Instrument-Based vs. Target-Based Rules

Marina Halac   Pierre Yared

Yale University   Columbia University

November 2019

Motivation

- Should central bank incentives be based on instruments or targets?
  - Instruments: interest rate, exchange rate, money growth
  - Targets: inflation, price level, output growth

Motivation

- Should central bank incentives be based on instruments or targets?
  - Instruments: interest rate, exchange rate, money growth
  - Targets: inflation, price level, output growth
- Global central banks have moved towards inflation targets
  - 26 central banks since 1990, 14 EMs
  - But many EMs continue fixed exchange rate regimes

Motivation

- Should central bank incentives be based on instruments or targets?
  - Instruments: interest rate, exchange rate, money growth
  - Targets: inflation, price level, output growth
- Global central banks have moved towards inflation targets
  - 26 central banks since 1990, 14 EMs
  - But many EMs continue fixed exchange rate regimes
- This paper: Do target-based rules dominate instrument-based ones?

What We Do

- Monetary model to study instrument-based vs. target based rules
  - Rule is optimal mechanism in setting with non-contractible information

What We Do

- Monetary model to study instrument-based vs. target based rules
  - Rule is optimal mechanism in setting with non-contractible information
- Elucidate benefits of each class, when one is preferred over the other
  - Compare performance as a function of the environment

What We Do

- Monetary model to study instrument-based vs. target based rules
  - Rule is optimal mechanism in setting with non-contractible information
- Elucidate benefits of each class, when one is preferred over the other
  - Compare performance as a function of the environment
- Characterize optimal unconstrained or hybrid rule
  - Examine how combining instruments and targets can improve welfare

Preview of Model

- Canonical New Keynesian model with demand shocks

Preview of Model

- Canonical New Keynesian model with demand shocks
- Central bank (CB) lacks commitment, has private forecast of demand
  - Inflation/output depends on monetary policy and realized demand

Preview of Model

- Canonical New Keynesian model with demand shocks
- Central bank (CB) lacks commitment, has private forecast of demand
  - Inflation/output depends on monetary policy and realized demand
- Incentives: Socially costly punishments (money burning); no transfers
  - Instrument-based rule: Punishment depends on interest rate
  - Target-based rule: Punishment depends on inflation

Main Results

- In each class, optimal rule is a maximally enforced threshold
  - Instrument-based: Punish interest rates below a threshold
  - Target-based: Punish inflation above a threshold

Main Results

- In each class, optimal rule is a maximally enforced threshold
  - Instrument-based: Punish interest rates below a threshold
  - Target-based: Punish inflation above a threshold
- Target-based dominate instrument-based iff CB info is precise enough
  - More appealing on the margin if CB commitment problem is less severe

Main Results

- In each class, optimal rule is a maximally enforced threshold
  - Instrument-based: Punish interest rates below a threshold
  - Target-based: Punish inflation above a threshold
- Target-based dominate instrument-based iff CB info is precise enough
  - More appealing on the margin if CB commitment problem is less severe
- Optimal hybrid rule improves with a simple implementation
  - Instrument threshold that is relaxed when target threshold is satisfied
  - E.g., interest rate rule which switches to inflation target once violated

Related Literature

- Optimal monetary policy institutions
  - Rogoff 1985, Bernanke-Mishkin 1997, McCallum-Nelson 2005, Svensson 2005, Giannoni-Woodford 2017
  - This paper: Mechanism design to characterize and compare rules
- Commitment vs. flexibility in policymaking
  - Athey-Atkeson-Kehoe 2005, Amador-Werning-Angeletos 2006, Halac-Yared 2014,19
  - This paper: Condition incentives on outcome in addition to action
- Delegation in principal-agent setting
  - Holmstrom 1977,84, Alonso-Matouschek 2008, Amador-Bagwell 2013
  - This paper: Condition incentives on outcome in addition to action

Model

- New Keynesian model:

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa x_t \qquad \text{(Phillips Curve)}$$

$$x_t = \mathbb{E}_t x_{t+1} - \zeta(i_t - \mathbb{E}_t \pi_{t+1}) - \theta_t/\kappa \qquad \text{(Euler Equation)}$$

$$\theta_t \text{ i.i.d. with } \mathbb{E}\theta_t = 0 \qquad \text{(Demand Shock)}$$

