Evolving Reputation for Commitment: The Rise, Fall and Stabilization of US Inflation

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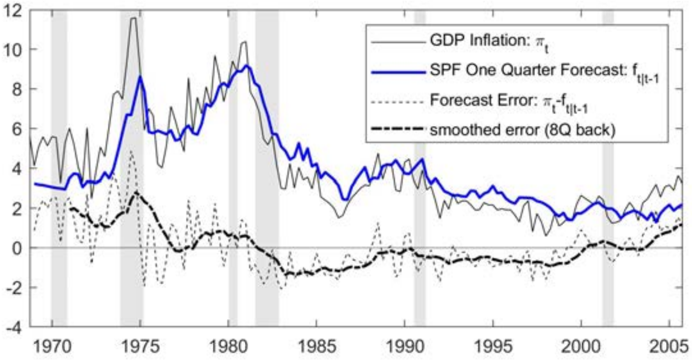
Context and Questions

- Consensus: Managing Expectations is central to inflation policy
  - CB communicates *intentions* about inflation, output, etc
  - Macrotheory portrays CB as dominant player with *strategic power*
  - Strategic power derives from *commitment capability*
- What if private sector is *skeptical* about commitment capability?
  1. what alternative policies expected by private sector?
  2. how committed policymaker affects such perceived alternatives?
  3. what is private sector likelihood of alternative policies happening?
  4. how committed policymaker affects that likelihood (reputation)?
- How important is evolving reputation for commitment?
  - Conceptually, for choices by committed policymaker
  - Empirically, for joint behavior of US expected and actual inflation.

Features of US inflation: private sector learning

Quarterly PGDP inflation and prior quarter SPF forecast



- Lengthy runs of positive and negative forecast errors
- Croushore (2010), Coiboin, et al (2018), Farmer, et al (2023).

1980s Learning about monetary policy | 1990s Markov Switching Studies

What we do theoretically

Mechanism design approach to solve PBE recursively

A regime-switch model with private sector learning, but

- Purposeful committed policymaker type
  - strategically uses its policy plan to “manage expectations"
- Purposeful opportunistic policymaker type
  - responds to expectations
- Imperfect public monitoring
  - richer reputation dynamics
  - reputation loss depends on deviation of outcome from plan
- Forward-looking expectations
  - expectations can be used to smooth shocks

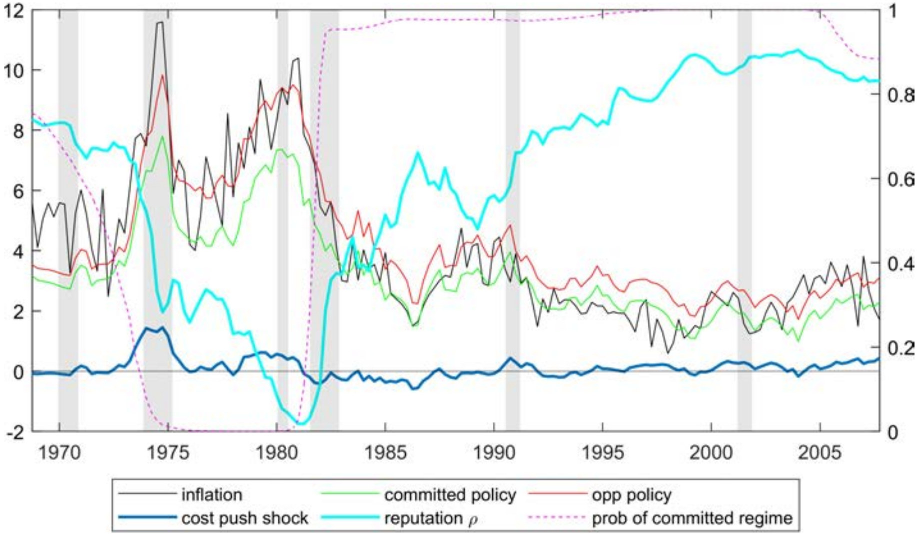
What we do quantitatively

Model-consistent nonlinear Kalman filter with Markov-switching

- Extract latent states (reputation etc.) only from SPF1Q, SPF3Q
- Model-implied inflation tracks observed inflation
- Smoothed probability of policymaker replacement peaks at 1981
- Smoothed probability of policymaker type at each date
  - opportunistic policy closer to observed inflation 1970-1981
  - committed policy closer to observed inflation 1981-2005
- Counterfactual: naive committed policymaker
  - optimizes **without influence on private sector learning**
  - lengthy period of low reputation and high inflation

