Inflation Targeting

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Outline

1 Introduction: Inflation targeting

1. An announced numerical inflation target
2. Forecast targeting, flexible inflation targeting: Choose policy rate path so forecast of inflation and real economy "looks good" (stabilizes inflation around target and resource utilization around normal)
3. A high degree of transparency and accountability

2 History and macroeconomic effects

- Starts 1990 in NZ, now about 25 countries
- Effects on inflation, inflation expectations, and output
- Success: Flexible, resilient, and robust monetary-policy regime

Outline

3 Theory

- Central role of projections
- Policy choice: Choice of interest-rate path, **not** policy function, in feasible set of projections
- Targeting rules
- Implementation of policy and equilibrium determination
- Uncertainty: State of the economy (additive), the transmission mechanism (model, multiplicative)
- Judgment

Outline

4 Practice

- Publishing a policy-rate path
- Case studies: The Riksbank and Norges Bank
- Preconditions for emerging-market economics

5 Future

- Price-level targeting
- Inflation targeting and financial stability: Lessons from the financial crisis

6 Conclusions

2 History and macroeconomic effects

- Inflation targeting starts 1990 in New Zealand
- Bundesbank inflation targeter in disguise?
- Now about 10 advanced and 15 emerging-market and developing countries

2 History: Approximate adoption dates

Country	Date	Country	Date
New Zealand	1990 q1	Korea	2001 m1
Canada	1991 m2	Mexico	2001 m1
United Kingdom	1992 m10	Iceland	2001 m3
Sweden	1993 m1	Norway	2001 m3
Finland	1993 m2	Hungary	2001 m6
Australia	1993 m4	Peru	2002 m1
Spain	1995 m1	Philippines	2002 m1
Israel	1997 m6	Guatemala	2005 m1
Czech Republic	1997 m12	Slovakia	2005 m1
Poland	1998 m10	Indonesia	2005 m7
Brazil	1999 m6	Romania	2005 m8
Chile	1999 m9	Turkey	2006 m1
Colombia	1999 m9	Serbia	2006 m9
South Africa	2000 m2	Ghana	2007 m5
Thailand	2000 m5		

2 History and macroeconomic effects

- Effects on inflation, inflation expectations, and output for advanced and emerging-market countries
- Success: Flexible, robust, and resilient monetary-policy regime

3 Theory

Linear quadratic model (approximation around stochastic steady state)

$$\begin{bmatrix} X_{t+1} \\ Hx_{t+1|t} \end{bmatrix} = A \begin{bmatrix} X_t \\ x_t \end{bmatrix} + Bi_t + \begin{bmatrix} C \\ 0 \end{bmatrix} \varepsilon_{t+1} \tag{1}$$

X_t *predetermined*, x_t *forward-looking* variables, i_t (policy) *instruments*

3 Theory

Y_t *target* variables, typically $Y_t \equiv (\pi_t - \pi^*, y_t - \bar{y}_t, ...)'$

$$Y_t = D \begin{bmatrix} X_t \\ x_t \\ i_t \end{bmatrix} \equiv [D_X \;\; D_x \;\; D_i] \begin{bmatrix} X_t \\ x_t \\ i_t \end{bmatrix} \tag{2}$$

Intertemporal loss function

$$\mathrm{E}_t \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+\tau} \quad (0 < \delta < 1) \tag{3}$$

Period loss

$$L_t \equiv Y_t' \Lambda Y_t \tag{4}$$

Λ weight matrix, typically $\Lambda \equiv \mathrm{Diag}(1, \lambda, ...)$

$$L_t = (\pi_t - \pi^*)^2 + \lambda (y_t - \bar{y}_t)^2$$

3 Theory

Optimization under commitment in a timeless perspective, solution:

$$\begin{bmatrix} x_t \\ i_t \end{bmatrix} = F \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix} \equiv \begin{bmatrix} F_x \\ F_i \end{bmatrix} \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix} \tag{5}$$

$$\begin{bmatrix} X_{t+1} \\ \Xi_t \end{bmatrix} = M \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix} + \begin{bmatrix} C \\ 0 \end{bmatrix} \varepsilon_{t+1} \tag{6}$$

$$Y_t = D \begin{bmatrix} I \;\; 0 \\ F \end{bmatrix} \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix} \equiv \tilde{D} \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix} \tag{7}$$

