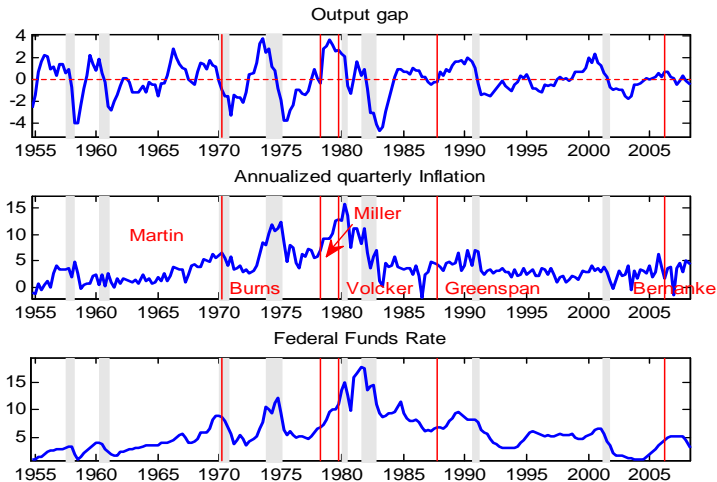


Regime Switches, Agents' Beliefs, and Post-World War II U.S. Macroeconomic Dynamics

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Good Policy or Good Luck?

- **'Good Policy'**: The changes described above are the result of a substantial switch in the anti-inflationary stance of the Federal Reserve
- **'Good Luck'**: Changes in the volatilities of the structural disturbances were the key driver behind the stabilization of the U.S. economy

Looking for a model that...

...allows for

- Changes in the behavior of the Federal Reserve
- Changes in the volatility of the structural shocks

and

- A role for agents' beliefs around the behavior of the Federal Reserve

A MS-DSGE model

In a Markov-Switching Dynamic Stochastic General Equilibrium model:

- Structural parameters are allowed to differ across regimes
- Volatility of structural shocks can change over time
- Agents are aware of the possibility of regime changes and they take this into account when forming expectations: **The law of motion of the state variables depends on agents' beliefs**

Allowing for Markov-switching regimes

Linearized Euler equation and expectations augmented Phillips curve:

$$\tilde{y}_t = E_t(\tilde{y}_{t+1}) - \tau^{-1}(\tilde{R}_t - E_t(\tilde{\pi}_{t+1})) + g_t \quad (1)$$

$$\tilde{\pi}_t = \beta E_t(\tilde{\pi}_{t+1}) + \kappa(\tilde{y}_t - z_t) \quad (2)$$

Markov-switching Taylor rule:

$$\tilde{R}_t = \rho_R(\zeta_t^{sp})\tilde{R}_{t-1} + (1 - \rho_R(\zeta_t^{sp}))(\psi_1(\zeta_t^{sp})\tilde{\pi}_t + \psi_2(\zeta_t^{sp})\tilde{y}_t) + \epsilon_{R,t} \quad (3)$$

Heteroskedasticity is modelled as an independent Markov-switching process:

$$(\epsilon_{R,t}, \epsilon_{z,t}, \epsilon_{g,t}) \sim N(0, Q(\zeta_t^{er})), \quad Q(\zeta_t^{er}) = \text{diag}(\theta^{er}(\zeta_t^{er})) \quad (4)$$

The model in state space form

The DSGE state vector

$$S_t = \left[\tilde{y}_t, \tilde{\pi}_t, \tilde{R}_t, g_t, z_t, E_t(\tilde{y}_{t+1}), E_t(\tilde{\pi}_{t+1}) \right]'$$

evolves according to the following law of motion:

$$S_t = T(\theta^{sp}, \zeta_t^{sp}, H^m) S_{t-1} + R(\theta^{sp}, \zeta_t^{sp}, H^m) \epsilon_t$$
$$\epsilon_t \sim N(0, Q(\theta^{er}, \zeta_t^{er}))$$

The probability of moving across regimes is given by:

$$H^{sp}(\cdot, i) \sim D(a_{ii}^{sp}, a_{ij}^{sp}), \quad H^{er}(\cdot, i) \sim D(a_{ii}^{er}, a_{ij}^{er})$$