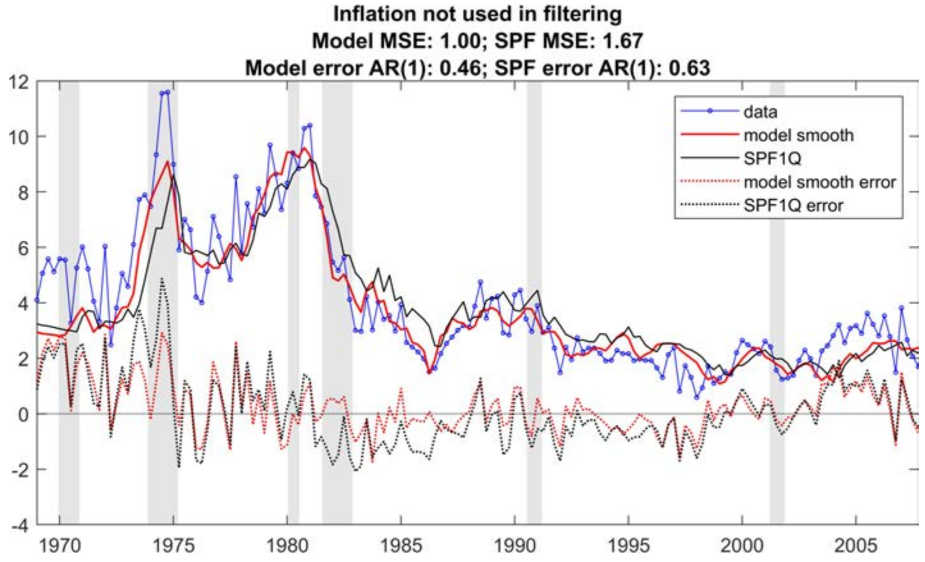
Preview: Reputation and Cost-push Shock

Smoothed estimates based on matching model expectations to SPF fullsample



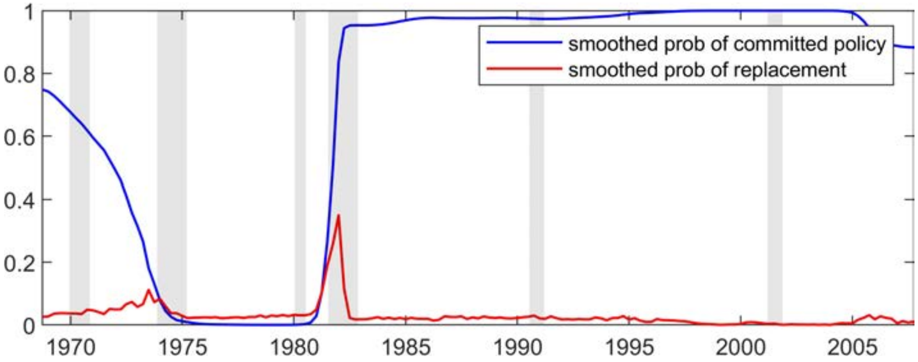
Preview: Model-implied Inflation versus SPF1Q

Smoothed estimates based on matching model expectations to SPF fullsample



Preview: Retrospective Estimates of Prevailing Regime

Smoothed estimates based on matching model expectations to SPF fullsample



Policymaker: type and objective

- Committed type (τ_a) chooses and commits to contingent plan $\{a_t\}_{t=0}^{\infty}$
- Opportunistic type (τ_α) chooses intended policy α_t
- Inflation deviates from policy intentions by i.i.d. error $v_\pi \sim N(0, \sigma_{v,\pi})$

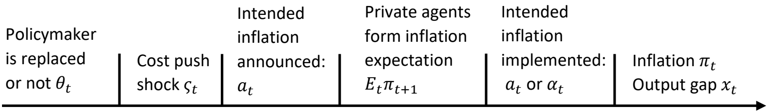
$$\pi_t = \begin{cases} a_t + v_{\pi,t} & \text{with committed type } \tau_a \\ \alpha_t + v_{\pi,t} & \text{with opportunistic type } \tau_\alpha \end{cases} \tag{1}$$

- Quadratic objective in inflation π and output gap x

$$u(\pi, x) = -\frac{1}{2}\{(\pi - \pi^*)^2 + \vartheta_x (x - x^*)^2\} \tag{2}$$

- Committed type (τ_a) patient with β_a
- Opportunistic type (τ_α) myopic

Private sector: information and NK inflation dynamics



- Information structure
  - Policymaker is replaced ($\theta = 1$) w/ prob q each period.
  - Replacement event is observed by private agents.
  - Policymaker type and policy intention not observed.
  - Private agents must learn policymaker type from π_t.
- NK standard Phillips curve

$$\pi_t = \underbrace{\beta E_t^p \pi_{t+1}}_{e_t} + \kappa x_t + \varsigma_t \tag{3}$$

