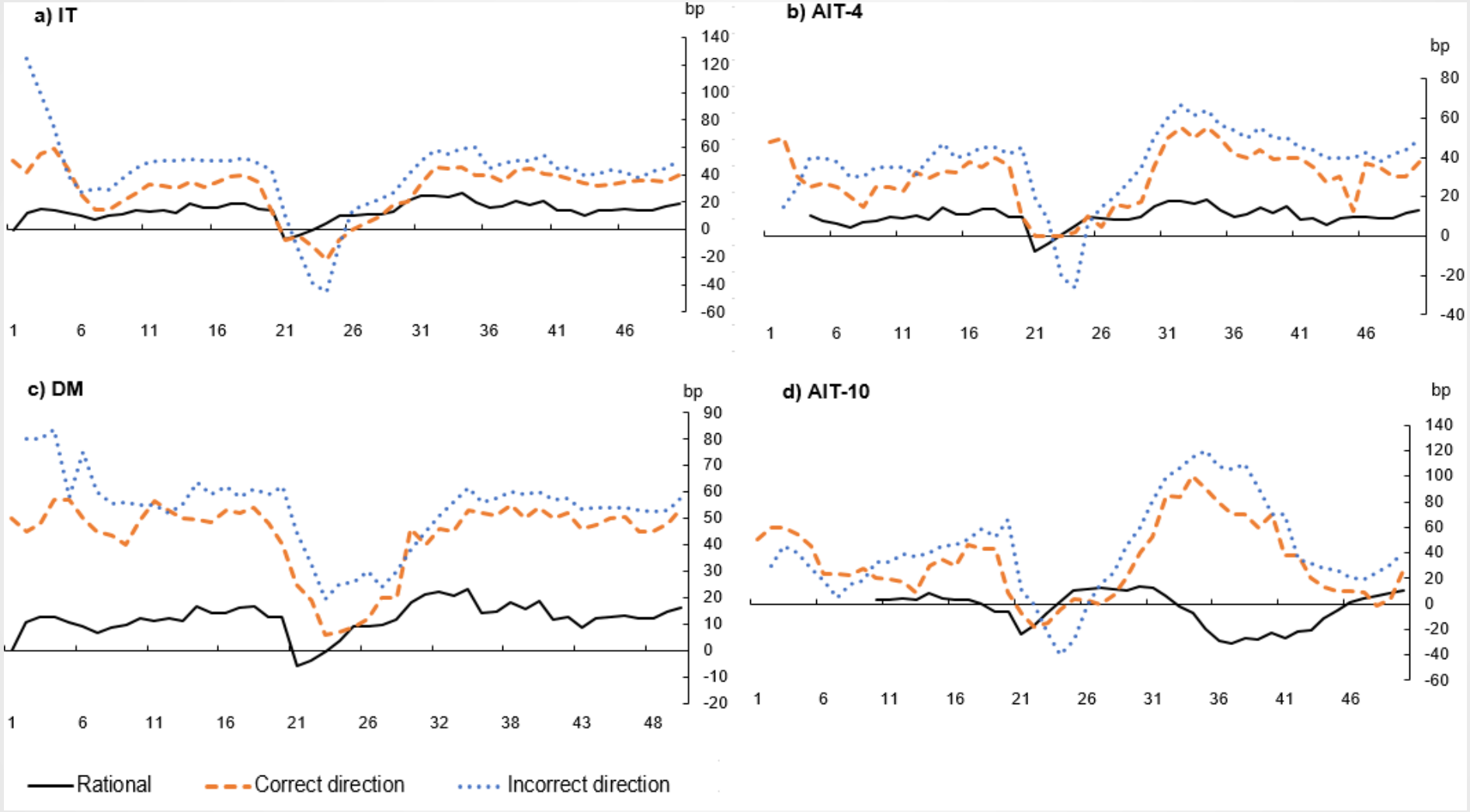
Basic Rationality

	Preshock (Periods 1-19)			Shock (Periods 20-21)		
	Inflation	Output	Both	Inflation	Output	Both
NGDP	0.59	0.49	0.26	0.85	0.22	0.12
PLT	0.49	0.64	0.29	0.71	0.58	0.49
DM	0.47	0.49	0.25	0.63	0.56	0.27
IT	0.54	0.54	0.33	0.70	0.49	0.26
AIT-4	0.48	0.62	0.32	0.58	0.52	0.20
AIT-10	0.48	0.57	0.33	0.63	0.80	0.51

On impact of shock,

- Rationality in inflation increases in all treatments
- Half of PLT and AIT-10 subjects understand the correct direction for both variables
- NGP subjects focus more on inflation than output

Median Inflation Forecasts and Basic Rationality



Deviations from rationality relatively small in IT, DM, AIT-4 (20-50 bps),
Larger in AIT-10 (10-120 bps)
Persistent upward bias even among those with basic rationality

Basic Rationality

	Preshock (Periods 1-19)			Shock (Periods 20-21)			Postshock (Periods 22-50)		
	Inflation	Output	Both	Inflation	Output	Both	Inflation	Output	Both
NGDP	0.59	0.49	0.26	0.85	0.22	0.12	0.29	0.29	0.18
PLT	0.49	0.64	0.29	0.71	0.58	0.49	0.36	0.38	0.26
DM	0.47	0.49	0.25	0.63	0.56	0.27	0.36	0.57	0.16
IT	0.54	0.54	0.33	0.70	0.49	0.26	0.46	0.54	0.21
AIT-4	0.48	0.62	0.32	0.58	0.52	0.20	0.43	0.56	0.25
AIT-10	0.48	0.57	0.33	0.63	0.80	0.51	0.51	0.65	0.36

After the shock,

- Rationality in inflation decreases in all treatments
- Decline in basic rationality in all treatments relative to pre-shock (except AIT-10).

Basic Rationality

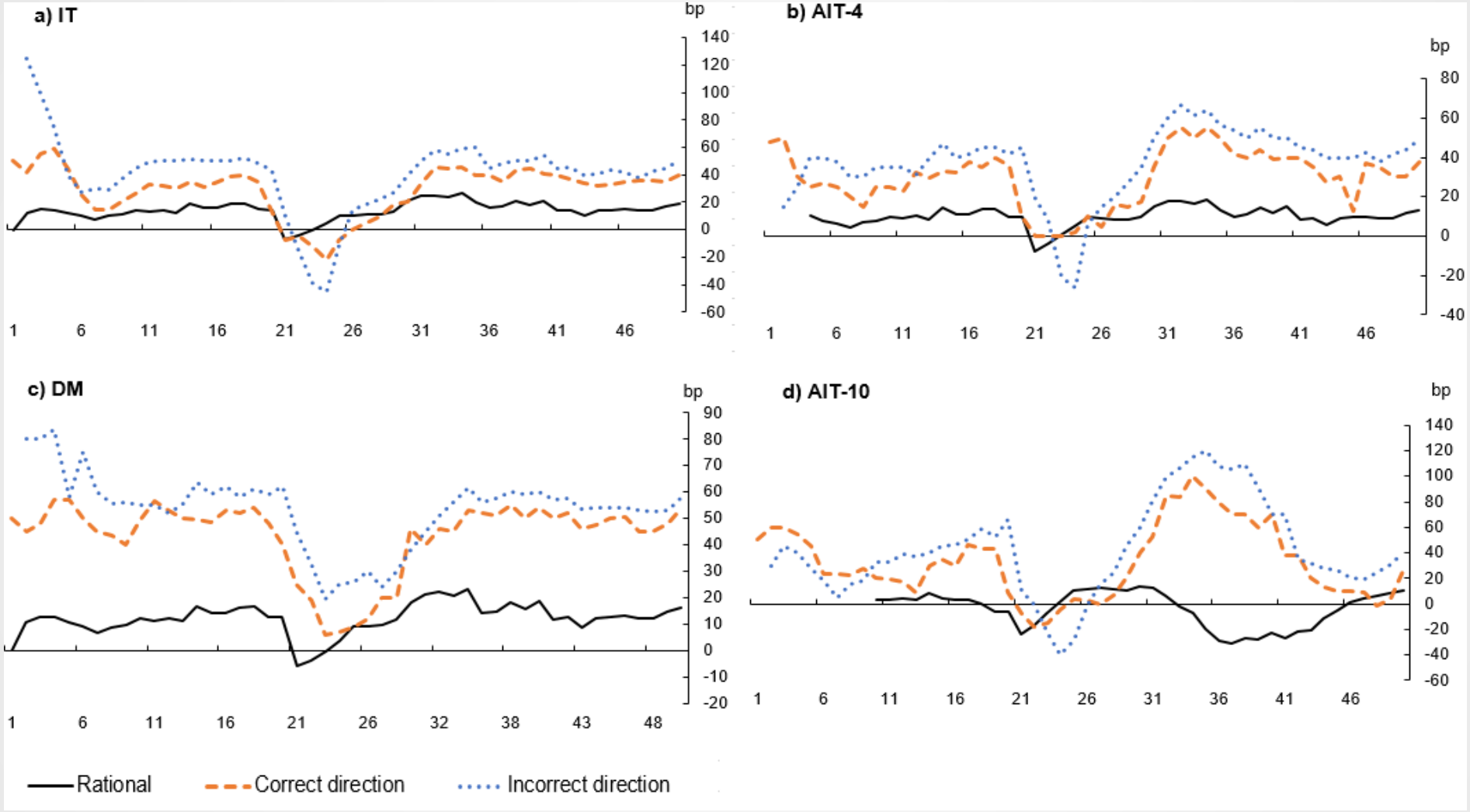
	Preshock (Periods 1-19)			Shock (Periods 20-21)			Postshock (Periods 22-50)		
	Inflation	Output	Both	Inflation	Output	Both	Inflation	Output	Both
NGDP	0.59	0.49	0.26	0.85	0.22	0.12	0.29	0.29	0.18
PLT	0.49	0.64	0.29	0.71	0.58	0.49	0.36	0.38	0.26
DM	0.47	0.49	0.25	0.63	0.56	0.27	0.36	0.57	0.16
IT	0.54	0.54	0.33	0.70	0.49	0.26	0.46	0.54	0.21
AIT-4	0.48	0.62	0.32	0.58	0.52	0.20	0.43	0.56	0.25
AIT-10	0.48	0.57	0.33	0.63	0.80	0.51	0.51	0.65	0.36

