The Optimal Degree of Discretion in Monetary Policy in a New Keynesian Model with Private Information

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Introduction

Introduction

- Rule vs. discretion is a recurrent theme in macroeconomics.
- Emphasis is on the importance of rules.
- Monetary policy is often delegated to an independent group of professionals with some flexibility and restrictions.
    - Dual mandate, inflation targeting
- Q: What is the optimal degree of discretion (flexibility) in monetary policy?

Optimal Degree of Discretion

Use a mechanism design approach:

- Benevolent government sets up an independent central bank at time 0.
- It designs and credibly imposes rules (a mechanism) on CB.

Optimal mechanism may grant some discretion to CB, as

- CB is benevolent but is **unable to commit**, and
- CB has **superior (private) information** that is useful in improving social welfare.

New Keynesian Model

- Canonical New Keynesian model
- Inflation and output gap must satisfy the New Keynesian Phillips curve.
- Consistent with various costly price adjustment specifications
- Introduces a specific form of time-inconsistency problem.
    - New Keynesian Phillips curve is forward-looking
      $\rightarrow$ A promise to make future policy history-dependent can improve current outcome through expected future inflation.
    - CB in the future is tempted to renege such promise.
- The stronger the desire to renege is, the tighter the gov't must constrain CB.

Preview of Our Results

Several properties of the optimal mechanism:

1. Optimal mechanism is dynamic.
   - State variable = previous period's inflation promise
   - No need to keep track of CB's continuation utility
2. "Degree of discretion" varies endogenously over time and is negatively linked to the "severity of time-inconsistency problem".
3. Private information limits history-dependence.
4. No-discretion is not a long-run outcome.
5. History-dependent inflation targeting rule can do as good as the optimal direct mechanism.

Literature

- Monetary policy in New Keynesian models
  - e.g. Woodford (1999): no private info. & no gain from discretion.
- Monetary policy with private information
  - Canzoneri (1985), Sleet (2001), Athey, Atkeson, and Kehoe (2005): static Phillips curve
- Dynamic contract
  - Green (1987), Atkeson and Lucas (1992), etc.: iid private information
- Delegation
  - Holmstrom (1977, 1984), Alonso and Matouschek (2008), Amador and Bagwell (2013): static problems

The Set-up

This presentation

- This presentation uses a two-period model: $t = 0, 1$.
- (See the paper for an infinite horizon model.)

Exogenous shock

- The central bank (CB) privately observes the "state of the economy," θ_t.
- θ_t is drawn from an interval $\Theta = [\underline{\theta}, \overline{\theta}]$ in an IID fashion over time.
- $p(\theta) > 0$ is the probability density function;
- $E[\theta] = 0$ WLOG.
- No other shocks.

Endogenous Variables

- The gov't chooses an **allocation** (mechanism) that is "feasible" and "incentive compatible."
- An allocation specifies
  1. inflation rate in both periods: π_0, π_1
  2. output gap in period 0: x_0, and
  3. "inflation promise" in period 0: π_0^e,

  as functions of shock history: $\pi_0(\theta_0), x_0(\theta_0), \pi_0^e(\theta_0), \pi_1(\theta_0, \theta_1)$.
- No output gap in period 1, just for simplicity.

Feasibility

- An allocation is **feasible** from π^e_{-1} if

$$\begin{aligned} \text{New Keynesian PC:} \quad & \pi_0(\theta_0) = \kappa x_0(\theta_0) + \beta \pi^e_0(\theta_0), \quad \forall \theta_0 \\ \text{"Promise-keeping" in pd. 1:} \quad & \pi^e_0(\theta_0) = E[\pi_1(\theta_0, \theta_1)|\theta_0], \quad \forall \theta_0 \\ \text{"Promise-keeping" in pd. 0:} \quad & \pi^e_{-1} = E[\pi_0(\theta_0)] \end{aligned}$$

- NKPC requires an allocation be consistent with price setters' incentive.
- Last condition is there just to make the whole problem recursive.

Quadratic Social Welfare

- The gov't maximizes a quadratic **social welfare**:

$$E\Big[-(\pi_0(\theta_0)-\theta_0)^2 - bx_0(\theta_0)^2 - \beta E\left[(\pi_1(\theta_0,\theta_1)-\theta_1)^2|\theta_0\right]\Big].$$

- θ is the desirable inflation rate that varies over time e.g. redistribution effects through inflation.
- (Social welfare used in the paper:

$$E[\sum_{t=0}^{\infty}\beta^t R(\pi_t(\theta^t), x_t(\theta^t), \theta_t)].$$

R is slightly more general than quadratic.)