ς Markov-chain cost-push shock

Reputation and Inflation Expectations

- History within a regime $h_t = \{h_{t-1}, \pi_{t-1}, \varsigma_t\}$
- **Reputation** within a regime $\rho(h_t) = \Pr(\tau_a | h_t)$

$$\rho\left(h_{t+1}\right) = \rho\left(h_t, \pi_t\right) \equiv \frac{\rho\left(h_t\right) g(\pi_t | a\left(h_t\right))}{\rho\left(h_t\right) g(\pi_t | a\left(h_t\right)) + (1 - \rho\left(h_t\right)) g(\pi_t | \alpha\left(h_t\right))} \quad (4)$$

- Private sector inflation expectations: Detail

$$\begin{aligned} e(h_t) &= \beta E^p(\pi_{t+1} | h_t) \\ &= \beta \rho(h_t) \underbrace{E\pi_{t+1} | (h_t, \tau_a)}_{\text{committed policy}} + \beta(1 - \rho(h_t)) \underbrace{E\pi_{t+1} | (h_t, \tau_\alpha)}_{\text{opportunistic policy}} \end{aligned} \quad (5)$$

- Reputation passes on to a new regime with prob δ_ρ
  - New policymaker's reputation $\rho_0 = \phi_t \rho(h_t) + (1 - \phi_t) v_{\rho,t}$
  - $\phi_t \sim$ Bernoulli(δ_ρ) and $v_{\rho,t} \sim$ Beta$(\overline{\rho}, \sigma_\rho)$.

Optimal opportunistic policy for myopic case

- Opportunistic type optimizes taking expected inflation as given

$$\alpha = \underset{\alpha}{\text{argmax}} \int u(\pi, x) g\left(\pi|\alpha\right) d\pi \tag{6}$$

s.t.

$$\pi = e(h_t) + \kappa x + \varsigma$$

- Linear best response

$$\alpha(h_t) = Ae(h_t) + B(\varsigma_t) \tag{7}$$

- Lower optimal $\alpha(h_t)$ if lower $e(h_t)$.

Forward-looking alternative

Inflation bias without commitment

contrasting two concepts

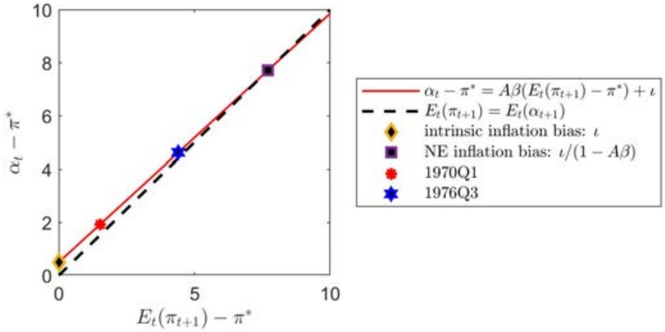
$$\alpha(e) = Ae + B(\varsigma), A = .94, \beta = .995$$

- Intrinsic inflation bias (small)

$$\alpha(e = \beta\pi^*) - \pi^* = 0.5\%.$$

- Nash Eq inflation bias (BIG)

$$\alpha(e = \beta\alpha) - \pi^* = 8\%$$



Optimal committed policy plan

At start of his term, choose $\{a(h_t)\}_{t=0}^{\infty}$ to maximize

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta_a^t (1-q)^t \underline{u}\left(a(h_t), e(h_t), \varsigma_t\right)$$

$\underline{u}\left(a, e, \varsigma\right) \equiv \int u(\pi, x(\pi, e, \varsigma)) g(\pi|a) d\pi$ and $x(\pi, e, \varsigma) = \frac{\pi - e - \varsigma}{\kappa}$

- "Strategic power" of $\{a(h_t)\}_{t=0}^{\infty}$ on $\{e(h_t)\}_{t=0}^{\infty}$
  - **manage expectation**: $a(h_{t+1})$ directly affects $e(h_t)$
  - **manage perceived alternative**: $\alpha(h_t)$ best response to $e(h_t)$
  - **build reputation**: $a(h_{t-1})$ and $\alpha(h_{t-1})$ affect $\rho(h_t)$.

