Monetary Policy Switching to Avoid a Liquidity Trap

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Large negative demand shock can send nominal interest rate to zero
- Conventional monetary policy loses ability to stimulate
- Equilibrium values for inflation and output can become indeterminate

Design monetary policy switching to
- Stimulate economy following a large negative demand shock
- While avoiding a liquidity trap
- And avoiding indeterminacy
Other Literature
Policy in Liquidity Trap

- **Bernanke, Reinhart (2004), Bernanke, Reinhart, Sack (2004):** keep long-term interest rate low through non-standard policy
- **Svensson (2003):** raise inflationary expectations by currency depreciation
- **Krugman (1998):** raise inflationary expectations with permanent increase in money
- **Eggertson and Woodford (2003):** optimal policy with price level target
- **Jung, Teranish, Watanabe (2005):** optimal policy under discretion versus commitment
- **Adam and Billi (2006):** optimal policy commitment under zero lower bound
- **Nakov (2008):** optimal policy with truncated Taylor rule
- **Coibin, Gorodnichenko and Wieland (2012):** permanent increase in inflation target
The Sticky Price New-Keynesian DSGE Model
Woodford (2003), Walsh (2010)

- **Expectational IS:**

\[ E_t(y_{t+1}) = y_t + \sigma [\hat{i}_t - E_t(\pi_{t+1})] + u_t, \sigma \geq 1 \]

- **Sticky Price Phillips curve:**

\[ \pi_t = \beta E_t(\pi_{t+1}) + \kappa y_t, \quad \kappa \in (0, \infty) \]
Optimal Monetary Policy
Woodford (2003)

- **Loss function:**

\[
L_t = \frac{1}{2} E_t \sum_{j=0}^{\infty} \beta^j (\pi_{t+j}^2 + \lambda y_{t+j}^2), \quad \beta \in (0, 1), \quad \lambda \in [0, \infty)
\]

- **Optimal policy chooses** \( \hat{i} \) **to**
  - minimize loss
  - subject to
    - IS equation
    - Phillips Curve equation
    - feasibility: \( i_t \geq 0 \)
Optimal value for interest rate

- \( \hat{i} \) is interest deviation from long-run equilibrium
- \( \bar{i} \) is long-run equilibrium interest
- set nominal interest rate at natural rate of interest \( (-\sigma^{-1}u_t) \)

\[
\hat{i}_t = i_t - \bar{i} = -\sigma^{-1}u_t
\]

- keep output and inflation at long-run values and loss at zero

\[
y_t = \pi_t = L_t = 0
\]
\( \Delta y = 0 \) curve

- equation

\[
E_t (y_{t+1}) - y_t = \sigma \hat{\iota}_t - u_t - \frac{\sigma}{\beta} (\pi_t - \kappa y_t) = 0
\]

- positive slope

\[
y_t = \kappa^{-1} \pi_t
\]

- arrows of motion point away

\[
\frac{\partial [E_t (y_{t+1}) - y_t]}{\partial y_t} = \frac{\sigma}{\beta} \kappa > 0
\]
\( \Delta \pi = 0 \) curve

- Equation

\[
E_t (\pi_{t+1}) - \pi_t = \frac{1}{\beta} [(1 - \beta) \pi_t - \kappa y_t] = 0
\]

- Positive slope, but flatter than slope of \( \Delta y = 0 \) curve

\[
y_t = \frac{1 - \beta}{\kappa} \pi_t
\]

- Arrows of motion point away

\[
\frac{\partial [E_t (\pi_{t+1}) - \pi_t]}{\partial \pi_t} = \frac{1 - \beta}{\beta} > 0
\]
Graph of Phase Diagram with Optimal Interest Rate

Saddlepath
Equilibrium indeterminacy

- no feedback on endogenous variables
- yields model with saddlepath
- sunspot shocks can place the system on saddlepath to non-explosive equilibrium

Infeasible for large adverse demand shock due to liquidity trap

- nominal interest rate cannot be negative
Taylor Rule for Interest Rate

- Taylor Rule with Taylor principle eliminates indeterminacy

\[ \hat{i}_t = i^* + \phi_\pi \pi_t + \phi_y y_t \]