Incentive-Compatibility

- CB's objective = SWF (i.e. he is **benevolent**)
- An allocation is **incentive compatible** if and only if

$$-(\pi_1(\theta_0,\theta_1)-\theta_1)^2 \geq -(\pi_1(\theta_0,\theta')-\theta_1)^2, \quad \forall \theta_0,\theta_1,\theta',$$

and

$$\begin{aligned} & -(\pi_0(\theta_0)-\theta_0)^2 - bx_0(\theta_0)^2 - \beta E\left[(\pi_1(\theta_0,\theta_1)-\theta_1)^2|\theta_0\right] \\ \geq & -(\pi_0(\theta')-\theta_0)^2 - bx_0(\theta')^2 - \beta E\left[(\pi_1(\theta',\theta_1)-\theta_1)^2|\theta_0\right], \quad \forall \theta_0,\theta' \end{aligned}$$

Mechanism Design Problem

$$\overline{W}_{-1}(\pi^e_{-1}) := \sup E\Big[- (\pi_0(\theta_0) - \theta_0)^2 - bx_0(\theta_0)^2 - \beta E\left[(\pi_1(\theta_0, \theta_1) - \theta_1)^2 | \theta_0\right] \Big].$$

subject to feasibility from π^e_{-1} and incentive-compatibility.

CB's inability to commit

- CB is not required to report in a way that the promised expected inflation is indeed delivered.
- It is the government's job to incentivize CB to deliver the promised inflation.
- **Lack of commitment power** for CB.

In the following...

We consider

- the full-information benchmark, and
- two private-information cases
  1. only θ_1 is private;
  2. both θ_0 and θ_1 are private,

to understand how the private information imposes restrictions on the second-best allocation.

Full-information Problem

$$W^{FI}(\pi^e_{-1}) = \sup E\Big[-(\pi_0(\theta_0)-\theta_0)^2 - bx_0(\theta_0)^2 - \beta E\left[(\pi_1(\theta_0,\theta_1) - \theta_1)^2|\theta_0\right]\Big].$$

subject to

$$\left.\begin{aligned} \pi_0(\theta_0) &= \kappa x_0(\theta_0) + \beta\pi^e_0(\theta_0), \quad \forall\theta_0 \\ \pi^e_0(\theta_0) &= E[\pi_1(\theta_0,\theta_1)|\theta_0], \quad \forall\theta_0 \\ \pi^e_{-1} &= E[\pi_0(\theta_0)], \end{aligned}\right\} \text{Feasibility}$$

- Inflation promise π^e_0 serves as the state variable.

Full-information Problem: Period 1

Period 1 problem:

$$\max_{\pi} -E\left[(\pi(\theta_1) - \theta_1)^2\right] \quad \text{s.t. } \pi_0^e = E[\pi(\theta_1)].$$

- Solution $\pi_1(\theta_1, \pi_0^e) = \theta_1 + \pi_0^e$
  (FONC: $\pi_1(\theta_1, \pi_0^e) = \theta_1 - \mu$ and $E[\pi_1(\theta_1, \pi_0^e)] = -\mu$)
- π_1 increasing in θ_1 and π_0^e.
- Period-1 social welfare following the promise π_0^e is

$$-(\pi_0^e)^2.$$

Full-information Problem: Period 0

$$\sup E\Big[-(\pi_0(\theta_0)-\theta_0)^2 - bx_0(\theta_0)^2 - \beta\pi_0^e(\theta_0)^2\Big].$$

subject to

$$\begin{aligned} \text{NKPC} \qquad & \pi_0(\theta_0) = \kappa x_0(\theta_0) + \beta\pi_0^e(\theta_0), \quad \forall\theta_0 \\ \text{“Promise keeping”} \qquad & \pi^e_{-1} = E[\pi_0(\theta_0)]. \end{aligned}$$

- π_0 increasing in θ_0 and π^e_{-1}.
- (x_0, π_0^e, π_1) is “efficient” given π_0 in that

$$\text{Welfare from } (x_0, \pi_1) \text{ for } \theta_0 \quad = \max_{(x,\pi^e):\pi_0(\theta_0)=\kappa x+\beta\pi^e} -bx^2 - \beta(\pi^e)^2.$$

- $\pi_0^e(\theta_0)$ increasing in $\theta_0 \Rightarrow \pi_1(\theta_0, \theta_1)$ increasing in θ_0.

