Optimal monetary policy in the open economy with labor market frictions

Cholwoo Kim

University of Warwick

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Motivation

- In a frictionless closed economy, optimal monetary policy follows the **Friedman rule** (1969): set nominal interest rate to zero.
- But in reality, deviations from the Friedman rule arise because of frictions and international interactions.
- **New Keynesian Approach**
  - Nominal rigidities (sticky prices, sticky wages).
  - Monetary policy stabilizes inflation-output trade-offs.
  - Justifies positive nominal interest rates for stabilization.
- **Cooley and Quadrini (2003)**
  - Flexible prices, but open economy with working capital.
  - Monetary policy affects **terms of trade (TOT)**.
  - Higher interest rates improve TOT, raising consumption.
  - Leads to inflationary bias in non-cooperative equilibria.

Motivation

- Optimal monetary policy in a closed economy, incorporating labor market frictions such as Thomas (2008), Arsenau and Chugh (2008), Faia (2009), and Blanchard and Gali (2010)
  - Thomas (2008) studies optimal monetary policy, incorporating a New Keynesian model with labor search models and wage rigidity in the closed economy. He shows that optimal policy is to stabilize price.
  - Blanchard and Gali (2010) demonstrate real wage rigidity generates a case against price stability with a simpler framework in the closed economy.
- Monetary policy in open economies such as Benigno and Benigno (2006), Catão and Chang(2013), Galí and Monacelli (2005), Dmitriev and Hoddenbagh (2012), and Cacciatore and Ghironi (2021)
  - Cacciatore and Ghironi (2021) address the effects of trade integration for the conduct of monetary policy. According to them, the need of positive inflation targeting decreases as trade is more integrated, focusing on the cooperative optimal monetary policy.

Motivation

Core Inquiry

Is the TOT effect powerful enough to sustain a positive bias in the optimal interest rate **once labor market frictions are introduced**?

- Labor market frictions: search-and-matching framework.
- Monetary policy affects vacancy posting, job creation, and unemployment.
- With these frictions, the liquidity/cost channel dominates $\rightarrow$ the TOT effect cannot overturn the Friedman-rule logic.
  - Because vacancies and employment fall, domestic production capacity shrinks.
  - Households lose labor income and future employment opportunities.
  - So the gain from cheaper imports (TOT improvement) is much smaller relative to the loss in output/employment.
- In the short run, the optimal policy still raises R_t in response to productivity shocks, generating positive international co-movement.

Framework

Framework

- Two-country (home and foreign), two-goods DSGE model
- Perfect competitive goods markets
- Search and matching in labor markets (DMP model)
- Working capital: Firms finance wages with working capital prior to their production, following Christiano et al. (1997)
- Cash-in-advance assumption for households
- The law of one price holds.
- Flexible prices and wages

Households

- The representative household has a continuum of members, who are either employed or unemployed. Members currently unemployed are searching for jobs.
- The representative household is assumed as an extended family, following Merz (1995). This assumption provides full consumption insurance between employed and unemployed members since all members gather their income and consume the same amount.
- The number of employed members in the representative household is n_t that is determined through the search and matching process.
- At the beginning of each period, the household holds money stock, M_t, on hand and decides how much cash it deposits with domestic financial intermediaries. The remaining cash is allocated for consumption. (cash-in-advance constraint)
- Once the decision of deposits is made, the monetary authority injects money, X_t, into financial intermediaries.

Households

- Household maximizes its expected life-time utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\ln c_t \right)$$

subject to

$$P_t c_t \leq M_t - D_t$$

$$P_t c_t + M_{t+1} \leq M_t + \left(R_t - 1 \right) D_t + P_t w_t n_t + \left(1 - n_t \right) P_t b + R_t X_t + T_t,$$

where D_t: deposits, X_t: money injection, b: unemployment benefit, R_t: gross interest rate, T_t: lump-sum tax, and c_t: aggregate consumption.

$$c_t = \left[\omega^{1/z} c_{h,t}^{(z-1)/z} + (1-\omega)^{1/z} c_{f,t}^{(z-1)/z} \right]^{z/(z-1)},$$

where $\omega \in (0,1)$ denotes measure of openness and $z > 0$ is the elasticity of substitution between home and foreign goods. When ω is larger than a half, consumption of the home household has the home-biased property.

Households

- Euler equation

$$\mathbb{E}_{t-1}\left[\beta R_t \frac{c_t}{c_{t+1}} \frac{1}{\pi_{t+1}}\right] = 1$$

- Note that the expectations operator in the equation is $\mathbb{E}_{t-1}$, instead of $\mathbb{E}_t$, as in Christiano et al. (1997). This is because savings are determined in advance and cannot be readjusted within the period.