Ξ_t Lagrange multipliers for lower block of (1)
Optimal instrument rule (optimal policy function),

$$i_t = F_i \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix} \tag{8}$$

Certainty equivalence:
Matrices F and M depend on A, B, H, D, Λ, and δ, but not on C

3 Theory

Standard theory of (optimal) monetary policy:

- Central bank commits to some (optimal) policy function F_i
- Private sector combines policy function with model, solves for rational-expectations equilibrium

Not in practice:

- Inflation-targeting central bank chooses and announces current policy rate, indicates or announces path of future policy rate, publishes forecast of inflation and the real economy
- Private sector responds to this information, and the actual equilibrium results
- Forecasts and projections of the policy rate, inflation, and the real economy take center stage

How to model and understand?

3 Theory

- All inflation-targeting central banks not well described by this theory
- Theory is idealization (like consumption theory of actual consumer behavior)
- Theory of mature inflation targeting, potential best-practice inflation targeting
- Actual inflation targeting, w/ one innovation after the other, moving in this direction
- Some inflation-targeting central banks may be pretty close

3 Theory

Some misunderstandings to be avoided:
Two things that inflation targeting is not

- Not *strict* inflation targeting, not $L_t = (\pi_t - \pi^*)^2$.
  Always *flexible* inflation targeting.
- Not simple policy rule, such that $i_t = \alpha(\pi_t - \pi^*)$ or $i_t - i_{t-1} = \alpha(\pi_t - \pi^*)$.
  Instead, inflation targeting implies that central banks respond to much more information, namely all information that affects the forecast of inflation and the real economy (resource utilization)

3.2 Projection model; feasible set of projections

- $u^t \equiv \{u_{t+\tau,t}\}_{\tau=0}^{\infty}$ *projection* (conditional mean forecast) in period t
- *Projection model* for the projections (X^t, x^t, i^t, Y^t) in period t ($\varepsilon_{t+\tau,t} = 0$ for $\tau \geq 1$)

$$\begin{bmatrix} X_{t+\tau+1,t} \\ Hx_{t+\tau+1,t} \end{bmatrix} = A \begin{bmatrix} X_{t+\tau,t} \\ x_{t+\tau,t} \end{bmatrix} + Bi_{t+\tau,t} \tag{9}$$

$$Y_{t+\tau,t} = D \begin{bmatrix} X_{t+\tau,t} \\ x_{t+\tau,t} \\ i_{t+\tau,t} \end{bmatrix} \tag{10}$$

$$X_{t,t} = X_{t|t} \tag{11}$$

$X_{t|t}$ estimate of predetermined variables in period t (allows for imperfectly observed state of the economy)

- $\mathcal{T}(X_{t|t})$ *feasible set of projections* for given $X_{t|t}$, the set of projections (X^t, x^t, i^t, Y^t) that satisfy (9)-(11)

3.3 Optimal policy choice

- Policy problem in t: Determine optimal projection $(\hat{X}^t, \hat{x}^t, \hat{\imath}^t, \hat{Y}^t)$ that minimizes intertemporal forecast loss function,

$$\mathcal{L}(Y^t) = \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+\tau,t} \;\; (0 < \delta \leq 1), \tag{12}$$

subject to $(X^t, x^t, i^t, Y^t) \in \mathcal{T}(X_{t|t})$
Period forecast loss

$$L_{t+\tau,t} \equiv Y_{t+\tau,t}{}' \Lambda Y_{t+\tau,t} \tag{13}$$

- Optimization under commitment in timeless perspective, modified loss function (Svensson-Woodford 05)

$$\min_{i^t, Y^t} \left\{ \mathcal{L}(Y^t) + \frac{1}{\delta} \Xi'_{t-1} H(x_{t,t} - x_{t,t-1}) \right\} \text{ s.t. } (X^t, x^t, i^t, Y^t) \in \mathcal{T}(X_{t|t}) \tag{14}$$