Mechanism design approach for within-regime equilibrium

Committed type chooses $\{a_t, \alpha_t, e_t\}_{t=0}^{\infty}$ to maximize

$$U_0 = E_0\{\sum_{t=0}^{\infty} \beta_a^t (1-q)^t \underline{u}(a_t, e_t, \varsigma_t)\} \tag{8}$$

subject to 3 constraints each period:

1. Rational inflation expectations: $e_t = \beta E_t^p \pi_{t+1}$
2. Incentive compatibility of opportunistic policy: $\alpha_t = Ae_t + B(\varsigma_t)$
3. Bayesian learning: $\rho_{t+1} = \frac{\rho_t g(\pi_t|a_t)}{\rho_t g(\pi_t|a_t)+(1-\rho_t)g(\pi_t|\alpha_t)}$

Change of measure

Recursive optimal policy problem for committed type

Generalization of Bellman (using pseudo state μ):

$$W(\varsigma, \rho, \mu) = \min_{\gamma} \max_{a,\alpha,e} \{ \underline{u}(a, e, \varsigma, \tau_a) + (\gamma e + \mu\omega) \tag{9}$$

$$+\beta_a (1-q) \int \sum_{\varsigma'} \varphi(\varsigma'; \varsigma)\, W(\varsigma', \rho', \mu')\, g(\pi|a)\, d\pi \}$$

subject to $\alpha = Ae + B(\varsigma)$ and

$$\omega \equiv -[(1-q)\,a + qz] - \frac{1-\rho}{\rho}[(1-q)\,\alpha + qz] \tag{10}$$

$$\mu' = \frac{\beta}{\beta_a (1-q)} \gamma\rho, \text{ with } \mu_0 = 0 \tag{11}$$

$$\rho' = \frac{\rho g(\pi|a)}{\rho g(\pi|a) + (1-\rho)\, g(\pi|\alpha)} \tag{12}$$

Contrast to NK Ramsey

Linking the theory to the data

Model inputs

- 3 structural shocks $v_t = (v_\varsigma, v_\rho, v_\pi)$
- 3 state variables $s_t = (\varsigma_t, \rho_t, \mu_t)$
- 3 discrete states $\Theta_t = (\theta_t, \phi_t, \tau_t)$ Def and Trans

Model outputs:

- committed and opportunistic policies $a(s_t)$ and $\alpha(s_t)$
- inflation $\pi_t = \tau_t a(s_t) + (1 - \tau_t)\alpha(s_t) + v_{\pi,t}$
- inflation forecasts at various horizons $E^p(\pi_{t+k}|s_t) = e(s_t, k)$

Data:

- SPF inflation forecasts at various horizons
- Inflation, food and energy price shock

State space model with Markov-switching

$$X_t = [\varsigma_t, \rho_t, \mu_t, \pi_t]' = F(X_{t-1}, v_t | \Theta_t = (\theta_t, \phi_t, \tau_t))$$

$$= \begin{bmatrix} \delta_\varsigma \varsigma_{t-1} + v_{\varsigma,t} \\ (1-\theta_t+\theta_t\phi_t) b(\varsigma_{t-1}, \rho_{t-1}, \mu_{t-1}, \pi_{t-1}) + \theta_t(1-\phi_t) v_{\rho,t} \\ (1-\theta_t) m(\varsigma_{t-1}, \rho_{t-1}, \mu_{t-1}) \\ \tau_t a(\varsigma_t, \rho_t, \mu_t) + (1-\tau_t)\alpha(\varsigma_t, \rho_t, \mu_t) + v_{\pi,t} \end{bmatrix}$$

$$Y_t = \begin{bmatrix} f_{t+1|t} \\ f_{t+2|t} \\ f_{t+3|t} \\ f_{t+4|t} \\ \frac{1}{40}\sum_{k=1}^{40} f_{t+k|t} \\ \widetilde{\pi}_t \\ \widetilde{\varsigma}_t \end{bmatrix} = \begin{bmatrix} e(\varsigma_t, \rho_t, \mu_t, 1) + u_{1t} \\ e(\varsigma_t, \rho_t, \mu_t, 2) + u_{2t} \\ e(\varsigma_t, \rho_t, \mu_t, 3) + u_{3t} \\ e(\varsigma_t, \rho_t, \mu_t, 4) + u_{4t} \\ \overline{e}(\varsigma_t, \rho_t, \mu_t, 40) + u_{40,t} \\ \pi_t + u_{\pi t} \\ \varsigma_t + u_{zt} \end{bmatrix} = H(X_t, u_t)$$

State space model with Markov-switching

$$X_t = [\varsigma_t, \rho_t, \mu_t, \pi_t]' = F(X_{t-1}, v_t | \Theta_t = (\theta_t, \phi_t, \tau_t))$$