- Taylor Rule: interest rate responds to endogenous variables
- Taylor principle (Bullard and Mitra, 2002): responsiveness must be large enough

\[ \phi_\pi + \phi_y \left( \frac{1 - \beta}{\kappa} \right) - 1 > 0 \]

- Taylor Rule with time-varying intercept, given by natural rate of interest (Woodford 2003)
  - Implements optimal policy (out of a liquidity trap)
  - Eliminates indeterminacy

\[ \hat{i}_t = -\sigma^{-1} u_t + \phi_\pi \pi_t + \phi_y y_t \]
Phase Diagram with Taylor Rule

\( \Delta y = 0 \) curve

- equation

\[
E_t (y_{t+1}) - y_t = \sigma \left[ \phi_\pi \pi_t + \phi_y y_t \right] - \frac{\sigma}{\beta} (\pi_t - \kappa y_t) = 0
\]

- slope less than \( \Delta \pi = 0 \) if Taylor Principle satisfied (draw as negative)

\[
y_t = \frac{1 - \beta \phi_\pi \pi_t}{\kappa + \beta \phi_y} 
\]

- arrows of motion point away

\[
\frac{\partial}{\partial y_t} \left[ E_t (y_{t+1}) - y_t \right] = \sigma \left( \frac{\kappa}{\beta} + \phi_y \right) > 0
\]
Phase Diagram with Taylor Rule
Globally Unstable
Taylor Principle yields globally unstable model

- Non-explosive equilibrium is unique $\iff$ determinacy $\iff$ no sunspots

Unless economy receives a **large adverse demand shock** ($u_t > \sigma\tilde{\tau}$)

- monetary authority reduces nominal interest rate to zero yielding liquidity trap
- set $\phi_\pi = \phi_y = 0$, violating Taylor Principle, yielding indeterminacy
Our Policy: Time-Varying Inflation Target

- **Evidence**
  - significant variation in inflation target in post-war US
  - Taylor rule with time-varying inflation target better capture interest rate movement of US
  - expectation theory of term structure works better for US under time-varying inflation target

- Introduce time-varying inflation target into Taylor Rule

\[ \hat{i}_t = \pi_t^* - \sigma^{-1} u_t + \phi_\pi (\pi_t - \pi_t^*) + \phi_y (y_t - y_t^*), \]
Model
Stochastic Demand Disturbances

- Demand disturbance is AR(1) with two innovations
  \[ u_t = \rho_u u_{t-1} + v_t + w_t, \]

- \( v_t \in V \) normal distribution with bounds \((-\bar{v}, \bar{v})\) and zero mean
- bounds small \( \rightarrow \) no liquidity trap even with worst draw forever
  \[ \frac{\bar{v}}{1 - \rho_u} \leq \sigma (\bar{I} - i_{min}) \]

- \( w_t \in W \) distribution with two equally probable time-varying elements
  \[ w_t \in \{ w - \rho_u u_{t-1}, -w - \rho_u u_{t-1} \} \]

- time varying expectation kills autoregressive element
  \[ E_{t-1}(w_t|W) = -\rho_u u_{t-1} \]

- large such that negative draw creates a liquidity trap
  \[ w > \sigma (\bar{I} - i_{min}) \]
Normal times occur with high probability ($\psi$) and draw from $V$

- no liquidity trap

Rare events occur with low probability ($1 - \psi$) and draw from $W$

- Negative draw is a liquidity trap
- Economy is in worst possible state
- Probability of entering liquidity trap is fixed over time

Liquidity trap is a rare event, not the cumulation of small shocks

- Consistent with two US liquidity traps in Great Depression and Financial Crisis
- Facilitates solution by making switching probability independent of time
Switching Policy
Evolution of the Inflation Target

- If demand innovation from $V$ distribution, inflation target evolves as

$$\pi_t^* = \rho \pi_{t-1}$$

- If demand innovation from $W$ distribution, policy-switching occurs with the inflation target reset at

$$\pi_t^* = \bar{\pi} \text{ if } w > 0$$
$$\pi_t^* = -\bar{\pi} \text{ if } w < 0$$

where $\bar{\pi}$ chosen to assure $i \geq i^{\text{min}}$

- Expectation of inflation target, conditional upon switching, is zero, yielding

$$E_t \pi_{t+j} = (\psi \rho \pi)^j \pi_t^*$$
Taylor Rule with Time-varying Inflation Target

\[ \hat{i}_t = \pi_t^* - \sigma^{-1} u_t + \phi_\pi (\pi_t - \pi_t^*) + \phi_y (y_t - y_t^*), \]

