Experimental study on the effect of price level targeting with guidance

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- Experimental study on the effect of monetary policy with
  1. **Price Level target** and
  2. **guidance**.
- Simple DSGE model with zero-lower bound on the interest rate. Subjects predict inflation and output gap for 50 periods.
- **Main results:**
  - PLT can stabilize the economy...
  - ...but only if *reacts strongly* to price level and output deviations.
  - Guidance seems to play *little role*.
  - Subjects are heterogeneous and focus on simple adaptive/trend chasing forecasting rules.

Motivation

- Zero-lower bound recession in Eurozone.
- ZLB can trigger a self-sustaining spiral of deflation—output contraction (eg. Benhabib et al., 2001).
- Lesson – more *robust* monetary policy required, eg., Honkapohja and Mitra (2015):
  1. *nominal price level targeting* (PLT);
  2. manage expectations through *guidance*.

Challenge: 2007 crisis → *dynamics far from the steady state*.

Away from the steady state

- 2007 crisis took us away from the Great Moderation.
- How will agents react to the uncertainty?
- **Rational interpretation:** agents can coordinate on different equilibrium paths towards different steady states.
- **Behavioral interpretation:** different learning mechanisms result in *very different* dynamics.
- Example: PLT under adaptive learning requires agents to trust in guidance (Honkapohja and Mitra, 2015).
- We need an **empirical laboratory test** for the monetary policy.

Lesson from learning models

- Macroeconomy can be described as a mechanism driven by *expectations*.
- Consider partial equilibrium in simple DSGE model: *expected* inflation and output $\rightarrow$ *realized* inflation and output.

$$\begin{pmatrix} \pi_t \\ y_t \end{pmatrix} = F \begin{pmatrix} \pi^e_{t+1} \\ y^e_{t+1} \end{pmatrix}.$$

- *Positive feedback* – higher expectations lead to higher realized variables, $F'(\cdot) > 0$ (positive partial derivatives).

Lesson from learning models (cont.)

- **Learning models:** if the positive feedback is (sufficiently) strong, learning dynamics can yield *self-reinforcing oscillations*.
- HSM example: price oscillations in *asset markets* (Anufriev and Hommes, 2012), because agents learn to *coordinate on price trend*.
- Intuition confirmed by experiments (eg., Hommes et al., 2005, Bao and Hommes, 2014) and market studies (eg., Boswijk et al., 2007, Dieci and Westerhoff, 2016).
- **Rational interpretation:** initial uncertainty leads to coordination on explosive equilibria (e.g. rational bubbles or ZLB).

Lesson: robust monetary policy must *tame* the positive feedback.

Why an experiment?

- *Complementary* study to empirical and theoretical work.
- *Direct control* over the market, information and monetary policy.
- We can *directly observe* expectations with repeated *ceteris paribus* samples (*as if* NK economy).
- Inflation expectations depend on 'normal people', like the subjects.
- **Test for what can we assume about the agents:**
  - will they trust guidance?
  - what behavior will they coordinate on?

Experimental design

Added value of the paper!

- Learning to Forecast experiment: Duffy (2012), Assenza et al., (2014).
- Standard DSGE economy (Benhabib et al., 2014, Mitra and Honkapohja, 2015).
- Six subjects, who are tasked to *forecast inflation* and *output gap* **two periods ahead**.
- *Realized* inflation and output gap based on the *forecasts*.
- Subjects rewarded conditional on their *forecasting accuracy*.
- This is repeated for 50 rounds.

Two treatment dimensions: Taylor rule and information given to the subjects.

Experimental economy

- The aggregate consumption:

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

- The Phillips curve:

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

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

$$K(c_t, \pi^e_{t+1}) = \beta\pi^e_{t+1}(\pi^e_{t+1} - 1) + \frac{\nu}{\alpha\gamma}(c_t + \bar{g})^{(1+\varepsilon)/\alpha} + \frac{1-\nu}{\gamma}(c_t + \bar{g})c_t^{-\sigma}.$$

Dimension: Taylor rule

$$R_t = 1 + \max\left\{0, \bar{R} - 1 + \psi_P \Psi_t + \psi_y \frac{y^e_{t+1} - y^*}{y^*}\right\}.$$

- $\Psi_t = \pi^e_{t+1} - \pi^*$ means inflation targeting $\rightarrow$ standard specification with $\psi_P = 1.5$, $\psi_y = 1$.
- $\Psi_t = (P^e_{t+1} - \bar{P}_{t+1})/\bar{P}_{t+1}$ with $\bar{P}_{t+1} = \pi^* \bar{P}_t$ means PLT $\rightarrow$ *how to choose parameters?*
- Under **naive expectations**, the system is stable only if ψ parameters are relatively **high** $\rightarrow$ $\psi_P = 3$ and $\psi_y = 2$.
- This is 'unreasonably harsh' under rational expectations or **adaptive learning** $\rightarrow$ Honkapohja and Mitra (2015) suggest $\psi_y = 1$ and $\psi_P = 0.25$ (under guidance).

Dimension: Information set

Always:

1. *Qualitative* story about the market.
2. Individual past forecasts, realized inflation, output gap and CB interest rate until the previous period.

Guidance treatments $\rightarrow$ following *Honkapohja and Mitra (2015):*

1. Subjects explained that the CB wants to keep *prices, not inflation* on a certain trajectory.
2. Deviations from the intended price level shown to the subjects.

Never:

1. Number of subjects in one economy (price-takers).
2. Decisions and earnings of other subjects.
3. The actual laws of motion and steady state values (real life).

Five treatments

1. **Inflation targeting** $\rightarrow$ benchmark (& other experiments).
2. **PLT:** 2×2 design.

	Stability	
Taylor rule	Weak PLT rule	Strong PLT rule
Guidance	Unstable/Guidance Unstable/No g.	Stable/Guidance Stable/No g.

Stability: only strong rule stable under *naive expectations*.
Guidance: additional information about the intended price path.

Experiment

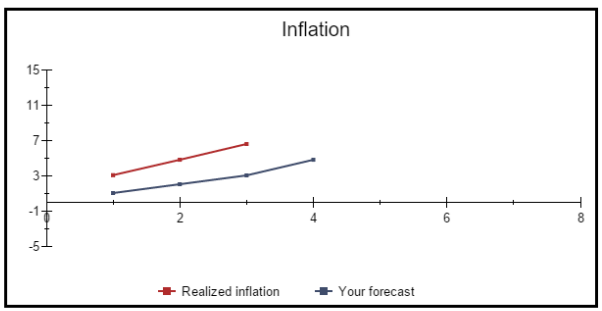
- 6 groups per treatment, each with 6 subjects.
- One treatment: 36 subjects.
- 180 subjects in total.
- Sessions in November and December 2015 and January and February 2016 in the CREED lab in Amsterdam.
- Typical earnings: around 15EUR in unstable, and 25EUR in stable groups.