The model in state space form

The law of motion of the DSGE state vector can be combined with an observation equation:

$$Y_t = D(\theta^{ss}) + ZS_t + \Lambda^{1/2}v_t$$

$$Y_t = \begin{bmatrix} GDP_t \\ INFL_t^A \\ FFR_t \end{bmatrix} \quad D(\theta^{ss}) = \begin{bmatrix} 0 \\ 4\pi^* \\ 4(\pi^* + r^*) \end{bmatrix}$$

$$Z = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 4 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 4 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Taylor rule parameters

$$\zeta_t^{SP} = 1 \text{ (Hawk)}$$

Parameter	Mode	Mean	5th prc	95th prc
ψ_1	2.2265	2.0528	1.3721	2.5916
ψ_2	0.2998	0.2744	0.1088	0.4529
ρ_R	0.7724	0.7530	0.6299	0.8323

$$\zeta_t^{SP} = 2 \text{ (Dove)}$$

Parameter	Mode	Mean	5th prc	95th prc
ψ_1	0.4844	0.5907	0.3505	0.9892
ψ_2	0.3161	0.3824	0.2112	0.7882
ρ_R	0.7668	0.7881	0.6994	0.8798

Volatilities

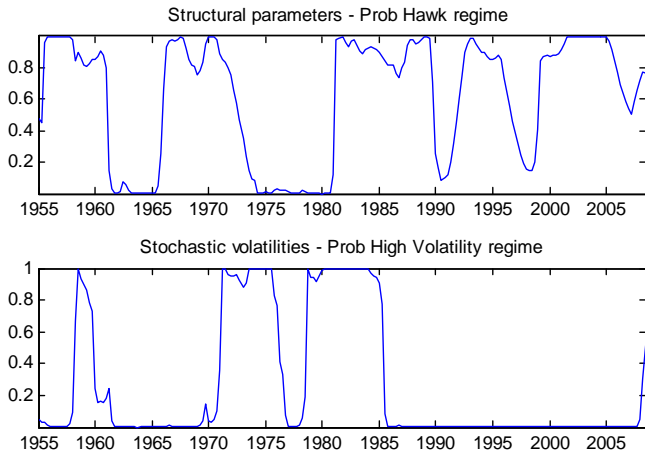
$\bar{\zeta}_t^{er} = 1$ (*High Volatility*)

Parameter	Mode	Mean	5th prc	95th prc
σ_R	0.3170	0.3211	0.2555	0.4097
σ_g	0.3509	0.3522	0.2689	0.4552
σ_z	1.4014	1.8538	1.2719	2.6622

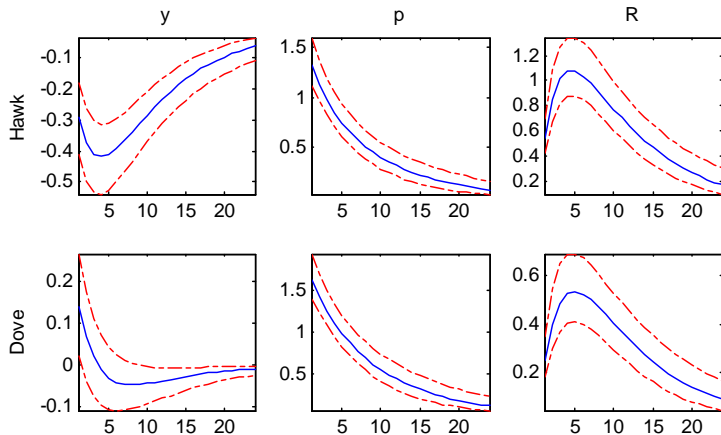
$\bar{\zeta}_t^{er} = 2$ (*Low Volatility*)

Parameter	Mode	Mean	5th prc	95th prc
σ_R	0.0679	0.0741	0.0616	0.0883
σ_g	0.1502	0.1483	0.1184	0.1821
σ_z	0.4727	0.5842	0.3961	0.8352

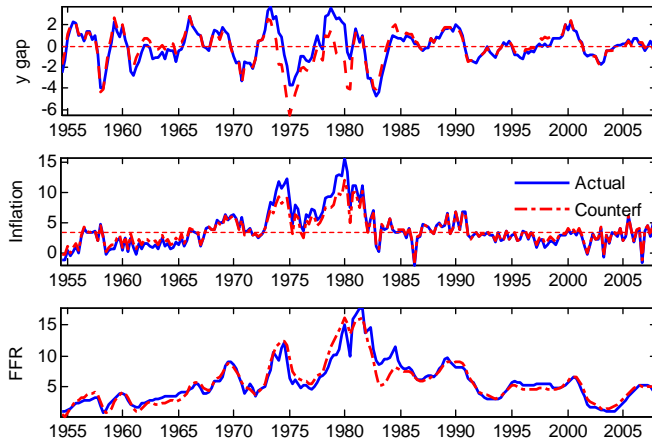
Probabilities of regimes 1 (posterior mode)