After the shock,

- Rationality in inflation decreases in all treatments
- Decline in basic rationality in all treatments relative to pre-shock (except AIT-10).

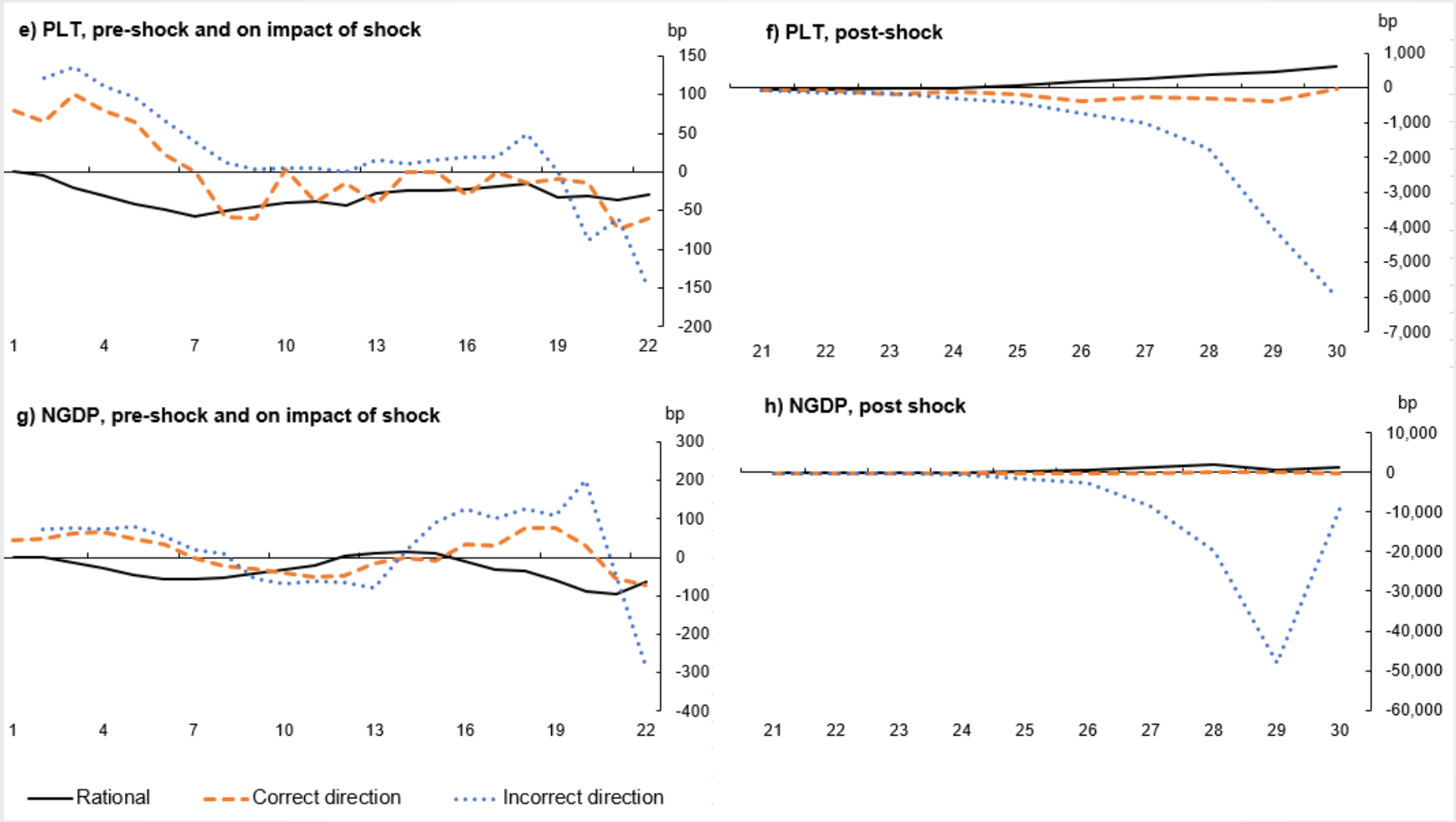
Level and rate treatments do not differ meaningfully in terms of basic rationality

Median Inflation Forecasts and Basic Rationality



Deviations from rationality relatively small in IT, DM, AIT-4 (20-50 bps),
Larger in AIT-10 (10-120 bps)
Persistent upward bias even among those with basic rationality

Median Inflation Forecasts and Basic Rationality



Even larger deviations from rationality pre-shock (75-200 bps)

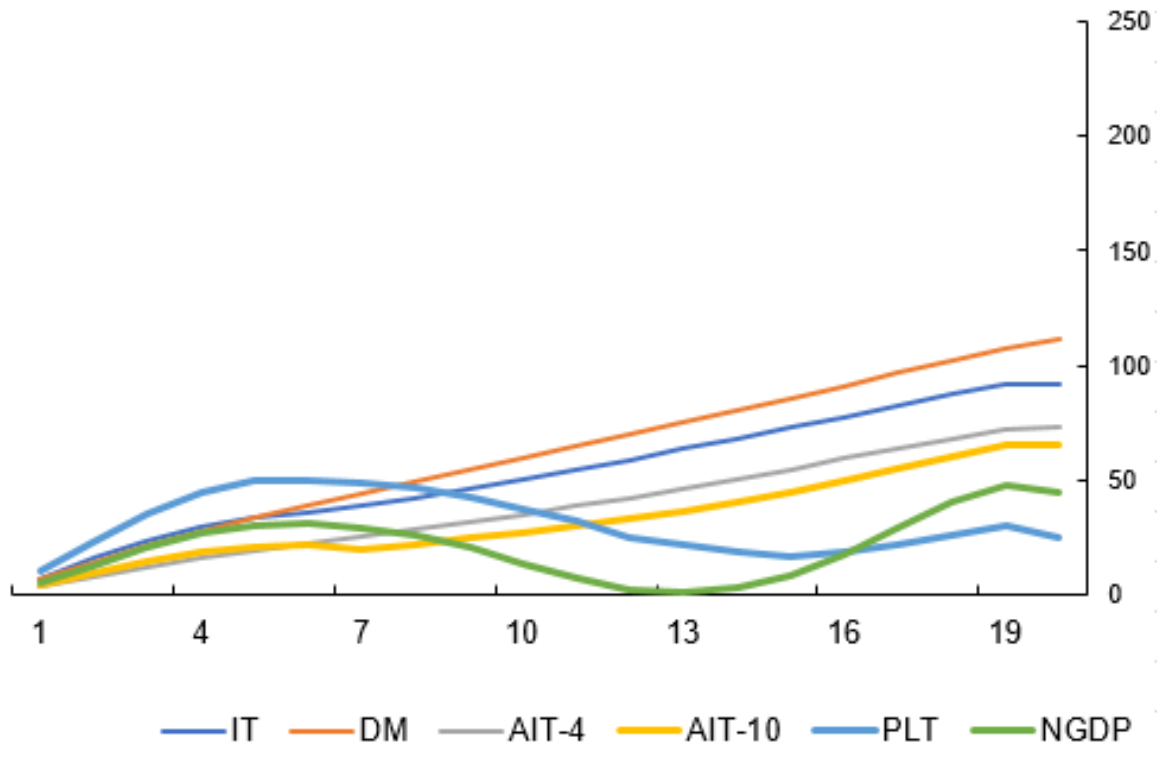
Insufficiently positive expectations in post-shock for those with basic rationality