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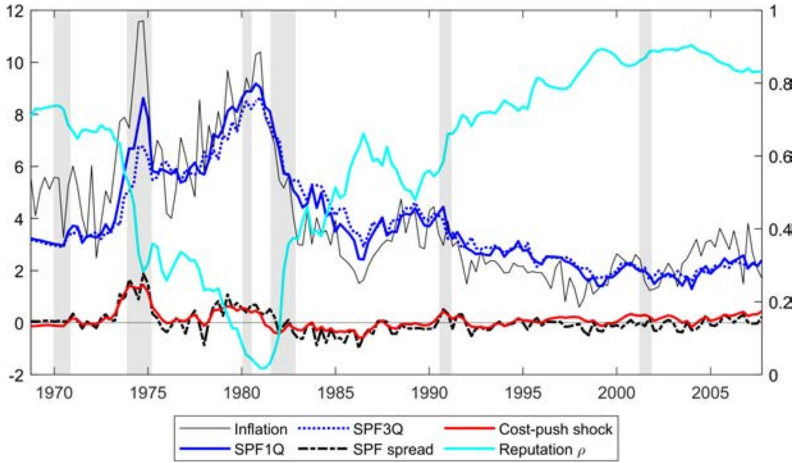
Extracting states: term structure intuition about SPF



- SPF1Q more sensitive to temporary price shocks
- SPF3Q better reflects reputation

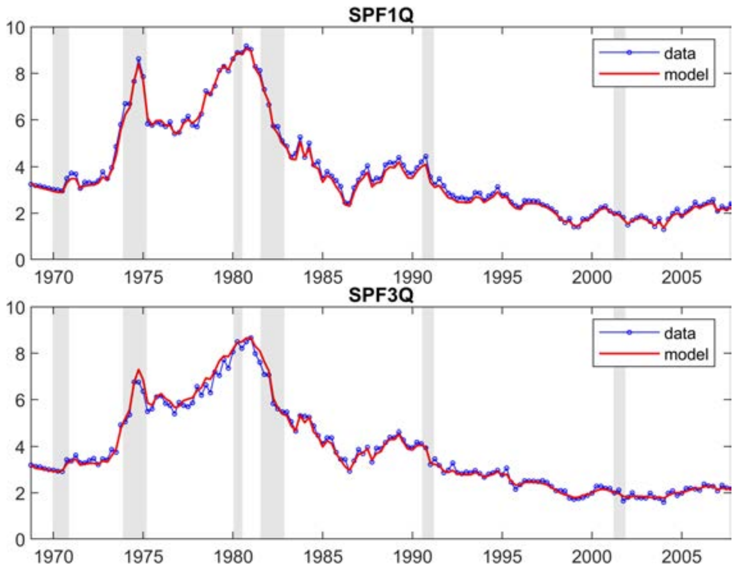
Calibration of parameters

β, β_a	Discount factor (private, committed type)	0.995
q	Replacement probability	0.03
κ	PC output slope	0.08
π^*	Inflation target	1.5%
ϑ_x	Output weight	0.1
x^*	Output target	1.73%
δ_ς	Persistence of cost-push shock	0.7
$\sigma_{v,\varsigma}$	Std of cost-push innovation	0.7%
$\sigma_{v,\pi}$	Std of implementation error v_π	1.2%
δ_ρ	prob of reputation inheritance	0.9
$\overline{\rho}$	mean of reputation draw	0.1
σ_ρ	std of reputation draw	0.05

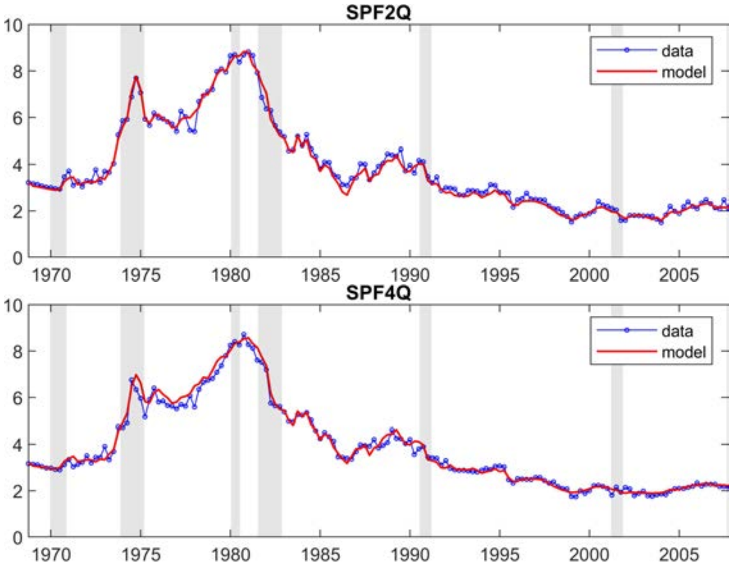
- Implies $A = 0.94$, $\iota = 0.5\%$, NE bias$= 8\%$

