On Robustness of Average Inflation Targeting

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Motivation

- In August 2020, Fed announces new policy framework of average inflation targeting (AIT).
- We have imperfect knowledge about the new framework.
  - **What is the averaging window?**
  - What does average inflation precisely mean?
- Several papers studied AIT under RE.
  - RE is restrictive, especially in times that are outside "normal".
  - Bounded rationality (Budianto et al. 2020); rule-of-thumb (Amano et al. 2020).
  - Expectations and AIT (Coibion et al. 2020; Salle, 2021).
- **Question:** How does AIT perform if there is imperfect knowledge and private agents are adaptively learning?

Preview of Results

Our analysis raises **warning signals** concerning robustness of AIT under conditions of imperfect knowledge:

1. Target equilibrium can be locally unstable under learning.
2. Stability of the target depends on price rigidity.

How to implement AIT successfully?

1. Transparency about averaging window improves outcomes.
2. Asymmetric policy *rules* that respond more to below-target than to above-target average inflation improve outcomes.

We need to think more carefully about AIT *reaction functions*.

Simple Example

- Consider a log-linearized New Keynesian model:

$$\begin{aligned}\hat{y}_t &= \hat{y}_t^e - \sigma(\hat{R}_t - \hat{\pi}_t^e) \\ \hat{\pi}_t &= \beta\hat{\pi}_t^e + \kappa\hat{y}_t,\end{aligned}$$

where $\hat{y}$ is the output gap, $\hat{\pi}$ is inflation.

- **AIT monetary policy:** nominal interest rate is set in response to an average of deviations from inflation target π^*

$$\hat{R}_t = \psi \sum_{k=0}^{L-1} \hat{\pi}_{t-k}.$$

- Assume $1 < \psi$ (**Taylor principle**).

Adaptive Learning (with Opacity)

How do agents forecast? Let $x_t = (\hat{y}_t, \hat{\pi}_t)^T$.

- **Rational expectations equilibrium (REE):** $x_t = \sum_{k=1}^{L-1} \Omega_k x_{t-k}$.

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- **Adaptive learning:** $x_t = A_{t-1} + \sum_{k=1}^{L-1} B_{k,t-1} x_{t-k}$.
  - A_t, $B_{k,t}$ updated recursively (e.g. using least squares or constant-gain algorithm).
  - *Cognitive consistency principle:* agents should be about as smart (or dumb) as economists.
  - Agents understand functional form of REE, but must estimate its parameters.

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  - *Cognitive consistency principle:* agents should be about as smart (or dumb) as economists.
  - Agents understand functional form of REE, but must estimate its parameters.
- **Adaptive learning + Opacity:** $x_t = A_{t-1}$.
  - How do agents know the averaging window?

Simple Example

- With opacity about monetary policy, private agents forecast inflation using a weighted average of past inflation (steady state learning with constant gain)

$$\hat{\pi}_t^e = \hat{\pi}_{t-1}^e + \omega(\hat{\pi}_{t-1} - \hat{\pi}_{t-1}^e),$$

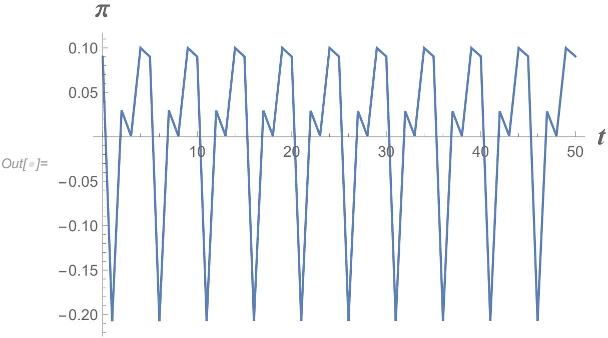
where $\omega > 0$ is small.

- For simplicity assume: $\hat{y}_t^e = \frac{1-\beta}{\kappa}\pi_t^e$.
- Temporary equilibrium relation:

$$\begin{aligned} \hat{\pi}_t &= \frac{1 - \kappa\sigma\omega(\psi - 1)}{\kappa\sigma\psi + 1}\hat{\pi}_{t-1} - \frac{\omega\kappa\sigma\psi}{1 + \kappa\sigma\psi}\sum_{k=2}^{L}\hat{\pi}_{t-k} \\ &+ \frac{\kappa\sigma\psi(1 - \omega)}{\kappa\sigma\psi + 1}\hat{\pi}_{t-L}. \end{aligned}$$

Simple Example

Remark: *In the flexible price limit* $(\kappa \to \infty)$, *the steady state* π^* *is locally stable if* $L \leq 3$ *but is explosive if* $L = 4$ *and for many higher values of* L.



