Resolving New Keynesian Puzzles

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This research does not reflect views of the Bank of Finland

Motivation I

New Keynesian Puzzles at the Zero Lower Bound (ZLB)

- The effective ZLB is a dominant feature of 21^{st} century macroeconomic outcomes
- Modeling it properly is central to evaluating past policy and designing better policy
- Standard New Keynesian models used throughout academia and policy institutions predict *puzzling* dynamics at the ZLB

Motivation II

Consider forecasting the following policy:

> *... 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 August, 9^{th} 2011*

Motivation III

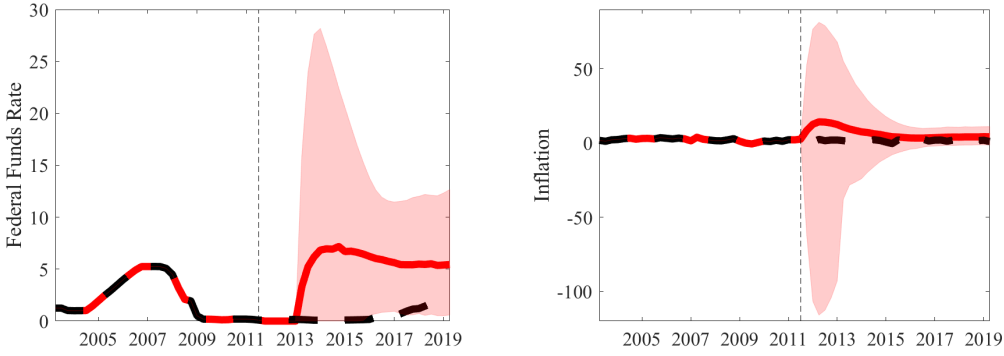

Figure: Smets and Wouters (2007) posterior estimates with data ending in 2004

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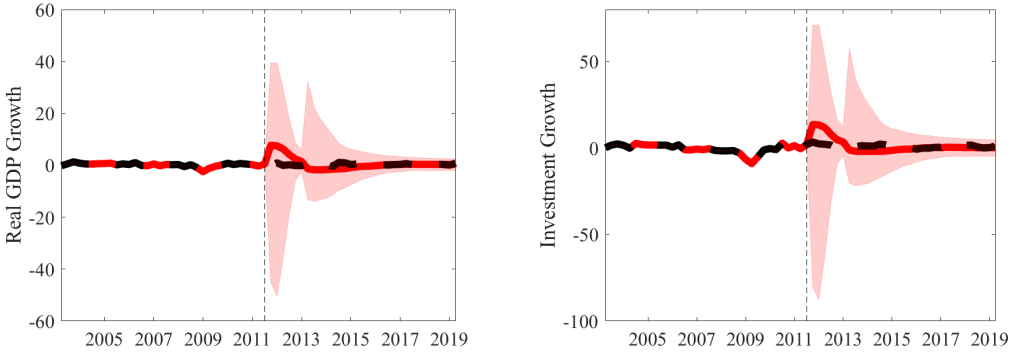

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Literature Review

What's wrong here? Existing literature's answer:

- Forward guidance and even modest ZLB spells are never expected/credible
  - Del Negro, Giannoni, and Patterson (2012, 2023), Haberis, Harrison, and Waldron (2019), Bundick and Smith (2020), Gibbs and McClung (2023)
- Full information rational expectations is implausible
  - Carlstrom, Fuerst, and Pastian (2015), Kiley (2016), Angeletos and Lian (2018), Farhi and Werning (2019), Gabaix (2020)
- The complete market assumption is wrong
  - McKay, Nakamura, and Steinsson (2016, 2017), Bilbiie (2020, 2024)
- Inflation is actually controlled by fiscal policy (Fiscal Theory of the Price Level)
  - Cochrane (2017, 2023)

Modeling Exercise I

How should we model the following policy announcement?