Calibration

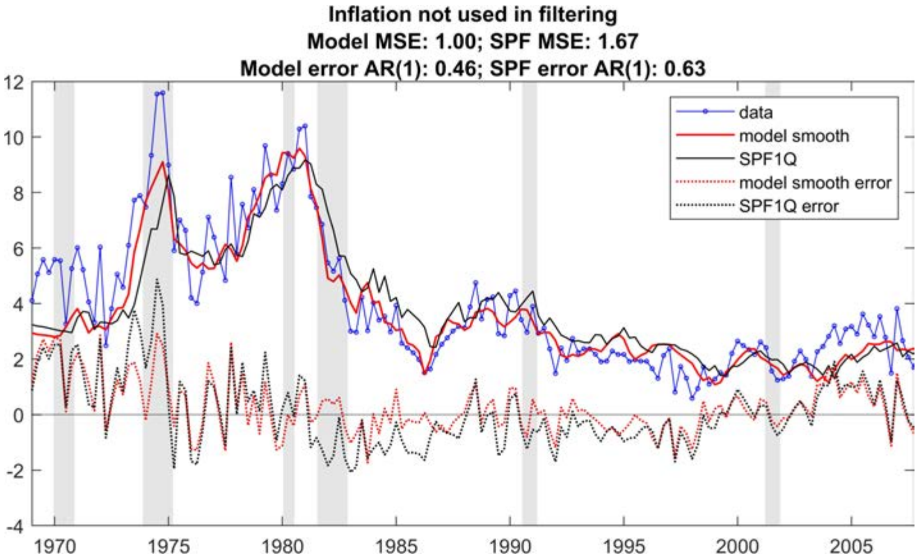
Fitting SPFs



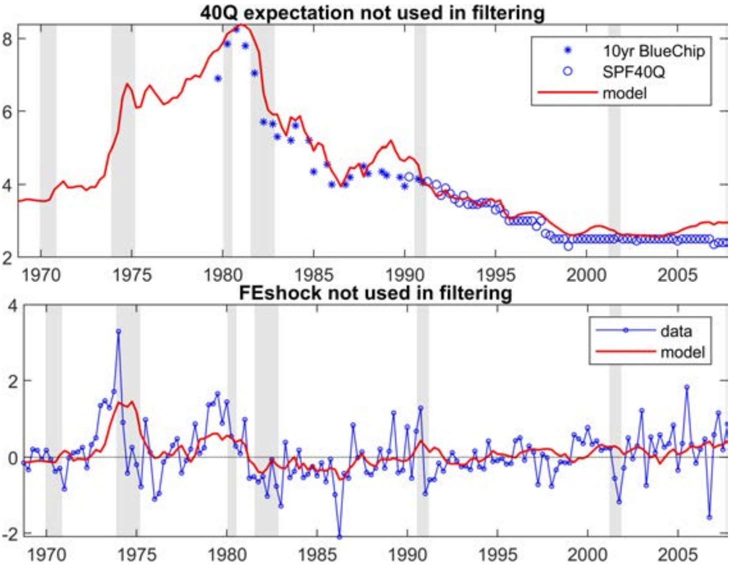
Untargeted: SPF2Q and SPF4Q



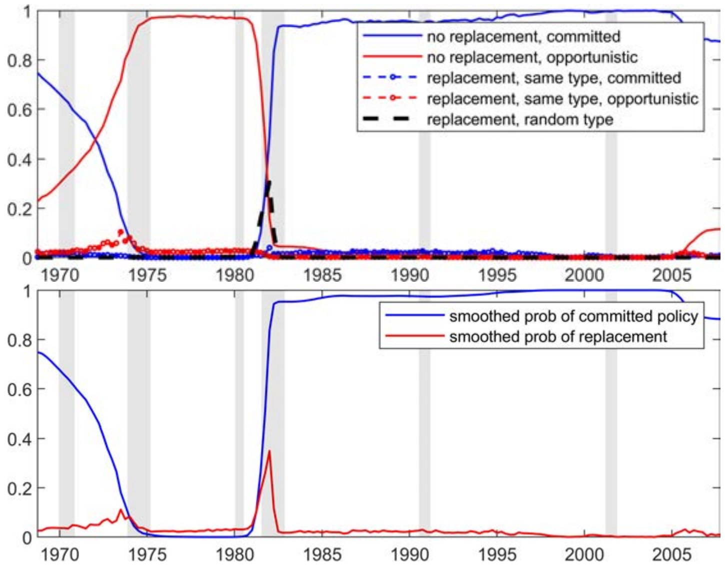
Untargeted: Inflation filtered result



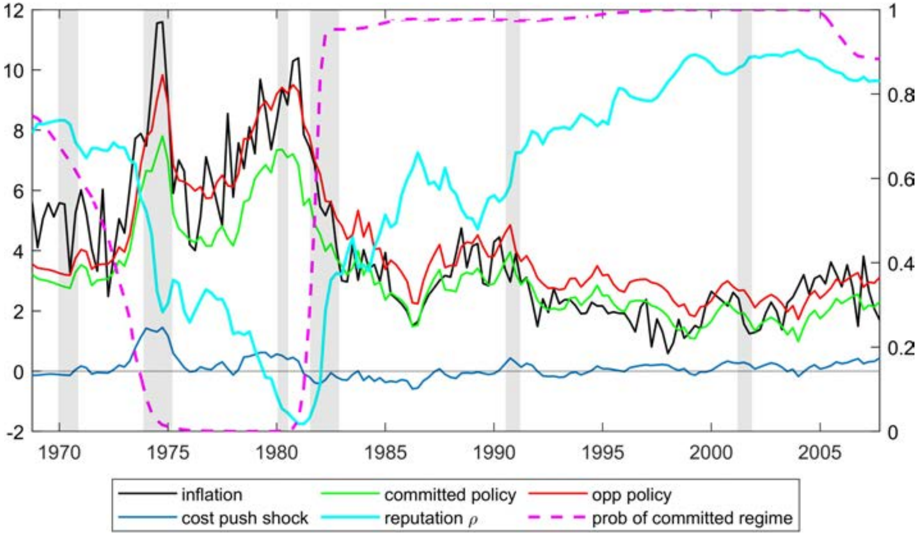
Untargeted: SPF40Q, Food and Energy Price Shock long



Smoothed Probability



Model-based interpretation of inflation history



Counterfactuals with Naive Committed Policy

Literature on dynamics of U.S. inflation

- Policymaker belief change: Sargent (1999), Primiceri (2006)
- Possible regime change: Bianchi (2013), Debortoli & Lakdawla (2016)
- Private agent learning: Orphanides & Williams (2005), Cogley et al (2005), Matthes (2015), Melosi (2016).