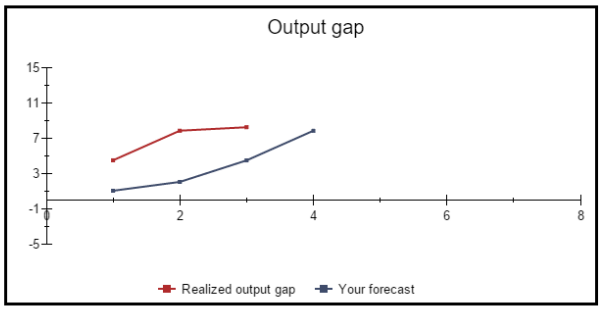
Subject computer screen

Period 4

->You have 2 decisions left.

Please state your **inflation** forecast for **period 5**: your forecast Submit forecast





Please state your **output gap** forecast for **period 5**: your forecast Submit forecast

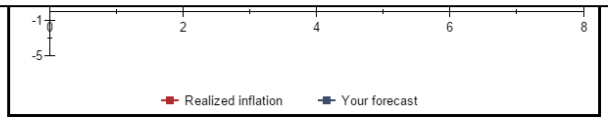
Price deviation from intended level and interest rate

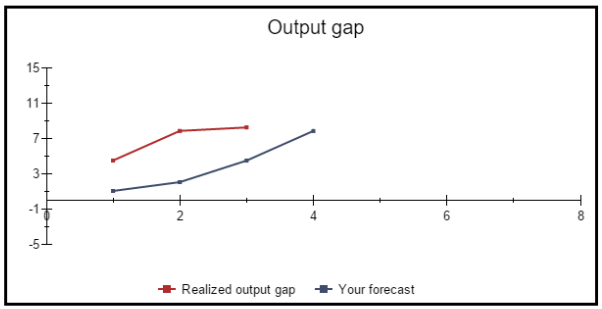
Period	Inflation forecast	Realized inflation	Payoff	Output gap forecast	Realized output gap	Payoff	Interest rate	Price level deviation
4	4.770000	???	???	7.800000	???	???	???	???
3	3.000000	6.557268	21.942973	4.440000	8.196779	21.022630	5.345861	-3.825123
2	2.000000	4.770651	26.520617	2.000000	7.805010	14.695056	0.000000	-5.230659
1	1.000000	3.029205	33.011962	1.000000	4.449818	22.472830	0.000000	-5.023203
Total points:	-----	**Inflation forecast points:**	81.475552	-----	**Output gap forecast points:**	58.190517	-----	-----

Subject computer screen

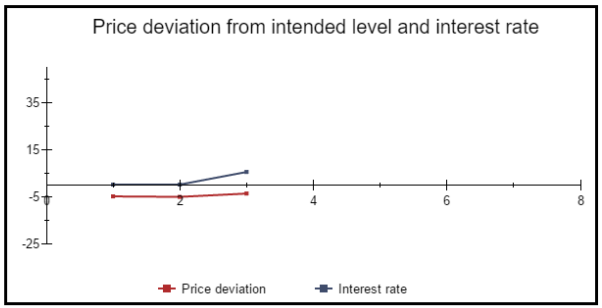
Period 4

->You have 1 decisions left.





Decision submitted.



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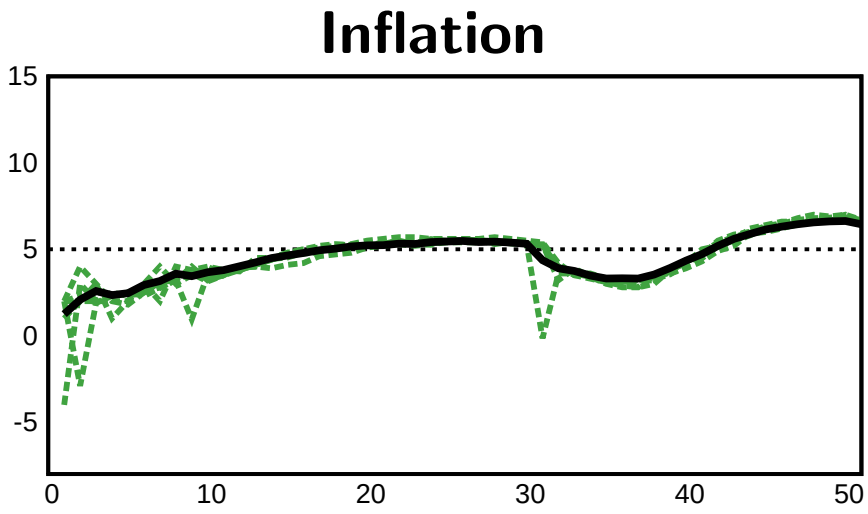
Experimental hypotheses

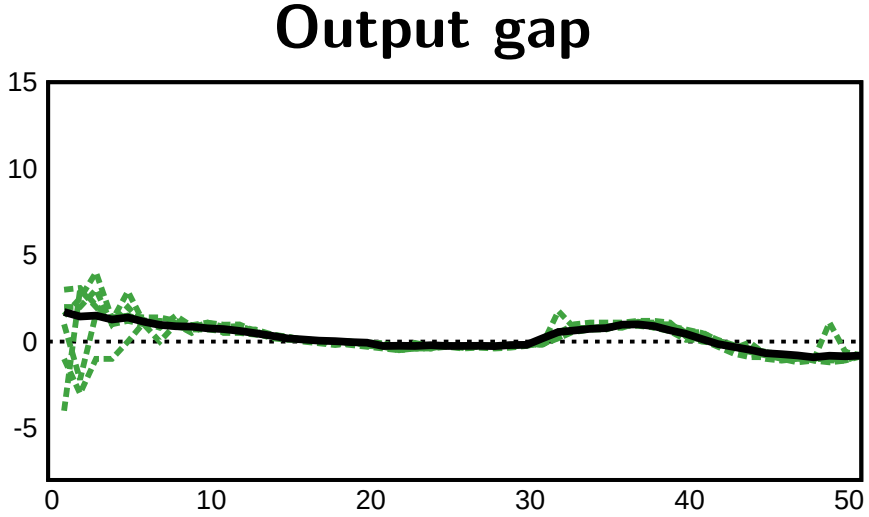
H1 Under PLT weak Taylor rule sufficient for stability.

H2 Guidance can help to *stabilize* the economy.

H3 Subjects will learn *RE equilibrium*: no trend chasing type of expectations.

