Inflation During and After the ZLB

S. Borağan Aruoba
University of Maryland

Frank Schorfheide
University of Pennsylvania, CEPR, NBER

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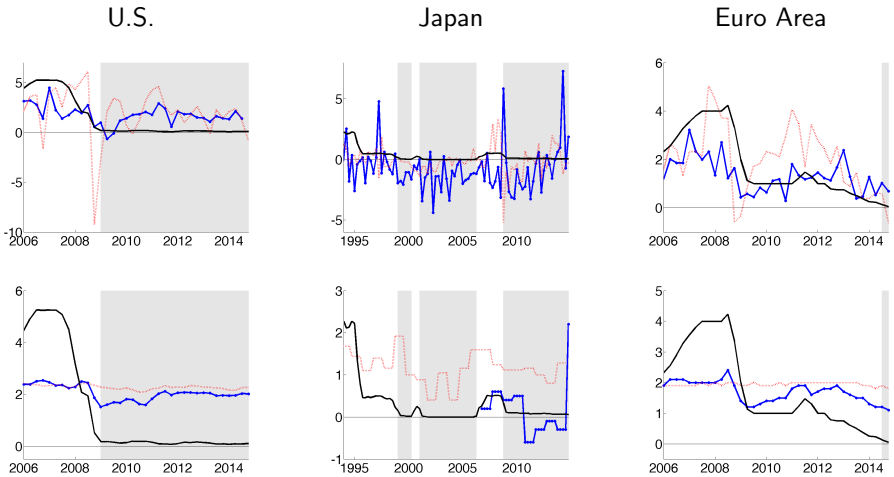
This Talk is Based on

- B. Aruoba and F. Schorfheide (2015): "Inflation During and After the Zero Lower Bound," prepared for the 2015 Jackson Hole Economic Policy Symposium.
- B. Aruoba, P. Cuba-Borda, and F. Schorfheide (2014): "Macroeconomic Dynamics Near the ZLB: A Tale of Two Countries," *PIER Working Paper*, 14-035.

Introduction

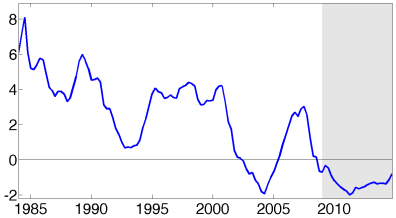
- ZLB has become binding in U.S., Japan, and Euro Area.
- ZLB constrains monetary policy responses to adverse shocks.
- This talk will examine four broad questions:
  - Q1 Inflation outlook for Japan, U.S., and Euro Area (as of 2nd quarter 2015)?
  - Q2 Inflation dynamics before and after lift off?
  - Q3 Did Japan and U.S. (and Euro Area) enter a persistent regime in which inflation rates will remain below the values targeted by the central bank?
  - Q4 What if U.S. had adopted higher inflation target?

Inflation and Inflation Expectations

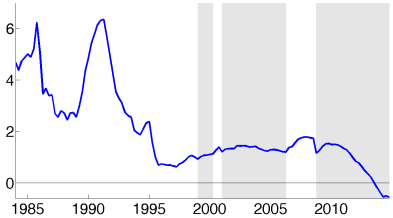


Ex Ante Real Rates (See Below for $\mathbb{E}_t[\pi_{t+1}]$)

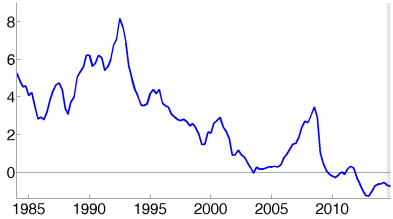
U.S.