Model

- New Keynesian model:

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa x_t \qquad \text{(Phillips Curve)}$$

$$x_t = \mathbb{E}_t x_{t+1} - \zeta(i_t - \mathbb{E}_t \pi_{t+1}) - \theta_t/\kappa \qquad \text{(Euler Equation)}$$

$$\theta_t \text{ i.i.d. with } \mathbb{E}\theta_t = 0 \qquad \text{(Demand Shock)}$$

- Social welfare at $t = 0$:

$$\mathbb{E}_{-1} \sum_{t=0}^{\infty} \beta^t \left[\alpha \kappa x_t - \gamma \frac{(\kappa x_t)^2}{2} - \frac{\pi_t^2}{2} \right]$$

Model

- New Keynesian model:

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa x_t \qquad \text{(Phillips Curve)}$$

$$x_t = \mathbb{E}_t x_{t+1} - \zeta(i_t - \mathbb{E}_t \pi_{t+1}) - \theta_t/\kappa \qquad \text{(Euler Equation)}$$

$$\theta_t \text{ i.i.d. with } \mathbb{E}\theta_t = 0 \qquad \text{(Demand Shock)}$$

- Social welfare at $t = 0$:

$$\mathbb{E}_{-1} \sum_{t=0}^{\infty} \beta^t \left[\alpha \kappa x_t - \gamma \frac{(\kappa x_t)^2}{2} - \frac{\pi_t^2}{2} \right]$$

- Substituting with Phillips curve:

$$\mathbb{E}_{-1} \left\{ \alpha \pi_0 + \sum_{t=0}^{\infty} \beta^t \left[-\gamma \frac{(\pi_t - \beta \mathbb{E}_t \pi_{t+1})^2}{2} - \frac{\pi_t^2}{2} \right] \right\}$$

Timing

1. CB privately observes signal $s_t = \{s^L, s^H\}$
   - Where $s^H = -s^L = \Delta$ and each signal has equal probability

Timing

1. CB privately observes signal $s_t = \{s^L, s^H\}$
    - Where $s^H = -s^L = \Delta$ and each signal has equal probability
2. CB publicly chooses interest rate i_t

Timing

1. CB privately observes signal $s_t = \{s^L, s^H\}$
   - Where $s^H = -s^L = \Delta$ and each signal has equal probability
2. CB publicly chooses interest rate i_t
3. Aggregate demand θ_t is publicly observed, where $\theta_t | s_t \sim \mathcal{N}\left(s_t, \sigma^2\right)$
   - Unconditional distribution has $\mathbb{E}(\theta_t) = 0$ and $Var(\theta_t) = \sigma^2 + \Delta^2$

Timing

1. CB privately observes signal $s_t = \{s^L, s^H\}$
   - Where $s^H = -s^L = \Delta$ and each signal has equal probability
2. CB publicly chooses interest rate i_t
3. Aggregate demand θ_t is publicly observed, where $\theta_t | s_t \sim \mathcal{N}\left(s_t, \sigma^2\right)$
   - Unconditional distribution has $\mathbb{E}(\theta_t) = 0$ and $Var(\theta_t) = \sigma^2 + \Delta^2$
4. Expectations are formed, output gap and inflation are realized

Timing

1. CB privately observes signal $s_t = \{s^L, s^H\}$
   - Where $s^H = -s^L = \Delta$ and each signal has equal probability
2. CB publicly chooses interest rate i_t
3. Aggregate demand θ_t is publicly observed, where $\theta_t | s_t \sim \mathcal{N}\left(s_t, \sigma^2\right)$
   - Unconditional distribution has $\mathbb{E}(\theta_t) = 0$ and $Var(\theta_t) = \sigma^2 + \Delta^2$
4. Expectations are formed, output gap and inflation are realized
5. CB punished according to rule: $P_t \in [0, \overline{P}]$ based on i_t and/or π_t