Matching process

- Each firm posts vacancies, $v_t(i)$, and the total number of vacancies is $v_t = \int_0^1 v_t(i)di$. Each firm i also employs $n_t(i)$ workers and the aggregate employed worker is $n_t = \int_0^1 n_t(i)di$.
- It is assumed that newly hired workers go to work immediately, following Blanchard and Galí (2010). Thus, employment evolves:

$$n_t = (1-\rho)\, n_{t-1} + m_t.$$

where ρ: the exogenous separation rate and m: the number of new matched workers.

- Matching function (a la. Mortensen and Pissarides, 1994).

$$m_t = \sigma_m u_t^{\sigma} v_t^{1-\sigma}, \qquad 0 < \sigma < 1$$

- u: number of unemployed workers
- v: number of unemployed vacancies posted by firms
- σ: elasticity of matching w.r.t. u
- σ_m: the efficiency of the matching process

Firms

- As in Ravenna and Walsh (2011), nominal interest rates, R_t, have an impact on the real profits of the firm directly through the cost channel because wage bills are financed by working capital.
- The representative firm maximizes its profit

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \left(\frac{\lambda_{t+s}}{\lambda_t} \right) \left[\frac{P_{h,t+s}}{P_{t+s}} y_{t+s} - R_{t+s} w_{t+s} n_{t+s} - \kappa v_{t+s} \right]$$

subject to

$$\begin{aligned} y_t &= a_t n_t \\ n_t &= (1-\rho) n_{t-1} + m_t, \end{aligned}$$

where κ: vacancy posting costs.

- Job creation condition

$$\frac{\kappa}{\sigma_m}\theta_t^{\sigma} = \left[\Phi_t^{-1} a_t - R_t w_t\right] + (1-\rho)\mathbb{E}_t \beta_{t,t+1} \frac{\kappa}{\sigma_m}\theta_{t+1}^{\sigma},$$

where $\theta(= v/u)$: labor market tightness, $\Phi^{-1} = P_h/P$.

  - The left-hand side is the cost of hiring a worker, whereas the right-hand side represents the current marginal profit of the firm (in the bracket) and the continuation value of the match.
  - The job creation condition implies that the expected cost of hiring a worker should be equal to the expected value of a match.
  - Note that the nominal interest rates affect the job creation by changing current marginal profit of the firm. If the interest rate rises, the expected value of a match declines due to a fall of the current marginal profit.

Wage bargaining

- The firm and the worker negotiate real wages with Nash bargaining process

$$\max_{w_t} \left(S_t^H\right)^{\eta} \left(S_t^F\right)^{1-\eta}$$

  - S_t^F: firm's surplus from a match
  - S_t^H: worker's surplus from a match
  - η : Worker's bargaining power

- Wage decision

$$w_t = \frac{1}{\eta R_t + (1-\eta)} \left[\eta \Phi_t^{-1} a_t + (1-\eta) b + \eta \mathbb{E}_t \beta_{t,t+1} (1-\rho) \kappa \theta_{t+1}\right]$$

  - The real wage depends on aggregate productivity, relative price of the product, unemployment benefits, and labor market tightness.
  - Different from the conventional search and matching model, the real wage is affected by the nominal interest rates as well.

Monetary Authority and Government

- The monetary authority transfers money, X_t, to financial intermediaries at the beginning of period t.

$$X_t = M_{t+1} - M_t$$

  - The monetary authority is assumed to control the growth rate of money, $x_t = X_t / M_t$, as a policy instrument.
  - Using the cash-in-advance constraint, the growth rate of money determines the nominal interest rate of the home country:

$$R_t = \frac{M_{t+1}}{D_t + X_t} - 1 = \frac{1 - d_t}{d_t + x_t},$$

    where $d_t \equiv D_t / M_t$ is predetermined.

- The government imposes a lump-sum tax on households to finance the unemployment benefit:

$$T_t = (1 - n_t) P_t b.$$

International relative prices

- I define the terms of trade (TOT), the real exchange rate (q), and the ratio of the consumer price index to the domestic price index as:

$$TOT_t \equiv \frac{P_{f,t}}{P_{h,t}}, \; q_t \equiv \frac{e_t P_t^*}{P_t}, \; \Phi_t \equiv \frac{P_t}{P_{h,t}}, \; \Phi_t^* \equiv \frac{P_t^*}{P_{f,t}^*}$$

- With these three new variables, it is possible to derive following relations among them.

$$\begin{aligned} q_t &= \Phi_t^* \Phi_t^{-1} TOT_t \\ \Phi_t^{1-z} &= \omega + (1-\omega)\, TOT_t^{1-z} \\ \Phi_t^{*1-z} &= \omega + (1-\omega)\, TOT_t^{z-1} \end{aligned}$$