Japan



Euro Area



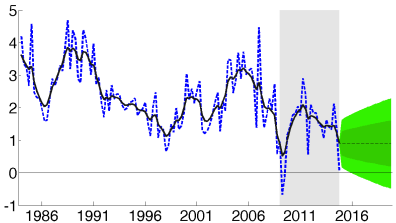
Q1: Forecasts from a Simple Time Series Model

- Stock and Watson (2007)
- Unobserved components model with stochastic volatility:

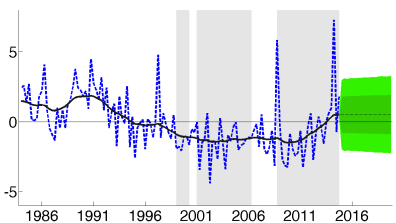
$$\begin{aligned}
\pi_t &= \tau_t + \sigma \exp(h_{\epsilon,t})\epsilon_t, \\
\tau_t &= \tau_{t-1} + (\varphi\sigma)\exp(h_{\eta,t})\eta_t \\
h_{j,t} &= \rho_j h_{j,t-1} + \sqrt{1-\rho_j^2}\sigma_{v_j} v_{j,t}, \quad j \in \{\epsilon, \eta\}.
\end{aligned}$$

Q1: Inflation Outlook

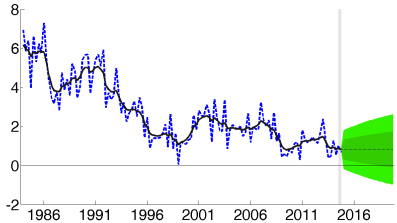
U.S.



Japan



Euro Area



Next Steps

- Textbook-style New Keynesian DSGE Model.
- We focus on ambiguity of predictions arising from multiplicity of predictions
- Multiplicity is blessing and curse:
  - \+ helps explaining different macroeconomic experiences;
  - \- policy implications are ambiguous;
  - ? central bank actions & statements may influence coordination of beliefs and lead to selection of desirable equilibrium.

Key Elements of the NK DSGE Model

- Consumption Euler Equation / Fisher Equation:

$$1 = \beta \mathbb{E}_t \left[\left(\frac{\delta_{t+1}}{\delta_t} \right) Q_{t+1|t} \frac{R_t}{\pi_{t+1}} \right], \quad r_t^f = \frac{1}{\beta} \left\{ \mathbb{E}_t \left[\left(\frac{\delta_{t+1}}{\delta_t} \right) Q_{t+1|t} \right] \right\}^{-1}$$

  In steady state: $R_* = r_*^f \pi_*$.

- New Keynesian Phillips curve:

$$\widehat{\pi}_t = \beta \mathbb{E}_t[\widehat{\pi}_{t+1}] + \kappa \widehat{mc}_t + \lambda_t.$$

- Monetary policy rule:

$$\begin{aligned} R_t &= \max\left\{1, \ \bar{R}_t e^{\epsilon_{R,t}}\right\}, \quad \bar{R}_t = \left(r_*^f \bar{\pi}_t \left(\frac{\pi_t}{\bar{\pi}_t} \right)^{\psi_1} \left(\frac{Y_t}{\bar{Y}_t} \right)^{\psi_2} \right)^{1-\rho_R} R_{t-1}^{\rho_R} \\ \ln \bar{Y}_t &= \alpha \ln \bar{Y}_{t-1} + (1-\alpha) \ln Y_t + \alpha \ln \gamma. \end{aligned}$$

ZLB and Multiplicity of Equilibria

Recall Our Questions:

Q2 Inflation dynamics before and after lift off?

Q3 Did Japan and U.S. (and Euro Area) enter a persistent regime in which inflation rates will remain below the values targeted by the central bank?

Q4 What if U.S. had adopted higher inflation target?

Using the NK DSGE model, we will look at:

- perfect foresight dynamics: Cochrane (2005); Benhabib, Schmitt-Grohe, Uribe (2001, ...) – (Q2);
- a stochastic two-regime equilibrium: Aruoba, Cuba-Borda, and Schorfheide (2014) – (Q2, Q3, Q4)

A Simplified Log-Linearized, Perfect Foresight Model

- Consumption Euler equation:

$$\widehat{c}_t = \widehat{c}_{t+1} - (\widehat{R}_t - \widehat{r}_t - \pi_{t+1})$$

