Resolving New Keynesian Puzzles

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*The views expressed in this presentation are not the views of the Bank of Finland.

Motivation

- The effective zero lower bound (ZLB) on interest rates is a dominant feature of 21^{st} century macroeconomics.
- Modeling it is paramount to understanding history and evaluating policy.
- New Keynesian models of nearly all varieties predict *puzzling* dynamics at the ZLB under *standard* modeling practices.

Motivation - GFC Example

... the Committee decided today to keep the target range for the federal funds rate at 0 to 1/4 percent. The Committee currently anticipates that economic conditions ... are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013.

— *FOMC Statement 09/08/2011*

What effect does the standard structural monetary policy model predict for this policy?

Motivation - GFC Example

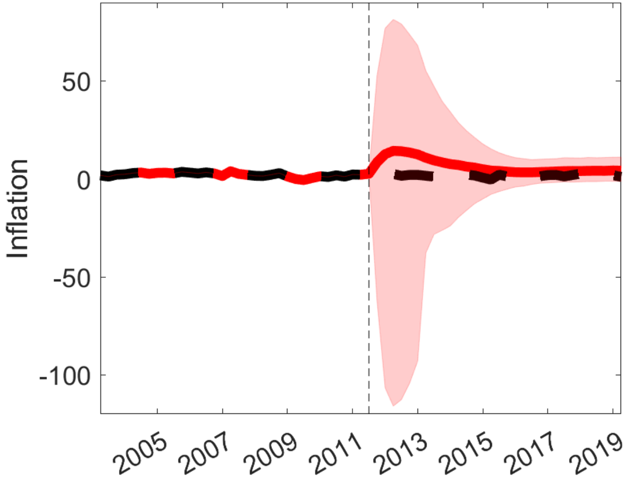


Figure: Smets and Wouters (AER 2007). Posterior draws from original data ending in 2004.

Fixing The Forward Guidance Puzzle

A long list of papers mitigate the puzzle:

- **Structural remedies**: myopia (Gabaix, 2020), incomplete markets (McKay et al., 2016), imperfect common knowledge (Angeletos and Lian, 2018), sticky information (Carlstrom et al., 2015; Kiley, 2016), credibility (Haberis et al., 2019),...
- **Policy remedies**:
  - Fiscal theory of the price level (Cochrane, 2017).
  - Money growth or interest on reserves (Diba and Loisel, 2021).

Outline

- The New Keynesian Puzzles are a result of implausible monetary policy... not an implausible model.
  - Lack of history dependence in monetary policy $\implies$ policymakers retroactively tolerate wild inflation dynamics at the ZLB.
  - Forward guidance requires commitment, and (optimal) commitment implies history dependence.
- Simple implementable rules that loosely approximate optimal commitment policy *at the ZLB* select a locally unique and puzzle-free equilibrium.
- Under a history dependent monetary policy framework the puzzles are perhaps not puzzles.

How do people model the ZLB?

The standard way to close an NK Model

$$i_t = (1-\rho)\bar{r} + \rho i_{t-1} + (1-\rho)(\phi_\pi \pi_t + \phi_y y_t). \tag{1}$$

The standard way to add the ZLB

$$i_t = \max\left\{(1-\rho)\bar{r} + \rho i_{t-1} + (1-\rho)(\phi_\pi \pi_t + \phi_y y_t), 0\right\}. \tag{2}$$

What's the problem?

- Instrument rules are not the same as a policy framework.
- A central bank is a maximizing agent in the economy

$$\min_{\pi_t, y_t, i_t} \left\{ \frac{1}{2} E_t \sum_{T=t}^{\infty} \beta^{T-t} (\pi_t^2 + \alpha y_t^2) \right\}, \tag{3}$$

  - (3) happens to be a second order approximation to household welfare for particular α
  - (3) happens to correspond to what a dual mandate central banks think their job is

- An inertial Taylor rule is an **approximate** way to implement a policy that minimize (3) and they are not unique.

