Optimal Monetary Policy

Lars E.O. Svensson
Sveriges Riksbank
www.princeton.edu/svensson

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Outline

(Some parts build on Adolfson-Laséen-Lindé-Svensson 08a,b)
(Sole responsibility...)

- What is optimal monetary policy (in theory and in practice)?
- Alternatives to optimal monetary policy?
- The loss function: Welfare or mandate?
- Interest-rate smoothing
- Resource utilization, potential output
- Commitment (in a timeless perspective)
- Conclusions, summary
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What is optimal monetary policy (in theory)?

- **Best way to achieve CB’s monetary-policy mandate**
- Flexible inflation targeting: Set instrument rate so as to stabilize both inflation around inflation target and the real economy (resource utilization, output gap)
- Loss function (quadratic)

\[
E_t \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+\tau}
\]

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

- Model (linear)

\[
\begin{bmatrix}
X_{t+1} \\
Hx_{t+1|t}
\end{bmatrix} = A \begin{bmatrix}
X_t \\
x_t
\end{bmatrix} + B i_t + \begin{bmatrix}
C \\
0
\end{bmatrix} \varepsilon_{t+1}
\]

- $X_t$ predetermined variables in quarter $t$, $x_t$ forward-looking variables, $i_t$ instrument rate, $\varepsilon_{t+1}$ i.i.d. shocks
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$X_t$ predetermined variables in quarter $t$, $x_t$ forward-looking variables, $i_t$ instrument rate, $\varepsilon_{t+1}$ i.i.d. shocks
What is optimal monetary policy (in theory)?

- **Target variables**

\[
\mathbf{Y}_t = \begin{bmatrix}
\pi_t - \pi^* \\
y_t - \bar{y}_t
\end{bmatrix}
\]

\[
\mathbf{Y}_t = D \begin{bmatrix}
X_t \\
x_t \\
i_t
\end{bmatrix},
\]

- **Loss function**

\[
L_t = \mathbf{Y}_t' \Lambda \mathbf{Y}_t
\]

\(\Lambda\) positive semidefinite matrix of weights

\[
\Lambda = \begin{bmatrix}
1 & 0 \\
0 & \lambda
\end{bmatrix}
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What is optimal monetary policy (in theory)?

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What is optimal monetary policy (in theory)?

- Minimize intertemporal loss function subject to model, under commitment in a timeless perspective
- Optimal policy, policy function, explicit instrument rule

\[ i_t = F_i \left[ \begin{array}{c} X_t \\ \Xi_{t-1} \end{array} \right] \]

\( \Xi_{t-1} \) vector of Lagrange multipliers of model equations for forward-looking variables, from optimization in previous period

\[ \Xi_t = M_{\Xi X} X_t + M_{\Xi \Xi} \Xi_{t-1} \]
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\Xi_t = M_{\Xi X} X_t + M_{\Xi \Xi} \Xi_{t-1}
\]
What is optimal monetary policy (in theory)?

Solution, optimal equilibrium

\[
\begin{bmatrix}
    x_t \\
    i_t
\end{bmatrix}
= \begin{bmatrix}
    F_x \\
    F_i
\end{bmatrix}
\begin{bmatrix}
    X_t \\
    \Xi_{t-1}
\end{bmatrix}
\]

\[
Y_t = \bar{D}
\begin{bmatrix}
    X_t \\
    \Xi_{t-1}
\end{bmatrix}
\]

\[
\begin{bmatrix}
    X_{t+1} \\
    \Xi_t
\end{bmatrix}
= M
\begin{bmatrix}
    X_t \\
    \Xi_{t-1}
\end{bmatrix}
+ \begin{bmatrix}
    C \\
    0
\end{bmatrix}
\varepsilon_{t+1}
\]
What is optimal monetary policy (in theory)?

- In theory: Solve for optimal policy function once and for all, then set instrument rate according to

\[ i_t = \begin{bmatrix} F_x \\ F_i \end{bmatrix} \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix} \]

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- Not so in practice
What is optimal monetary policy (in theory)?

- In theory: Solve for optimal policy function once and for all, then set instrument rate according to

\[ i_t = \begin{bmatrix} F_x \\ F_i \end{bmatrix} \begin{bmatrix} X_t \\ \mathbb{E}_{t-1} \end{bmatrix} \]

\[ \mathbb{E}_t = M_{XX} X_t + M_{E\mathbb{E}} \mathbb{E}_{t-1} \]

- Not so in practice
What is optimal monetary policy (in practice)?