- Numerical example of divergence: $L = 4$ and $\omega = 0.001$.

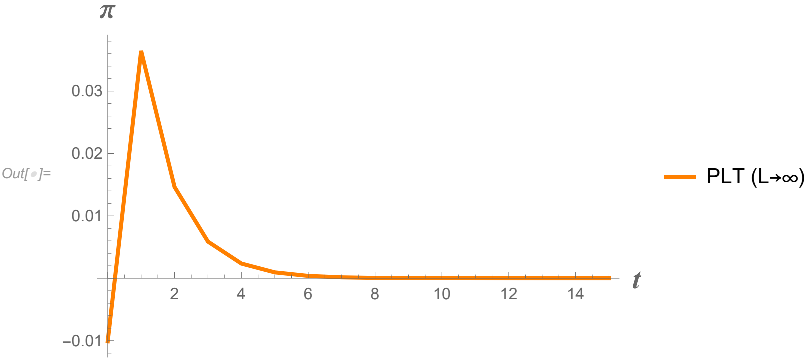
Simple Example

What drives instability under AIT?

1. **Makeup:** inflation overshoots after period of undershooting.
2. **Finite data window** ("bygones are bygones") $\rightarrow$ pattern of over-/undershooting.
3. **Opacity:** long-term expectations drift.

We have local stability under price level targeting and traditional inflation targeting.

Makeup inflation



Finite data window: bygones are bygones

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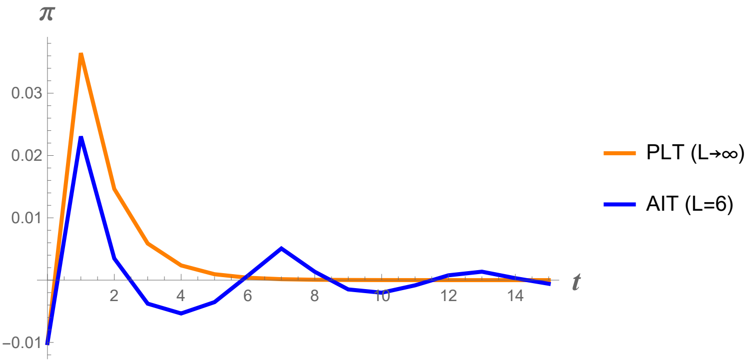
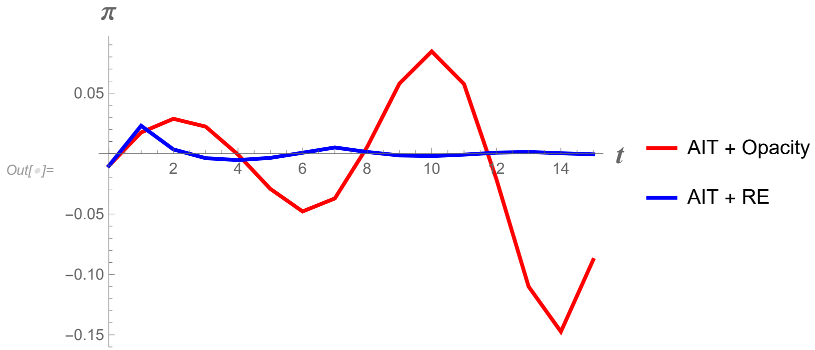


Opacity



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Remark: *We also have instability for $L \geq 4$ if agents have AR(1) forecasting model.*

Stability with sticky prices?

- Temporary equilibrium relation is

$$\hat{\pi}_t = \frac{1-\kappa\sigma\omega(\psi-1)}{\kappa\sigma\psi+1}\hat{\pi}_{t-1} - \frac{\omega\kappa\sigma\psi}{1+\kappa\sigma\psi}\sum_{k=2}^{L}\hat{\pi}_{t-k} + \frac{\kappa\sigma\psi(1-\omega)}{\kappa\sigma\psi+1}\hat{\pi}_{t-L}.$$

  - When prices are very sticky (κ is small), small ω

$$\hat{\pi}_t \approx A\hat{\pi}_{t-1}$$

  with A slightly smaller than 1 (given small ω).