Inflation targeting – INF04

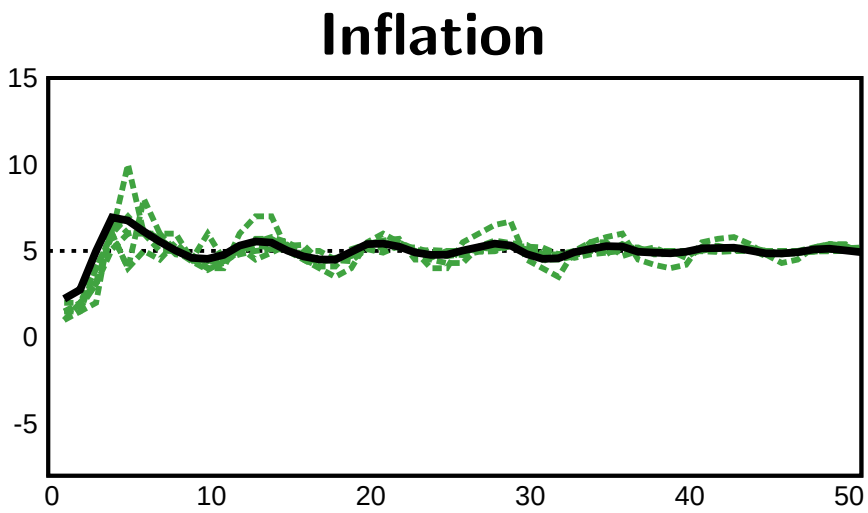


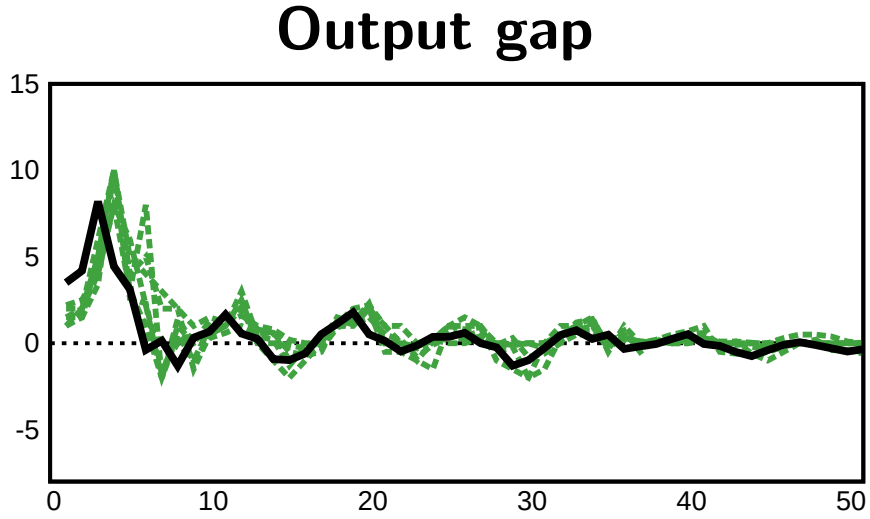


Mild oscillations, possible stability.

Good coordination between the subjects.

PLT targeting – Strong, no guidance – PLTStableNo04



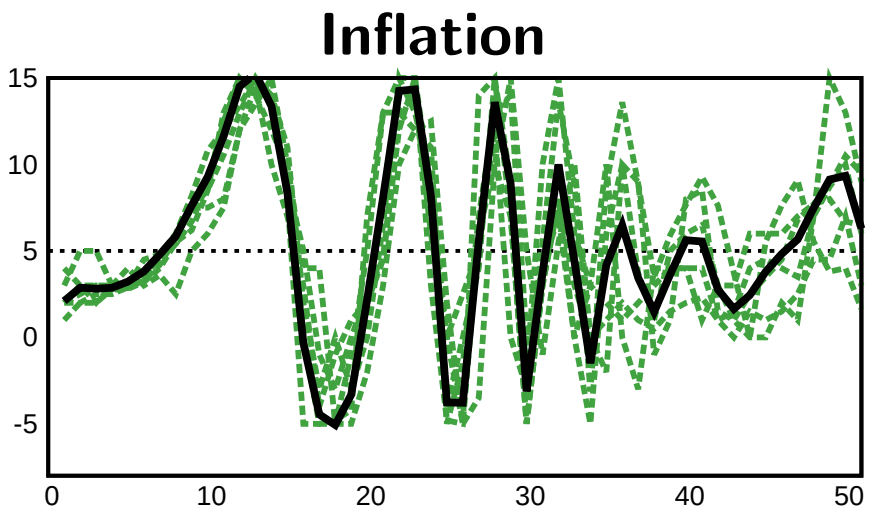


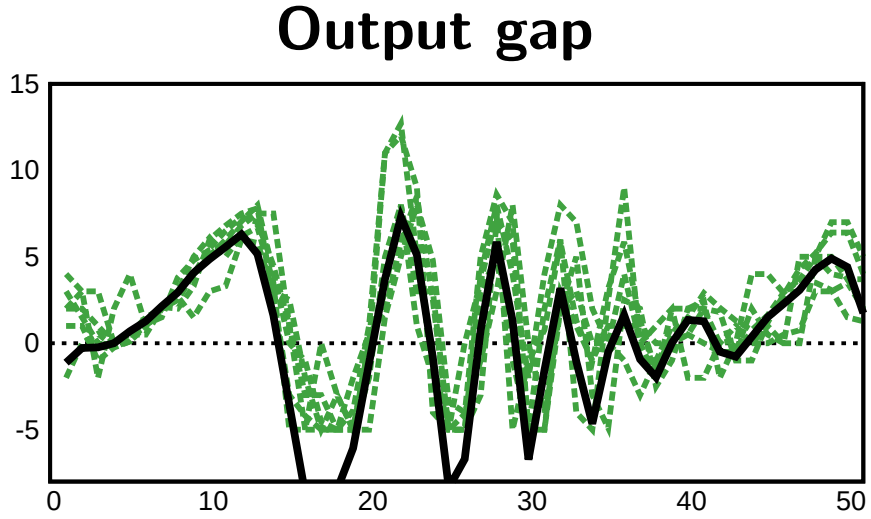
Initial period 'volatile', but. . .

. . . *oscillations die out and groups converge* to the 'normal' steady state.

Good coordination between the subjects.

PLT – Weak, no guidance – PLTUNStableNo05





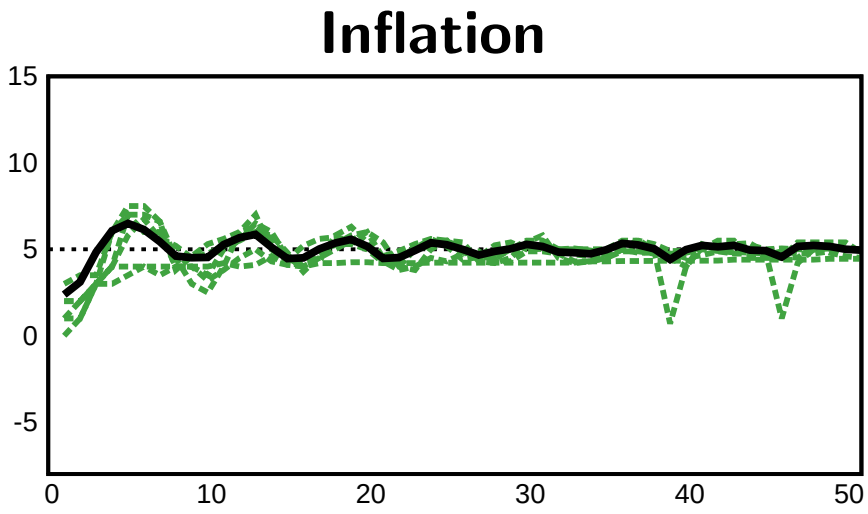
Large oscillations that do not die out → without forecasting boundaries (−8% and 15%), economies would *explode/implode*.