- Forecast targeting (mean forecast, approximate certainty equivalence)
  - Choose instrument rate path so that the forecast of inflation and resource utilization “looks good”
  - “Looks good”: Inflation goes to target and resource utilization (output gap) goes to normal (zero) at an appropriate pace
  - Choose instrument-rate path (forecast) so as to minimize intertemporal loss function of forecast of inflation and resource utilization
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- Choose instrument-rate path (forecast) so as to minimize intertemporal loss function of forecast of inflation and resource utilization
What is optimal monetary policy (in practice)?

- Projections (conditional mean forecasts)
  \( z_{t+\tau,t} \) projection in period \( t \) of realization of variable \( z_{t+\tau} \) in period \( t + \tau \)
  \( z^t \equiv \{z_{t+\tau,t}\}_{\tau=0}^t \equiv \{z_{t,t}, z_{t+1,t}, \ldots\} \) projection path in period \( t \)
  of variable \( z_t \)

- Projection model (projection in period \( t \) for horizon \( \tau \geq 0 \), \( \varepsilon_{t+\tau,t} = 0 \))

\[
\begin{bmatrix}
X_{t+\tau+1,t} \\
Hx_{t+\tau+1,t}
\end{bmatrix}
= A \begin{bmatrix}
X_{t+\tau,t} \\
x_{t+\tau,t}
\end{bmatrix}
+ Bi_{t+\tau,t}
\]

\[
Y_{t+\tau,t} = D \begin{bmatrix}
X_{t+\tau,t} \\
x_{t+\tau,t} \\
i_{t+\tau,t}
\end{bmatrix}
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- **Projections (conditional mean forecasts)**
  \( z_{t+\tau,t} \) projection in period \( t \) of realization of variable \( z_{t+\tau} \) in period \( t + \tau \)
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- **Projection model (projection in period \( t \) for horizon \( \tau \geq 0 \), \( \varepsilon_{t+\tau,t} = 0 \))**

\[
\begin{bmatrix}
X_{t+\tau+1,t} \\
Hx_{t+\tau+1,t}
\end{bmatrix} = A \begin{bmatrix}
X_{t+\tau,t} \\
x_{t+\tau,t}
\end{bmatrix} + B_i_{t+\tau,t}
\]

\[
\gamma_{t+\tau,t} = D \begin{bmatrix}
X_{t+\tau,t} \\
x_{t+\tau,t} \\
i_{t+\tau,t}
\end{bmatrix}
\]
What is optimal monetary policy (in practice)?

- Set of feasible projections \( T(X_t|t) \equiv \) set of projections \((i_t, Y_t, X_t, x_t)\) that satisfy the projection model for given \(X_{t,t} = X_{t|t}\) (estimated state of the economy)

- Loss function over projections (with “commitment term”, Svensson-Woodford 05)

\[
L(Y_t, x_{t,t} - x_{t,t-1}, \bar{E}_{t-1,t-1}) \equiv \\
\sum_{\tau=0}^{\infty} \delta^\tau Y_{t+\tau, t} \Lambda Y_{t+\tau, t} + \frac{1}{\delta} \bar{E}_{t-1,t-1} (x_{t,t} - x_{t,t-1})
\]

- Optimal policy projection (OPP) \((\hat{i}_t, \hat{Y}_t)\) minimizes
\[
L(Y_t, x_{t,t} - x_{t,t-1}, \bar{E}_{t-1,t-1}) \text{ subject to } (i_t, Y_t, x_t, t) \in T(X_t|t)
\]

- Linear set of feasible projections, convex loss function, OPP unique
What is optimal monetary policy (in practice)?

- Set of feasible projections $\mathcal{T}(X_{t|t}) \equiv$ set of projections $(i_t, Y_t, X_t, x_t)$ that satisfy the projection model for given $X_{t,t} = X_{t|t}$ (estimated state of the economy)

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- Optimal policy projection (OPP) $(\hat{i}^t, \hat{Y}^t)$ minimizes $L(Y_t, x_{t,t} - x_{t,t-1}, \Xi_{t-1,t-1})$ subject to $(i_t, Y_t, x_t) \in \mathcal{T}(X_{t|t})$

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$$\sum_{\tau=0}^{\infty} \delta^{\tau} Y'_{t+\tau,t} \Lambda Y_{t+\tau,t} + \frac{1}{\delta} \mathbb{E}'_{t-1,t-1}(x_{t,t} - x_{t,t-1})$$

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- Linear set of feasible projections, convex loss function, OPP unique
What is optimal monetary policy (in practice)?