(Adverse) Supply shock



Hawk regime always in place



The *Eagle* regime

A new type of counterfactual simulation:

- I introduce a third regime, the *Eagle* regime, that is meant to capture the behavior of an extremely conservative chairman, like Volcker
- Compared to the *Hawk* regime, under the *Eagle* regime the response...
 - ...to inflation is doubled
 - ...to output is halved

$$\tilde{R}_t = \rho_R \tilde{R}_{t-1} + (1 - \rho_R)(\psi_1 \tilde{\pi}_t + \psi_2 \tilde{y}_t) + \epsilon_{R,t}$$

$$\psi_1 (\textit{Eagle}) = 2\psi_1 (\textit{Hawk})$$

$$\psi_2 (\textit{Eagle}) = 0.5\psi_2 (\textit{Hawk})$$

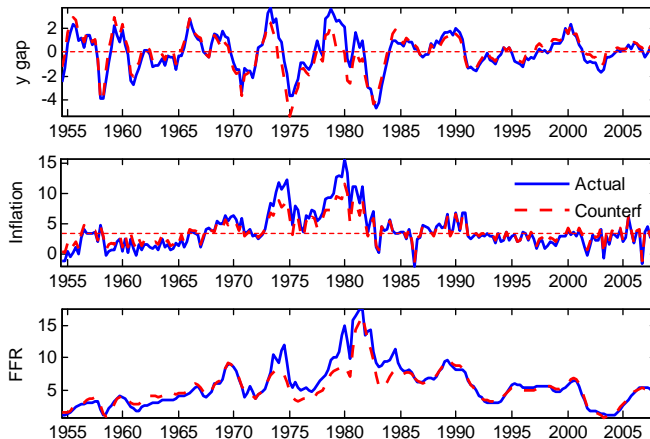
An *Eagle* on stage

- Only two regimes: The *Dove* and the *Eagle*
- The persistence of the *Eagle* regime is equal to the persistence of the *Hawk* regime. The persistence of the *Dove* regime is decreased by 30%

$$H^m = \begin{bmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{bmatrix} \Rightarrow H_E^m = \begin{bmatrix} p_{11} & 1 - 0.7p_{22} \\ p_{12} & 0.7p_{22} \end{bmatrix}$$

- The *Eagle* regime occurs in place of the *Hawk* regime

An Eagle on stage



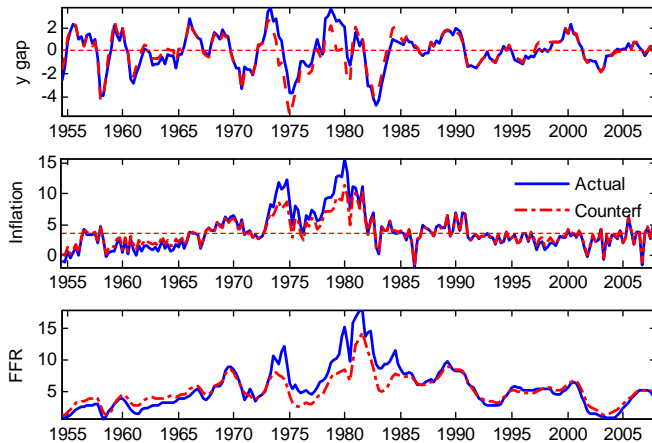
An *Eagle* behind the scenes

- When agents observe the *Dove* regime, they regard the *Eagle* regime as the alternative scenario and they put a relatively large probability on its occurrence
- The persistence of the *Eagle* regime is equal to the persistence of the *Hawk* regime and from the *Eagle* regime the economy can move only to the *Hawk* regime

$$H^m = \begin{bmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{bmatrix} \Rightarrow H_E^m = \begin{bmatrix} p_{11} & 0 & p_{12} \\ p_{12} & 0.7p_{22} & 0 \\ 0 & 1 - 0.7p_{22} & p_{11} \end{bmatrix}$$

- However, the *Eagle* regime never occurs

An *Eagle* behind the scenes



Counterfactual sacrifice ratios

These are computed as

$$SR_{T_0, T_1} = \frac{\sum_{t=T_0}^{T_1} (y_t - \hat{y}_t)}{\sum_{t=T_0}^{T_1} (\pi_t - \hat{\pi}_t)}$$

Sacrifice ratios for the period 1970:I-1984:I:

<i>Counterfactual</i>	<i>Mean</i>	<i>5th prc</i>	<i>95th prc</i>
<i>Hawk</i>	1.1133	0.8843	1.4349
<i>Eagle behind</i>	0.5292	0.4184	0.6736
<i>Eagle on stage</i>	0.6256	0.4976	0.7835

Gains and Losses

Percentage change in the sum of squared deviations from the target for the three counterfactuals:

Counterfactual	$\widehat{D\%SSD}_y$	$\widehat{D\%SSD}_{\pi^A}$
<i>Hawk</i>	+17.77% (+1.99%, +38.97%)	-45.76% (-56.57%, -29.79%)
<i>Eagle behind</i>	+1.12% (-5.59, +10.36)	-55.89% (-64.88, -45.78%)
<i>Eagle on stage</i>	+16.99% (+7.68%, +28.80)	-66.36% (-74.18%, -57.61%)

Analytical variances

Consider the model in state space form:

$$S_t = T(\theta^{sp}, \zeta_t^{sp}, H^m)S_{t-1} + R(\theta^{sp}, \zeta_t^{sp}, H^m)\epsilon_t$$

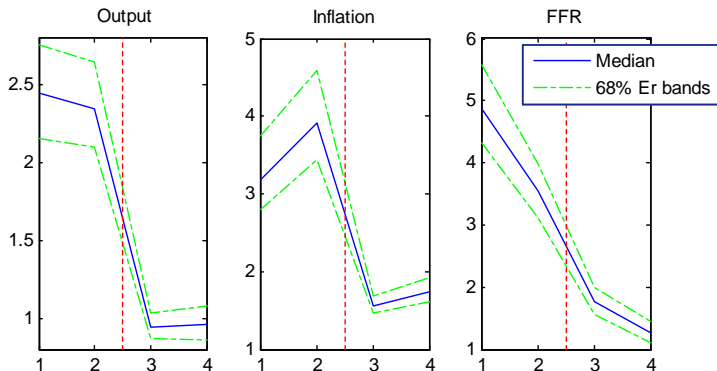
$$\epsilon_t \sim N(0, Q(\theta^{er}, \zeta_t^{er}))$$

$$Y_t = D(\theta^{ss}) + ZS_t + \Lambda^{1/2}v_t$$

For each Gibbs sampling draw, we can compute the covariance matrix as implied by the different regime combinations (ζ^{sp}, ζ^{er}) :

$$V(Y_t | \theta^{sp}, \theta^{er}, \zeta_t^{sp}, \zeta_t^{er}, H^m) = ZV(S_t | \theta^{sp}, \theta^{er}, \zeta_t^{sp}, \zeta_t^{er}, H^m)Z' + \Lambda$$

Analytical standard deviations



1 → (High Volat, *Hawk*) 2 → (High Volat, *Dove*)
 3 → (Low Volat, *Hawk*) 4 → (Low Volat, *Dove*)

Marginal Data Density

- Posterior odds ratio:

$$\frac{P(M_i|Y_T)}{P(M_j|Y_T)} = \frac{P(Y_T|M_i) P(M_i)}{P(Y_T|M_j) P(M_j)}$$

- Comparing the different specifications (q : fraction of draws that are included)

Model	$q = 0.1$	$q = 0.3$	$q = 0.5$
MS T.R.+heter.+ind H^m	2,391.6	2,390.5	2,390.4
MS T.R.+heter.	2,390.1	2,390.1	2,390.0
Just Good Luck (heter.)	2,379.0	2,379.0	2,379.0
One-time-only switch	2,349.4	2,349.1	2,349.1

Marginal data density (log)

The Good Luck - Good Policy Debate

- 1 There were regime changes in US monetary policy: The best performing model is one in which the behavior of the Fed moves between a *Hawk*- and a *Dove*- regime
- 2 The idea that US economic history can be divided into *pre*- and *post-Volcker* turns out to be misleading
 - The *Dove* regime was certainly in place during the '70s
 - The appointment of Volcker marked a change in the conduct of monetary policy
 - On the other hand, regime changes have been relatively frequent
- 3 Following an adverse technology shock, the Fed is willing to accept a severe recession in order to fight inflation only under the *Hawk* regime

The role of agents' beliefs

Counterfactual simulations show that:

- 1 Simply imposing the *Hawk* regime throughout the sample would not have prevented inflation from rising in the '70s
- 2 If in the '70s agents had anticipated the appointment of a very conservative chairman, the Great Inflation would have been a less extreme event
- 3 Monetary policy does not need to be constantly hawkish to guarantee low and stable inflation. Deviations are allowed as long as agents' beliefs are not affected: **Constrained discretion**