Optimal monetary policy

Claim: Inertial Taylor rules loosely approximate optimal commitment

$$\min_{\pi_t, y_t, i_t} \left\{ \frac{1}{2} E_t \sum_{T=t}^{\infty} \beta^{T-t} (\pi_t^2 + \alpha y_t^2) \right\}$$

subject to

$$\begin{aligned}
y_t &= E_t y_{t+1} - \frac{1}{\sigma}(i_t - E_t \pi_{t+1} - r_t^n) \\
\pi_t &= \beta E_t \pi_{t+1} + \kappa y_t + \mu_t \\
r_t^n &= \bar{r} + \rho_r (r_{t-1}^n - \bar{r}) + \epsilon_{r,t} \\
\mu_t &= \rho_\mu \mu_{t-1} + \epsilon_{\mu,t}
\end{aligned}$$

Optimal monetary policy

Target criteria

- Discretion

$$y_t = -\frac{\kappa}{\alpha}\pi_t$$

- Timeless perspective commitment

$$y_t - y_{t-1} = -\frac{\kappa}{\alpha}\pi_t$$

- Unconditional commitment (Blake, 2001; Jensen and McCallum, 2002)

$$\mathbf{y_t} - \boldsymbol{\beta}\mathbf{y_{t-1}} = -\frac{\boldsymbol{\kappa}}{\boldsymbol{\alpha}}\boldsymbol{\pi}_\mathbf{t}$$

Optimal monetary policy

Unconditional target criterion: $y_t = -\frac{\kappa}{\alpha}\frac{\pi_t}{1-\beta L}.$

Proposition

The optimal target criterion may be implemented by either of the following interest rate rules

$$Optimal\ Rule\ 1: \quad i_t = \beta i_{t-1} + \frac{\kappa}{\sigma\alpha}\pi_t + (1-\beta L)\left(\frac{1}{\sigma}E_t y_{t+1} + E_t\pi_{t+1} + r_t^n\right) \tag{4}$$

$$Optimal\ Rule\ 2: \quad \begin{aligned} i_t &= \tfrac{\kappa}{\sigma\alpha(1-\beta)}\omega_t^\pi + \tfrac{1}{\sigma}E_t y_{t+1} + E_t\pi_{t+1} + r_t^n \\ \omega_t^\pi &= \omega_{t-1}^\pi + (1-\beta)(\pi_t - \omega_{t-1}^\pi) \end{aligned} \tag{5}$$

Holding the policy framework constant at the ZLB

Note the following equivalent representations:

$$i_t - \rho i_{t-1} = (1-\rho)\bar{r} + (1-\rho)(\phi_\pi \pi_t + \phi_y y_t)$$

$$i_t = \bar{r} + (1-\rho)\sum_{j=0}^{t} \rho^j \left(\phi_\pi \pi_{t-j} + \phi_y y_{t-j}\right)$$

$$\begin{aligned} i_t &= \bar{r} + \phi_\pi \omega_t^\pi + \phi_y \omega_t^y \\ \omega_t^\pi &= \omega_{t-1}^\pi + (1-\rho)(\pi_t - \omega_{t-1}^\pi) \\ \omega_t^y &= \omega_{t-1}^y + (1-\rho)(y_t - \omega_{t-1}^x) \end{aligned}$$

Claim: The rules imply identical dynamics when ZLB ignored, but different under ZLB.

Motivation - GFC Example - *Puzzles Resolved*

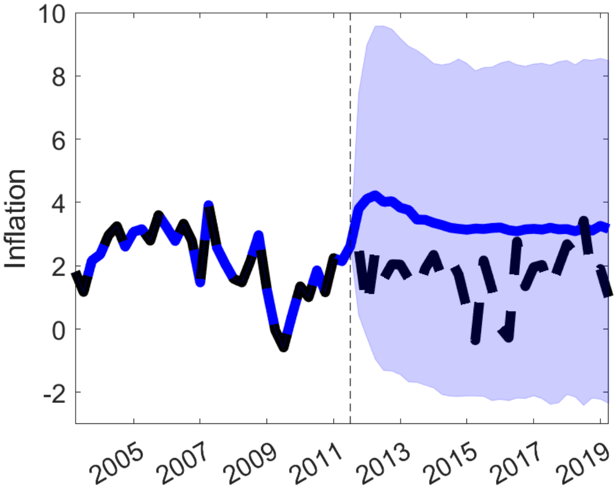


Figure: Smets and Wouters (AER 2007). Posterior draws from original data ending in 2004.