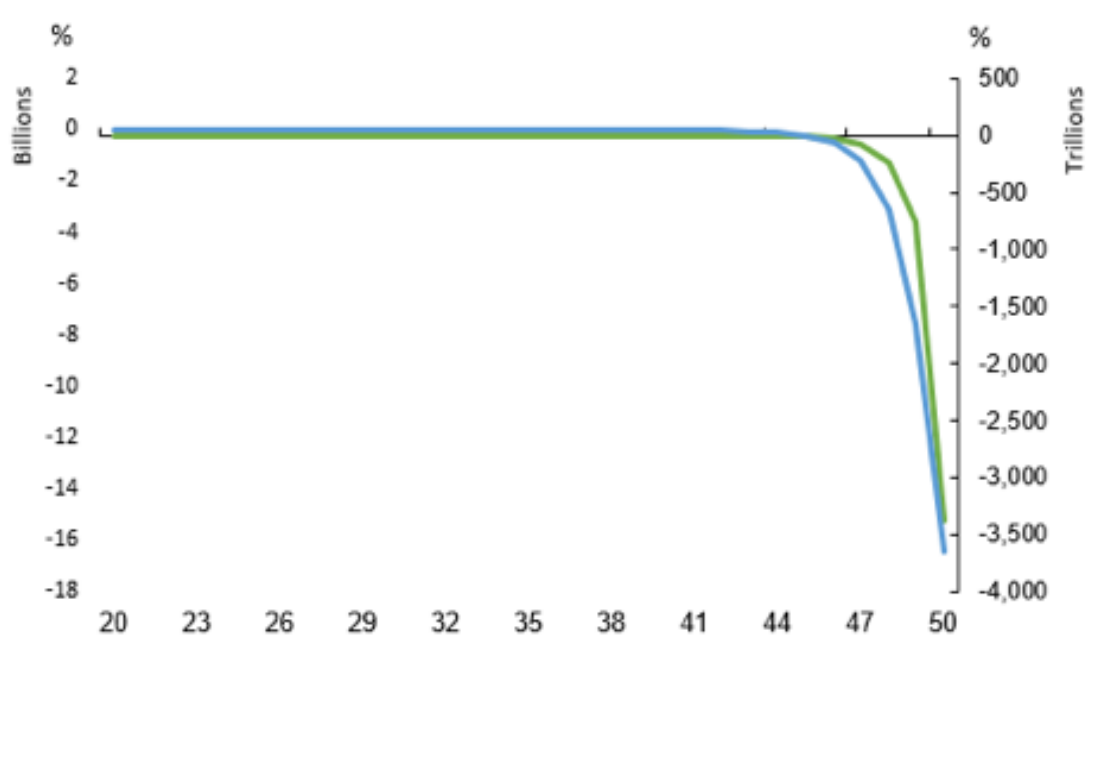
"Too little, too late"

Need to see it to believe it

- The central bank failed to achieve its targets in the level treatments pre-shock

Deviations of price level from (implied) target





Need to see it to believe it

Strong anchoring on target in IT, DM, AIT not present in PLT and NGDP

- The central bank failed to achieve its targets in PLT/NGDP pre-shock
- Pre-shock, less than 30% of participants are forecasting in the correct direction (lack of credibility?)
- When the large shock occurs, that jumps to roughly 50% in PLT, but declines quickly after.
- Insufficient improvement following the shock leads to a plummeting of credibility.

Forecasting heuristics

- Level-targeting regimes require a high level of forward-looking expectations
- Are participants using backward-looking heuristics more frequently in more complicated treatments?
- Do level-targets create more confusion and disagreement?

How are heuristics assigned?

1. Compute the mean absolute error of a participant's expectations to a given heuristic.

   E.g.

$$MAE_i^{Rational} = \frac{1}{T}\sum_{t=1}^{T}\left|E_{it}\pi_{t+1} - E_t^{Rational}\pi_{t+1}\right|$$

2. Assign the heuristic that produces the lowest MAE.

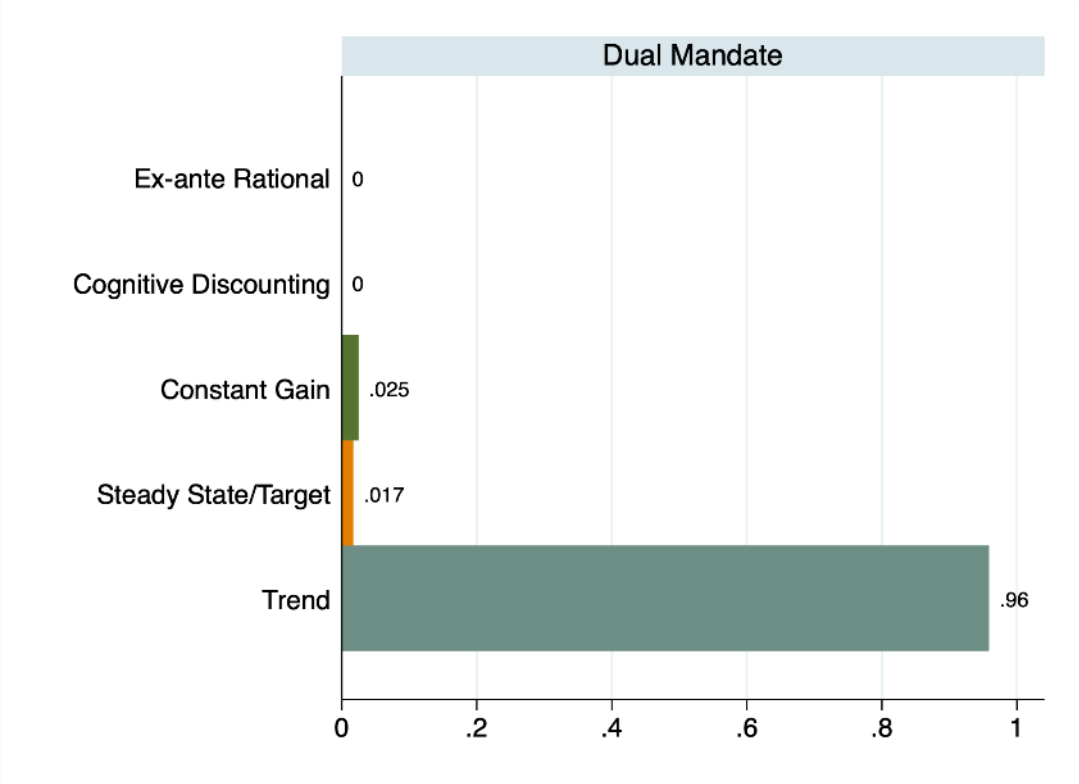
Forecasting rules

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	$E_{i,t}x_{t+1} = x_{t-1} + \tau(x_{t-1} - x_{t-2})$ $E_{i,t}\pi_{t+1} = \pi_{t-1} + \tau(\pi_{t-1} - \pi_{t-2})$

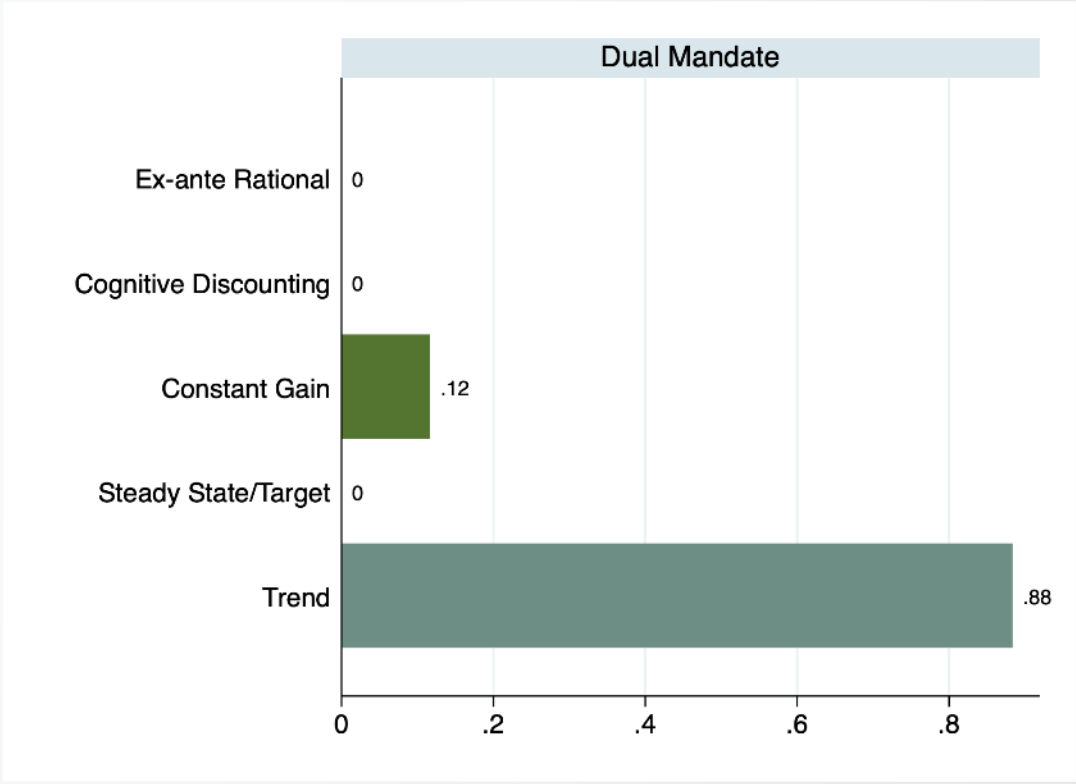
Models of expectations as functions of exogenous or historical data.
$\alpha \in [0.1, 0.9]$, γ and $\tau \in [0, 1.5]$ in increments of 0.1.