- **Question:** is the steady state **robustly stable** (i.e. stable for plausible calibrations of ω)?

Formal Analysis

We develop a non-linear New Keynesian model with Rotemberg price adjustment costs and infinite-horizon learning agents

1. Equilibrium Conditions

$$\begin{aligned} y_t &= G(\tilde{g}_t, R_t, \{R^e_{t+j-1}\}_{j=1}^{\infty}, \{\pi^e_{t+j}\}_{j=1}^{\infty}, \{y^e_{t+j}\}_{j=1}^{\infty}) \\ \pi_t &= F(\tilde{g}_t, y_t, \{y^e_{t+j}\}_{j=1}^{\infty}) \end{aligned}$$

   y is output; $\tilde{g}$ gov't spending; R is gross nominal rate.

2. AIT Rule with ZLB

$$R_t = 1 + \max[\bar{R} - 1 + \psi_p \left[(\pi^*)^{-L} \prod_{i=0}^{L-1} \pi_{t-i} - 1 \right] + \psi_y [\frac{y_t}{y^*} - 1], 0].$$

Formal Analysis

- **Opacity:** forecast future $\hat{y}, \hat{\pi}, \hat{R}$ without any lagged endogenous variables (lagged inflation rates in the policy rule). Only observed regressors used.

- **Perceived law of motion (PLM)**: Agents estimate the regressions

$$s_u = a_s + b_s \tilde{g}_{u-1} + \varepsilon_{s,u},$$

  where $s = y$, π, R by using a version of least squares and data for periods $u = 1, ..., t-1$.

- The equilibrium involves misspecified PLM and is thus a **restricted perceptions equilibrium**, also called **self-confirming equilibrium.**

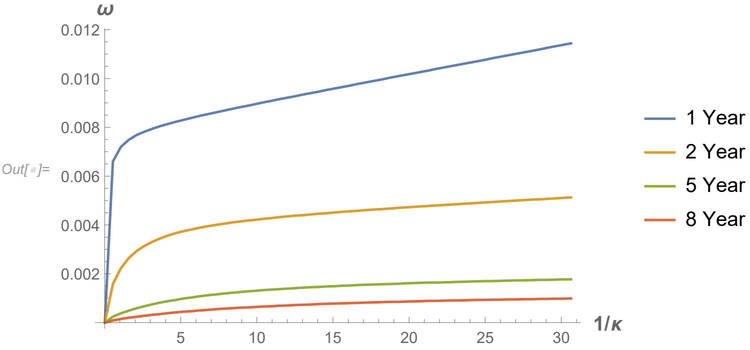
Formal Analysis

We investigate the following:

1. Stability of the target equilibrium under constant-gain learning with opacity.
2. The importance of communication near the target and at the ZLB.
3. The importance of symmetry.

#1. Stability of the Target Equilibrium

- **Proposition.** Target equilibrium (π^*) is unstable for $L \geq 4$ if prices are flexible.
- **Definition.** π^* is **robustly stable**, if stable for $\omega < .01$.



- **Result.** Target equilibrium (π^*) is not **robustly stable** if prices are rigid.

#2. Importance of Communication

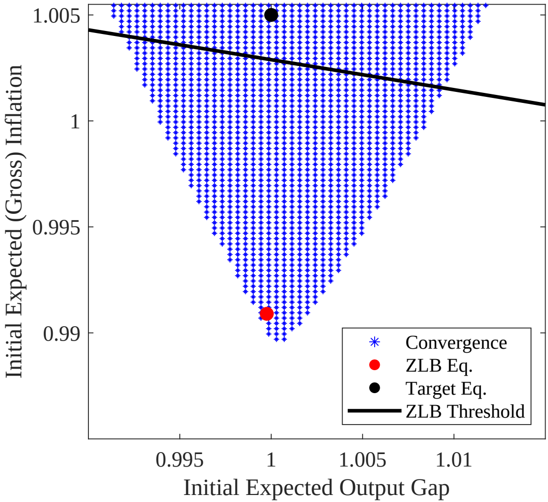
- If agents understand L, then the target is robustly stable.
- **Perceived law of motion (PLM)**: Agents estimate the regressions

$$s_u = a_s + b_s \tilde{g}_{u-1} + \sum_{j=1}^{L-1} c_{s,j} ln(\pi_{u-j}) + \varepsilon_{s,u},$$

  where $s = ln(y)$, $ln(\pi)$, $ln(R)$ by using a version of least squares and data for periods $u = 1, ..., t-1$.
- The PLM has the same functional form of the minimal state variable RE solution of the linearized model.

