Optimal Monetary and Fiscal Policy at the ZLB in a Small Open Economy

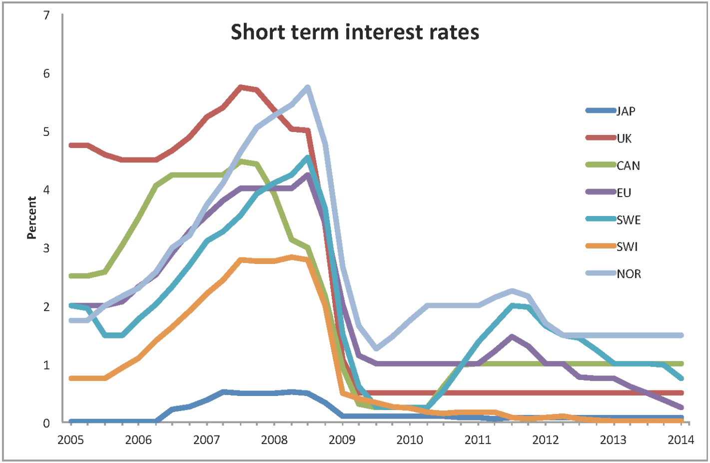
Saroj Bhattarai Konstantin Egorov

Pennsylvania State University

Norges Bank/HEC Montreal Workshop
on
New Developments in Business Cycle Analysis
June 20, 2014

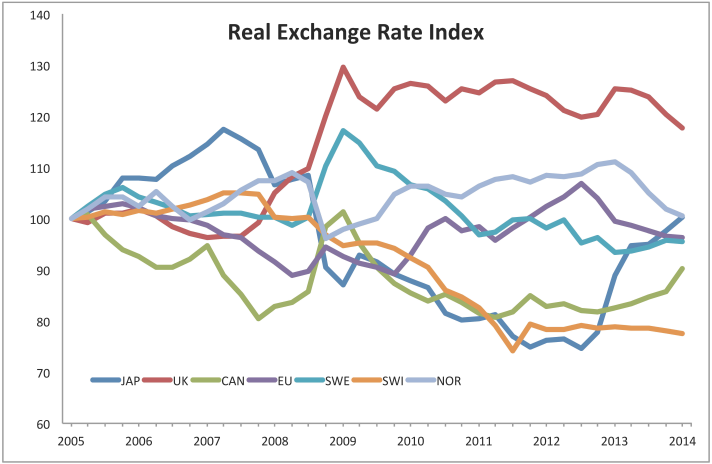
Motivation-Data

- ZLB a concern recently for several SOEs



Motivation-Data

- Real exchange rate appreciation



Motivation-Theory

- Large recent literature on policy implications of hitting the ZLB
  - Negative output gap and deflation; govt spending powerful; credibility problem of optimal commitment policy severe
- This literature typically discards the open-economy aspect
- Allow for non-trivial open-economy aspects in a SOE model
  - No restrictive parameterization (log utility and unit trade elasticity)
  - Do not shut down the terms of trade externality (no balanced trade)
  - Open economy problem no longer "isomorphic" to the closed economy

Research Questions

- How does trade elasticity affect outcomes at the ZLB?
- Comparison of optimal policy under commitment and discretion
  - What is the role played by (real) exchange rate dynamics in ZLB?
  - In addition to the "deflationary bias" of discretionary policy at the ZLB, what new "bias" emerges in an open economy?
- Joint consideration of optimal monetary and fiscal policy
  - What is the role for govt spending at the ZLB?
  - How does trade elasticity affect the extent of increase in govt spending?