Markov Perfect Equilibrium

- Focus on Markov CB strategy, conditioning on s_t only and not history
  - Implication: Constant future expectations ($\mathbb{E}\pi$, $\mathbb{E}x$) on- and off-path

Markov Perfect Equilibrium

- Focus on Markov CB strategy, conditioning on s_t only and not history
  - Implication: Constant future expectations ($\mathbb{E}\pi$, $\mathbb{E}x$) on- and off-path

- Given expectations, CB's choice of i_t implies choice of μ_t:

$$\mu_t \equiv (\beta + \kappa\zeta)\mathbb{E}\pi + \kappa\mathbb{E}x - \kappa\zeta i_t$$

Markov Perfect Equilibrium

- Focus on Markov CB strategy, conditioning on s_t only and not history
  - Implication: Constant future expectations ($\mathbb{E}\pi$, $\mathbb{E}x$) on- and off-path
- Given expectations, CB's choice of i_t implies choice of μ_t:

$$\mu_t \equiv (\beta + \kappa\zeta)\mathbb{E}\pi + \kappa\mathbb{E}x - \kappa\zeta i_t$$

- Therefore,

$$\begin{aligned} \pi_t &= \mu_t - \theta_t \\ \mathbb{E}\pi &= \mathbb{E}\mu \\ x_t &= \frac{\mu_t - \theta_t - \beta\mathbb{E}\mu}{\kappa} \end{aligned}$$

Welfare

- Social welfare from timeless perspective:

$$\mathbb{E}\left[U(\mu, \theta, \mathbb{E}\mu) - P(\mu, \mu - \theta)\right]$$

$$\text{where } U(\mu, \theta, \mathbb{E}\mu) = -\gamma \frac{\left[\mu - \theta - \beta \mathbb{E}\mu\right]^2}{2} - \frac{(\mu - \theta)^2}{2}$$

Welfare

- Social welfare from timeless perspective:

$$\mathbb{E}\left[U(\mu, \theta, \mathbb{E}\mu) - P(\mu, \mu - \theta)\right]$$

$$\text{where } U(\mu, \theta, \mathbb{E}\mu) = -\gamma \frac{\left[\mu - \theta - \beta \mathbb{E}\mu\right]^2}{2} - \frac{(\mu - \theta)^2}{2}$$

- Given $\mathbb{E}\mu$, CB of type s^j chooses μ^j to maximize

$$\mathbb{E}_{s^j}\left[\alpha\left(\mu^j - \theta - \beta \mathbb{E}\mu\right) + U(\mu^j, \theta, \mathbb{E}\mu) - P(\mu^j, \mu^j - \theta)\right]$$

Welfare

- Social welfare from timeless perspective:

$$\mathbb{E}\left[U(\mu,\theta,\mathbb{E}\mu) - P(\mu,\mu-\theta)\right]$$

$$\text{where } U(\mu,\theta,\mathbb{E}\mu) = -\gamma\frac{\left[\mu-\theta-\beta\mathbb{E}\mu\right]^2}{2} - \frac{(\mu-\theta)^2}{2}$$

- Given $\mathbb{E}\mu$, CB of type s^j chooses μ^j to maximize

$$\mathbb{E}_{s^j}\left[\alpha\left(\mu^j-\theta-\beta\mathbb{E}\mu\right) + U(\mu^j,\theta,\mathbb{E}\mu) - P(\mu^j,\mu^j-\theta)\right]$$

- Thus, CB is better informed but biased relative to society:

First best policy: $\mu = s$, implying $\mathbb{E}\pi = \mathbb{E}x = 0$

Flexible policy: $\mu = s + \dfrac{\alpha+\gamma\beta\mathbb{E}\mu}{1+\gamma}$ implying $\mathbb{E}\pi > 0$, $\mathbb{E}x > 0$

Classes of Rules

- Compare different classes of rules
  - Instrument-based: $P(\mu, \mu - \theta)$ depends only on μ
  - Target-based: $P(\mu, \mu - \theta)$ depends only on $\mu - \theta$