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Modeling Exercise II

Modeling decisions

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   - Stabilize inflation around a target and close the output gap

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   - Credible commitment to zero interest rates for seven quarters

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   - Stabilize inflation around a target and close the output gap
3. Choose an interpretation of the policy statement...
   - Credible commitment to zero interest rates for seven quarters
4. Choose a policy to implement in expectation following the end of the commitment...
   - What does policy do after lift off?

Modeling Exercise III

How do we model lift off policy?

- Do you think the monetary policy objectives are the same after before, during, and after the ZLB?

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  - *My answer:* Yes! Objectives are the same. ZLB is constraint on an instrument and not a policy regime change.

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- All else equal, do you think that interest rates would rise faster after seven quarters if inflation is above target during the ZLB episode?

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  - *My answer:* Yes! Policy rate normalization is faster.

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- All else equal, do you think that interest rates would rise faster after seven quarters if inflation is above target during the ZLB episode?
  - *My answer:* Yes! Policy rate normalization is faster.

Implication: Yes to both means standard Taylor rules are not appropriate summaries of policy

Modeling Exercise IV

Standard modeling assumptions

- The standard way to close an NK Model

$$i_t = (1-\rho_i)\bar{r} + \rho i_{t-1} + (1-\rho)(\phi_\pi \pi_t + \phi_x x_t), \tag{1}$$

- The standard way to add the ZLB

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

Modeling Exercise IV

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$$i_t = (1-\rho_i)\bar{r} + \rho i_{t-1} + (1-\rho)(\phi_\pi \pi_t + \phi_x x_t), \tag{3}$$

- The standard way to add the ZLB

$$i_t = \max\left\{(1-\rho_i)\bar{r} + \rho i_{t-1} + (1-\rho)(\phi_\pi \pi_t + \phi_x x_t), 0\right\}. \tag{4}$$

Policy objectives the same?

Modeling Exercise IV

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Policy is history dependent?

Resolving New Keynesian Puzzles I

Note the following equivalent representations:

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

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

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

Resolving New Keynesian Puzzles II

History dependence at the ZLB

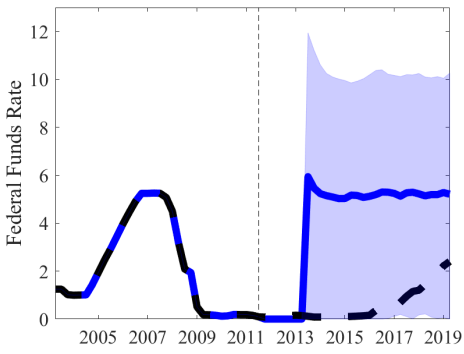
- At the ZLB the central bank ignores everything that occurred

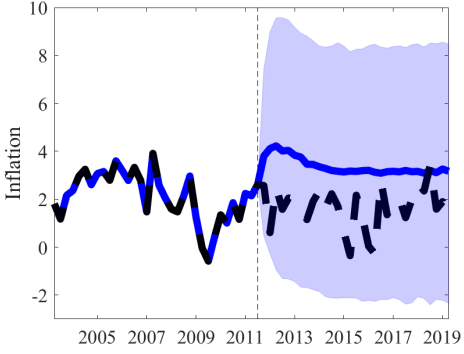
$$i_t = \max\{(1-\rho_i)\bar{r} + \rho i_{t-1} + (1-\rho)(\phi_\pi \pi_t + \phi_x x_t), 0\}$$

- Central bank and private sector can keep track of objectives even when $i_t = 0$

$$\begin{aligned} i_t &= \max\{\bar{r} + \phi_\pi \omega_t^\pi + \phi_x \omega_t^x, 0\} \\ \omega_t^\pi &= \omega_{t-1}^\pi + (1-\rho)(\pi_t - \omega_{t-1}^\pi) \\ \omega_t^x &= \omega_{t-1}^x + (1-\rho)(x_t - \omega_{t-1}^x) \end{aligned}$$