Households

- Two-country model with a limiting case of a "small open economy"
  - Foreign variables exogenous
- Representative household at home maximizes

$$E_t \sum_{s=0}^{\infty} \beta^s \left[u\left(C_{t+s}, \xi_{t+s}\right) - \int_0^1 v\left(h_{t+s}(i), \xi_{t+s}\right) di \right]$$

- Consumption good is an aggregate of home and foreign goods

$$C_t = \left[(1-\alpha)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \ P_t = \left[(1-\alpha) P_{H,t}^{1-\eta} + \alpha P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}}$$

- $C_{H,t}$ and $C_{F,t}$ in turn aggregates of a continuum of varieties with an elasticity of substitution ε
- Perfect international risk-sharing

Firms

- Continuum of firms produce differentiated varieties

$$y_t(i) = f(h_t(i), \xi_t)$$

- Dynamic price-setting problem due to adjustment costs $d\left(\frac{p_{H,t}(i)}{p_{H,t-1}(i)}\right)$
- The firm maximizes (steady-state production subsidy $(1+s)$)

$$E_t \sum_{s=0}^{\infty} \rho_{t,t+s} Z_{t+s}(i)$$

$$Z_t(i) = \left[(1+s)\, p_{H,t}(i) y_t(i) - n_t(i) h_t(i) - d\left(\frac{p_{H,t}(i)}{p_{H,t-1}(i)}\right) P_{H,t}\right]$$

- Focus on a symmetric equilibrium

International Pricing

- No price discrimination

$$p_{H,t}(i) = S_t p^*_{H,t}(i), \quad p_{F,t}(i) = S_t p^*_{F,t}(i)$$

where S_t is the nominal exchange rate

- PPP does not hold because of "home bias"
- Definitions of the real exchange rate (Q_t) and the terms of trade (ς_t)

$$Q_t = \frac{S_t P^*_t}{P_t}, \; \varsigma_t = \frac{P_{F,t}}{P_{H,t}}$$

- Re-write

$$r(\varsigma_t) = \frac{P_t}{P_{H,t}}, \; Q_t = \frac{\varsigma_t}{r(\varsigma_t)} = q(\varsigma_t)$$

Private Sector Equilibrium

- Asset-pricing condition

$$\frac{1}{1+i_t} = E_t\left[\beta \frac{u_C\left(C_{t+1},\xi_{t+1}\right)}{u_C\left(C_t,\xi_t\right)}\Pi_{t+1}^{-1}\right];\ i_t \geq 0$$

- Optimal pricing equation

$$\varepsilon Y_t\left[\frac{\varepsilon-1}{\varepsilon}(1+s)\,u_C\left(C_t,\xi_t\right)-\tilde{v}_y\left(Y_t,\xi_t\right)r(\varsigma_t)\right]+u_C\left(C_t,\xi_t\right)d'\left(\Pi_{H,t}\right)\Pi_{H,t}$$
$$= \quad E_t\left[\beta u_C\left(C_{t+1},\xi_{t+1}\right)\frac{r(\varsigma_t)}{r(\varsigma_{t+1})}d'\left(\Pi_{H,t+1}\right)\Pi_{H,t+1}\right]$$

- International risk-sharing

$$q(\varsigma_t) = \frac{u_C\left(C_t^*,\xi_t^*\right)}{u_C\left(C_t,\xi_t\right)}$$

- Accounting

$$\frac{\Pi_t}{\Pi_{H,t}} = \frac{r(\varsigma_t)}{r(\varsigma_{t-1})}$$

Government and Market Clearing

- Government budget constraint (lump-sum taxes)

$$B_t = (1 + i_{t-1}) B_{t-1} - P_t T_t$$

- Resource constraint and net exports

$$Y_t = (1 - \alpha) r(\varsigma_t)^\eta C_t + \alpha \varsigma_t^\eta C_t^* + d(\Pi_{H,t})$$

$$NX_t = \frac{(Y_t P_{H,t} - C_t P_t)}{P_{H,t}} = (Y_t - C_t r(\varsigma_t))$$

Efficient Equilibrium (First-best)

- The SOE planner maximizes

$$u\left(C_t,\xi_t\right)-\tilde{v}\left(Y_t,\xi_t\right)$$

st

$$Y_t=\left(1-\alpha\right)r(\varsigma_t)^{\eta}C_t+\alpha\varsigma_t^{\eta}C_t^*$$

$$q(\varsigma_t)=\frac{u_C\left(C_t^*,\xi_t^*\right)}{u_C\left(C_t,\xi_t\right)}$$