Full-information solution

- Properties that hold in private info. cases:
  - Solution is history-dependent.
  - State variable = previous period's inflation promise.
  - (x_0, π_0^e, π_1) is "efficient" given π_0.
- Properties that do not hold in private info. cases:
  - Period t inflation is strictly increasing in (π_{t-1}^e, θ_t).
  - $\pi_1 \neq \theta_1$ except when $\pi_0^e = 0$.

When θ_1 is private information: Period 1 problem

$$\overline{W}_0(\pi_0^e) = \max_{\pi} -E\left[(\pi(\theta_1) - \theta_1)^2\right].$$

subject to

$$\begin{aligned} &\text{“Promise-keeping”} && \pi_0^e = E[\pi(\theta_1)], \\ &\text{Incentive-compatibility} && -(\pi(\theta_1) - \theta_1)^2 \geq -(\pi(\theta') - \theta_1)^2, \quad \forall \theta_1, \theta'. \end{aligned}$$

- If the solution is differentiable at θ_1, then IC implies

$$(\pi_1(\theta_1, \pi_0^e) - \theta_1) \frac{\partial \pi_1(\theta_1, \pi_0^e)}{\partial \theta_1} = 0.$$

- Either $\pi_1(., \pi_0^e)$ is flat at θ_1 or equal to “discretionary best response” $\pi_{DBR}(\theta_1) = \theta_1$.
- $\pi_1(\theta_1) = \theta_1$ for all θ_1 is not feasible unless $\pi_0^e = E[\theta] = 0$.
- Tighter first constraint $\Rightarrow$ bigger deviation of $\pi_1(\theta_1, \pi_0^e)$ from θ_1.

π_1 is continuous in θ_1

Relaxed problem:

$$\max_{\pi,\delta} E\left[-(\pi(\theta_1) - \theta_1)^2 + \delta(\theta_1)\right].$$

subject to

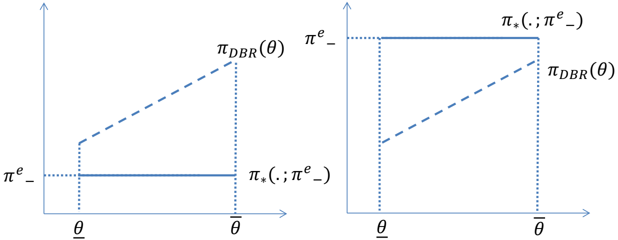
$$\pi_0^e = E[\pi(\theta_1)],$$
$$-(\pi(\theta_1) - \theta_1)^2 + \delta(\theta_1) \geq -(\pi(\theta') - \theta_1)^2 + \delta(\theta'), \quad \forall \theta_1, \theta',$$
$$\delta(\theta) \leq 0, \quad \forall \theta.$$

- Under the single-crossing condition and the monotone hazard condition, theorems in Athey, Atkeson, and Kehoe (2005) imply:
  1. the solution is continuous and satisfies $\delta(\theta) = 0$ for all θ, and
  2. the solution has a “cut-off” property.

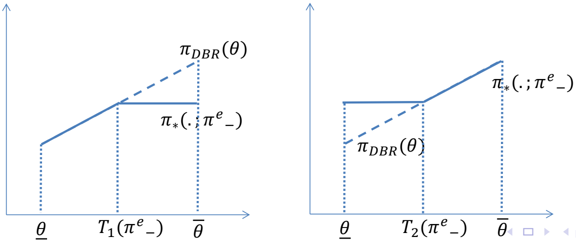
Cut-off property: Policy function as a function of type

Dependence on θ limited.

$\pi_{DBR}(\theta) = \theta$ and $\pi_{-}^{e*} := E[\pi_{DBR}] = 0$.