Resolving New Keynesian Puzzles III





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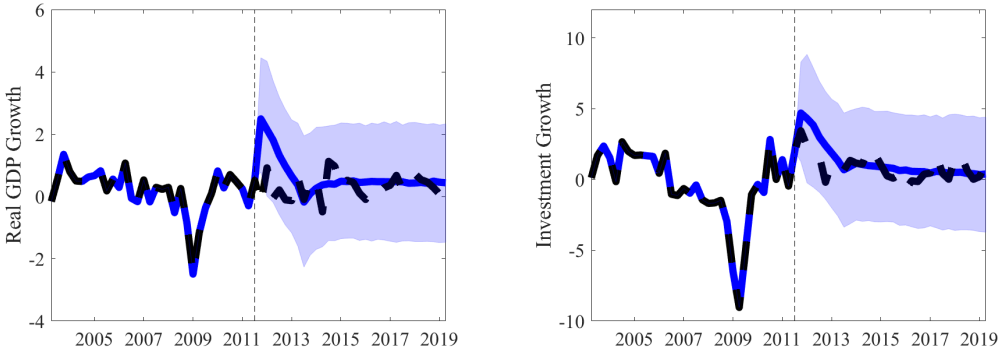

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What's wrong with a Taylor rule?

Svensson (JEL 2003) pg. 429 - 420

> *"Monetary policy by the world's more advanced central banks these days is at least as optimizing and forward-looking as the behavior of the most rational private agents. I find it strange that a large part of the literature on monetary policy still prefers to represent central bank behavior with the help of mechanical instrument rules."*

Implication: Study target criteria instead...

Optimal monetary policy I

Solve for optimal commitment from the timeless perspective:

$$\min \left\{ -\frac{1}{2}\mathbb{E}_t \sum_{T=t}^{\infty} \left(\pi_T^2 + \alpha x_T^2\right) \right\}$$

Subject to

$$\begin{aligned} x_t &= \mathbb{E}_t x_{t+1} - \frac{1}{\sigma}(i_t - \mathbb{E}_t \pi_{t+1} - r_t^n) \\ \pi_t &= \beta \mathbb{E}_t \pi_{t+1} + \kappa x_t + \mu_t \end{aligned}$$

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

$$x_t - \beta x_{t-1} = -\frac{\kappa}{\alpha}\pi_t$$

Optimal monetary policy II

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

Proposition

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

$$\textit{Optimal Rule 1}: \quad i_t = \beta i_{t-1} + \frac{\kappa}{\sigma\alpha}\pi_t + (1-\beta L)\left(\frac{1}{\sigma}E_t y_{t+1} + E_t\pi_{t+1} + r_t^n\right) \tag{7}$$

$$\textit{Optimal Rule 2}: \quad \begin{aligned} i_t &= \tfrac{\kappa}{\sigma\alpha(1-\beta)}\omega_t^\pi + \tfrac{1}{\sigma}E_t y_{t+1} + E_t\pi_{t+1} + r_t^n \\ \omega_t^\pi &= \omega_{t-1}^\pi + (1-\beta)(\pi_t - \omega_{t-1}^\pi) \end{aligned} \tag{8}$$

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Implication: We can approximate optimal policy in the absence of the ZLB with an inertial rule or a weighted average inflation rule.

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Implication: A weighted average inflation rule better approximates optimal policy with demand shocks

Flexible Average Inflation Targeting

Resolving puzzles:

- Weighted average rules with appropriate forward guidance approximate optimal commitment policy with ZLB constraint Here
  - Optimal commitment policy of Eggertsson and Woodford (2003) is puzzle free!