- Solution can be characterized in closed-form
  - Important benchmark for later as we express "gaps" as deviations from the efficient equilibrium

Commitment Equilibrium (Ramsey)

- The central bank maximizes

$$E_t \sum_{s=0}^{\infty} \beta^s u\left(C_{t+s}, \xi_{t+s}\right) - \tilde{v}\left(Y_{t+s}, \xi_{t+s}\right)$$

st

$$\begin{aligned}
& \varepsilon Y_t \left[\frac{\varepsilon - 1}{\varepsilon}(1+s)\, u_C\left(C_t, \xi_t\right) - \tilde{v}_y\left(Y_t, \xi_t\right) r(\varsigma_t)\right] \\
= \;& \beta r(\varsigma_t) E_t \left[u_C\left(C_{t+1}, \xi_{t+1}\right) d'\left(\Pi_{H,t+1}\right) \frac{\Pi_{H,t+1}}{r(\varsigma_{t+1})}\right] - u_C\left(C_t, \xi_t\right) d'\left(\Pi_{H,t}\right) \Pi_{H,t} \\
\frac{1}{1+i_t} = \;& E_t \left[\beta \frac{u_C\left(C_{t+1}, \xi_{t+1}\right)}{u_C\left(C_t, \xi_t\right)} \Pi_{t+1}^{-1}\right]; \;\; i_t \geq 0 \\
Y_t = \;& (1-\alpha)\, r(\varsigma_t)^{\eta} C_t + \alpha \varsigma_t^{\eta} C_t^* + d\left(\Pi_{H,t}\right) \\
q(\varsigma_t) = \;& \frac{u_C\left(C_t^*, \xi_t^*\right)}{u_C\left(C_t, \xi_t\right)}
\end{aligned}$$

- Dynamic time-inconsistency due to forward-looking variables

Discretion Equilibrium (Markov)

- The central bank maximizes

$$u\left(C_t, \xi_t\right) - \tilde{v}\left(Y_t, \xi_t\right)$$

st

$$\begin{aligned}
& \varepsilon Y_t \left[\frac{\varepsilon - 1}{\varepsilon}\left(1+s\right) u_C\left(C_t, \xi_t\right) - \tilde{v}_y\left(Y_t, \xi_t\right) r(\varsigma_t)\right] \\
= \; & \beta r(\varsigma_t) E_t\left[u_C\left(C_{t+1}, \xi_{t+1}\right) d'\left(\Pi_{H,t+1}\right) \frac{\Pi_{H,t+1}}{r(\varsigma_{t+1})}\right] - u_C\left(C_t, \xi_t\right) d'\left(\Pi_{H,t}\right) \Pi_{H,t} \\
\frac{1}{1+i_t} = \; & E_t\left[\beta \frac{u_C\left(C_{t+1}, \xi_{t+1}\right)}{u_C\left(C_t, \xi_t\right)} \Pi_{t+1}^{-1}\right]; \;\; i_t \geq 0 \\
Y_t = \; & \left(1-\alpha\right) r(\varsigma_t)^\eta C_t + \alpha \varsigma_t^\eta C_t^* + d\left(\Pi_{H,t}\right) \\
q(\varsigma_t) = \; & \frac{u_C\left(C_t^*, \xi_t^*\right)}{u_C\left(C_t, \xi_t\right)}
\end{aligned}$$

- Period-by-period problem and take expectations as given

Functional Forms

- Period-utility

$$u\left(C,\xi\right)=\xi^{C}\frac{C^{1-\sigma}}{1-\sigma},\ \ v\left(h(i),\xi\right)=\lambda\xi^{C}\frac{h(i)^{1+\phi}}{1+\phi}$$

- Production function

$$y(i)=\xi^{P}h(i)^{\kappa}$$

- Price-adjustment cost

$$d(\Pi_H)=d_1\left(\Pi_H-1\right)^2$$

- Shocks

$$\begin{aligned}\xi_t^P &= \rho\xi_{t-1}^P+\varepsilon_t^P\\ \xi_t^C &= \rho\xi_{t-1}^C+\varepsilon_t^C\end{aligned}$$