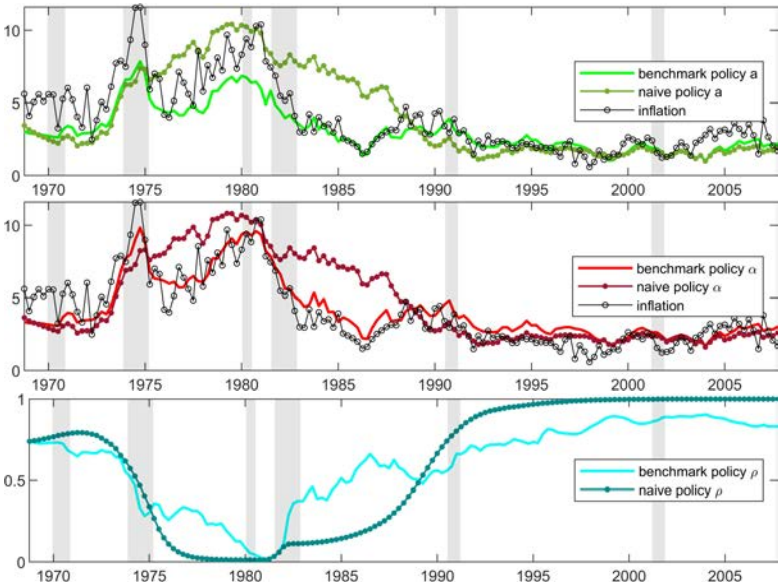
Our **committed type influences private agents' belief** (reputation)

- eq belief and optimal policy fit expected inflation and actual inflation

Counterfactual: **shut down reputation management**

- reputation still evolves endogenously according to Bayes' rule
- CB responds to time-varying reputation (Kreps, Cogley & Sargent)
- same cost-push shocks, discrete states prob, zero implementation errors

Naive Committed Policy counterfactual



Benchmark v.s. Naive Committed Policies

Blue: Benchmark committed

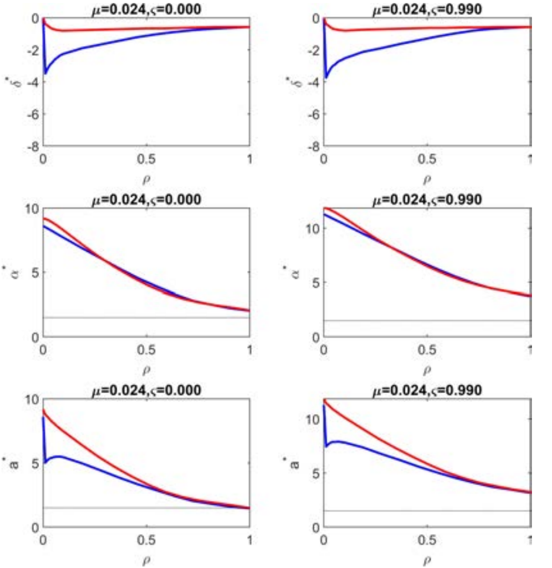
- larger $|a - \alpha|$ at lower ρ
- reputation building