Market clearing

- Loan market clearing condition:

$$P_t w_t n_t = D_t + X_t$$

- Goods market clearing condition:

$$y_t = c_{h,t} + c^*_{h,t} + \kappa v_t$$

Competitive eq'm conditions

Table: Model Summary

	Home	Foreign
Euler eq.	$\beta E_{t-1} R_t \frac{c_t}{c_{t+1}} \frac{1}{\pi_{t+1}} = 1$	$\beta E_{t-1} R_t^* \frac{c_t^*}{c_{t+1}^*} \frac{1}{\pi_{t+1}^*} = 1$
Resources	$a_t n_t = \omega \Phi_t^z c_t + (1-\omega) \Phi_t^z q_t^z c_t^* + \Phi_t \kappa v_t$	$a_t^* n_t^* = \omega \Phi_t^{*z} c_t^* + (1-\omega) \Phi_t^{*z} q_t^{-z} c_t + \Phi_t^* \kappa v_t^*$
Tightness	$\theta_t = \frac{v_t}{1-(1-\rho) n_{t-1}}$	$\theta_t^* = \frac{v_t^*}{1-(1-\rho) n_{t-1}^*}$
Employment	$n_t = (1-\rho) n_{t-1} + \sigma_m \theta_t^{-\sigma} v_t$	$n_t^* = (1-\rho) n_{t-1}^* + \sigma_m \theta_t^{*-\sigma} v_t^*$
Job creation	$\frac{\kappa}{\sigma_m} \theta_t^{\sigma} = \Phi_t^{-1} a_t - R_t w_t + (1-\rho) E_t \beta_{t,t+1} \left(\frac{\kappa}{\sigma_m} \theta_{t+1}^{\sigma} \right)$	$\frac{\kappa}{\sigma_m} \theta_t^{*\sigma} = \Phi_t^{*-1} a_t^* - R_t^* w_t^* + (1-\rho) E_t \beta_{t,t+1} \left(\frac{\kappa}{\sigma_m} \theta_{t+1}^{*\sigma} \right)$
Wage	$w_t = \frac{1}{\eta R_t + (1-\eta)} [\eta \Phi_t^{-1} a_t + (1-\eta) b + \eta (1-\rho) E_t \beta_{t,t+1} \kappa \theta_{t+1}]$	$w_t^* = \frac{1}{\eta R_t^* + (1-\eta)} [\eta \Phi_t^{*-1} a_t^* + (1-\eta) b^* + \eta (1-\rho) E_t \beta_{t,t+1} \kappa \theta_{t+1}^*]$
Rel. prices	$\Phi_t^{1-z} = \omega + (1-\omega) TOT_t^{1-z}$	$\Phi_t^{*1-z} = \omega + (1-\omega) TOT_t^{z-1}$
Real ex. rate	$q_t = \Phi_t^* \Phi_t^{-1} TOT_t$	
Trade	$c_t^* = \Phi_t^{1-z} \Phi_t^{*z-1} q_t^{1-2z} c_t$	

Analytical results

Optimal monetary policy in the long run

- Ramsey-optimal monetary policy
  - Maximizes the domestic household's utility such that all equilibrium conditions are met, taking foreign policy as given.
- Optimality condition in the long run

$$[1-\beta(1-\rho)]\frac{\kappa}{\sigma_m}\theta^{\sigma}=(1-\sigma)\Phi^{-1}-\sigma\beta(1-\rho)\kappa\theta$$

- Labor market equilibrium condition at the steady state

$$\begin{aligned}&[1-\beta(1-\rho)]\frac{\kappa}{\sigma_m}\theta^{\sigma}\\ =\quad&\Phi^{-1}-\frac{R}{\eta R+(1-\eta)}\left[\eta\Phi^{-1}+(1-\eta)b+\eta\beta(1-\rho)\kappa\theta\right]\end{aligned}$$

  - Above two conditions could be identical if 1) $\eta=\sigma$, 2) $b=0$ and 3) $R=1$. First two conditions are associated with labor market efficiency condition suggested by Hosios (1990).
  - Friedman rule is optimal, same as in the closed economy.