3.3 Optimal policy choice

- Alternative implementation of timeless perspective (Giannoni-Woodford 02, Svensson-Woodford 05): **Restriction** instead of modified loss function

$$x_{t,t} = F_x \begin{bmatrix} X_{t|t} \\ \Xi_{t-1} \end{bmatrix} \qquad (15)$$

  $\mathcal{T}(X_{t|t}, \Xi_{t-1})$, the **restricted** *feasible set of projections*, the subset of the feasible set of projections $\mathcal{T}(X_{t|t})$ that satisfy (15) for given $X_{t|t}$ and Ξ_{t-1}

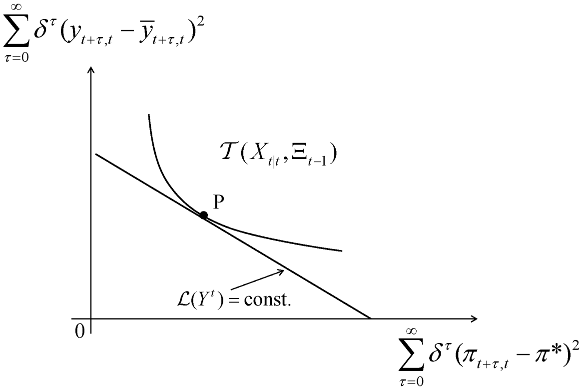
- Optimal policy projection is also the solution to the problem

$$\min_{i^t, Y^t} \mathcal{L}(Y^t) \text{ subject to } (X^t, x^t, i^t, Y^t) \in \mathcal{T}(X_{t|t}, \Xi_{t-1}) \qquad (16)$$

3.4 The **forecast** Taylor curve

$$\mathcal{L}(Y^t) = \sum_{\tau=0}^{\infty} \delta^\tau (\pi_{t+\tau,t} - \pi^*)^2 + \lambda \sum_{\tau=0}^{\infty} \delta^\tau (y_{t+\tau,t} - \bar{y}_{t+\tau,t})^2 \qquad (17)$$

Sums of discounted squared inflation and output gaps (forecasts)



3.6 Targeting rules

- General targeting rule (Giannoni-Woodford 09, Svensson 99)

$$\sum_{s=-a}^{b} g_s Y_{t+s+\tau,t} = 0 \quad (\tau \geq 0)$$

- Simplest New Keynesian model (Svensson-Woodford 05)

$$\pi_{t+\tau,t} - \pi^* + \frac{\lambda}{\kappa}[(y_{t+\tau,t} - \bar{y}_{t+\tau,t}) - (y_{t+\tau-1,t} - \bar{y}_{t+\tau-1,t})] = 0$$

- Simple, robust, and practical way to characterize optimal policy in small models
- Complex in larger models
- Arguably, for practical policy, policymakers need to look at graphs only

3.7 Implementation and equilibrium determination

Determination of equilibrium?
Period t:

- Central bank chooses and announces forecast $(\hat{X}^t, \hat{x}^t, \hat{\imath}^t, \hat{Y}^t)$ and sets $i_t = \hat{\imath}_{t,t}$
- Private sector believes forecast: $x_{t+1|t} = x_{t+1,t}$
- Private sector determines x_t given $x_{t+1|t}$, X_t, and i_t:

$$\begin{aligned} Hx_{t+1|t} &= A_{21}X_t + A_{22}x_t + B_2 i_t \\ x_t &= A_{22}^{-1}(Hx_{t+1|t} - A_{21}X_t - B_2 i_t) \end{aligned}$$

Period $t+1$:

- Private sector determines X_{t+1} given X_t, x_t, i_t, and ε_{t+1}

$$X_{t+1} = A_{11}X_t + A_{12}x_t + B_1 i_t + C\varepsilon_{t+1}$$

3.7 Implementation and equilibrium determination

Determinacy/uniqueness of rational-expectations equilibrium?