Steady-State and Subsidy

- We consider a non-stochastic steady-state
  - Linearize around this steady-state to analyze dynamic responses to shocks
- Allow an appropriate production subsidy such that the First-best, Ramsey, and Markov steady-states coincide
  - Convenient choice to compare various equilibria
- In this (symmetric) steady-state
  - $\Pi_H = \Pi = \varsigma = 1$, $(1+i)^{-1} = \beta$, $C = C^* = Y = 1$, and $\xi = 1$

Steady-State and Subsidy

Theorem

The following production subsidy ensures that the First-best, Ramsey, and the Markov steady-states coincide

$$1 + s = \left[\left(1 - (1-\alpha)^2\right)\eta\sigma + (1-\alpha)^2\right]^{-1}(1-\alpha)\left(\frac{\varepsilon}{\varepsilon - 1}\right).$$

- Previous literature
  - Closed-economy ($\alpha = 0$); Gali and Monacelli (2005) ($\eta = \sigma = 1$)
  - Farhi and Werning (2012)
- Accounts for both "internal" and "external" distortions
  - The weight on the terms of trade externality depends on openness
  - Higher η and σ lead to terms of trade appreciation motive
  - Subsidy is higher than $(1-\alpha)\frac{\varepsilon}{\varepsilon-1}$ when $\eta\sigma < 1$

Private Sector Equilibrium

- Linearized PSE ("canonical" representation)

$$\hat{x}_t = E_t \hat{x_{t+1}} - \frac{(1-\alpha)}{\sigma}\hat{r}_t^{gap} + \left(\frac{2-\alpha}{1-\alpha}\right)\eta\alpha\left(\hat{q}_t^{gap} - E_t\hat{q}_{t+1}^{gap}\right)$$

$$\hat{\imath}_t \geq \beta^{-1} - 1$$

$$\hat{\pi}_{H,t} = \beta E_t \hat{\pi}_{H,t+1} + \Psi_1 \hat{x}_t + \Psi_2 \hat{q}_t^{gap} + \Psi_3 \hat{\xi}_t^P$$

$$\hat{x}_t = \left[\left(\frac{2-\alpha}{1-\alpha}\right)\eta\alpha + \left(\frac{1}{1-\alpha}\right)\frac{1}{\sigma}\right]\hat{q}_t^{gap}$$

$$\hat{\pi}_t = \hat{\pi}_{H,t} + \frac{\alpha}{1-\alpha}\left(\hat{q}_t^{gap} - \hat{q}_{t-1}^{gap}\right) + \Psi_4\left(\hat{\xi}_t^P - \hat{\xi}_{t-1}^P\right)$$

where $\Psi_3 = 0$ under $\sigma = \eta = 1$.

Optimal Targeting Rule-Commitment

Theorem

The targeting rule under commitment takes the form of a time-varying price level target where the central bank chooses i_t to achieve

$$p^*_{H,t} = p_{H,t} + \frac{\tilde{\lambda}}{\tilde{\kappa}}\tilde{x}_t$$

if possible. Otherwise, it sets $i_t = 0$. The target for next period is determined as

$$p^*_{H,t+1} = p^*_{H,t} + \frac{1+\tilde{\kappa}\tilde{\sigma}}{\tilde{\beta}}\left(p^*_{H,t} - p_{H,t} - \frac{\tilde{\lambda}}{\tilde{\kappa}}x_t\right) - \frac{1}{\tilde{\beta}}\left(p^*_{H,t-1} - p_{H,t-1} - \frac{\tilde{\lambda}}{\tilde{\kappa}}x_{t-1}\right).$$

Here,

$$\begin{aligned} \tilde{x}_t &= \Phi_1 \hat{x}_t + \Phi_2 \hat{q}_t^{gap} + \Phi_3 \hat{\xi}_t^P \\ \hat{x}_t &= \left[\left(\frac{2-\alpha}{1-\alpha}\right)\eta\alpha + \left(\frac{1}{1-\alpha}\right)\frac{1}{\sigma}\right]\hat{q}_t^{gap} \end{aligned}$$

where $\Phi_3 = 0$ under $\sigma = \eta = 1$.