Output target must be consistent implying

\[ y_t^* = \frac{\pi_t^* - \beta E_t (\pi_{t+1}^*)}{\kappa} \]

Substitute and collect terms

\[ i_t = \bar{i} - z \pi_t^* - \sigma^{-1} u_t + \phi_\pi \pi_t + \phi_y y_t \]

where

\[ z = \phi_\pi + \phi_y \left( \frac{1 - \psi \rho_\pi \beta}{\kappa} \right) - 1 > 0 \]

with inequality required by Taylor Principle
Equilibrium with Time-Varying Inflation Target

- **Output**

\[ y_t = \frac{1 - \psi \rho \pi \beta}{\beta (\lambda_1 - \psi \rho \pi)(\lambda_2 - \psi \rho \pi)} \sigma z \pi_t^* \]

- **Inflation**

\[ \pi_t = \frac{\kappa}{\beta (\lambda_1 - \psi \rho \pi)(\lambda_2 - \psi \rho \pi)} \sigma z \pi_t^* \]

- **Nominal interest rate**

\[ i_t = \bar{i} + \pi_t^* - \sigma^{-1} u_t + \phi_{\pi} (\pi_t - \pi_t^*) + \phi_y (y_t - y_t^*) \]

\[ = \bar{i} - z \pi_t^* - \sigma^{-1} u_t + \phi_{\pi} \pi_t + \phi_y y_t \]

\[ = \bar{i} - \sigma^{-1} u_t + q z \pi_t^* \]

- Direct effect of inflation target is to reduce \( i_t \)
- Indirect effect is to raise inflationary expectations
  - Stimulating demand
  - Raising \( \pi \) and \( y \)
Policy requires $\rho_\pi$ **high enough**

$$q = \left[ \frac{\phi_\pi \kappa + \phi_y (1 - \psi \rho_\pi \beta)}{\beta (\lambda_1 - \psi \rho_\pi) (\lambda_2 - \psi \rho_\pi)} \sigma - 1 \right] > 0$$
Define $\omega$

$$w = \left( \frac{\bar{v}}{1 - \rho_u} \right) + \omega \quad \text{where} \quad \omega > \sigma \left( \bar{i} - i^{\text{min}} \right) - \left( \frac{\bar{v}}{1 - \rho_u} \right) \geq 0.$$ 

Value for $\bar{\pi}$ with $\rho_{\pi} \geq \rho_u$ keeps $i \geq i^{\text{min}}$

$$\bar{\pi} = \frac{\sigma^{-1} \omega}{qz}$$
Monetary Transmission Mechanism

- Negative demand shock reduces output and inflation
- Monetary authority needs low real rate to stimulate
  - Lowers real rate by reducing nominal rate
  - Until nominal rate falls to zero
- Increase in inflation target reduces the real interest rate by raising inflationary expectations
  - Lower real rate by raising inflation target
  - Promise to keep it high for a long period of time by promising high persistence
  - With sufficient persistence, output and inflation rise while nominal rate remains positive
Promise of persistence requires the inflation target to remain high even after the demand disturbance has fallen sufficiently that a traditional Taylor Rule could stimulate:

- Policy is dynamically inconsistent
- Policy depends on past values as with optimal policy
- Requires ability to commit to a rule
Calibration

- Adam and Billi RBC parameterization (2006):
  \[ \sigma = 1, \ \beta = 0.99, \ \kappa = 0.057, \ \rho_u = 0.8 \]

- Standard Taylor Rule values
  \[ \phi_\pi = 1.5, \ \phi_y = 0.5 \]

- Probability of a liquidity trap \( \psi \)
  - Two periods of very low interest rates in 153 years between 1860 and 2013
  - 75 years between ZLB in 1933 and in 2008
  - Approximately one event in 75 years for annual probability of 1.3% and quarterly of 0.3%
  - Assume equal probability of extreme positive event such that
    \[ 1 - \psi = 0.006 \]
\( i^{\text{min}} \)