Classes of Rules

- Compare different classes of rules
  - Instrument-based: $P(\mu, \mu - \theta)$ depends only on μ
  - Target-based: $P(\mu, \mu - \theta)$ depends only on $\mu - \theta$
- Compare as we vary info precision keeping $\mathbb{E}(\theta)$ and $Var(\theta)$ fixed
  - Uninformative signal: $\sigma \to \sqrt{Var(\theta)}$ and $\Delta \to 0$
  - Perfect signal: $\sigma \to 0$ and $\Delta \to \sqrt{Var(\theta)}$

Classes of Rules

- Compare different classes of rules
  - Instrument-based: $P(\mu, \mu - \theta)$ depends only on μ
  - Target-based: $P(\mu, \mu - \theta)$ depends only on $\mu - \theta$
- Compare as we vary info precision keeping $\mathbb{E}(\theta)$ and $Var(\theta)$ fixed
  - Uninformative signal: $\sigma \to \sqrt{Var(\theta)}$ and $\Delta \to 0$
  - Perfect signal: $\sigma \to 0$ and $\Delta \to \sqrt{Var(\theta)}$
- Assumptions:
  1. Types are close: $\alpha/(1+\gamma) \geq 2\Delta$
     - Implies both types prefer higher action than either type's first best
  2. Large maximum punishment: $\overline{P} \geq \frac{\alpha^2}{1+\gamma} \frac{1}{2\phi(1|0,1)}$
     - Implies sufficient breadth of incentives to use in relationship

Optimal Instrument-Based Rule

$$\max_{\mu^L,\mu^H,P^L,P^H} \sum_{j=L,H} \frac{1}{2}\mathbb{E}\left[U(\mu^j,\theta,\mathbb{E}\mu) - P^j | s^j\right]$$

subject to, for $j = L, H$,

$$\mathbb{E}\left[\alpha\mu^j + U(\mu^j,\theta,\mathbb{E}\mu) - P^j | s^j\right] \geq \mathbb{E}\left[\alpha\mu^{-j} + U(\mu^{-j},\theta,\mathbb{E}\mu) - P^{-j} | s^j\right]$$

$$\mathbb{E}\left[\alpha\mu^j + U(\mu^j,\theta,\mathbb{E}\mu) - P^j | s^j\right] \geq \max_{\widetilde{\mu}} \mathbb{E}\left[\alpha\widetilde{\mu} + U(\widetilde{\mu},\theta,\mathbb{E}\mu) - \overline{P} | s^j\right]$$

$$P^j \in [0, \overline{P}]$$

Optimal Instrument-Based Rule

- Proposition: Optimal rule implemented with maximally-enforced instrument threshold $\mu^* = 0$.
  - If $\mu \leq \mu^*$, $P(\mu) = 0$. Otherwise $P(\mu) = \overline{P}$

Optimal Instrument-Based Rule

- Proposition: Optimal rule implemented with maximally-enforced instrument threshold $\mu^* = 0$.
  - If $\mu \leq \mu^*$, $P(\mu) = 0$. Otherwise $P(\mu) = \overline{P}$
- Proof: Solve relaxed problem with only L's private info constraint
  - Optimal mechanism admits $\mu^L = \mu^H = \mu^* = 0$, $P^L = P^H = 0$

Optimal Instrument-Based Rule

- Proposition: Optimal rule implemented with maximally-enforced instrument threshold $\mu^* = 0$.
  - If $\mu \leq \mu^*$, $P(\mu) = 0$. Otherwise $P(\mu) = \overline{P}$
- Proof: Solve relaxed problem with only L's private info constraint
  - Optimal mechanism admits $\mu^L = \mu^H = \mu^* = 0$, $P^L = P^H = 0$
- Mechanism deters CB from choosing excessively expansionary policy
  - Enforcement constraint non-binding, punishment occurs off path

Optimal Target-Based Rule

$$\max_{\mu^L,\mu^H,P(\pi)} \sum_{j=L,H} \frac{1}{2}\mathbb{E}\left[U(\mu^j,\theta,\mathbb{E}\mu) - P(\mu^j-\theta)|s^j\right]$$

subject to, for $j = L, H$,

$$\mu^j \in \arg\max_{\widetilde{\mu}} \mathbb{E}\left[\alpha\widetilde{\mu} + U(\widetilde{\mu},\theta,\mathbb{E}\mu) - P(\widetilde{\mu}-\theta)|s^j\right]$$

$$P(\pi) \in \left[0,\overline{P}\right] \text{ for all } \pi$$

Optimal Target-Based Rule

- Proposition: Optimal rule implemented with maximally-enforced target threshold π^*.
  - If $\pi \leq \pi^*$, $P(\pi) = 0$. Otherwise $P(\pi) = \overline{P}$