- NK Phillips curve:

$$\widehat{\pi}_t = \beta \widehat{\pi}_{t+1} + \kappa \widehat{c}_t$$

- Monetary policy rule

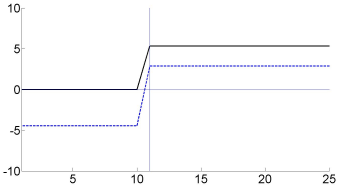
$$\widehat{R}_t = \max \left\{ -\ln(r_*^f \bar{\pi}),\ \psi_1 \widehat{\pi}_t \right\}.$$

- Real rate $\hat{r}_t$ is exogenous.
- Two steady states
- Local indeterminacy once ZLB is binding

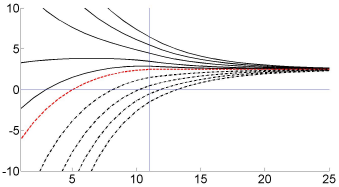
Q2: Cochrane (2015): Exit From ZLB After Real Rate Shock

Prices are sticky; transitory real rate shock pushes economy to ZLB.

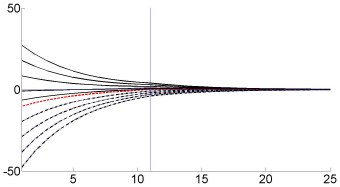
Interest Rates



Inflation

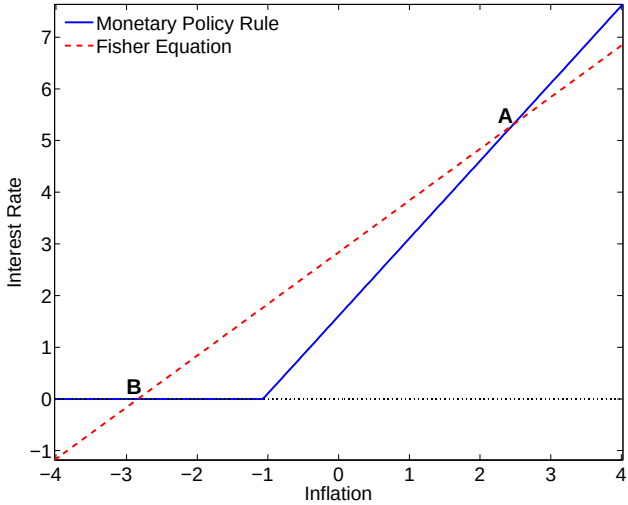


Consumption



- First, trace out stable consumption & inflation dynamics: multiplicity!
- Second, implement desired path with interest rate rule targeting desired inflation path π_t^*.

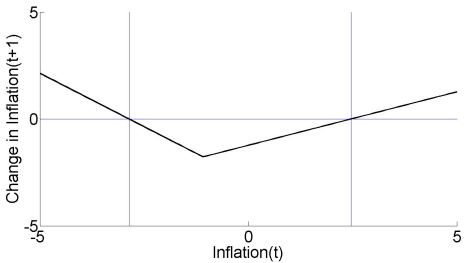
Steady State Multiplicity

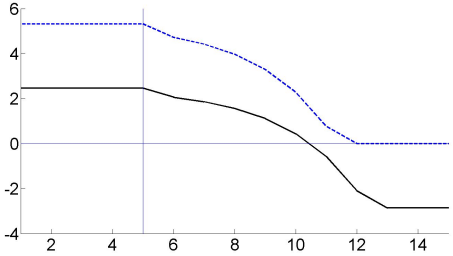


Q2: Benhabib, Schmitt-Grohe, Uribe (2001, ...): Transition to Deflation Steady State

Combine policy rule and consumption Euler equation, assume prices are flexible:

$$\widehat{\pi}_{t+1} = \max \left\{ -\ln(r_*^f \bar{\pi}),\ \psi_1 \widehat{\pi}_t \right\}$$





- "Bad shock" may trigger a transition to deflation steady state.