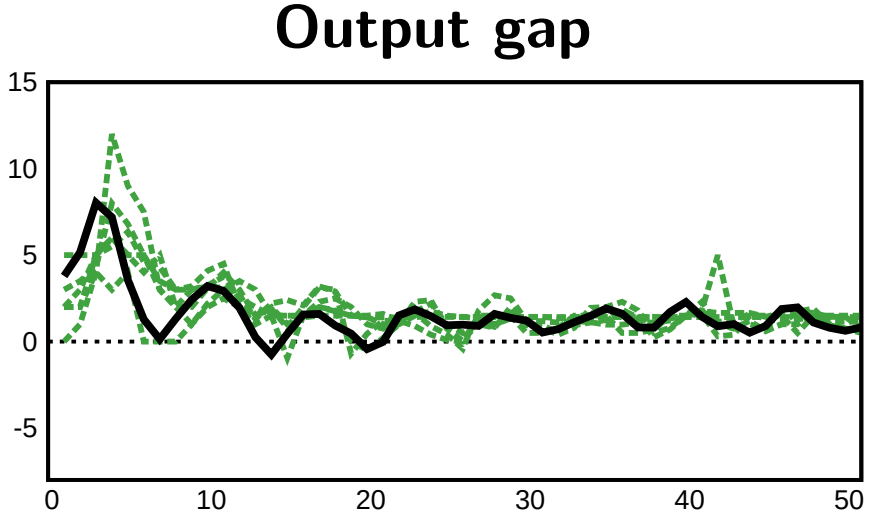
Subject coordination weaker → more difficult environment.

Economy explodes under weak PLT Taylor rule and is stable under strong one $\rightarrow$ **H1** *false!*

(confirmed by a statistical test, see following slides)

PLT – Strong, guidance – PLTStableGuid02

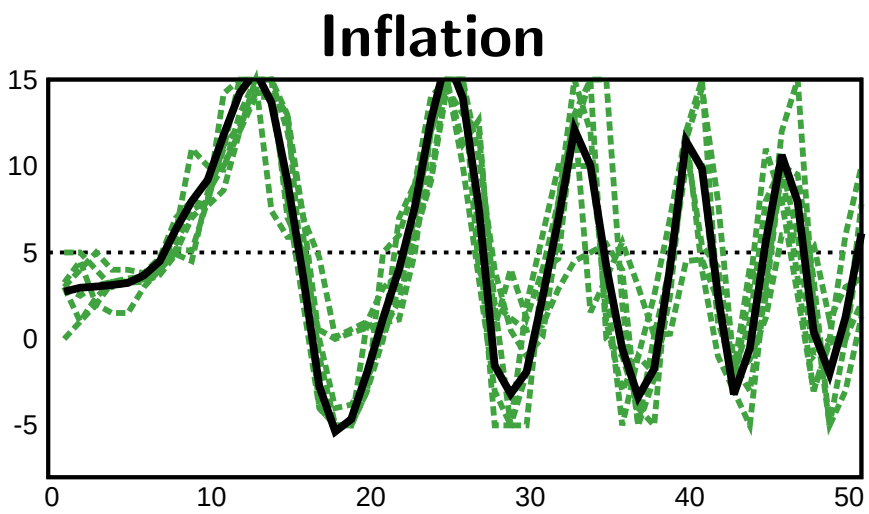


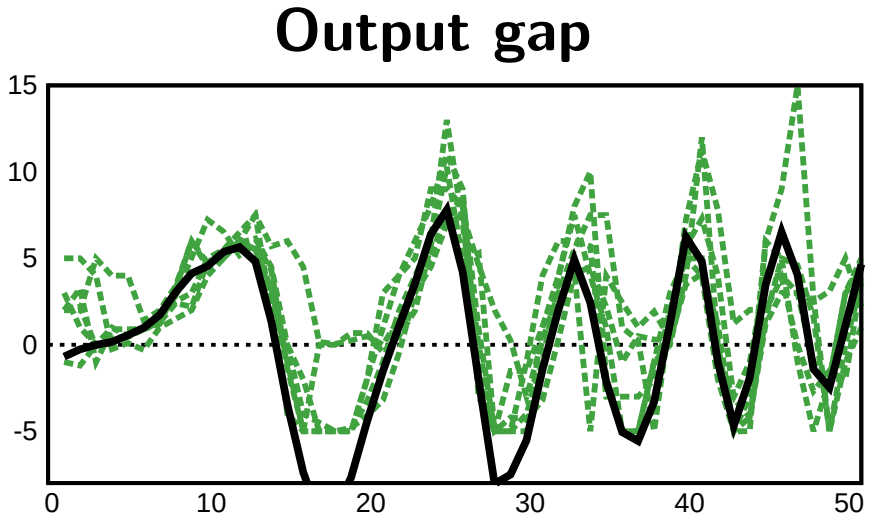


Dampening oscillations, groups converge to the 'normal' steady state.

Very similar to no guidance counterpart.

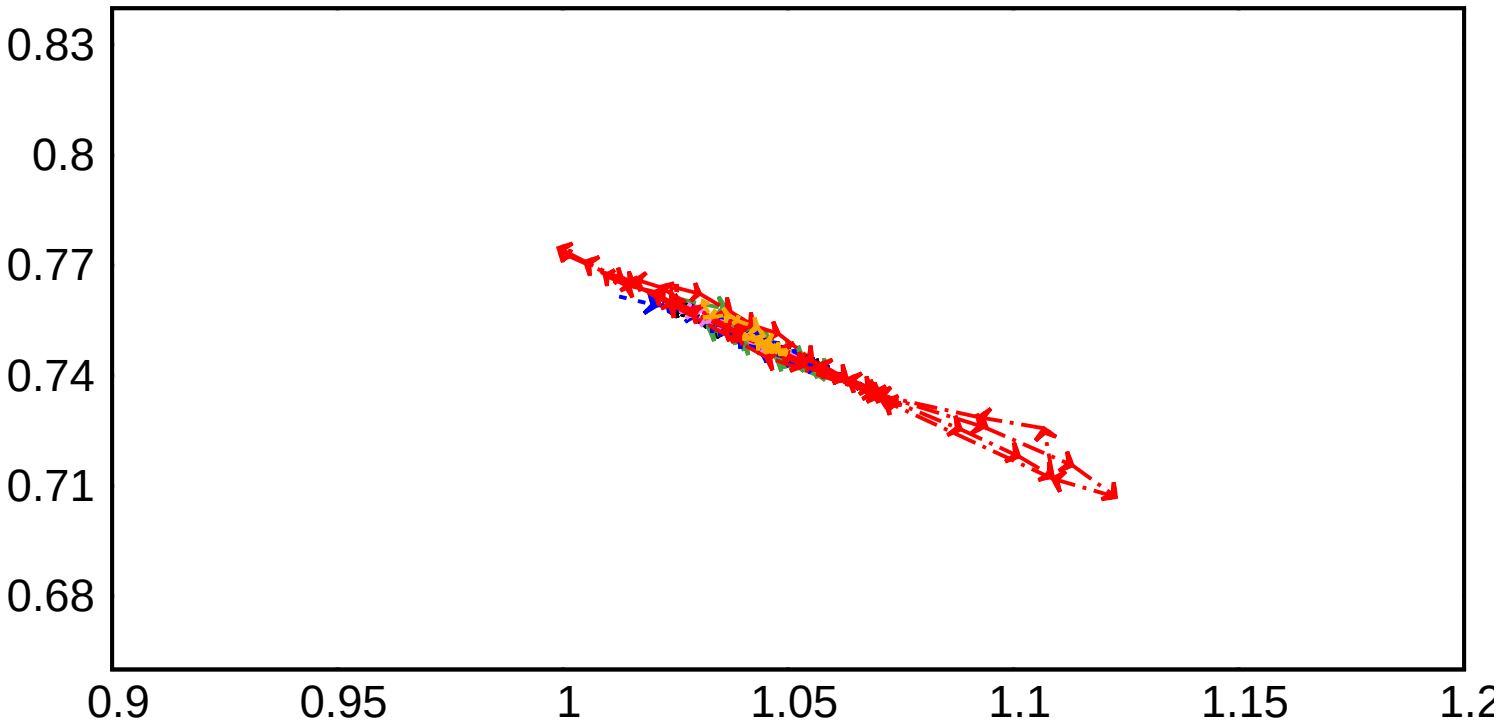
PLT – Weak, guidance – PLTUNStableGuid03