Optimal Targeting Rule-Discretion

Theorem

The targeting rule under discretion takes the form of an inflation target where the central bank chooses i_t to achieve

$$\hat{\pi}^*_{H,t} = \hat{\pi}_{H,t} + \frac{\tilde{\lambda}}{\tilde{\kappa}}\tilde{x}_t = 0$$

if possible. Otherwise, it sets $i_t = 0$. Here,

$$\begin{aligned} \tilde{x}_t &= \Phi_1 \hat{x}_t + \Phi_2 \hat{q}_t^{gap} + \Phi_3 \hat{\xi}_t^P \\ \hat{x}_t &= \left[\left(\frac{2-\alpha}{1-\alpha} \right) \eta\alpha + \left(\frac{1}{1-\alpha} \right) \frac{1}{\sigma} \right] \hat{q}_t^{gap} \end{aligned}$$

where $\Phi_3 = 0$ under $\sigma = \eta = 1$.

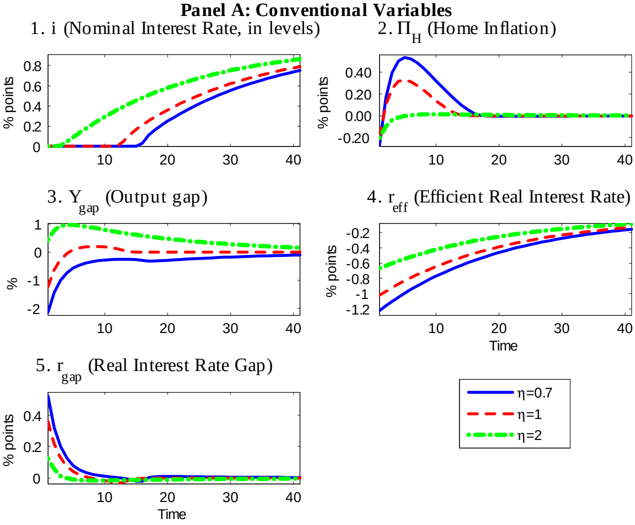
Calibration

- Standard calibration (Faia and Monacelli (2008))

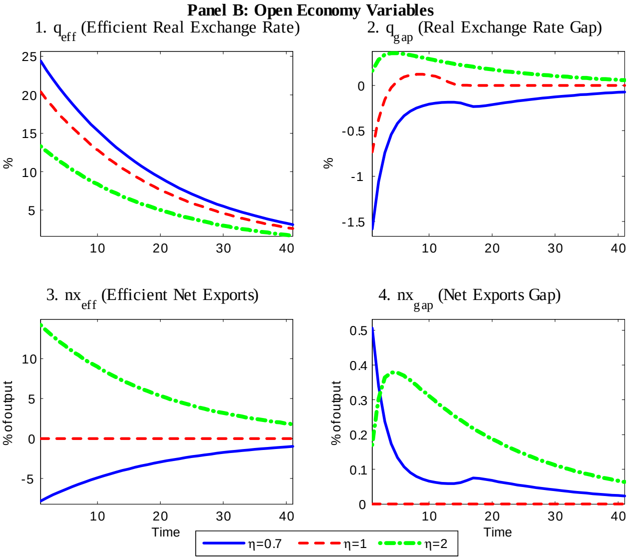
Parameter	Value	Parameter	Value
β	0.99	η	0.7, 1, 2
σ	1	κ	1
α	0.4	d_1	75/2
ϕ	3	ε	7.5

- Deterministic simulation where a large one-time unexpected shock ($\rho = 0.95$) makes the ZLB bind
  - Piece-wise linear algorithm with guess-and-verify for duration of ZLB
  - Follow Jung, Teranishi, and Watanabe (2005)