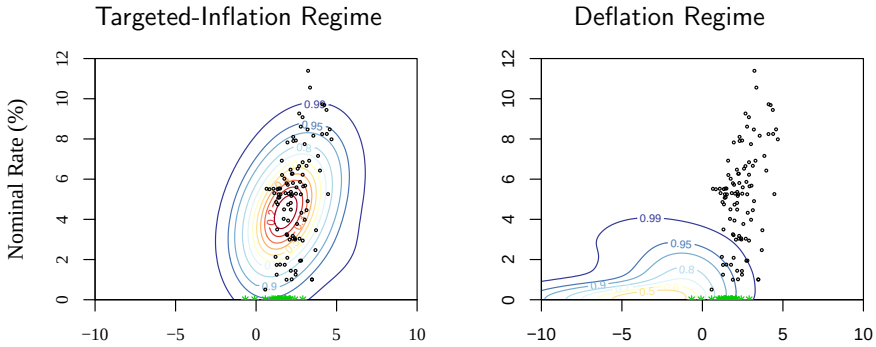
Q3: Aruoba, Cuba-Borda, and Schorfheide (2014): Sunspot Equilibrium

- Bullard (2010) [Seven Faces of "The Peril"]:
  - The U.S. is closer to a Japanese-style outcome today than at any time in recent history.
  - Promising to remain at zero for long time is a double-edged sword. The policy is consistent with the idea that inflation and inflation expectations should rise in response to the promise and that this will eventually lead the economy back toward the targeted equilibrium.
  - But the policy is also consistent with the idea that inflation and inflation expectations will instead fall and that the economy will settle in the neighborhood of the unintended steady state, as Japan has in recent years.
- We will assess the likelihood of a switch to the deflation regime – (Q3).
- Perfect foresight analysis is not sufficient.

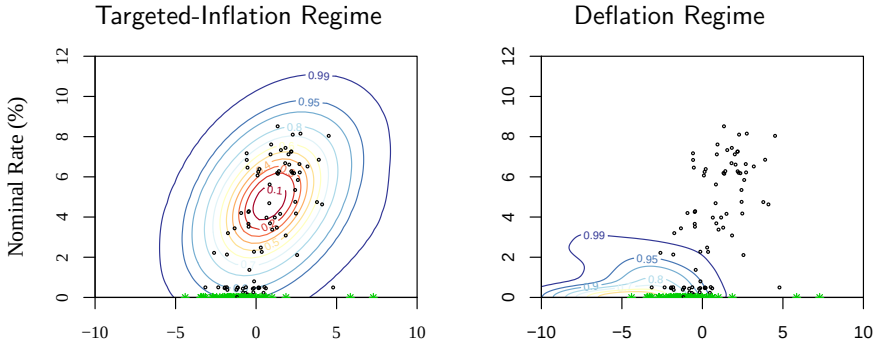
Aruoba, Cuba-Borda, and Schorfheide (2014): Sunspot Equilibrium

- Assume that agents can coordinate beliefs on exogenous sunspot shock $s_t \in \{0, 1\}$ that follows Markov switching process.
- Model also contains fundamental shocks to: technology growth, government spending, monetary policy, and discount factor.
- We consider an equilibrium with two regimes: targeted-inflation regime and deflation regime.
- Nonlinear model is solved using projection methods; in particular, accounting for ZLB.
- We estimate NK DSGE model based on pre-ZLB output growth, consumption, inflation, and interest rate data assuming that the economies are in the targeted-inflation regime.
- Then conduct nonlinear analysis on ZLB data.

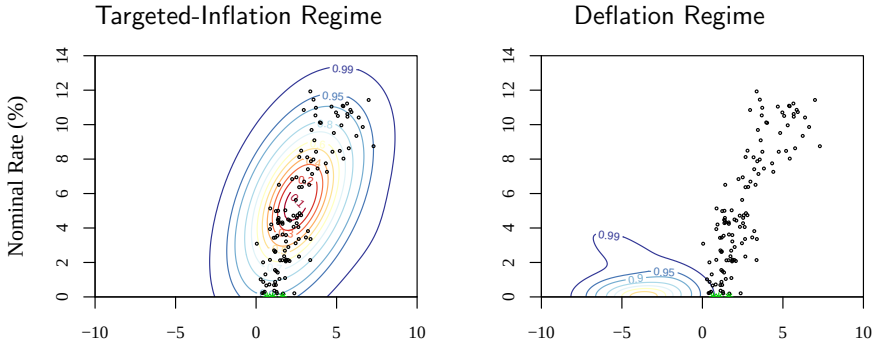
Q3: Data and Ergodic Distribution – U.S.