Large oscillations that seem similar to no guidance counterpart.

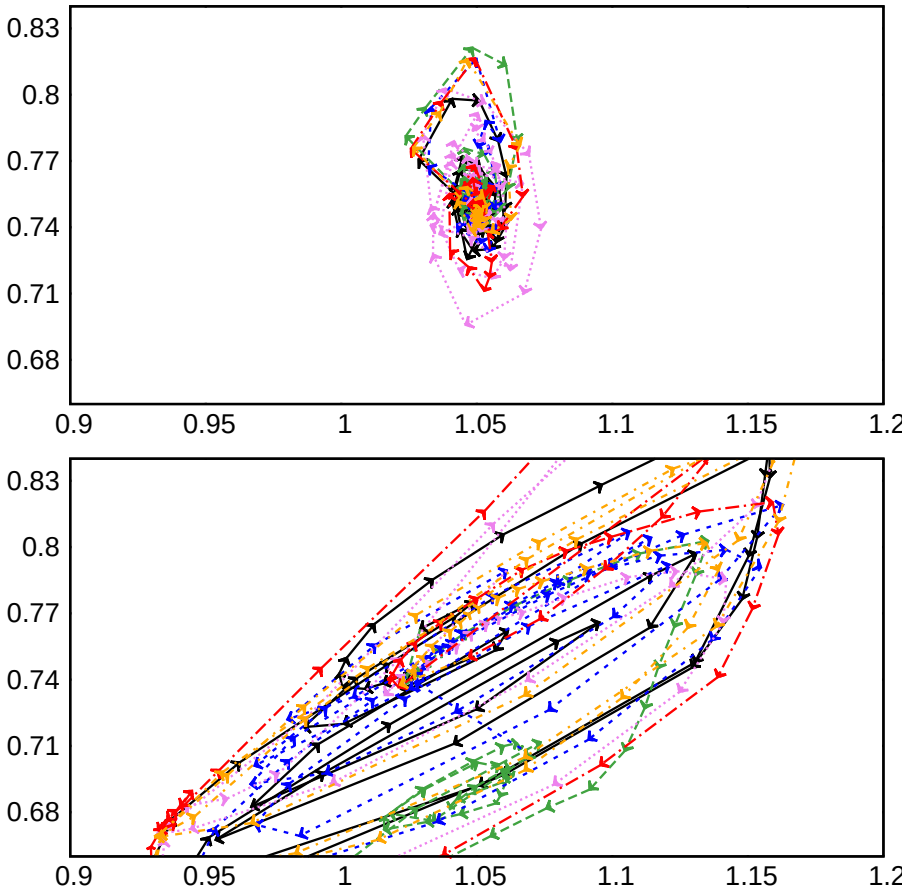
Phase plots – Inflation targeting



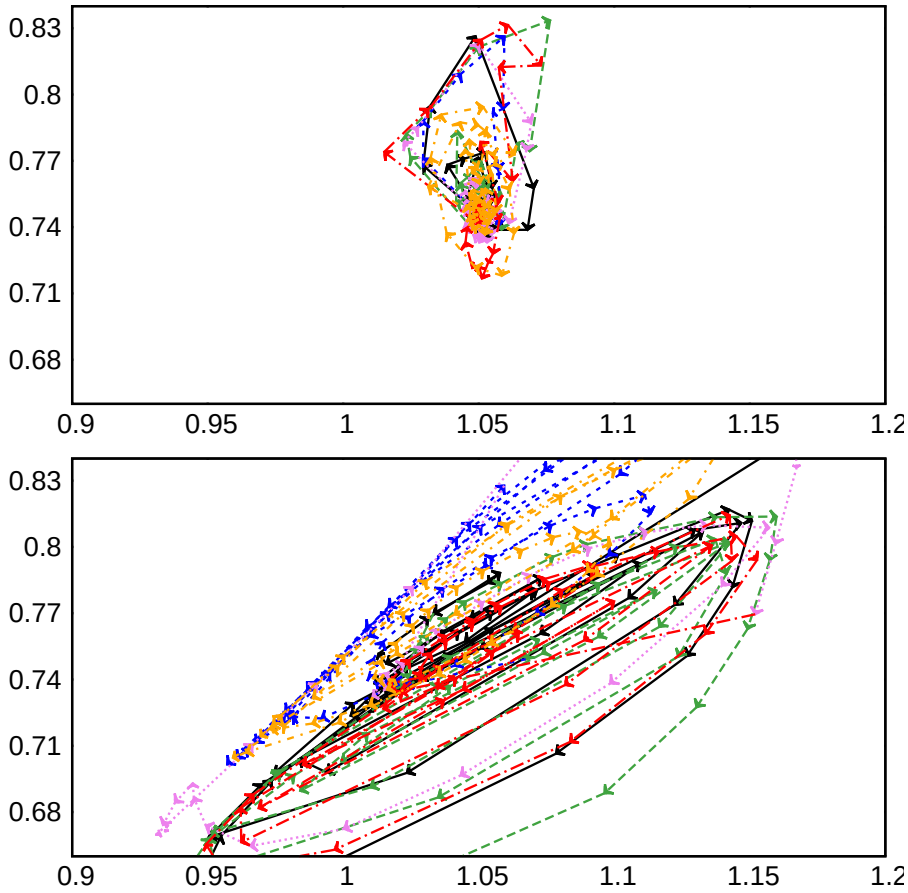
Consider $\pi_t \times c_t$ space (inflation versus consumption) for all six groups.

Phase plots – PLT (2×2 setup)

Guidance



No guidance



- Guidance plays no stabilizing role $\rightarrow$ **H2** *false!*
- **Formal test:** Relative Absolute Deviation measures.
- Mann Whitney U test on RAD distribution gives the following stability ranking:
  - **Inflation:** Strong PLT $>$ Inflation $>$ Weak PLT.
  - **Output gap:** Strong PLT $=$ Inflation $>$ Weak PLT.
- Tests confirm that guidance has *no significant effect*.