Dual mandate: inflation forecasting rules

Before shock



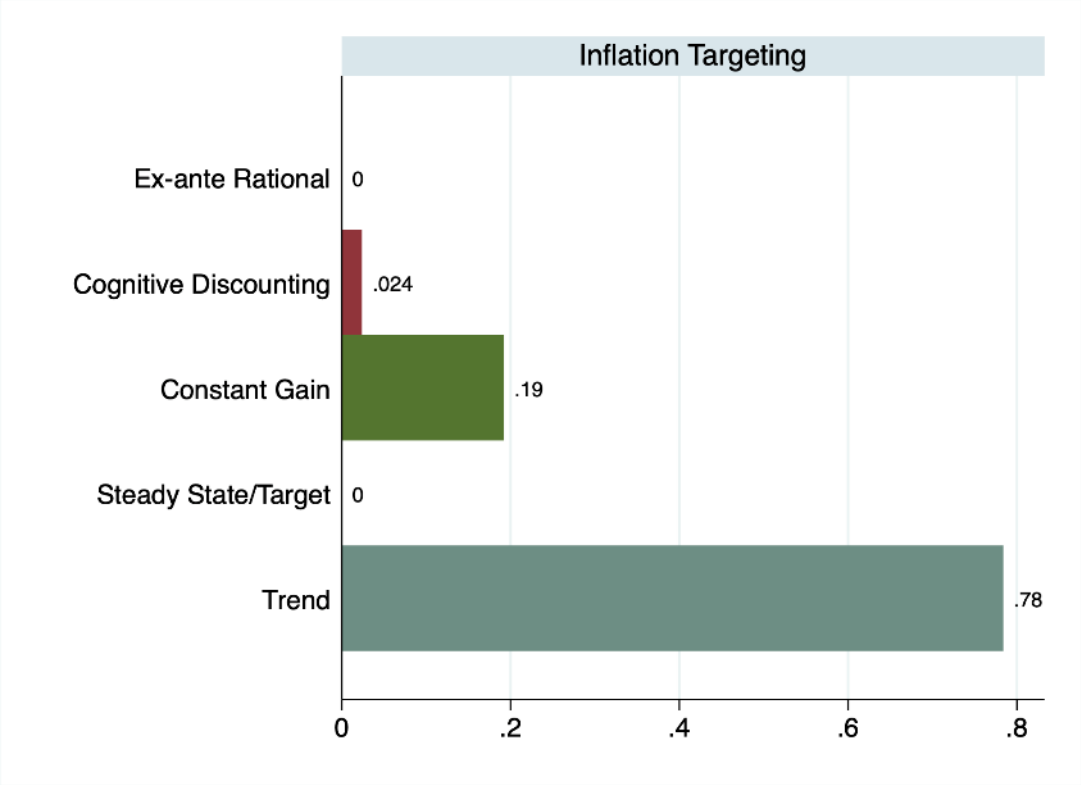
After shock



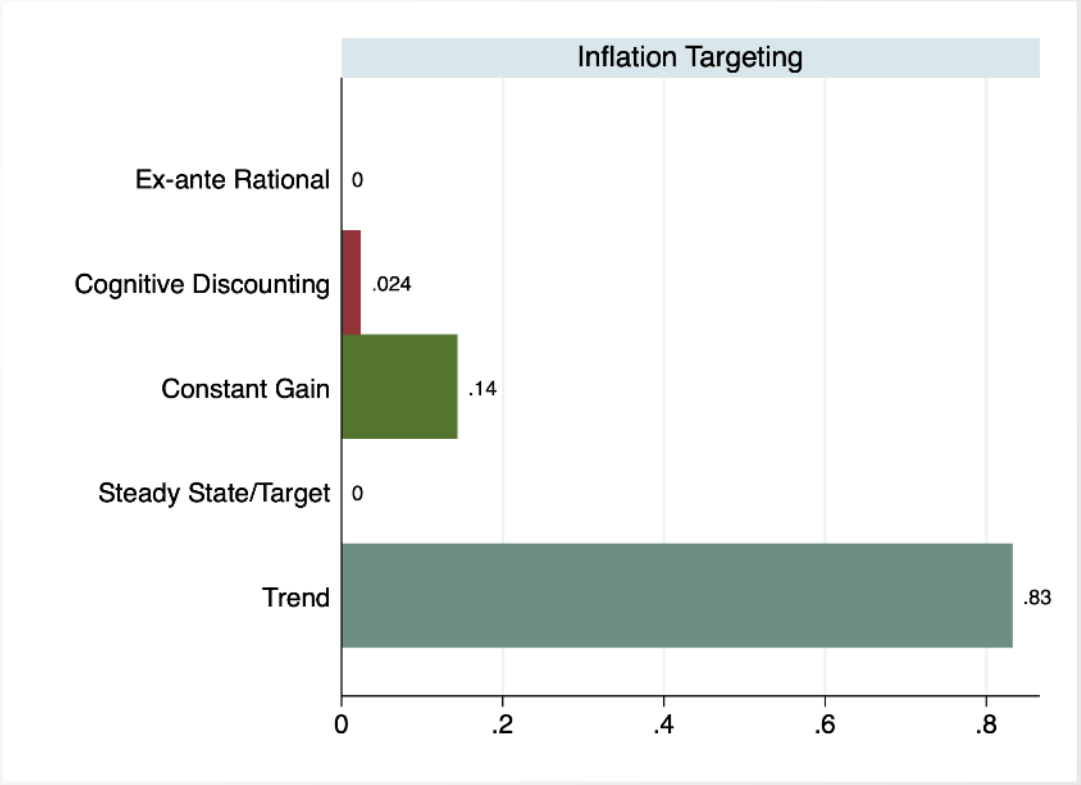
DM policy rule: $i_t = i^* + 4.5\tilde{x}_t + 4.5(\pi_t - \bar{\pi})$