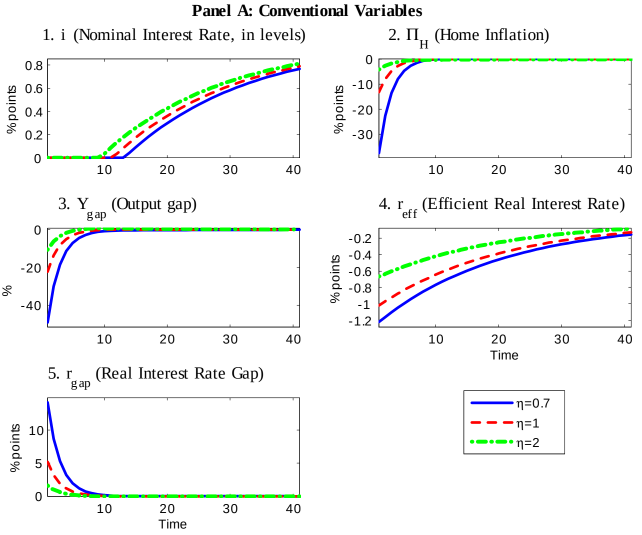
Commitment-Role of Trade Elasticity



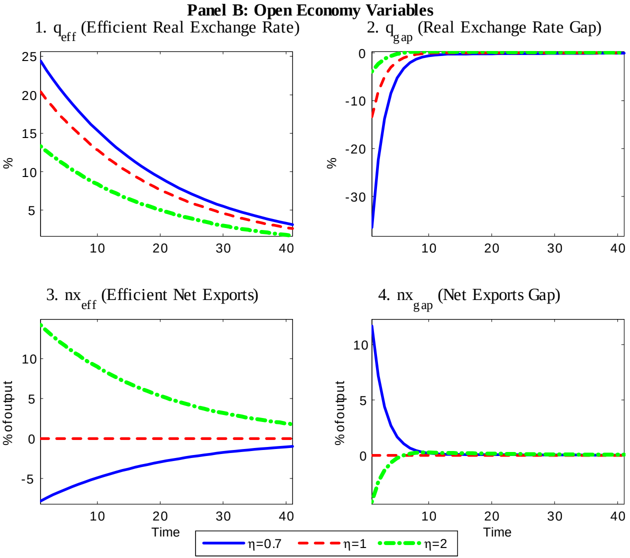
Commitment-Role of Trade Elasticity



Discretion-Role of Trade Elasticity

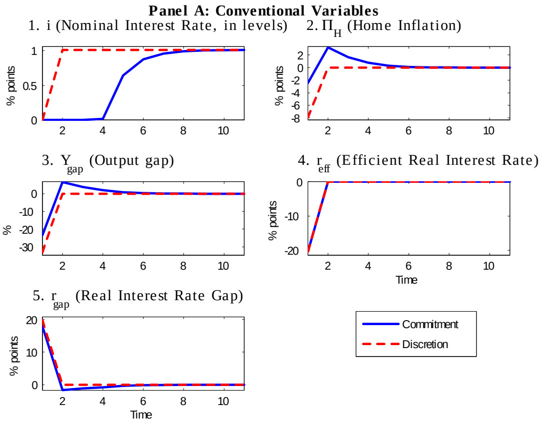


Discretion-Role of Trade Elasticity



Commitment vs. Discretion

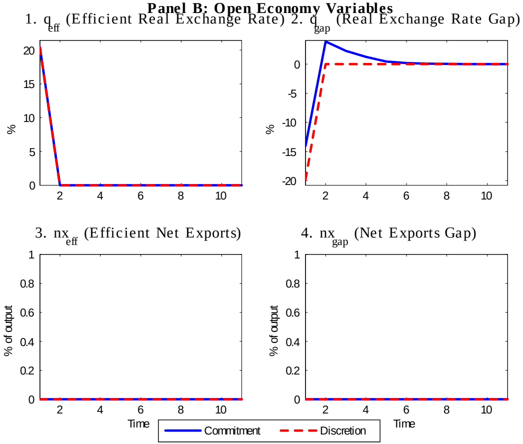
- $\eta = 1$ and iid shock (lack of history dependence)