Optimal Target-Based Rule

- Proposition: Optimal rule implemented with maximally-enforced target threshold π^*.
  - If $\pi \leq \pi^*$, $P(\pi) = 0$. Otherwise $P(\pi) = \overline{P}$
- Proof: Solve relaxed problem using a first-order approach
  - Given normal shocks, CB's FOC yields $\mu^j = s^j + \delta$ for some $\delta \gtreqqless 0$
  - Social welfare depends on δ and is independent of type

Optimal Target-Based Rule

- Proposition: Optimal rule implemented with maximally-enforced target threshold π^*.
    - If $\pi \leq \pi^*$, $P(\pi) = 0$. Otherwise $P(\pi) = \overline{P}$
- Proof: Solve relaxed problem using a first-order approach
    - Given normal shocks, CB's FOC yields $\mu^j = s^j + \delta$ for some $\delta \gtreqless 0$
    - Social welfare depends on δ and is independent of type
- Mechanism deters CB from choosing excessively expansionary policy
    - $\delta \in \left(0, \frac{\alpha+\gamma\beta\mathbb{E}\mu}{1+\gamma}\right)$: below flexible, above first best (to limit punishment)
    - $\mathbb{E}(\pi) = \delta < \pi^*$: CB undershoots cap (to limit punishment)

Role of Precision of Private Information

- Consider increasing precision σ^{-1} while keeping $Var(\theta)$ unchanged

Role of Precision of Private Information

- Consider increasing precision σ^{-1} while keeping $Var(\theta)$ unchanged
- Social welfare is unchanged under optimal instrument-based rule:

$$-(1+\gamma)\frac{Var(\theta)}{2}$$

Role of Precision of Private Information

- Consider increasing precision σ^{-1} while keeping $Var(\theta)$ unchanged
- Social welfare is unchanged under optimal instrument-based rule:

$$-(1+\gamma)\frac{Var(\theta)}{2}$$

  but it increases under optimal target-based rule:

$$-(1+\gamma)\frac{\sigma^2}{2} - \left[1+\gamma(1-\beta)^2\right]\frac{\delta^2}{2} - \Pr\left[\pi > \pi^* | \sigma^2\right]\overline{P}$$

Role of Precision of Private Information

- Consider increasing precision σ^{-1} while keeping $Var(\theta)$ unchanged
- Social welfare is unchanged under optimal instrument-based rule:

$$-(1+\gamma)\frac{Var(\theta)}{2}$$

but it increases under optimal target-based rule:

$$-(1+\gamma)\frac{\sigma^2}{2} - \left[1+\gamma(1-\beta)^2\right]\frac{\delta^2}{2} - \Pr\left[\pi > \pi^* | \sigma^2\right]\overline{P}$$

- Welfare at the extremes:
  - Perfect signal ($\sigma \to 0$, $\Delta \to \sqrt{Var(\theta)}$): target-based dominates
  - Uninformative ($\sigma \to \sqrt{Var(\theta)}$, $\Delta \to 0$): instrument-based dominates

Optimal Class of Rules

- Proposition: Take instrument-based and target-based rules and consider changing σ while keeping $Var(\theta)$ unchanged
  - There exists $\sigma^* > 0$ s.t target-based strictly optimal if $\sigma < \sigma^*$, instrument-based strictly optimal if $\sigma > \sigma^*$.
  - σ^* is decreasing in CB's bias α and increasing in punishment $\overline{P}$

Optimal Class of Rules

- Proposition: Take instrument-based and target-based rules and consider changing σ while keeping $Var(\theta)$ unchanged
  - There exists $\sigma^* > 0$ s.t target-based strictly optimal if $\sigma < \sigma^*$, instrument-based strictly optimal if $\sigma > \sigma^*$.
  - σ^* is decreasing in CB's bias α and increasing in punishment $\overline{P}$
- Low α and high $\overline{P}$ reduce punishment frequency in target-based rule
  - While not affecting welfare under instrument-based rule