Inflation targeting: inflation forecasting rules

Before shock



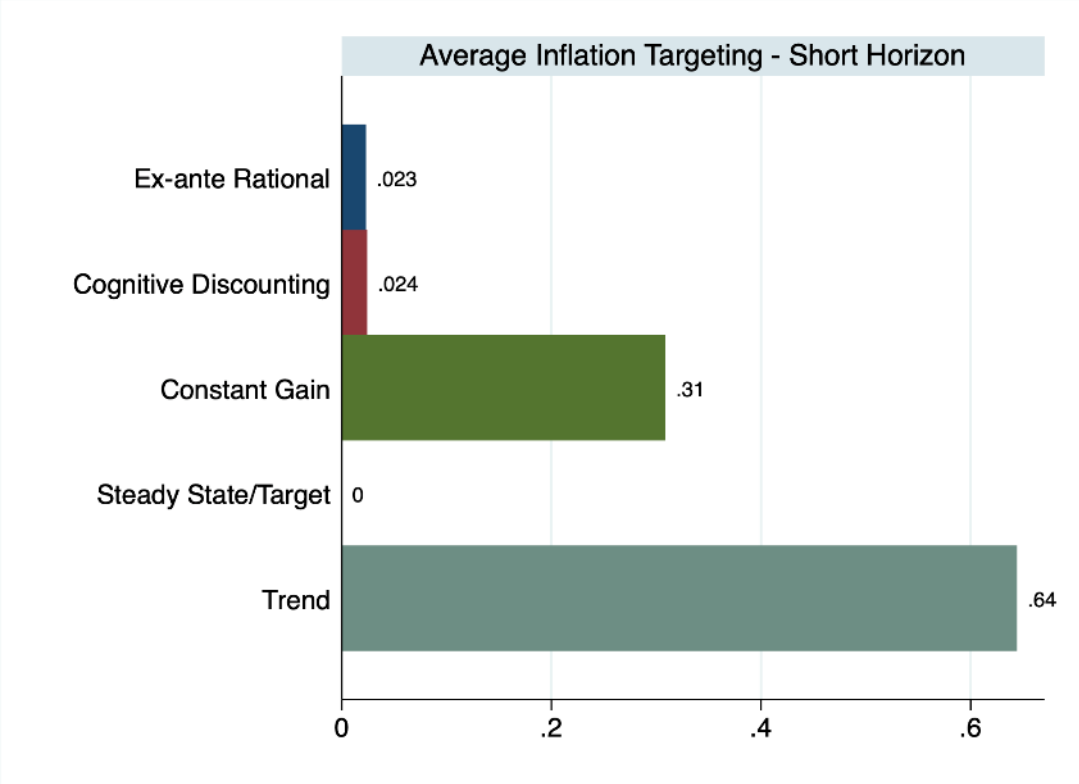
After shock



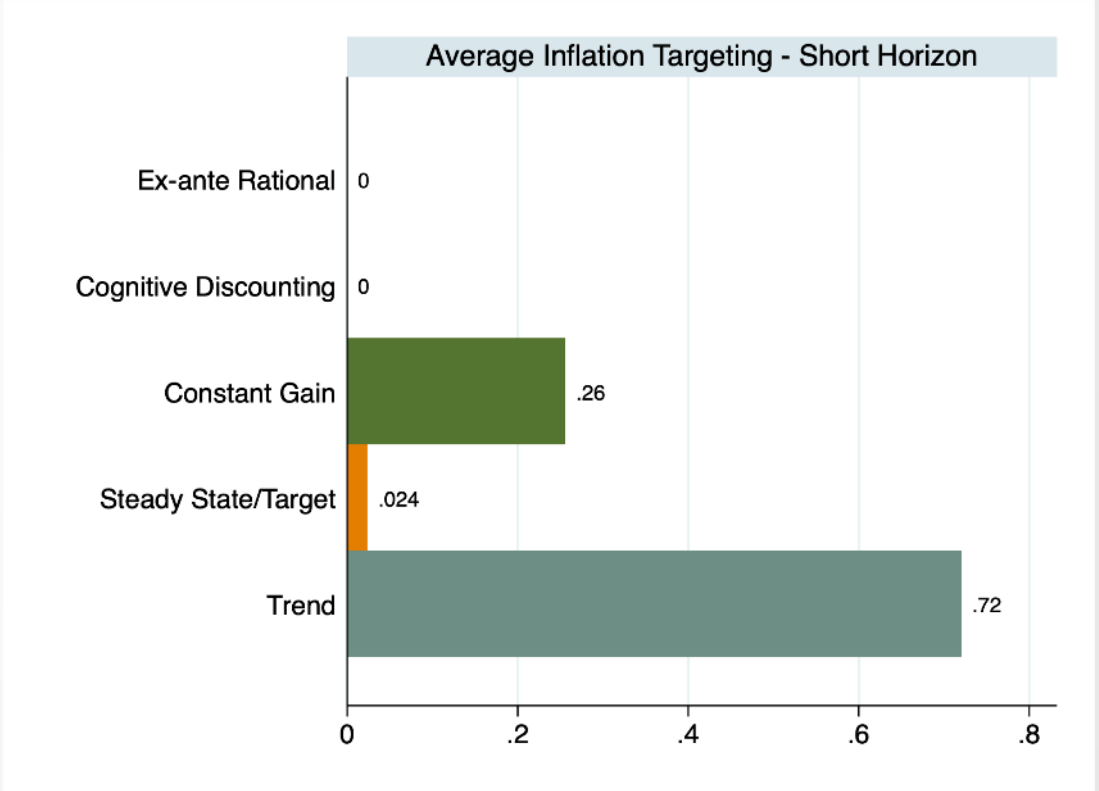
IT policy rule: $i_t = i^* + 3\tilde{x}_t + 5.5(\pi_t - \bar{\pi})$

AIT-4: inflation forecasting rules

Before shock



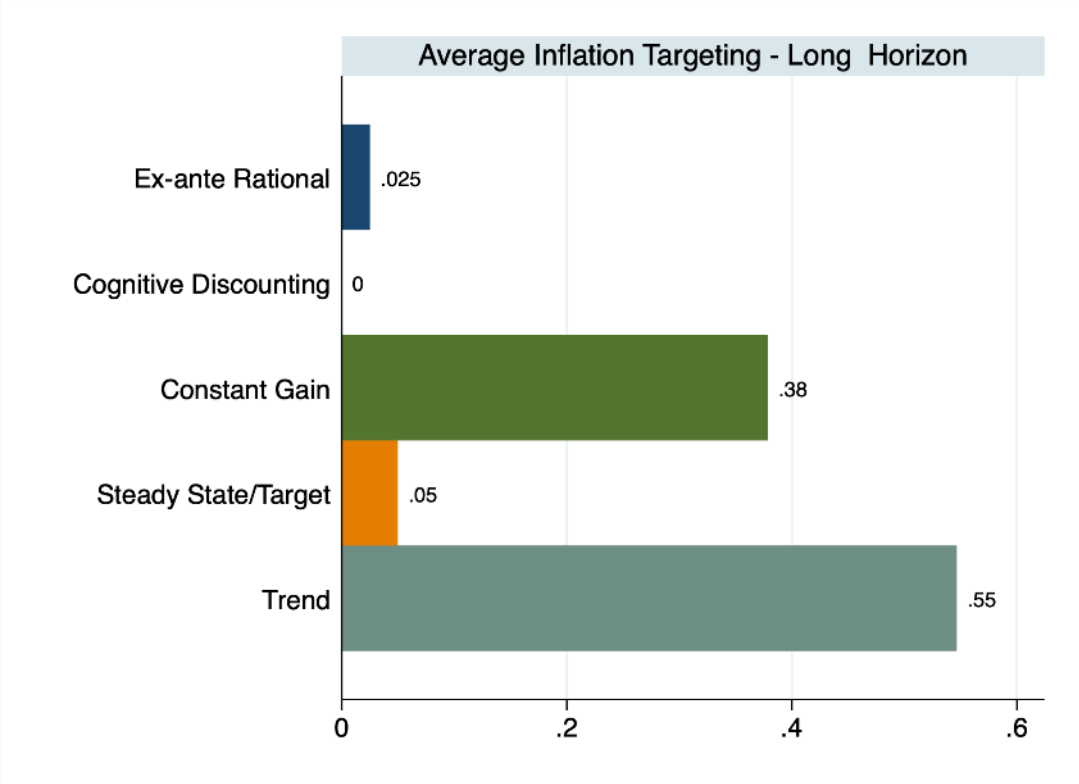
After shock



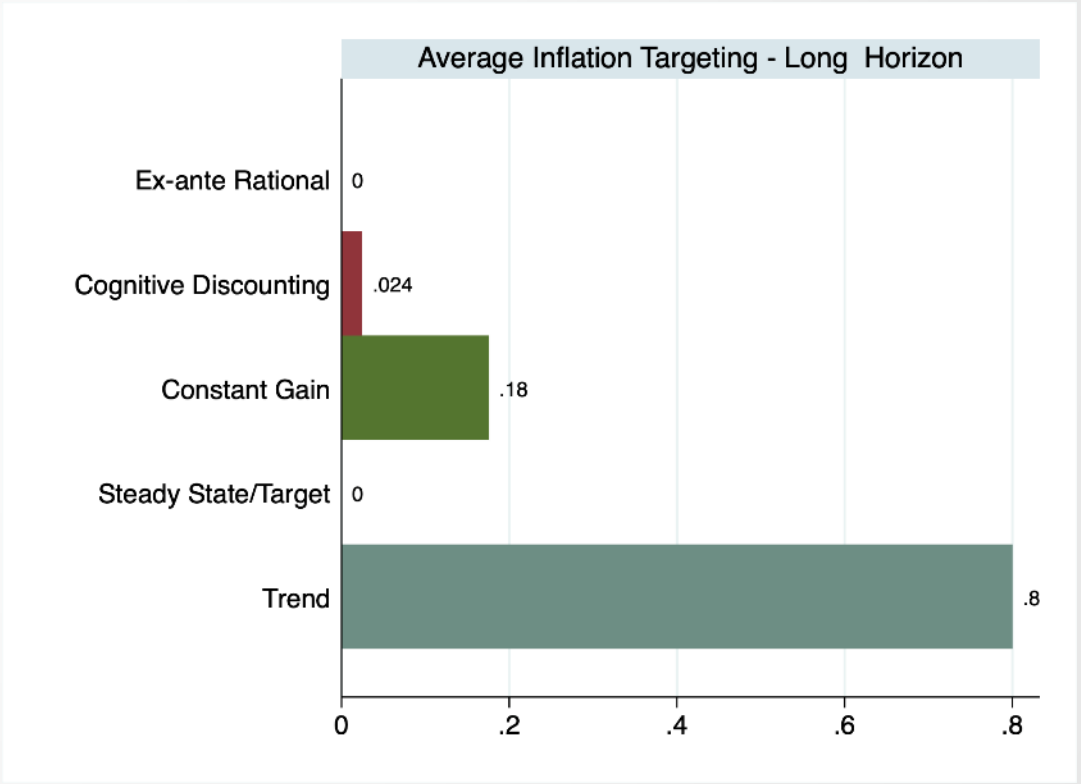
AIT policy rule: $i_t = i^* + 3\tilde{x}_t + 5.5(1/4\sum_{j=0}^{3}\pi_{t-j} - \bar{\pi})$