    $\Rightarrow$ **forward guidance still too powerful!**
- Weighted average rules resolve quantitative aspects of the other puzzle (flexibility, fiscal multiplier, and toil) Here
- To resolve all New Keynesian puzzles monetary policy must promise to more than make up for past misses (consistent with optimal commitment) Here
- We don't need bounded rationality, incomplete markets, imperfect credibility, the fiscal theory, or any other fix for New Keynesian puzzles

Conclusion

- Provide an explanation and resolution of the New Keynesian ZLB puzzles (forward guidance, paradox of flexiblity, paradox of toil, ect.)
- Explanation and resolution does not rely on
  - Bounded rationality or myopia
  - Incomplete markets or HANK considerations
  - Imperfect credibility
  - Any change whatsoever to micro-foundations of the NK model
- Demonstrate that study of **target criteria** reveals both the explanation and the resolution
- Four keys to the results:
  1. Explicitly specifying **monetary policy objectives in expectation** is the source of the puzzle
  2. Explicitly specifying that **monetary policy objectives remain the same** before, during, and after the ZLB resolves the puzzles
  3. **FAIT** can explicitly convey monetary policy objectives before, during and after ZLB episodes
  4. Even in the absence of NK puzzles policy is still too powerful

FAIT and optimal policy I

Solve for optimal commitment from the timeless perspective:

$$\min \left\{ -\frac{1}{2}\mathbb{E}_t \sum_{T=t}^{\infty} \beta^{T-t} \left(\pi_t^2 + \alpha x_t^2\right) \right\}$$

Subject to

$$\begin{aligned} x_t &= \mathbb{E}_t x_{t+1} - \frac{1}{\sigma}(i_t - \mathbb{E}_t \pi_{t+1} - r_t^n) \\ \pi_t &= \beta \mathbb{E}_t \pi_{t+1} + \kappa x_t \\ i_t &\geq 0 \end{aligned}$$

FAIT and optimal policy II

Eggertsson and Woodford (2003)

Before the shock: REE equilibrium with $x_t = \pi_t = 0, i_t = r_t^n = r_H$

The shock: Unexpectedly switch to $r_t^n = r_L < 0$

- Two-state Markov structure

$$D = \begin{pmatrix} 1-\delta & \delta \\ 0 & 1 \end{pmatrix}$$

- Low state (L) persists with prob. $1 - \delta$; high state (H) absorbing
- In the low state $i_t = 0$ always: ZLB constraint

FAIT and optimal policy III

Optimal policy

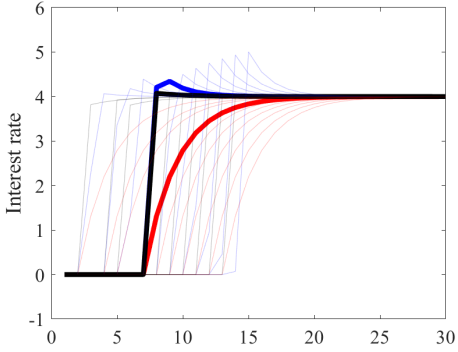
- The realized period of the shock is indexed by τ
- For each τ the central bank promises k_τ periods of forward guidance
- Forward guidance policy:

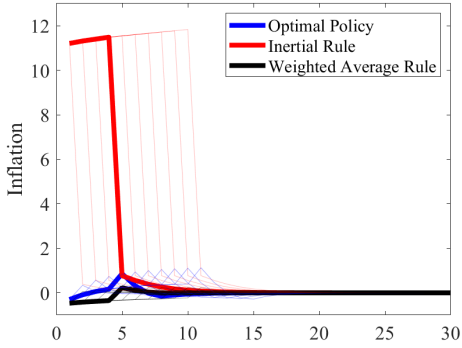
$$k_\tau = \{0, 1, 2, 2, 2, 3, 3, 4, ...\}$$