A bit of intuition

The standard model of monetary policy

$$i_t = \max\left\{(1-\rho)\bar{r} + \rho i_{t-1} + (1-\rho)(\phi_\pi \pi_t + \phi_y y_t), 0\right\}.$$

lets bygones be bygones.

- If crazy inflation happened in the last ZLB episode–so what?

Weighted average rules entail history dependence $\implies$ bygones are not bygones.

- Forward-looking agents understand that puzzling inflation dynamics at the ZLB are counteracted retroactively.
- History-dependence mitigates puzzles, and is a feature of optimal commitment at ZLB.

Optimal monetary policy with the ZLB

Claim: Inertial Taylor rules **do not** approximate optimal commitment at the ZLB but a weighted average rule does.

Optimal policy (Eggertsson and Woodford, 2003):

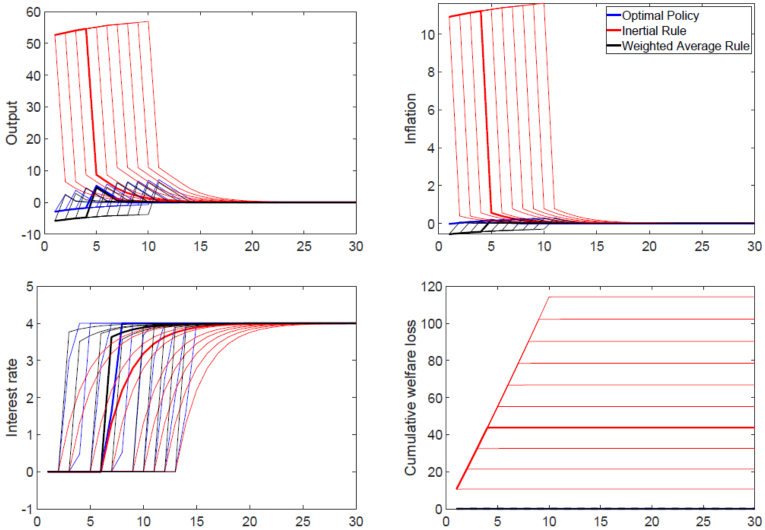
- Target criterion: price level overshoots to compensate for past ZLB misses.
- Implementation: state-contingent forward guidance (lower for longer).

The shock: Unexpectedly switch to $r_t^n = r_S < 0$, transition probability equal to $p < 1$.

- ZLB binds when $r_t^n = r_S$
- Absorbing state: $r_t^n = \bar{r}$.

Comparison: Optimal forward guidance + promised return to either inertial or weighted average rule ($\rho = 0.8$).

Comparing policies at the ZLB



Resolving the puzzles

Approximating optimal commitment with weighted average rule:

$$i_t = \begin{cases} 0 & \text{for } t = T, T+1, ..., T^* \\ \bar{i} + \phi^* \omega_t^\pi & \text{for } t > T^*, \end{cases} \quad (6)$$