- Implicit out-of-equilibrium commitment (Svensson-Woodford 05), for instance,

$$i_t = \hat{\imath}_{t,t} + \varphi(\pi_t - \pi_{t,t})$$

- Svensson-Woodford 05: $\varphi > 1$ (Taylor Principle) ensures determinacy

3. Theory

Main point of theory:

- Central bank does **not** choose and communicate a **policy function**,

$$\begin{aligned} i_t &= f_X X_t + f_x x_t \\ i_t &= f_\pi(\pi_t - \pi^*) + f_y(y_t - \bar{y}_t) \end{aligned}$$

- **Instead**, central bank chooses and communicates a **policy-rate path**,

$$i^t \equiv \{i_{t+\tau,t}\}_{\tau=0}^{\infty(T)}$$

$$\min_{i^t, Y^t} \mathcal{L}(Y^t) \text{ subject to } (X^t, x^t, i^t, Y^t) \in \mathcal{T}(X_{t|t}, ...)$$

3.8 Optimization under discretion

- The discretion equilibrium
- Degrees of commitment (Schaumburg and Tambalotti 07)

3.9 Uncertainty

- Uncertainty about the state of the economy
(additive uncertainty, certainty equivalence)
(Svensson-Woodford 03)
- Uncertainty about the model/transmission mechanism
(multiplicative uncertainty, not certainty equivalence)
(Onatski-Williams 03, Svensson-Williams 07 MJLQ)

3.10 Judgment

- Time-varying add factors/deviations (Reifschneider-Stockton-Wilcox 97, Svensson 05)
- FOMC Bluebook 02: "Policymaker perfect-foresight projections" Use judgment in Greenbook, optimal policy in FRB/US (Svensson-Tetlow 05)

4.1 Practice: The development of inflation targeting

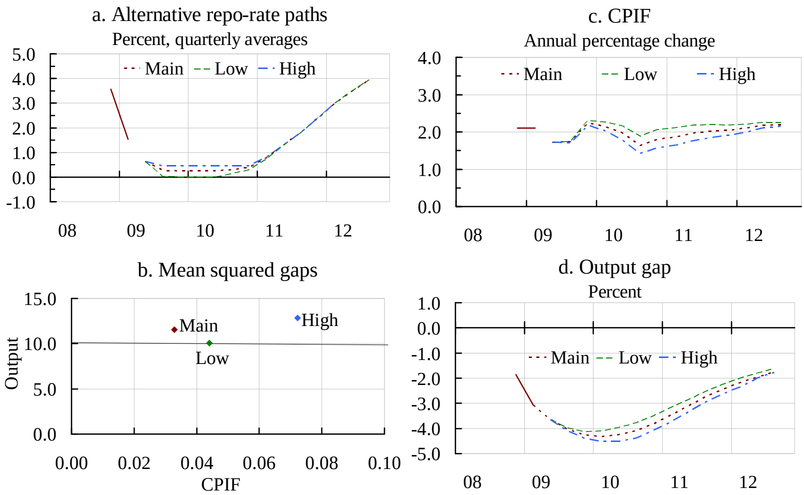
- RBNZ: Towards more flexible inflation targeting
- Away from a fixed policy horizon

4.2 Practice: Publishing an interest-rate path

- RBNZ (1997), Norges Bank (2005), Riksbank (2007), Czech National Bank (2008)