Individual behavior

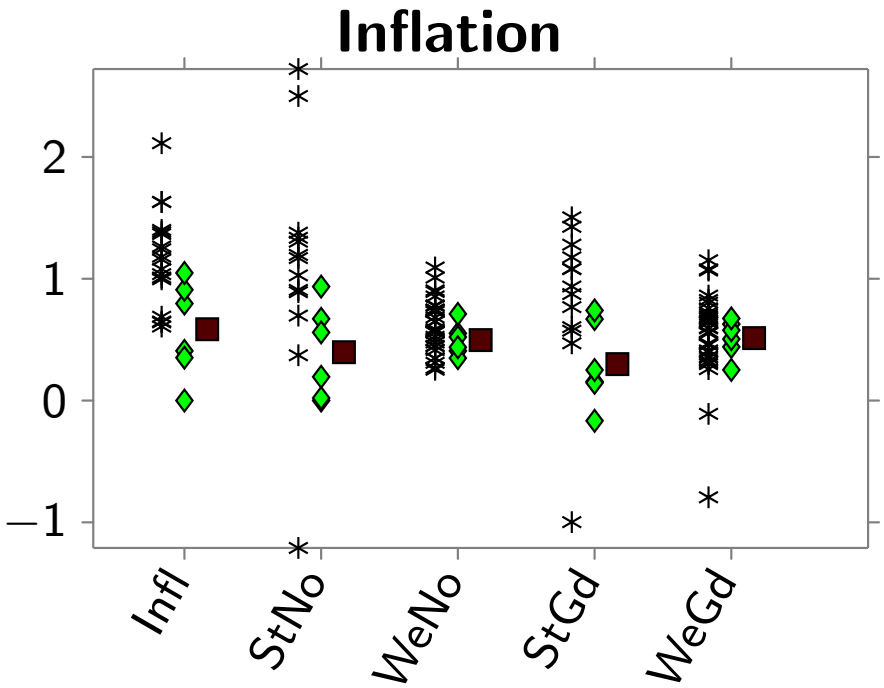
- For every subject: automated procedure to estimate two behavioral forecasting rules (inflation and output gap).
- *Joint* estimation based on a simple *First-Order rule*.
- Heterogeneity within groups and treatments and between treatments.
- Inflation rules, and rules in *stable* groups *simpler* $\rightarrow$ complicated behavior learned in complicated environment.
- Many subjects follow *adaptive* and/or *trend chasing* expectations $\rightarrow$ **H3** *treatment depended!*
- **2D positive feedback results similar to asset pricing experiments.**

Average (significant) used coefficient

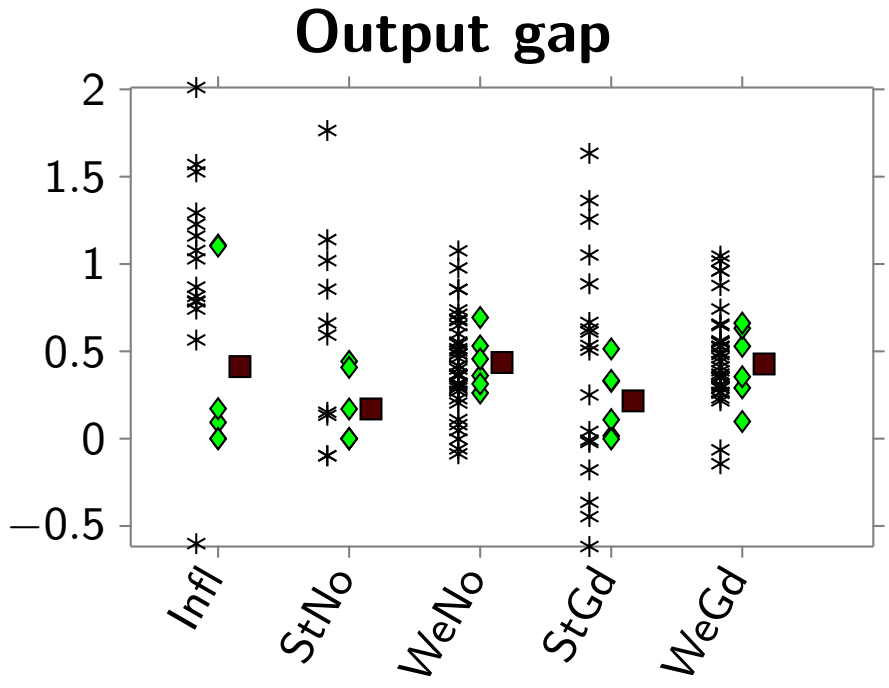
	Treatment				
Coeff.	**Inf**	**StrongNo**	**WeakNo**	**StrongGuid**	**WeakGuid**
Trend π	0.586	0.397	0.496	0.299	0.513
	(18)	(13)	(29)	(13)	(34)
Trend y	0.412	0.17	0.436	0.216	0.428
	(15)	(10)	(36)	(18)	(32)
PLT π				-0.349	-0.0313
				(13)	(23)
PLT y				-0.276	-0.046
				(22)	(28)

Estimated coefficients: *average* among significant and *number*/36 of significant.