- Duration of the ZLB for any realization of uncertainty

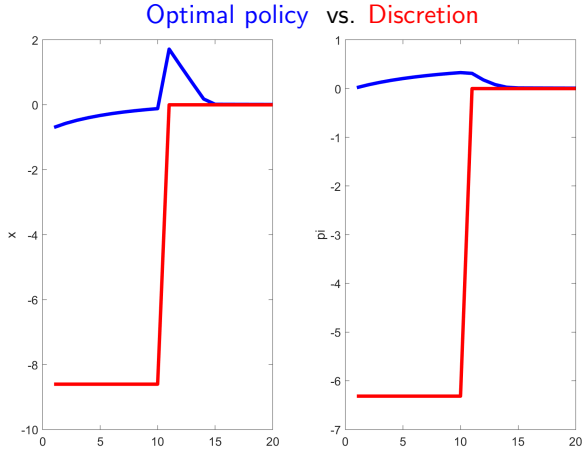
$$T_{zlb} = \tau + k_\tau$$

FAIT and optimal policy IV





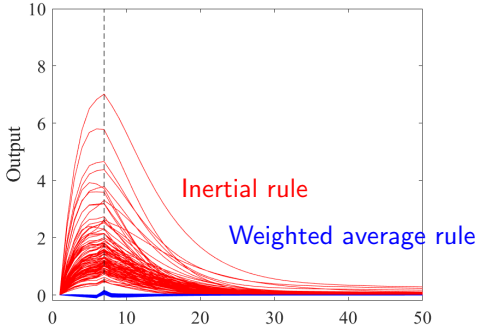
FAIT and optimal policy V



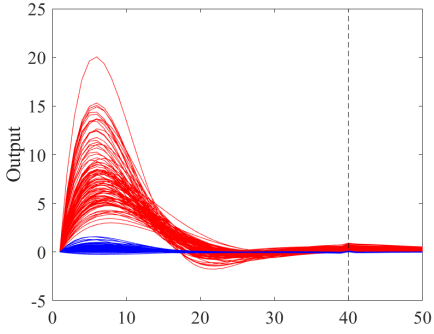
Policy is still too powerful! Back

Other puzzles I

Paradox of toil: anticipated negative productivity shock



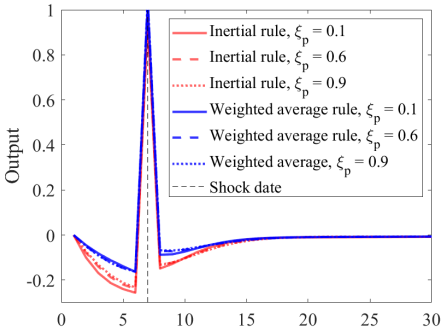
7 quarters



40 quarters

Other puzzles II

Fiscal multiplier puzzle and paradox of flexibility: anticipated gov. spending shock



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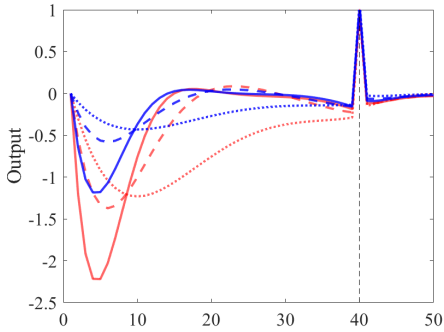

40 quarters

Back

Resolving limit puzzles I

Study anticipated interest rate, government spending, and productivity shocks:

$$y_t = E_t y_{t+1} - \sigma^{-1}\left(i_t - E_t \pi_{t+1} - r_t^n\right) + g_t - E_t g_{t+1} \tag{13}$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa\left(y_t - \delta_g g_t - a_t\right). \tag{14}$$

$$i_t = \begin{cases} \bar{i}_t + \phi \pi_t & \text{for } t = T, T+1, ..., T^* \\ \bar{i}_t + \phi^* \omega_t & \text{for } t > T^*, \end{cases} \tag{15}$$

$$\omega_t = \begin{cases} \rho \omega_{t-1} + \pi_t & \text{for } t = T, T+1, ..., T^* \\ \rho^* \omega_{t-1} + \pi_t & \text{for } t > T^*. \end{cases} \tag{16}$$

Resolving limit puzzles II

Definition 1 (forward guidance puzzle) *When the policy rate is expected to be set passively during the next $\Delta_p > 0$ periods, the response of current inflation and output to an expected policy-rate shock Δ_p periods ahead, $\bar{i}_{t+\Delta_p}$, goes to plus or minus infinity with Δ_p, i.e.,*

$$\lim_{\Delta_p \to +\infty} |\partial z_T / \partial \bar{i}_{T+\Delta_p}| = \infty \text{ where } z \in \{\pi, y\}.$$

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Proposition (Forward Guidance Puzzle)

The NK model with monetary policy given by equations (13), (14), (15) , and (16) with $\phi^* > 1$, $0 \leq \phi < 1$, and $0 < \rho^* < 1$ exhibits the forward guidance puzzle if $\rho < 1$. The forward guidance puzzle is resolved if $\rho > 1$.