#3. Importance of Communication

- At ZLB, traditional inflation targeting is about as effective.



#3. Symmetry vs. Asymmetry

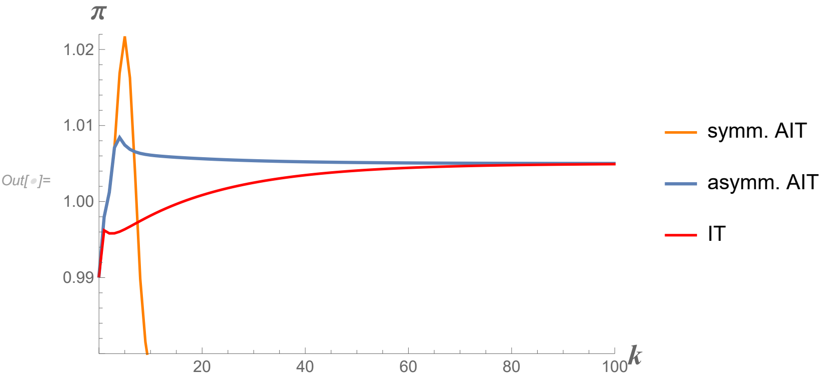
- Consider the following asymmetric AIT rule;

$$
\begin{aligned}
R_t &= 1 + \max[\bar{R} - 1 + \psi_p[\mathcal{P}_t - 1] + \psi_y[(y_t - y^*)/y^*], 0], \\
\mathcal{P}_t &= \begin{cases} \prod_{i=0}^{L-1} (\pi_{t-i}/\pi^*) & \text{if } \prod_{i=1}^{L} \pi_{t-i} < (\underline{\pi})^L \\ \pi_t/\pi^* & \text{if } \prod_{i=1}^{L} \pi_{t-i} \geq (\underline{\pi})^L, \end{cases}
\end{aligned}
$$

- **Remark.** $\underline{\pi} < \pi^* \implies$ robust stability under asymmetric AIT rules.
  - Stability obtains under flexible/rigid prices because asymmetric AIT rule and simple Taylor rule are identical near π^*.

- **Implication:** asymmetric AIT rules may be a viable alternative to a transparent averaging window.

Escaping the ZLB



Variations on a theme

1. A **discounted average** modestly improves stability outcomes.

$$R_t \equiv 1 + \max[\bar{R} - 1 + \psi_p \left[\sum_{i=0}^{L-1} \mu^i (\frac{\pi_{t-i}}{\pi^*} - 1) \right] + \psi_y [\frac{y_t}{y^*} - 1], 0],$$

   where $0 < \mu < 1$.

2. A **weighted (exponential moving) average** can stabilize expectations:

$$\begin{aligned} R_t &= 1 + \max[\bar{R} - 1 + \psi_p \left(\frac{\pi_t^{w_c} (\pi_t^{cb})^{1-w_c}}{\pi^*} - 1 \right), 0] \\ \pi_t^{cb} &= \pi_{t-1}^{w_c} (\pi_{t-1}^{cb})^{1-w_c} \end{aligned}$$

   where $0 < w_c < 1$.
   - ...or may destabilize expectations if $\omega \approx w_c \approx 0$ (e.g. Eusepi and Preston (2018)).

Conclusion

- Policymakers should be cautious when implementing AIT.
  - An opaque policy framework may fail to anchor and stabilize expectations.
- Transparency about the averaging window or asymmetric rules mitigate the problem of imperfect knowledge.
- **Extensions:**
  - More asymmetric and switching rules (e.g. Bernanke (2017), Mertens and Williams (2019), Reifschneider and Williams (2000)).
  - Calvo vs. Rotemberg: does the pricing rule matter?
  - Imperfect and evolving credibility after new regime is introduced.