Trend following – estimated coefficients



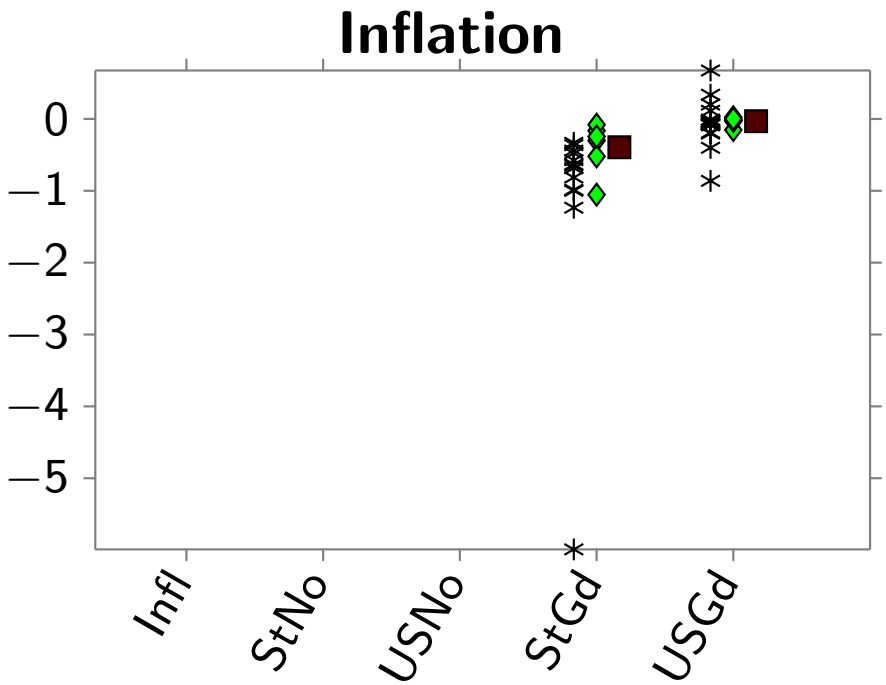
Significant: 18/13/29/13/34



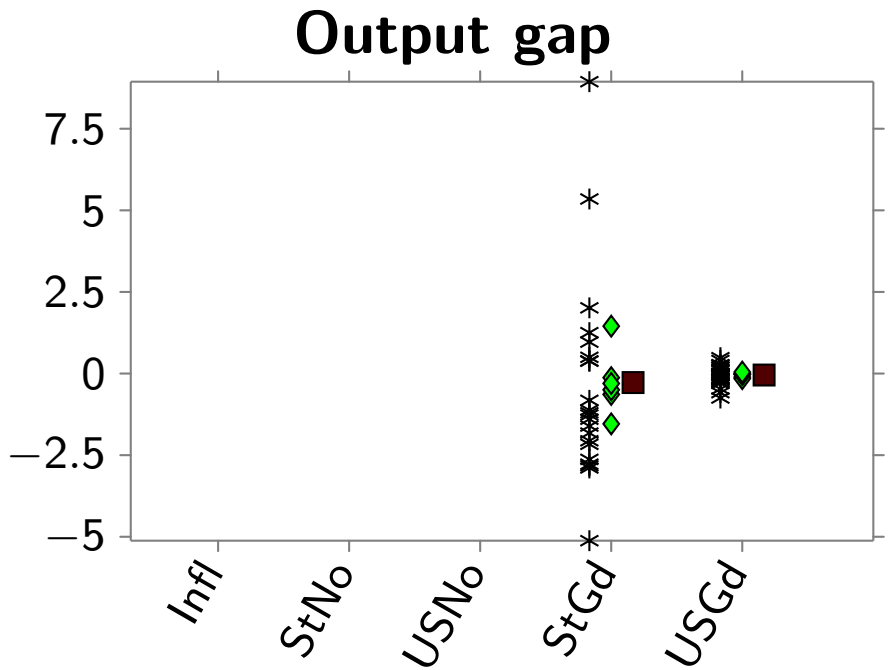
Significant: 15/10/36/18/32

Result: *trend chasing* is (1) *popular* and (2) *stronger* in unstable environments.

Guidance – estimated coefficients



Significant: NA/Na/NA/13/23



Significant: NA/NA/NA/22/28

Result: the effect of *guidance* is *weak*.

Conclusions

- Learning to Forecast experiment in macro setting.
- Typical DSGE economy, with *inflation* or nominal price level targeting (*PLT*).
- Five treatments: inflation target; *stability* and *guidance* of PLT.
- **No evidence for macro effect of guidance**.
- **Remark:** we used simple version of guidance, more studies should follow.
- Indirect expectations management *less efficient?*
- PLT can be stabilizing, but only if **harsh reaction to price level and output deviations**.
- Can Central Banks use harsh rules?

Conclusions: individual behavior

- DSGE is a 2D positive feedback system.
- Subjects learn to *chase trends*.
- **Behavioral interpretation:** *anchor and adjustment* like in asset pricing models/experiments.
- **Rational interpretation:** *easier to coordinate* on oscillatory equilibrium paths.
- Subjects focus more often on guidance in *unstable* economies, but...
- ...guidance *does not counterweight weak monetary policy*.

Result: CB's need to consider trend chasing for their monetary rules.

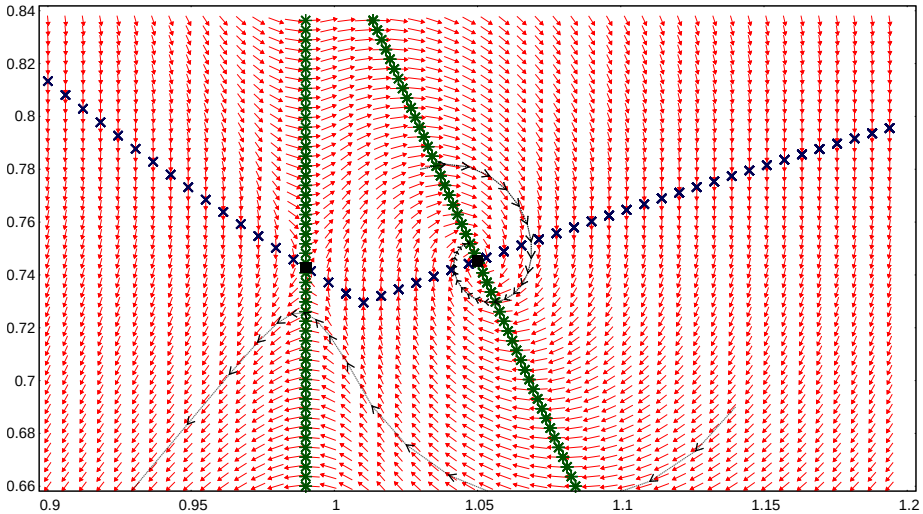
Questions? Comment?

Thank you for your attention!