Resolving limit puzzles III

Corollary (Resolution of the Quantitative Puzzles)

When $0 < \rho < 1$ *and* $\Delta_p > 0$,

$$\frac{\partial}{\partial \rho}\left(\left|\frac{\partial z_T}{\partial \bar{i}_{T+\Delta_p}}\right|\right) < 0.$$

- This explains why puzzles mitigated in estiamted model

Resolving limit puzzles IV

Definition 2 (fiscal multiplier puzzle) *When the policy rate is expected to be set passively during the next $\Delta_p > 0$ periods, the response of current inflation and output to an expected expansionary government spending shock Δ_p periods ahead, $g_{T+\Delta_p} > 0$, goes to plus or minus infinity with Δ_p, i.e.,*

$$\lim_{\Delta_p \to +\infty} |\partial z_T / \partial g_{T+\Delta_p}| = \infty \text{ where } z \in \{\pi, y\}.$$

Resolving limit puzzles IV

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$$\lim_{\Delta_p \to +\infty} |\partial z_T / \partial g_{T+\Delta_p}| = \infty \text{ where } z \in \{\pi, y\}.$$

Proposition (Fiscal Multiplier Puzzle)

The NK model with monetary policy given by equations (13), (14), (15) , and (16) with $\phi^* > 1$, $0 \leq \phi < 1$, $0 < \rho^* < 1$, and $\rho \neq \bar{\rho} < 1$ exhibits the fiscal multiplier puzzle if $\rho < 1$. The fiscal multiplier puzzle is resolved if $\rho > 1$.

Resolving limit puzzles V

Definition 3 (paradox of toil) *When the policy rate is expected to be set passively during the next $\Delta_p > 0$ periods, the response of current output to a positive supply shock Δ_p periods ahead, $a_{T+\Delta_p} > 0$, is weakly contractionary with Δ_p, i.e.,*

$$\partial y_T / \partial a_{T+\Delta_p} \leq 0.$$

Resolving limit puzzles V

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Proposition (The Paradox of Toil)

The NK model with monetary policy given by equations (13), (14), (15) , and (16) with $\phi^* > 1$, $0 \leq \phi < 1$, and $0 < \rho^* < 1$ has the property that there exists a $\tilde{\rho}$ such that if $\rho < \tilde{\rho}$, then equilibrium exhibits the paradox of toil, and if $\rho > \tilde{\rho}$, the paradox of toil is resolved.

Resolving limit puzzles VI

Definition 4 (paradox of flexibility) *When the policy rate is expected to be set passively during the next $\Delta_p > 0$ periods, the response of current inflation and output to an expected shock Δ_p periods ahead goes to plus or minus infinity as κ goes to infinity, i.e.,*

$$\lim_{\kappa \to +\infty} |\partial z_T / \partial v_{T+\Delta_p}| = \infty \text{ where } z \in \{\pi, y\} \text{ and } v = \{i^*, g, a\}.$$

Resolving limit puzzles VI

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$$\lim_{\kappa \to +\infty} |\partial z_T / \partial v_{T+\Delta_p}| = \infty \text{ where } z \in \{\pi, y\} \text{ and } v = \{i^*, g, a\}.$$

Proposition (Paradox of Flexibility)

The NK model with monetary policy given by equations (13), (14), (15) , and (16) with $\phi^* > 1$, $0 \leq \phi < 1$, and $0 < \rho^* < 1$ does not exhibit the paradox of flexibility if $\rho > 0$.

Back