Optimal Class of Rules

- Proposition: Take instrument-based and target-based rules and consider changing σ while keeping $Var(\theta)$ unchanged
  - There exists $\sigma^* > 0$ s.t target-based strictly optimal if $\sigma < \sigma^*$, instrument-based strictly optimal if $\sigma > \sigma^*$.
  - σ^* is decreasing in CB's bias α and increasing in punishment $\overline{P}$
- Low α and high $\overline{P}$ reduce punishment frequency in target-based rule
  - While not affecting welfare under instrument-based rule
- When does inflation-targeting dominate interest rate rule?
  - CB has highly superior non-contractible information
  - CB is not very biased, suffers large sanctions

Optimal Hybrid Rule

$$\max_{\mu^L,\mu^H,P^L(\theta),P^H(\theta)} \sum_{j=L,H} \frac{1}{2}\mathbb{E}\left[U(\mu^j,\theta,\mathbb{E}\mu) - P^j(\theta)|s^j\right]$$

subject to, for $j = L, H$,

$$\mathbb{E}\left[\alpha\mu^j + U(\mu^j,\theta,\mathbb{E}\mu) - P^j(\theta)|s^j\right] \geq \mathbb{E}\left[\alpha\mu^{-j} + U(\mu^{-j},\theta,\mathbb{E}\mu) - P^{-j}(\theta)|s^j\right]$$

$$\mathbb{E}\left[\alpha\mu^j + U(\mu^j,\theta,\mathbb{E}\mu) - P^j(\theta)|s^j\right] \geq \max_{\widetilde{\mu}} \mathbb{E}\left[\alpha\widetilde{\mu} + U(\widetilde{\mu},\theta,\mathbb{E}\mu) - \overline{P}|s^j\right]$$

$P^j(\theta) \in [0, \overline{P}]$ for all θ

Optimal Hybrid Rule

- Proposition: Optimal rule implemented with maximally-enforced hybrid threshold $\{\mu^*, \mu^{**}, \pi^*(\mu)\}$.
  - If $\mu \leq \mu^*$, $P(\mu, \theta) = 0$
  - If $\mu \in (\mu^*, \mu^{**}]$, $P(\mu, \theta) = 0$ if $\pi \leq \pi^*(\mu)$. Otherwise $P(\mu, \theta) = \overline{P}$
  - If $\mu > \mu^{**}$, $P(\mu, \theta) = \overline{P}$

Optimal Hybrid Rule

- Proposition: Optimal rule implemented with maximally-enforced hybrid threshold $\{\mu^*, \mu^{**}, \pi^*(\mu)\}$.
  - If $\mu \leq \mu^*$, $P(\mu, \theta) = 0$
  - If $\mu \in (\mu^*, \mu^{**}]$, $P(\mu, \theta) = 0$ if $\pi \leq \pi^*(\mu)$. Otherwise $P(\mu, \theta) = \overline{P}$
  - If $\mu > \mu^{**}$, $P(\mu, \theta) = \overline{P}$
- Proof: Solve relaxed problem with only L's private info constraint
  - Solution yields $\mu^L = \mu^* < \mu^H = \mu^{**}$

Optimal Hybrid Rule

- Proposition: Optimal rule implemented with maximally-enforced hybrid threshold $\{\mu^*, \mu^{**}, \pi^*(\mu)\}$.
  - If $\mu \leq \mu^*$, $P(\mu, \theta) = 0$
  - If $\mu \in (\mu^*, \mu^{**}]$, $P(\mu, \theta) = 0$ if $\pi \leq \pi^*(\mu)$. Otherwise $P(\mu, \theta) = \overline{P}$
  - If $\mu > \mu^{**}$, $P(\mu, \theta) = \overline{P}$
- Proof: Solve relaxed problem with only L's private info constraint
  - Solution yields $\mu^L = \mu^* < \mu^H = \mu^{**}$
- Optimal rule admits simple implementation, strictly improves welfare
  - Interest rate rule switches to inflation target if violated
  - $\uparrow$ flexibility vs. instrument-based, $\downarrow$ punishment vs. target-based