Q3: Data and Ergodic Distribution – Japan



Q3: Data and Ergodic Distribution - Euro Area



Q3: So far?

- Under targeted inflation regime reaching ZLB is unlikely.
- But, overlap in regime conditional distributions for low interest and inflation rates.
- Japan: observations appear more likely under deflation regime.
- U.S.: ambiguous
- Euro Area: too soon to tell.
- Contour plots ignore dynamic aspects and other observables.

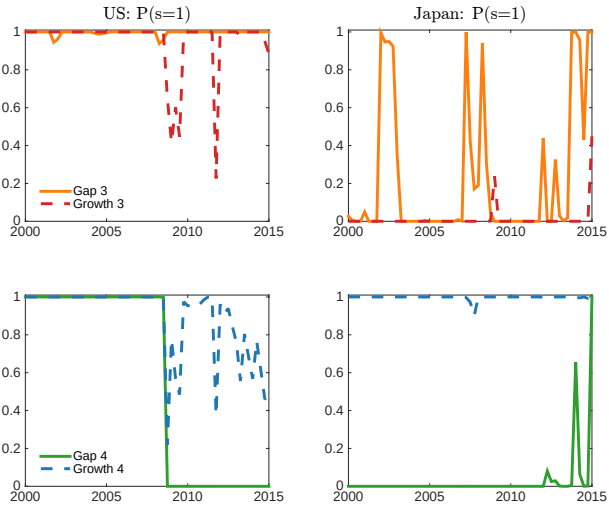
Q3: Results from a Nonlinear Filter

- The DSGE model has a nonlinear state-space representation of the form

$$\begin{aligned} y_t^o &= \Psi(x_t) + \nu_t \\ x_t &= F_{s_t}(x_{t-1}, \epsilon_t) \\ \mathbb{P}\{s_t = 1\} &= \begin{cases} (1 - p_{00}) & \text{if } s_{t-1} = 0 \\ p_{11} & \text{if } s_{t-1} = 1 \end{cases} \end{aligned} \tag{1}$$

- Construct filtered states: $\mathbb{P}\{s_t = 1 | Y_{1:t}^o\}$.

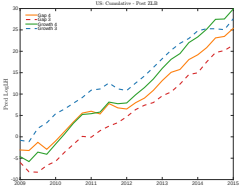
Q3: Filtered States for U.S. and Japan

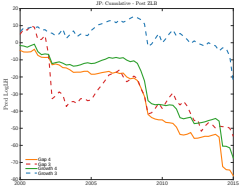


Q3: Aggregating the Results

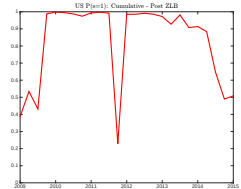
U.S. Japan

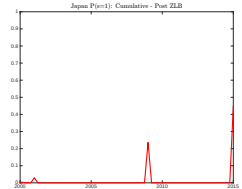
Cumulative Predictive Log Likelihood Score





Average $\mathbb{P}\{s_t = 1 | Y^o_{1:t}\}$ Across Specifications

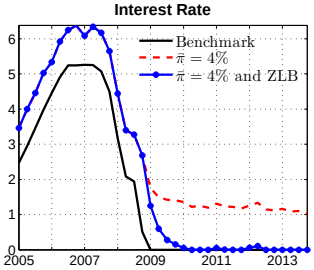


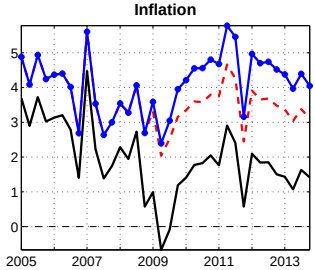


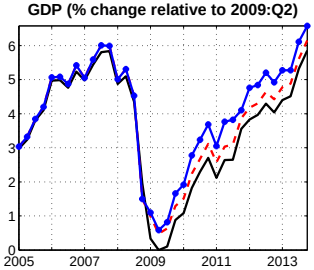
Q4: Policy Experiments – Increase in Inflation Target

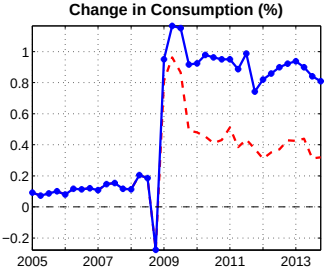
- How bad is deflation?
  - Adverse shocks that generate deflation are bad.
  - Welfare costs due to "New Keynesian" distortion.
  - Could be amplified by downward nominal wage rigidity.
- Experiment: change inflation target (in our model it is about 2.5%).