- very little to base this value on
- need reasonable magnitude of non-fundamentals inflation shock at base inflation of zero
- volatility of inflation is small when inflation is small
- \( i^{\text{min}} \) must be large enough that when non-fundamental inflation shock occurs, \( i^{\text{min}} \) can fall by \( \beta \phi_{\pi} \) and remain above zero

\[
i^{\text{min}} - \beta \phi_{\pi} \Delta \pi^e \geq 0
\]

- if let the largest \( \Delta \pi^e = 0.2\% \) quarterly,

\[
i^{\text{min}} = 0.3\%
\]

- quarterly (1.2\% annually), consistent with an annual interest rate of 0.5\% representing a liquidity trap
Calibration (cont)

- Persistence in inflation target $\rho_\pi$ set to yield $q > 0$
  \[ \rho_\pi = 0.92 \]
- Together values imply
  \[ q = 0.496 > 0 \quad \bar{\pi} = 0.0047 \]
- $\bar{v}$ set to keep $i \geq i^{\text{min}}$ even with $-\bar{v}$ forever
  \[ \bar{v} = 0.0014 \]
- Magnitude of adverse shock $\omega$
  - Choose value which would send nominal interest rate to zero, beginning from long-run equilibrium (quarterly) value of 1.01%\[ w = 0.0101 = \frac{\bar{v}}{1 - \rho_u} + \omega \]
  - Substituting yields
    \[ \omega = 0.0031 \]
Impulse Response with Policy-Switching

Figure 1: Impulse response of the Sticky Price model

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Liquidity Trap

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Reasonable fluctuations (annualized):
- maximum output gap is 2.67% annually
- maximum inflation is 1.61% annually

Interest rate remains above $i^{\text{min}}$, ruling out volatility associated with sunspot shocks
Comparison of Our Switching Policy with Alternatives in Liquidity Trap

- **Our switching policy**
  - Reduce nominal interest rate and raise inflation target
  - Stimulates output and inflation
  - Retain positive responsiveness of interest to output and inflation in Taylor Rule so retain determinacy

- **Truncated Taylor Rule**: reduce nominal interest to zero with fixed inflation target
  - Lose ability to stimulate since lose ability to reduce nominal interest rate
  - Lose responsiveness of interest to output and inflation so lose determinacy
  - Possibility of increased volatility, compared to fundamentals equilibrium, due to sunspot shocks
Woodford’s (2003) optimal policy in a liquidity trap

- Both rely on expectations of future inflation to stimulate
- Both retain low interest rates even after the shock has subsided enough that standard Taylor Rule would raise interest rate
- Woodford’s optimal policy has higher welfare
  - Periods of positive deviations and periods of negative deviations
  - Compared with positive deviations only

Switching could have credibility advantage

- Switching model promises higher inflation and delivers something close immediately
- Optimal policy targets a price level which it continually misses
- Switching policy is completely consistent with Taylor Rules central banks seem to follow already
- Both fail if they cannot manipulate expectations

\[
\pi_t = \left( \frac{1 - \theta}{\theta} \right) \alpha y_t + (1 - \theta) \sum_{j=0}^{\infty} \theta^j E_{t-1-j} \left[ \pi_t + \alpha (y_t - y_{t-1}) \right]
\]

- \(1 - \theta\) is the fraction of firms randomly selected to update their information each period
- \((1 - \theta) \theta^j\) represents the fraction of firms with updated information in period \(t - j\)

Similar results
- Avoid liquidity trap stimulating both output and inflation
- Peak effect on inflation delayed due to delay in information about new inflation target
Impulse Response with Sticky Information

![Graphs showing output, inflation, inflation target, nominal interest rate, and real interest rate over time.](image-url)
Conclusion

- Zero inflation target is an optimal policy under small demand shocks
- Switch to positive inflation target policy under large adverse demand shock
  - credible implementation avoids liquidity trap when persistence is high enough
  - policy works with either the sticky price or sticky information Phillips Curve
- Costs and benefits of switching policy
  - stimulates at cost of larger inflation and output deviations than optimal policy
  - avoids indeterminacy compared with truncated Taylor Rule
  - arguably easier to communicate than optimal policy
  - fails if cannot affect expectations
Thank You