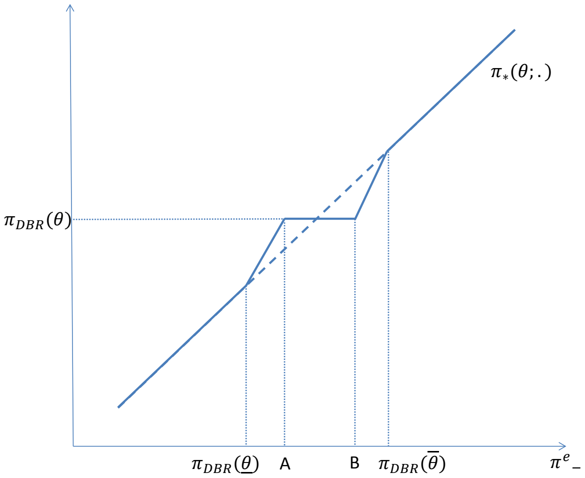


(1) $\pi^e{}_- < \pi_{DBR}(\underline{\theta})$ (2) $\pi^e{}_- > \pi_{DBR}(\overline{\theta})$



Amnesia: Policy function as a function of state

History-dependence limited.
$\pi_{DBR}(\theta) = \theta$ and $\pi_{-}^{e*} := E[\pi_{DBR}] = 0$.



When θ_1 is private information

- Value $\overline{W}_0(\pi_0^e)$ is strictly concave and peaked at $\pi_0^{e*} = E[\pi_{DBR}]$.
- (x_0, π_0^e, π_1) is "efficient" given π_0 in that

$$\text{Welfare from } (x_0, \pi_1) \text{ for report } \theta_0 = \max_{(x,\pi^e):\pi_0(\theta_0)=\kappa x+\beta\pi^e} -bx^2 + \beta\overline{W}(\pi^e).$$

Relation to Time-inconsistency

Definition

Optimal degree of discretion at π_0^e = prob. of $\pi_1(\theta_1; \pi_0^e) = \pi_{DBR}(\theta_1)$.

- This is one when $\pi_0^e = 0$ and decreases toward zero as $|\pi_0^e - \pi_0^{e*}| \uparrow$.

Definition

Severity of time-inconsistency at π_0^e = $\overline{W}(\pi_0^{e*}) - \overline{W}(\pi_0^e)$.

- I.e. gains from reneging the inflation promise.
- This is strictly convex & bottomed at π_0^{e*}.

$\Rightarrow$ They are negatively linked.

Implementation by Inflation Range Targeting

- Gov't doesn't need a direct mechanism: a history-dependent inflation targeting can achieve the second-best.
- In period 1,
  1. Gov't sets a range of permissible inflation rates conditional on π_0^e.
  2. Central bank freely chooses inflation from this range.
- $\Gamma_1(\pi_0^e) = [\min_\theta \pi_1(\theta; \pi_0^e), \max_\theta \pi_1(\theta; \pi_0^e)]$ is one example.
  1. CB's best choice = optimal mechanism's prescription.
  2. Inflation promise π_0^e is delivered.
- History-dependence through π_0^e is crucial.

When θ_0 is also private information

- (x_0, π_0^e, π_1) may be inefficient given π, i.e. for some θ_0,

$$\text{Welfare from } (x_0, \pi_1) \text{ for report } \theta_0 < \max_{(x,\pi^e):\pi_0(\theta_0)=\kappa x+\beta\pi^e} -bx^2 + \beta\overline{W}(\pi^e).$$

- Why? This potentially helps the planner incentivize the CB in $t = 0$.
- However this doesn't happen under the optimal mechanism.
- Idea:
  - When inefficient for some θ_0, it is essentially a penalty for reporting θ_0.
  - Consider a relaxed problem in which the planner can arbitrary penalize any report θ_0 and apply AAK's theorems, then it is shown optimal to have zero penalty for all θ_0.

Policy function properties still hold true

- Cut-off property holds in period 0, with “discretionary best response” appropriately defined.
- Amnesia property holds in period 0.
- When CB chooses $(\pi_0, x_0, \pi_0^e, \pi_1)$ subject to
  1. inflation targeting rule $\Gamma_t(\pi_{t-1}^e) = [\min_\theta \pi_t(\theta; \pi_{t-1}^e), \max_\theta \pi_t(\theta; \pi_{t-1}^e)]$ for all t, and
  2. New Keynesian Phillips curve: $\pi_0(\theta_0) = \kappa x_t(\theta_0) + \beta \pi_0^e(\theta_0)$,

  - CB’s optimal choice coincides with the optimal mechanism, and
  - $\pi_{t-1}^e = E[\pi_t]$ is satisfied.
  - $\rightarrow$ No rule needed for CB’s choice of x_0 and π_0^e.