- OPP will satisfy \((\mathbb{E}_{t-1,t} = \mathbb{E}_{t-1,t-1})\)

\[
\begin{bmatrix}
\hat{X}_{t+\tau,t} \\
\hat{i}_{t+\tau,t}
\end{bmatrix}
= 
\begin{bmatrix}
F_x \\
F_i
\end{bmatrix}
\begin{bmatrix}
X_{t+\tau,t} \\
\mathbb{E}_{t+\tau-1,t}
\end{bmatrix}
\]

\[
Y_{t+\tau,t} = \bar{D}
\begin{bmatrix}
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\[
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X_{t+\tau+1,t} \\
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= M
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\]

- \(\hat{i}^t\) and \(\hat{i}_t\) depend on \(X_{t|t}\) (state of the economy) and \(\mathbb{E}_{t-1,t-1}\) (commitment)
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F_i
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What is optimal monetary policy (in practice)?

- Policy decision \((\hat{i}^t, \hat{Y}^t)\): Implementation?
  - \(E_{t,t}\) is determined
  - Announce \(\hat{i}^t\) and \(\hat{Y}^t\) (possibly more), set \(i_t = \hat{i}_{t,t}\)
  - Private sector-expectations \(E^p_t x_{t+1}\) are formed
  - \(x_t, Y_t\) are determined in period \(t\)
  - In period \(t + 1\), \(\varepsilon_{t+1}\) is realized and \(X_{t+1}\) is determined
  - New policy decision in period \(t + 1\) given \(X_{t+1|t+1}, E_{t,t}\)
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What is optimal monetary policy (in practice)?

- Determinacy?

- May require out-of-equilibrium commitment (explicit or implicit). Deviate from $\hat{i}_{t,t}$ if economy deviates from optimal projection (Taylor principle, Svensson-Woodford 05)

$$i_t = \hat{i}_{t,t} + \varphi (\pi_t - \hat{\pi}_t)$$

$$i_t = \hat{i}_{t,t} + \varphi [\pi_t - \pi^* + \frac{\lambda}{\kappa} (y_t - \bar{y}_t) - (y_{t-1} - \bar{y}_{t-1})]$$
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i_t = \hat{i}_{t,t} + \varphi [\pi_t - \pi^* + \frac{\lambda}{\kappa} (y_t - \bar{y}_t) - (y_{t-1} - \bar{y}_{t-1})]
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What is optimal monetary policy (in practice)?

- **Judgment?**
  - Add judgment $z^t$ (add factors, Svensson 05, Svensson-Tetlow 05): $T(X_{t|t}, z^t)$
  
  $$z^{t+1} = A_z z^t + \eta^{t+1}$$

- $\hat{i}^t$ and $\hat{i}_t$ depend on $X_{t|t}, z^t$ (everything relevant) and $\Xi_{t-1,t}$
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- Add judgment $z^t$ (add factors, Svensson 05, Svensson-Tetlow 05): $T(X_{t|t}, z^t)$

$$z^{t+1} = A_z z^t + \eta^{t+1}$$

- $\hat{i}^t$ and $\hat{i}_t$ depend on $X_{t|t}$, $z^t$ (everything relevant) and $\Xi_{t-1,t}$
What is optimal monetary policy (in practice)?

Note:

Object of choice is $i^t$, instrument rate path, not policy function $F_i$:

Choose $i^t$ so as to minimize $L(Y^t, x_{t,t} - x_{t,t-1}, \mathbb{E}_{t-1,t-1})$
subject to $(i^t, Y^t, x_{t,t}) \in \mathcal{T}(X_{t|t})$
What is optimal monetary policy (in practice)?

- Riksbank, February 2008: Subset of $\mathcal{T}(X_t|t)$, feasible projections $(X^t, x^t, i^t, Y^t)$

![Repo rate](chart1)

![CPIX](chart2)

![GDP growth](chart3)

![Output gap](chart4)

- Riksbank chose Main Scenario
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Alternatives to optimal monetary policy?

- **Add hoc policy**
  - With or without explicit instrument-rate path?
  - Projections assuming historical policy function
    - Why follow historical policy (new board members)
    - Bad response for some shocks (ALLS)

- Simple instrument rule (Taylor-type rules, cross-checking only)
  - No CB follows simple instrument rule
  - All central banks use more information than the arguments of a simple instrument rule
  - Revealed preference: CB deviates from simple instrument rules in order to do better policy
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- Forecast targeting (Svensson 05, Woodford 07) better policy, and arguably better prescription: All info that affects the forecast of the target variables affects the instrument-rate path and current instrument-rate setting; all info that has no impact on forecast has no impact on instrument rate path and current setting.