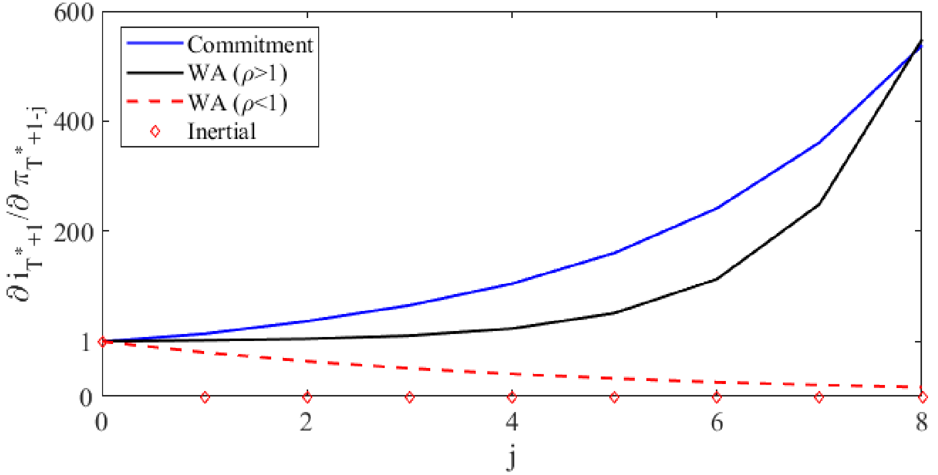
$$\omega_t^\pi = \begin{cases} \rho \omega_{t-1}^\pi + \pi_t & \text{for } t = T, T+1, ..., T^* \\ \rho^* \omega_{t-1}^\pi + \pi_t & \text{for } t > T^*, \end{cases} \quad (7)$$

where $0 < \rho^* \leq 1$, $\rho \geq 0$, $\phi^* > 1$, $\Delta_p \equiv T^* - T$ is duration of ZLB.

- ρ encodes history dependence at the ZLB.
- $\rho > 1$ delivers price level overshooting (not Wicksellian rule).

Claim: the weighted average rule (and the optimal commitment policy) do not exhibit the New Keynesian puzzles.

History dependence and optimal policy



The anatomy of the puzzles

Follow Diba and Loisel (2021) and add shocks to capture more puzzles:

$$
\begin{aligned}
y_t &= E_t y_{t+1} - \sigma^{-1}\left(i_t - E_t \pi_{t+1}\right) + g_t - E_t g_{t+1} \\
\pi_t &= \beta E_t \pi_{t+1} + \kappa\left(y_t - \delta_g g_t - a_t\right)
\end{aligned}
$$

Puzzles: when i_t is pegged for Δ_p periods:

1. Forward Guidance Puzzle: $\lim_{\Delta_p \to +\infty} \frac{\partial z_t}{\partial i_{t+\Delta_p}} = -\infty$ where $z = \pi, y$.
2. Fiscal Multiplier Puzzle: $\lim_{\Delta_p \to +\infty} \frac{\partial z_t}{\partial g_{t+\Delta_p}} = +\infty$ where $z = \pi, y$.
3. Paradox of Toil: $\frac{\partial y_t}{\partial a_{t+\Delta_p}} \leq 0$.
4. Paradox of Flexibility: $\lim_{\kappa \to \infty} \left|\frac{\partial z_t}{\partial v_{t+\Delta_p}}\right| = +\infty$ where $z = \pi, y$, and $v = i, a, g$.

Resolving the puzzles

Proposition

The NK model with monetary policy (6) has a unique equilibrium that

1. *is puzzle free if* $\rho > 1$
   - *Effects of forward/fiscal guidance converge to zero (unlike Wicksellian case:* $\rho = 1$*).*
2. *exhibits the forward guidance and fiscal multiplier puzzles for* $0 \leq \rho < 1$.
3. *decreasing effect of forward guidance shock as* ρ *increases from 0 to 1. Thus, history-dependence mitigates these puzzles.*
4. *does not exhibit paradox of toil if* ρ *is sufficiently large.*
5. *exhibits the paradox of flexibility if and only if* $\rho = 0$.

- Same results obtain numerically for optimal commitment policy.

Conclusion

- NK Puzzles are a result of modeling monetary policy in an ad hoc way.
  - Forward guidance, commitment and history-dependence go hand-in-hand.
- Modeling policy with sufficient history dependence eliminates the NK puzzles.
- Simple implementable rules that (loosely) approximate optimal commitment *at the ZLB* select a unique equilibrium which is puzzle-free.
- No *theoretical* need for myopia, incomplete markets, finite horizons, imperfect common knowledge, fiscal theory of the price level, etc.