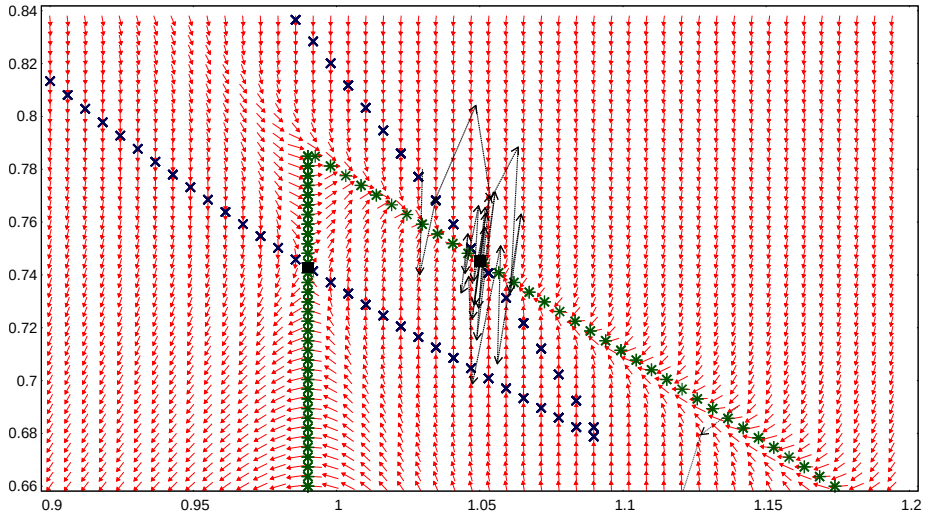
Appendix

Stability under inflation and stable price targeting

Inflation targeting



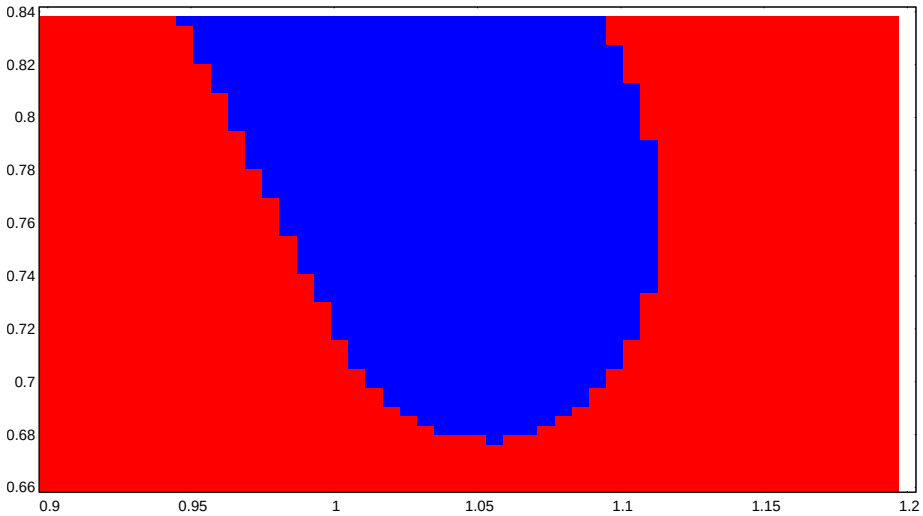
Price level targeting



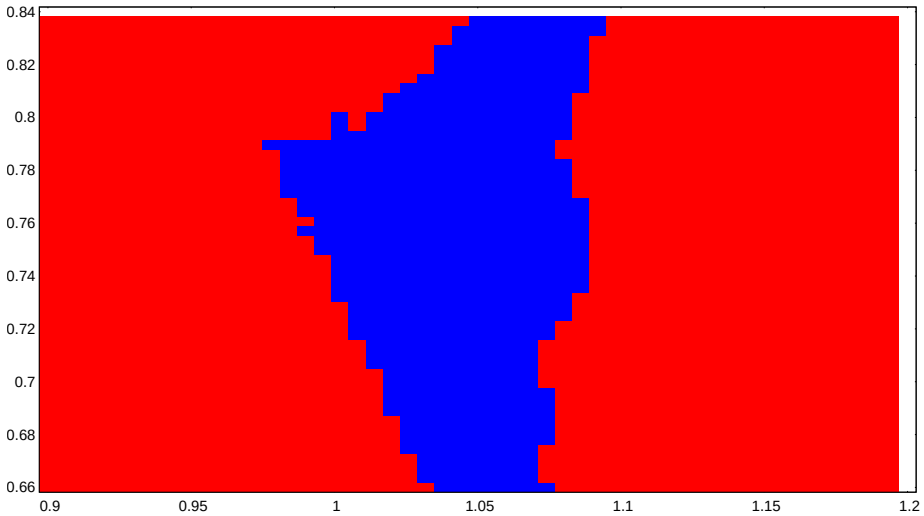
Phase diagrams under naive expectations in $\pi \times c$ space.

Stability under inflation and stable price targeting

Inflation targeting



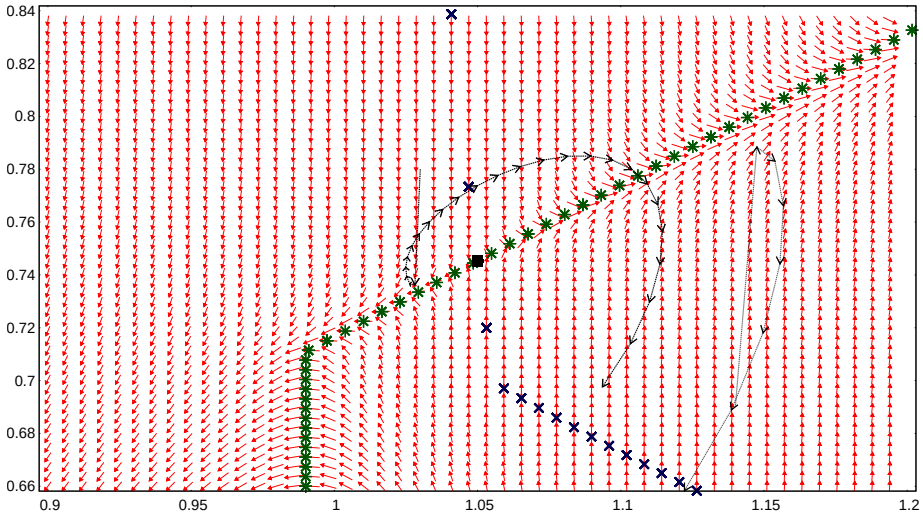
Price level targeting



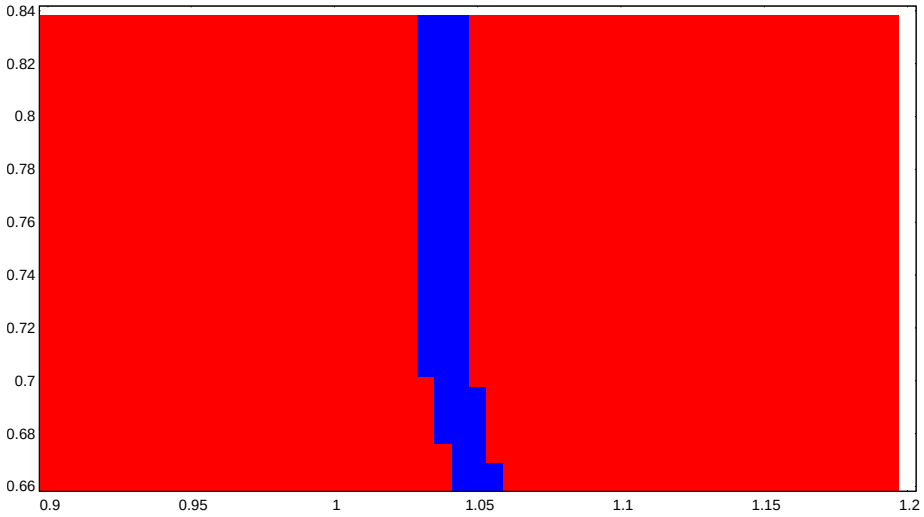
Attractor (blue means vicinity of the FSS; 20 periods).

Unstable price level targeting

Phase diagram



Attractor



Remark: after 10 more periods blue disappears.

Estimated rule

$$\pi^e_{t+1} = c^\pi + \alpha^\pi_1 \pi^e_t + \alpha^\pi_2 \pi_{t-1} + \alpha^\pi_3 \upsilon_{t-1} + \beta^\pi(\pi_{t-1} - \pi_{t-2}) + \delta^\pi r_{t-1} + \gamma^\pi D_{t-1} + \varepsilon^\pi_t, \quad (1)$$

$$\upsilon^e_{t+1} = c^\upsilon + \alpha^\upsilon_1 \pi^e_t + \alpha^\upsilon_2 \upsilon_{t-1} + \alpha^\upsilon_3 \pi_{t-1} + \beta^\upsilon(\upsilon_{t-1} - \upsilon_{t-2}) + \delta^\upsilon r_{t-1} + \gamma^\upsilon D_{t-1} + \varepsilon^\upsilon_t, \quad (2)$$

where

$$\begin{pmatrix} \varepsilon^\pi_t \\ \varepsilon^\upsilon_t \end{pmatrix} \equiv \varepsilon_t \sim NID\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma^2_\pi & \rho_{\pi,\upsilon}\sigma_\pi\sigma_\upsilon \\ \rho_{\pi,\upsilon}\sigma_\pi\sigma_\upsilon & \sigma^2_\upsilon \end{pmatrix} \right). \quad (3)$$

Use ML for estimation and LR test for model selection (significance driven).