- Usual "deflation bias" of discretionary policy

Commitment vs. Discretion

- $\eta = 1$ and iid shock



- New "overvaluation bias" of discretionary policy

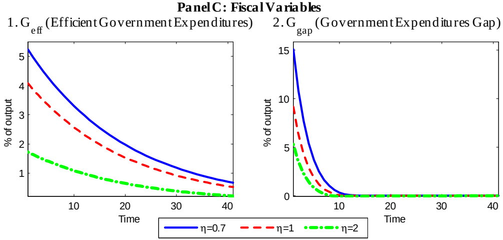
Optimal Monetary and Fiscal Policy

- Discretion outcomes worse but commitment policy is time-inconsistent
  - Allow for optimal govt spending under discretion
- Govt spending yields utility
  - $u\left(C_{t+s}, \xi_{t+s}\right) - \int_0^1 v\left(h_{t+s}(i), \xi_{t+s}\right) di + g\left(G_{t+s}, \xi_{t+s}\right)$
- Govt spending an aggregate of the two goods
  - $G_t = \left[(1-\alpha)^{\frac{1}{\eta}} G_{H,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} G_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$
- Main mechanism

$$\hat{r}_t = -\Theta_y\left[\hat{Y}_t - E_t \widehat{Y_{t+1}}\right] + \Theta_G\left[\hat{G}_t - E_t \widehat{G_{t+1}}\right]$$

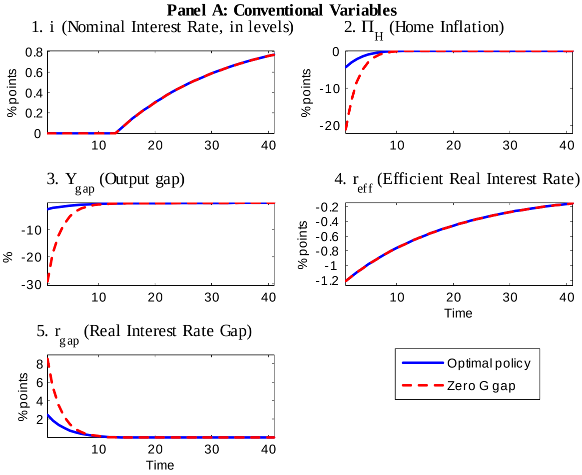
Optimal Monetary and Fiscal Policy-Discretion

- Countercyclical govt spending (level depends on η)

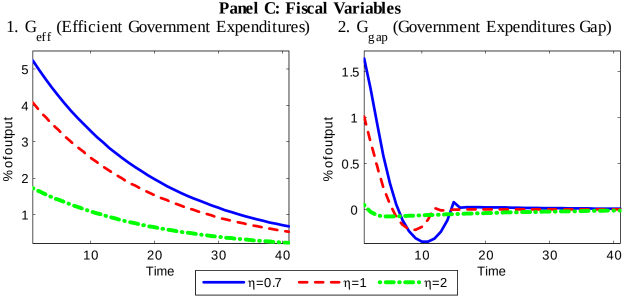


Optimal Monetary and Fiscal Policy-Discretion

- Comparison with setting govt spending equal to efficient level ($\eta = 0.7$)



Optimal Monetary and Fiscal Policy-Commitment



Conclusion

- ZLB leads to an appreciated real exchange rate
- Negative outcomes are more severe with lower trade elasticity
- Discretionary policy suffers from an "overvaluation" bias
- Countercyclical govt spending is optimal fiscal policy response
  - The increase in govt spending is lower with higher trade elasticity

Related Literature

- Optimal targeting rule under commitment in ZLB
  - Eggertsson and Woodford (2003) (price level target)
- Comparison of commitment with discretion in ZLB
  - Eggertsson (2006) (deflation bias)
- Optimal monetary and fiscal policy in ZLB
  - Eggertsson (2001) and Werning (2011)
- Optimal monetary policy in a small open economy without ZLB
  - Gali and Monacelli (2003) (restrictive parameterization)
  - Faia and Monacelli (2008) and De Paoli (2009) (generalization)
- Optimal monetary policy in a small open economy in ZLB
  - Svensson (2002) (without welfare-theoretic loss function)

Future work

- Law of one price deviation in traded goods
- Departure from perfect risk-sharing across countries
- Could fixed exchange rates be optimal under discretion?
- Optimal choice of composition of govt spending?