Q4: What If... the U.S. Had Targeted 4% Inflation?





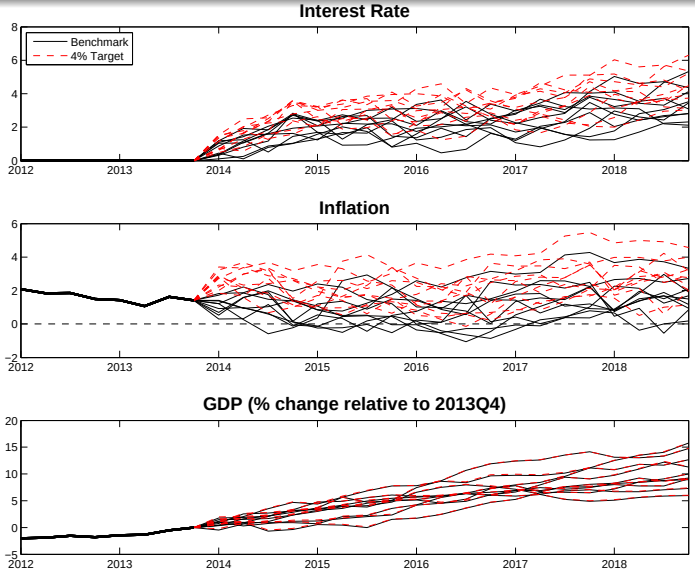




Q4: What If... the U.S. Had Targeted 4% Inflation?

- Benefit: Higher target inflation rate $\longrightarrow$ ability to conduct conventional expansionary monetary policy.
- Costs:
  - Increased price adjustment costs may lead to welfare loss.
  - Other costs, e.g., holding cash balances.
- Japan: spending long time at ZLB may be unrelated to inflation target.
- From ex ante perspective, costs and benefits have to be weighted by prob of reaching ZLB.
- From *ex ante* perspective, the case for a higher inflation target is not particularly strong.

Q4: What If... the U.S. Switches to a 4% Target?

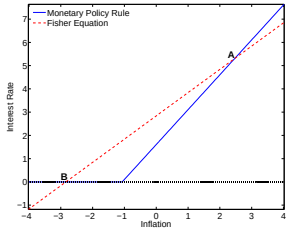


Q4: What If... the U.S. Switches to a 4% Target?

- Even if policy is credible, expected real effects of this policy change are essentially zero.
- Only positive effect would be the ability to execute unanticipated expansionary monetary policy actions in response to adverse shocks.
- Raising the target does not eliminate deflation regime.
- Potentially adverse effect on the credibility of the central bank.

Policies That Transcend the Model

- Managing expectations, e.g., through unconventional monetary policies.
- In ACS we argue that the aggressive unconventional monetary policies in the U.S., in contrast to the more measured and possibly contradictory responses of the Bank of Japan, may have prevented a switch to the deflation regime in the U.S.
- Eliminating the deflation steady state / regime: e.g., discontinuous monetary policy rule; active fiscal and passive monetary policy; fiscal authority that responds to level of nominal debt or directly to inflation, signaling that deflationary steady state is unsustainable.



Conclusions

- Tried to shed some light on how inflation dynamics may change once economy hits ZLB.
- Workhorse New Keynesian model leads to ambiguous predictions: multiplicity of equilibria.
- Can explain different experiences with the same model!
- But, a lot of uncertainty about effects of economic policies.
- Desirable to conduct policies in a way that prevents coordination of private sector expectations on a deflationary level; eliminate possibility of deflation regime altogether.
- Case for a higher inflation target is not particularly strong.