AIT-10: inflation forecasting rules

Before shock



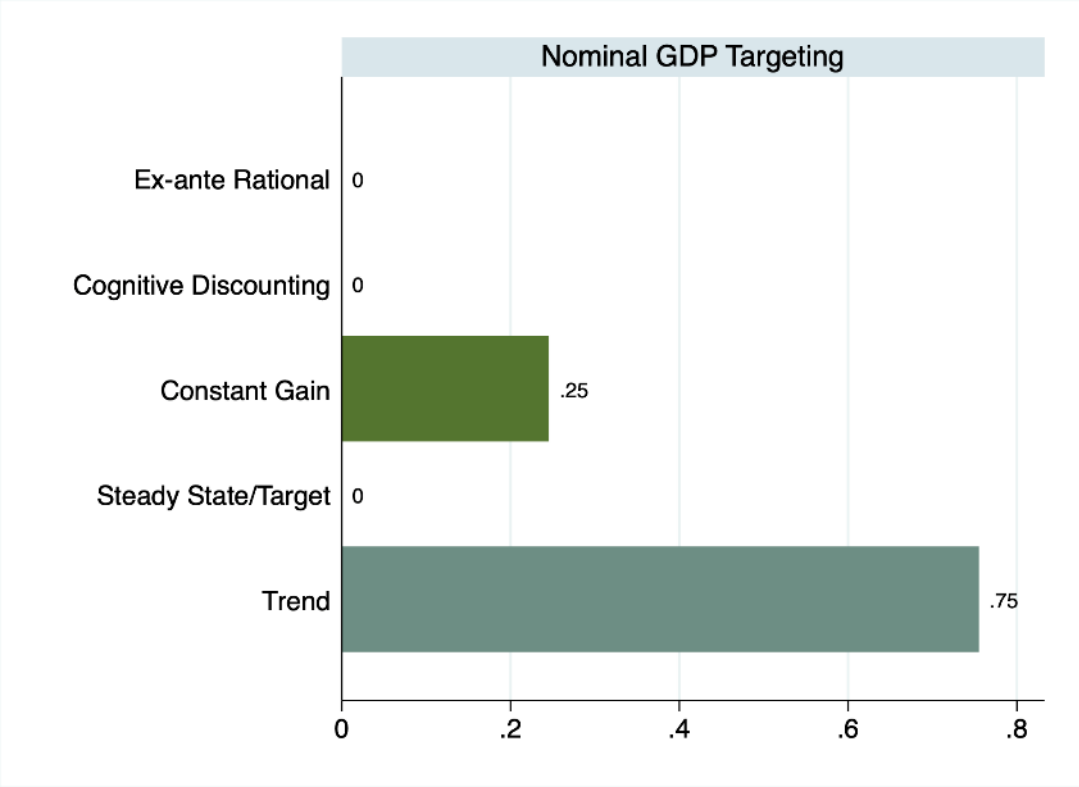
After shock



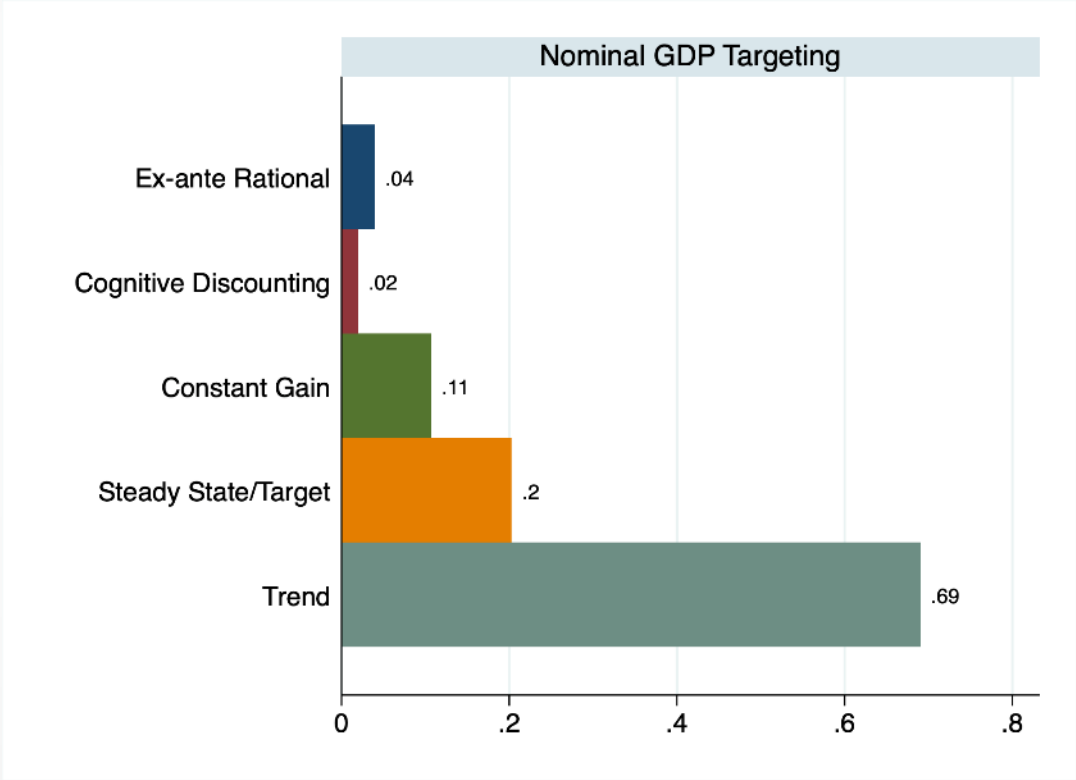
AIT policy rule: $i_t = i^* + 3\tilde{x}_t + 5.5(1/10\sum_{j=0}^{9}\pi_{t-j} - \bar{\pi})$