Optimal monetary policy in the long run

- Liquidity effect

$$\frac{\kappa}{\sigma_m}\theta^{\sigma} = \left[\Phi^{-1}a - Rw\right] + \beta(1-\rho)\frac{\kappa}{\sigma_m}\theta^{\sigma}$$

  - Keeping the terms of trade constant, increasing interest rates ($R \uparrow$) decreases domestic consumption.
  - Due to the financing cost effects for firms, Friedman rule is optimal.
- Terms of trade effect

$$TOT = \frac{P_f}{P_h} = \frac{n - \kappa v}{n^* - \kappa v^*}$$

  - Incentive to depart from Friedman rule: A monetary contraction increases prices of export goods. This improves the terms of trade of home country, generating a rise in consumption.
  - However, with labor market frictions, a higher interest rate decreases vacancies posted as well as employment. The terms of trade effect should be weakened.
  - The liquidity effect dominates the economic effects of nominal interest rates in the model.

Table: Parameters

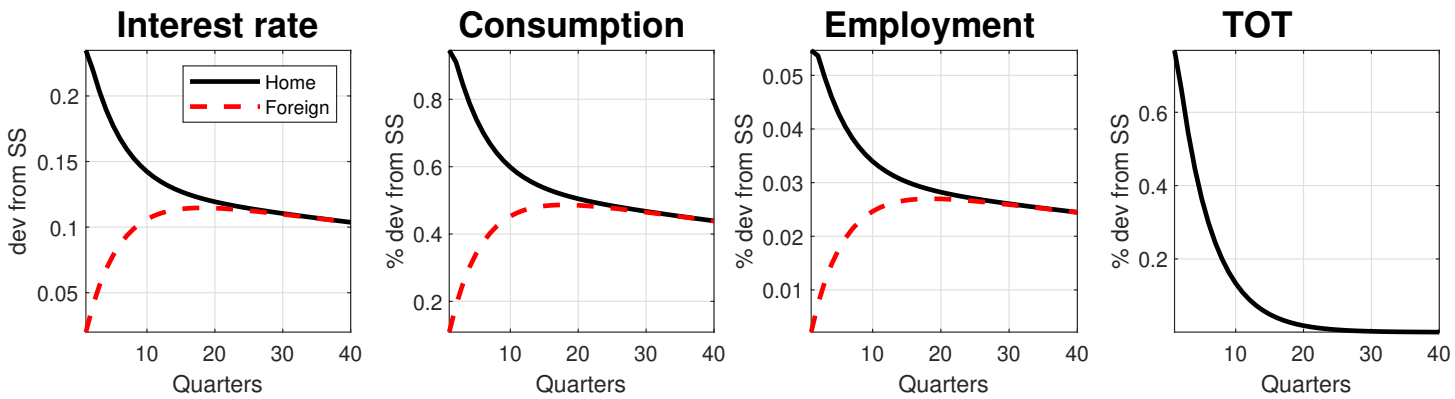
Parameters set exogenously			
Statistic	Parameter	Value	Sources
Discount factor	β	0.99	$\left(\beta^{-4}-1\right)\times 100 = 4.102\%$
Elasticity of match	σ	0.5	Mortensen and Pissarides (1994)
Efficiency of match	σ_m	4	Mortensen and Pissarides (1994)
Bargaining power	η	0.5	Mortensen and Pissarides (1994)
Armington elasticity	z	1.2	Ruhl (2008)
Transition rates	$[s, \rho]$	$[0.95, 0.105]$	Gertler et al. (2008)

Calibrated Parameters				
Statistic	Parameter	Value	Target(%)	Sources
Import share	ω	0.87	13	Bayoumi et al. (2008)
Replace. ratio	$[b, \kappa]$	$[0.48, 3.68]$	54	OECD (2006)

Note: The calibrated parameters are derived from U.S. steady-state targets.

Optimal monetary policy in the short run

- 1% positive productivity shock in the home country



- Findings
  - Pro-cyclical interest rates in the short-run
  - Similar patterns of consumption and employment in both countries.

Conclusion

- Open economy model with labor market frictions suggests the TOT effect is not strong enough to dominate the liquidity effect.
- With the Ramsey-optimal policy, I find optimal monetary policy implies pro-cyclical interest rates in the short run.
- A productive shock in the home country induces similar responses of consumption and employment in both countries.

Thank you

Appendix: Monetary policy and resources

- Gross nominal interest rate

$$R_t = \frac{M_{t+1}}{D_t + X_t} - 1 = \frac{1 - d_t}{d_t + x_t}$$

, where $d_t = D_t / M_t$, $x_t = X_t / M_t$.

  - Central bank can achieve a desired nominal interest rates, in turn inflation rates, by setting x_t because d_t is predetermined.

- Resource constraint

$$y_t = \omega \Phi_t^z c_t + (1 - \omega) \Phi_t^z q_t^z c_t^* + \Phi_t \kappa v_t$$

  - Home products are consumed by domestic households, foreign households or firms for posting vacancies.
  - Home production can be affected by the foreign demand as well as the domestic demand.