Recursive formulation

The following recursive formulation is justified:

$$\overline{W}_{-1}(\pi^e_{-1}) = \max_{\pi_0, x_0, \pi^e_0, w_0} E\left[-(\pi(\theta_0) - \theta_0)^2 - bx_0(\theta_0)^2 + \beta w_0(\theta_0)\right].$$

subject to

$$\begin{aligned}
&\pi^e_{-1} = E[\pi(\theta_0)], \\
&\pi_0(\theta_0) = \kappa x_0(\theta_0) + \beta \pi^e_0(\theta_0), \\
&-(\pi(\theta_0) - \theta_0)^2 - bx_0(\theta_0)^2 + \beta w_0(\theta_0) \\
&\quad \geq -(\pi(\theta') - \theta_0)^2 - bx_0(\theta')^2 + \beta w_0(\theta'), \quad \forall \theta_0, \theta', \\
&w_0(\theta) \leq \overline{W}_0(\pi^e_0(\theta_0)), \quad \forall \theta.
\end{aligned}$$

- Solution satisfies the last inequality with equality.
- Generalizes to the infinite horizon case.
- Can solve by VFI.

Numerical Experiments

Motivation

- Examine the long-run behavior of optimal degree of discretion.
- Our numerical example suggests no “no-discretion” in the long-run.

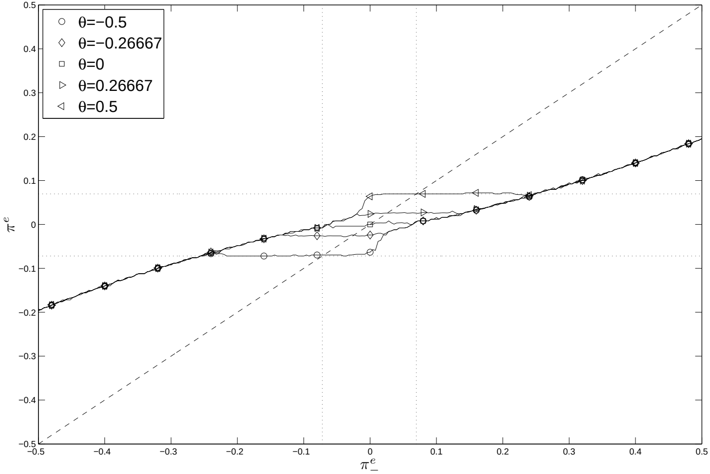
Parameter Values

Standard parameterization of a NK model with Calvo price setting.

- Calvo parameter $\gamma = 0.75$.
- Risk-aversion $\sigma = 1$; Labor elasticity parameter $\eta = 1$: $u(c, h) = \log c - \frac{1}{2}h^2$.
- $\beta = 0.99$.
- $\kappa = (1-\gamma)(1-\beta\gamma)/\gamma \times (\sigma + \eta) \approx 0.17$ (Calvo model with a single labor market),
- CES elasticity $\epsilon = 5$. (25% of markup)
- Θ is approximated as 31 equally-spaced grid points between -0.5% and 0.5%.
- $R(\pi, x, \theta) = -\frac{1}{2}\left[\frac{\kappa}{\epsilon}x^2 + (\pi - \theta)^2\right]$.

Transition Dynamics

Dynamics of the degree of discretion as the state variable changes over time: Some discretion in the ergodic set.



Conclusion

Summary

- Optimal degree of discretion when CB has private information and is unable to commit.
- Optimal mechanism is dynamic and utilizes private information, but
  1. its dependence on private information is limited (cut-off) and
  2. history-dependence is limited (amnesia)
- History-dependent inflation targeting is desirable.
  $\rightarrow$ Permissible range widens as the time-inconsistency becomes less severe.
- In the long-run some discretion is granted.

Future Work

Some other useful analysis:

- Impulse response analysis to quantify the history-dependence of optimal mechanism.

A little bit more ambitious things:

- Analyze general dynamic delegation problems.
- Lack of commitment on the side of the planner.
- "Biased" agent (non-benevolent central bank).