NGDP level targeting: inflation forecasting rules

Before shock



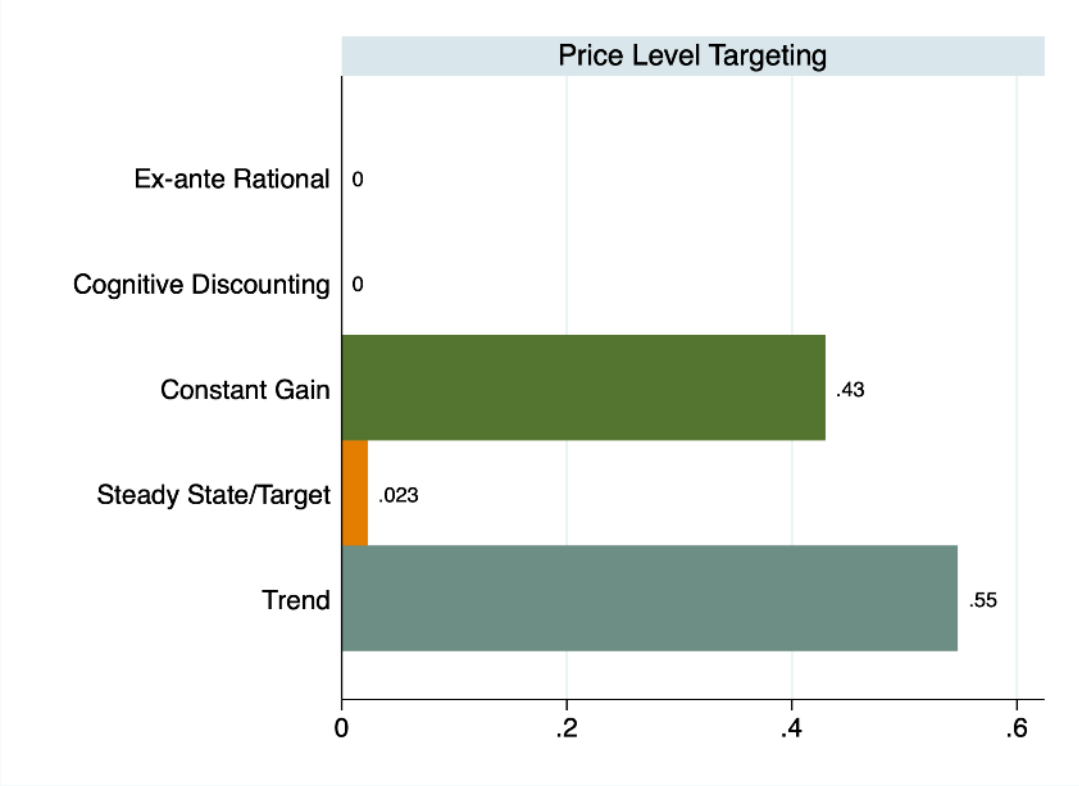
After shock



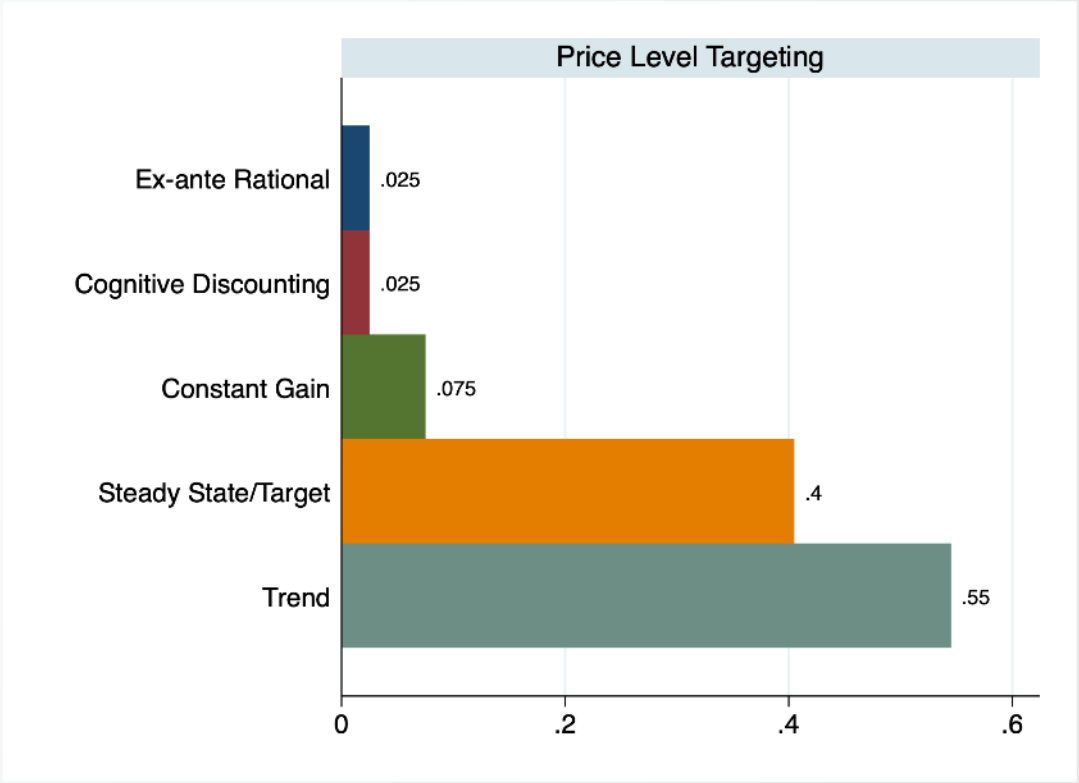
NGDP Level Targeting policy rule: $i_t = i^* + 1.1[(y_t + p_t^y) - (\bar{y}_t + \overline{p_t^y})]$

PLT: inflation forecasting rules

Before shock



After shock



PLT policy rule: $i_t = i^* + 1.3\widetilde{x_t} + 0.8(p_t - \overline{p_t})$

Heterogeneity in trend-chasing

For each subject classified as trend-chasing, what is their degree of trend-extrapolation?

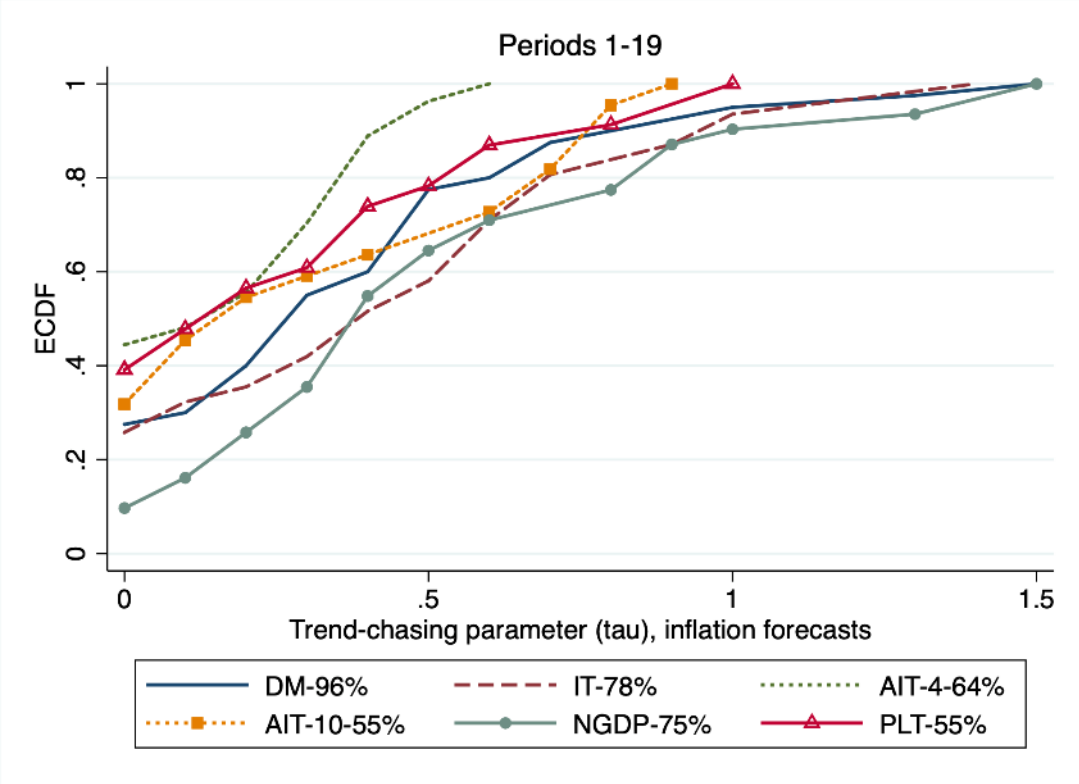
$$E_{it}\pi_{t+1} = \pi_{t-1} + \boldsymbol{\tau_i}(\pi_{t-1} - \pi_{t-2})$$

What is the best fitting $\tau_i \in [0,1.5]$ for each subject?

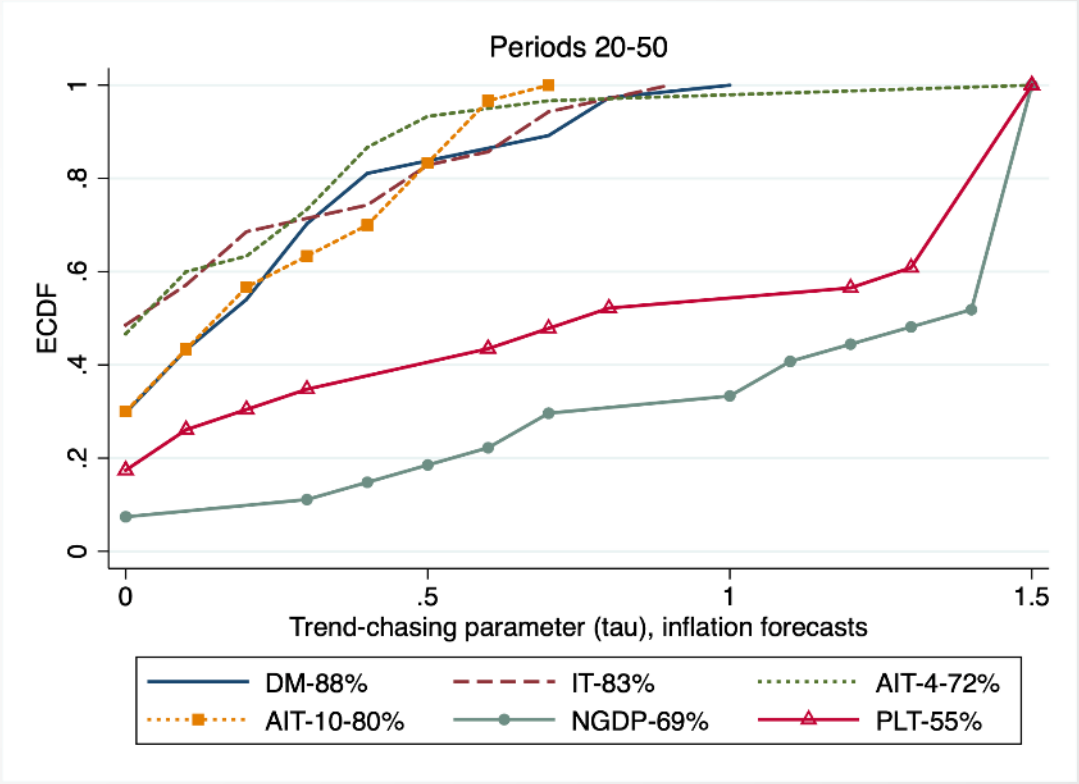
Does this change across policy rules?