Discussion: Other Instruments and Targets

- Results apply to output gap/price level target instead of inflation
  - Follows from divine coincidence

Discussion: Other Instruments and Targets

- Results apply to output gap/price level target instead of inflation
  - Follows from divine coincidence
- Results apply to open economy:

$$i_t = i_t^* + \mathbb{E}_t(\Delta e_{t+1}) \text{ (UIP)}$$

  - CB choice of Δe_{t+1} is equivalent to choice of i_t
  - Optimal instrument-based rule is cap on exchange rate devaluation

Discussion: Other Instruments and Targets

- Results apply to output gap/price level target instead of inflation
  - Follows from divine coincidence
- Results apply to open economy:

$$i_t = i_t^* + \mathbb{E}_t(\Delta e_{t+1}) \text{ (UIP)}$$

  - CB choice of Δe_{t+1} is equivalent to choice of i_t
  - Optimal instrument-based rule is cap on exchange rate devaluation
- Results apply to model with money growth

$$\Delta m_t = \pi_t + x_t - \eta i_t - x_{t-1} + \eta i_{t-1}$$

  - Optimal instrument-based rule is cap on money growth rate

Extension: Continuum of Types

- Suppose CB's signal is $s_t \sim \mathcal{N}\left(0, \Delta^2\right)$, with $\theta_t|_{s_t} \sim \mathcal{N}\left(s_t, \sigma^2\right)$
  - Unconditional distribution has $\mathbb{E}(\theta_t) = 0$ and $Var(\theta_t) = \sigma^2 + \Delta^2$
  - Let $\beta = 1$: Zero expected output gap, no expected inflation externality
    - Allows focus on welfare implications of local perturbations

Extension: Continuum of Types

- Suppose CB's signal is $s_t \sim \mathcal{N}\left(0, \Delta^2\right)$, with $\theta_t|_{s_t} \sim \mathcal{N}\left(s_t, \sigma^2\right)$
  - Unconditional distribution has $\mathbb{E}(\theta_t) = 0$ and $Var(\theta_t) = \sigma^2 + \Delta^2$
  - Let $\beta = 1$: Zero expected output gap, no expected inflation externality
    - Allows focus on welfare implications of local perturbations

- Proposition: Optimal instrument-based and target-based rules take the same implementation as under binary types. There exists $\sigma^* > 0$ s.t. target-based preferred if $\sigma < \sigma^*$, instrument-based if $\sigma > \sigma^*$

Extension: Continuum of Types

- Suppose CB's signal is $s_t \sim \mathcal{N}\left(0, \Delta^2\right)$, with $\theta_t|_{s_t} \sim \mathcal{N}\left(s_t, \sigma^2\right)$
  - Unconditional distribution has $\mathbb{E}(\theta_t) = 0$ and $Var(\theta_t) = \sigma^2 + \Delta^2$
  - Let $\beta = 1$: Zero expected output gap, no expected inflation externality
    - Allows focus on welfare implications of local perturbations
- Proposition: Optimal instrument-based and target-based rules take the same implementation as under binary types. There exists $\sigma^* > 0$ s.t. target-based preferred if $\sigma < \sigma^*$, instrument-based if $\sigma > \sigma^*$
- Target-based identical to two-type case. Instrument-based different:
  - Types $s < s^*$ and $s > s^{**}$ choose flexible action; $s \in [s^*, s^{**}]$ bunched
  - Moreover, types $s > s^{**}$ break threshold and are punished
  - Welfare increases with precision, but main result still valid

Extension: Persistent Shocks

- Suppose θ_{t-1} shifts mean of θ_t
  - Signal s_t also shifted by $\mathbb{E}_{t-1}(\theta_t)$
  - Implication: Action μ_t can be renormalized by $\mathbb{E}_{t-1}(\theta_t)$