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The loss function: Welfare or mandate?

- **Welfare-based loss function**
  - Quadratic approximation of utility of representative agent
  - Very model-dependent; not robust
  - Very complex; all distortions show up
  - Difficult to verify
  - Bad history

- **Simple loss function**
  - Interpretation of mandate (price stability, medium-term inflation target, avoid (unnecessary) real-economy fluctuations)
  - Flexible inflation targeting: Stabilize inflation around inflation target and real economy (resource utilization, output gap)
  - Standard quadratic
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- **Parameters**?
  - Estimate: $\lambda_y = 1.1, \lambda_{\Delta i} = 0.37$
  - Vote
  - Revealed-preference experiments

- If not agreement on parameters
  - Generate alternative feasible policy projections by OPPs for different loss function parameters
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The loss function: Interest-rate smoothing?

**Interest-rate smoothing:** \( \lambda \Delta i(i_t - i_{t-1})^2 \)?

- Empirical, but difficult to rationalize
- Not disturb markets
- Result of uncertainty, learning, estimation of current state of economy, Kalman filtering implies serial correlation
- Commitment, history dependence
- Less so recently: Fed, Riksbank, Bank of England
- Instrument-rate path adjustment, not just current instrument rate
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Resource utilization, output gap, potential output

- Stability of real economy (resource utilization)
  - Measures of resource utilization (gaps: output, employment, unemployment)
  - Output gap between output and potential output: Potential output?
  - (Stochastic) trend, unconditional flexprice, conditional flexprice, constrained efficient, efficient minus constant
  - Capital and other state variables
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Commitment in a timeless perspective

Commitment term in loss function (Svensson-Woodford 05, Marcet-Marimon 98): \( \frac{1}{\delta} \mathbb{E}'_{t-1} (x_t - x_{t|t-1}) \)

- Cost of deviating from previous expectations
- Requires whole vector of Lagrange multipliers and forward-looking variables (23 in Ramses)
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Commitment: Calculating initial $\Xi_{t-1}$

Adolfson-Laséen-Lindé-Svensson 08a

1. Assume past policy optimal: Equation for $\Xi_{t-1}$

$$\Xi_{t-1} = M_{\Xi X}X_{t-1} + M_{\Xi\Xi}\Xi_{t-2} = \sum_{\tau=0}^{\infty} (M_{\Xi\Xi})^{\tau}M_{\Xi X}X_{t-1-\tau}$$

2. Assume past policy systematic: Combine first-order conditions for shadow prices $\xi_t$ and $\Xi_t$ and estimated instrument rule with model equation, solve for $\Xi_{t-1}$

$$\bar{A}' \begin{bmatrix} \xi_{t+1} \\ \Xi_t \end{bmatrix} = \frac{1}{\delta} \bar{H}' \begin{bmatrix} \xi_t \\ \Xi_{t-1} \end{bmatrix} + \bar{W} \begin{bmatrix} X_t \\ x_t \\ i_t \end{bmatrix}$$

$$i_t = f_i X_t + f_{ix} x_t$$
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2. Assume past policy systematic: Combine first-order conditions for shadow prices $\zeta_t$ and $\Xi_t$ and estimated instrument rule with model equation, solve for $\Xi_{t-1}$

$$\bar{A}' \begin{bmatrix} \zeta_{t+1} | t \\ \Xi_t \end{bmatrix} = \frac{1}{\delta} \bar{H}' \begin{bmatrix} \zeta_t \\ \Xi_{t-1} \end{bmatrix} + \bar{W} \begin{bmatrix} X_t \\ x_t \\ i_t \end{bmatrix}$$

$$i_t = f_{iX} X_t + f_{ix} x_t$$
Conclusions, summary

- Do optimal monetary policy more explicitly
- Optimize over feasible set of projections rather than choosing policy function
- Loss function: Interpretation of CB mandate rather than welfare
- Loss function: Parameters
- Feasible in medium-sized DSGE models (Adolfson-Laséen-Lindé-Svensson 08a)
- Better than alternatives
- More work on measures of resource utilization, potential output
- Less interest-rate smoothing?
- Commitment in a timeless perspective feasible