Trend-chasing in inflation forecasts becomes stronger after shock in history-dependent rules

Before shock



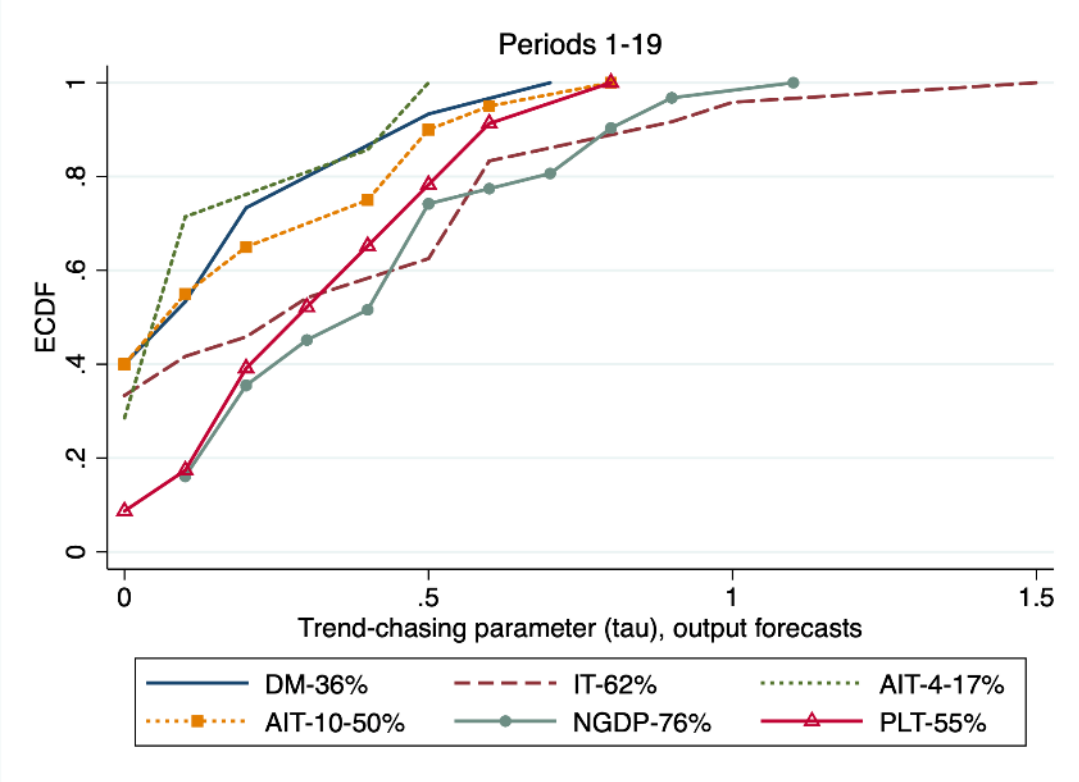
After shock



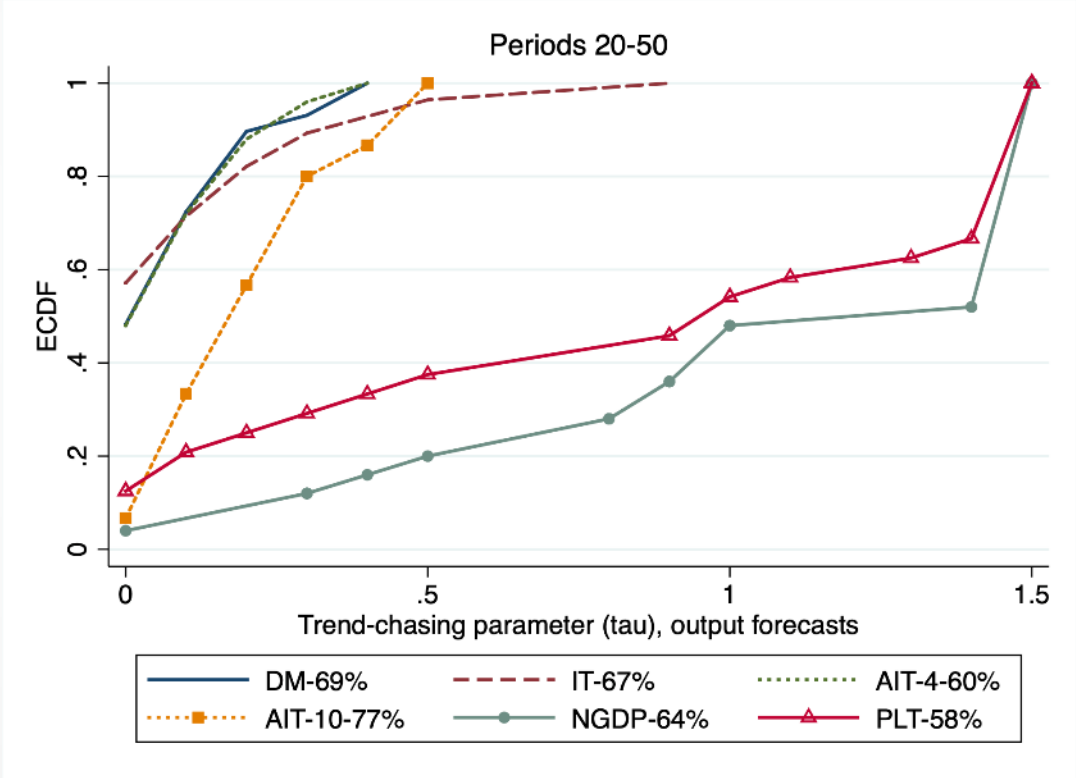
$$E_{it}\pi_{t+1} = \pi_{t-1} + \boldsymbol{\tau_i}(\pi_{t-1} - \pi_{t-2}) \quad \textit{where } \tau_i \in [0,1.5]$$

Trend-chasing in output forecasts becomes stronger after shock in history-dependent rules

Before shock

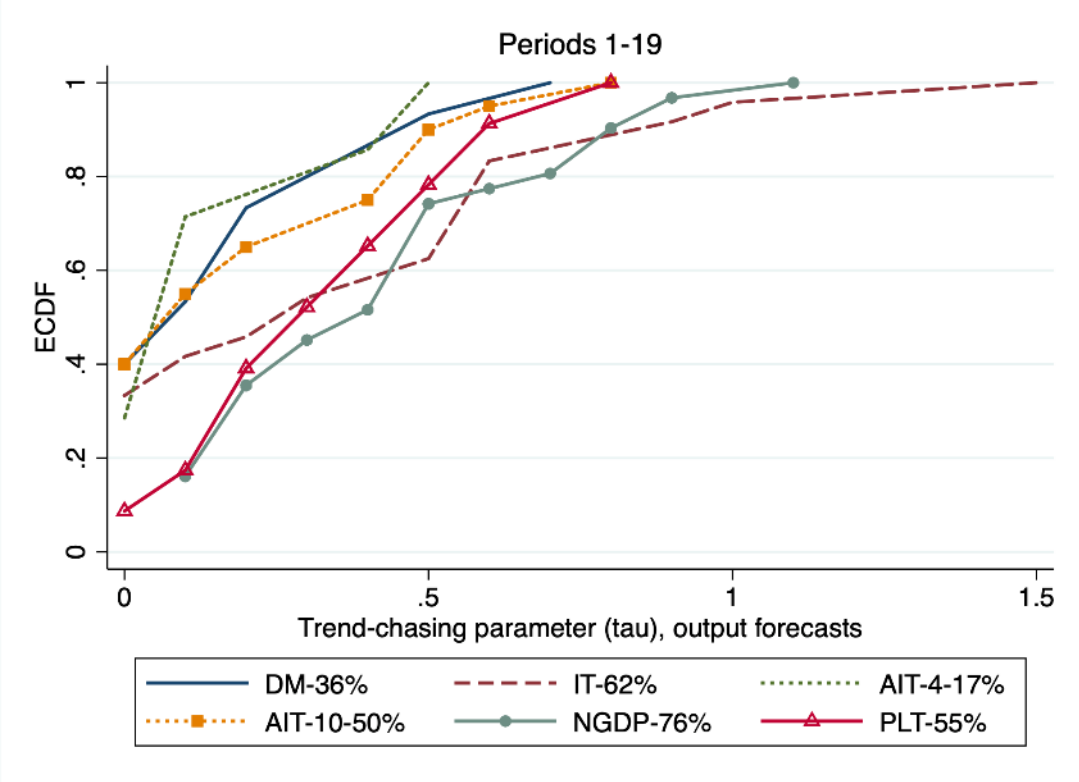


After shock



Trend-chasing in output forecasts becomes stronger after shock in history-dependent rules

Before shock



After shock