Extension: Persistent Shocks

- Suppose θ_{t-1} shifts mean of θ_t
  - Signal s_t also shifted by $\mathbb{E}_{t-1}(\theta_t)$
  - Implication: Action μ_t can be renormalized by $\mathbb{E}_{t-1}(\theta_t)$
- Proposition: Optimal instrument-based and target-based rules take the same implementation as under i.i.d shocks. There exists $\sigma^* > 0$ s.t. target-based preferred if $\sigma < \sigma^*$, instrument-based if $\sigma > \sigma^*$

Extension: Persistent Shocks

- Suppose θ_{t-1} shifts mean of θ_t
  - Signal s_t also shifted by $\mathbb{E}_{t-1}(\theta_t)$
  - Implication: Action μ_t can be renormalized by $\mathbb{E}_{t-1}(\theta_t)$
- Proposition: Optimal instrument-based and target-based rules take the same implementation as under i.i.d shocks. There exists $\sigma^* > 0$ s.t. target-based preferred if $\sigma < \sigma^*$, instrument-based if $\sigma > \sigma^*$
- Target-based identical to i.i.d. case. Instrument-based different:
  - Instrument threshold $\mu^* = \mathbb{E}_{t-1}(\theta_t)$
  - Interest rate rule is function of aggregate demand shock history

Extension: Asymmetric Punishments

- Suppose CB's welfare is given by

$$\mathbb{E}\left[\alpha\mu^j + U(\mu^j, \theta, \mathbb{E}\mu) - cP^j(\theta)|s^j\right] \text{ for } 1 < c < \frac{\alpha}{1+\gamma}\frac{1}{\Delta}$$

Extension: Asymmetric Punishments

- Suppose CB's welfare is given by

$$\mathbb{E}\left[\alpha\mu^j + U(\mu^j, \theta, \mathbb{E}\mu) - cP^j(\theta) | s^j\right] \text{ for } 1 < c < \frac{\alpha}{1+\gamma}\frac{1}{\Delta}$$

- Proposition: Optimal instrument-based and target-based rules take same implemenations as in baseline model. There exists $\sigma^* > 0$ s.t. target-based preferred if $\sigma < \sigma^*$, instrument-based if $\sigma > \sigma^*$

Extension: Asymmetric Punishments

- Suppose CB's welfare is given by

$$\mathbb{E}\left[\alpha\mu^j + U(\mu^j, \theta, \mathbb{E}\mu) - cP^j(\theta)|s^j\right] \text{ for } 1 < c < \frac{\alpha}{1+\gamma}\frac{1}{\Delta}$$

- Proposition: Optimal instrument-based and target-based rules take same implemenations as in baseline model. There exists $\sigma^* > 0$ s.t. target-based preferred if $\sigma < \sigma^*$, instrument-based if $\sigma > \sigma^*$
- Instrument-based identical to $c = 1$ case. Target-based different:
  - Rule induces smaller δ since incentives are now less costly
  - Main result follows from analogous logic as in benchmark

Concluding Remarks

- Compared CB incentives based on instruments versus targets
  - Optimal instrument-based and target-based rules take threshold form
  - Target-based rule dominates iff CB's info is precise enough
    - More appealing on the margin if low bias, severe punishment
  - Optimal hybrid rule improves welfare with simple implementation

Concluding Remarks

- Compared CB incentives based on instruments versus targets
  - Optimal instrument-based and target-based rules take threshold form
  - Target-based rule dominates iff CB's info is precise enough
    - More appealing on the margin if low bias, severe punishment
  - Optimal hybrid rule improves welfare with simple implementation
- Showed robustness to extensions. Other possible variations:
  - Asymmetric nonlinear punishments: "punishment fits the crime"?
  - Unknown magnitude and sign of CB bias

Concluding Remarks

- Compared CB incentives based on instruments versus targets
  - Optimal instrument-based and target-based rules take threshold form
  - Target-based rule dominates iff CB's info is precise enough
    - More appealing on the margin if low bias, severe punishment
  - Optimal hybrid rule improves welfare with simple implementation

- Showed robustness to extensions. Other possible variations:
  - Asymmetric nonlinear punishments: "punishment fits the crime"?
  - Unknown magnitude and sign of CB bias

- Other policy applications: fiscal rules, environmental policy