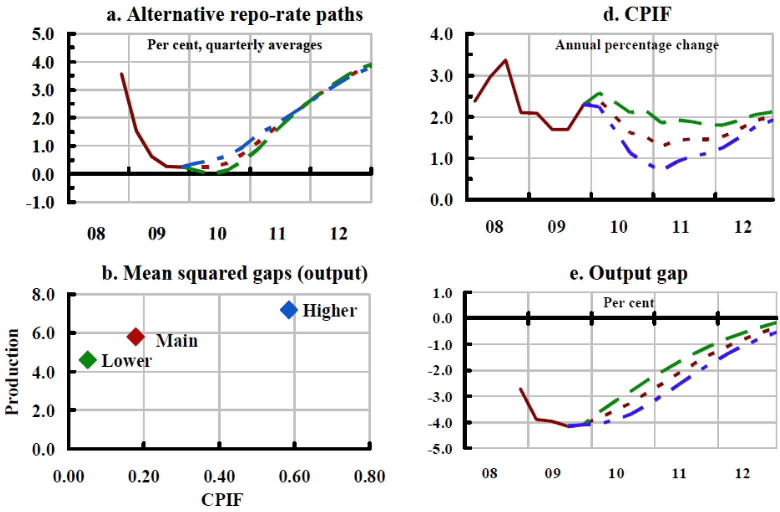
4.3 Practice: The Riksbank

Policy options, July 2009



4.3 Practice: The Riksbank

Policy options, February 2010



4.3 Practice: The Riksbank

Mean squared gaps: Simple theory

- Main scenario

$$(i^t, Y^t) \in \mathcal{T}(X_{t|t}, ...)$$

- Loss for main scenario ($\delta = 0$)

$$\begin{aligned} \frac{\mathcal{L}(Y^t)}{T+1} &\approx \frac{\sum_{\tau=0}^{T}(\pi_{t+\tau,t} - \pi^*)^2}{T+1} + \lambda \frac{\sum_{\tau=0}^{T}(y_{t+\tau,t} - \bar{y}_{t+\tau,t})^2}{(T+1)} \\ &= \text{MSG}(\pi^t) + \lambda \, \text{MSG}(y^t) \end{aligned}$$

- Alternative feasible interest-rate scenarios, variations (di^t, dY^t),

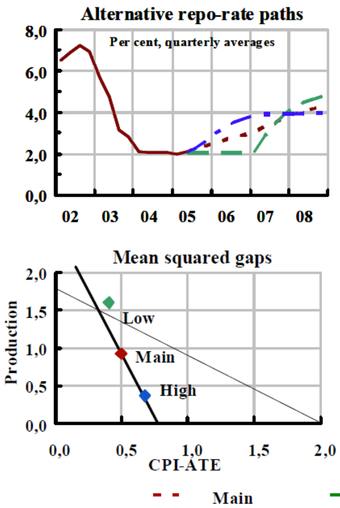
$$(i^t + di^t, Y^t + dY^t) \in \mathcal{T}(X_{t|t}, ...)$$

- If (i^t, Y^t) optimal,

$$\mathcal{L}(Y^t) \leq \mathcal{L}(Y^t + dY^t)$$

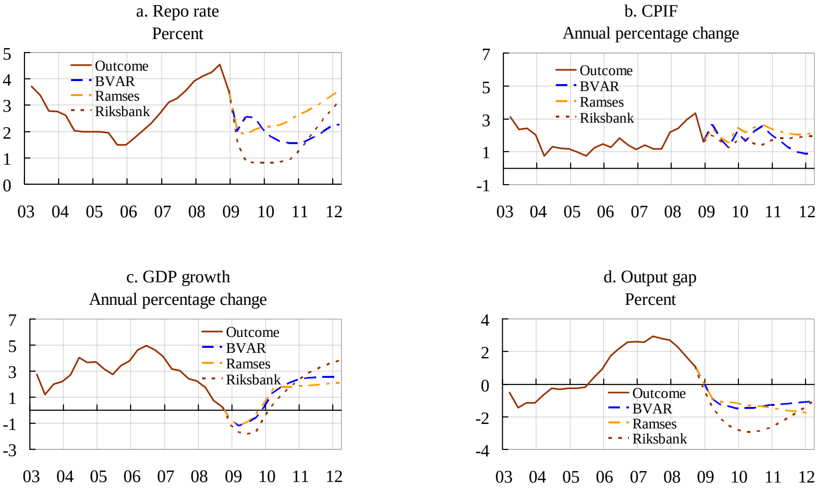
4.4 Practice: Norges Bank

Policy options, March 2005



4.3 Practice: The Riksbank

The application of judgment, February 2009



5 The future

- Price-level targeting
- Inflation targeting and financial stability: Lessons from the financial crisis