Red: Naive committed

- smaller $|a - \alpha|$ at lower ρ
- accommodating only

Take-away:

- Naive committed policy $->$ lengthy period of low reputation and high inflation



Summary and conclusions

- Our model:
  - Monetary regimes, optimal inflation policies, and private agent learning
  - Committed regime policies: managing expectations
  - Opportunistic regime policies: responding to expectations
  - Interplay between agents learning and optimal policies
- Our results:
  - Extract states only from SPF1Q and SPF3Q
  - Inflation data well tracked by model-implied inflation
  - A policymaker type switch from opportunistic to committed in 1981
  - Managing reputation important for escaping low reputation trap

What about signaling? What's the simple narrative?

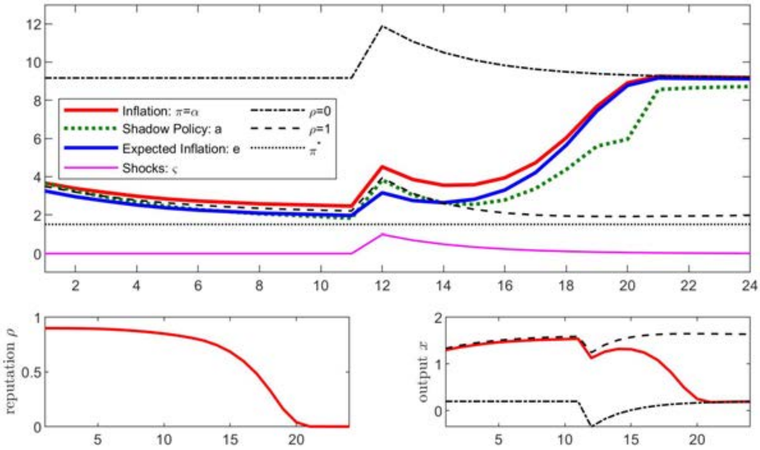
Summary and conclusions

- Our methods
  - Dynamic game with expectations linkages across periods
  - Equilibrium via mechanism design approach
  - Recursive formulation
  - Model-consistent nonlinear Kalman filter with Markov-switching
- Looking forward
  - term structure of interest rates
  - long horizon opportunistic type

Opportunistic regime simulation

Great inflation style: high initial reputation 0.9, response to 1% supply shock in t=12

$\pi = \alpha$: slow learning for a long while, supply shock speeds up learning



Learning and policy analysis

of course, we're not the first to think about learning and monetary policy

- Baxter (JME 85): "Role of Expectations in Stabilization Policy"
- Bayesian learning (BL) about unobserved policy
- Optimal policy by non-committed type with private sector BL
  - Backus and Driffill (AER 85): "Inflation and Reputation"
  - Barro (JME 86): "Rules, Discretion, and Reputation..."
- FRBUS (from its earliest days)
  - analysis with model consistent expectations
  - analysis with VAR expectations (sometimes with coefficient updating)
- Erceg and Levin (JME 2003): "Imperfect Credibility ..."
  - Volcker disinflation when agents must learn Taylor rule intercept

Learning and policy analysis

of course, we're not the first to think about learning and monetary policy

- Cukierman's theoretical work closest to us, but expectations aren't forward looking
- *We think our analysis*
  - develops and displays a new toolkit for studying these issues
  - reaches new substantive conclusions
  - provides path for connecting dynamic equilibrium models to data
- But no "Managing Beliefs Under Discretion", Mertens (JMCB 2016)

Return

Evidence of learning in survey data

1990s regime switching analyses by Evans and Wachtel

- Markov switching with stochastic trend in regime 2

$$\begin{aligned}
\pi_t &= \pi_{1t} s_t + (1 - s_t)\pi_{2t} \\
\pi_{1t} &= c_0 + c_1 \pi_{1,t-1} + \nu_{1t} \\
\pi_{2t} &= \pi_{2,t-1} + \nu_{2t}
\end{aligned}$$

Evidence of learning in survey data

1990s regime switching analyses by Evans and Wachtel

- Econometric results: estimates and implications

$$\begin{aligned} \lambda_t &= pr(s_t = 1|\Omega_t) \\ E\pi_{t+k}|\Omega_t &= \lambda_t E\pi_{t+k}|(s_t = 1, \Omega_t) + (1-\lambda_t) E\pi_{t+k}|(s_t = 2, \Omega_t) \end{aligned}$$

- runs of forecasting errors, just as in survey data
- correspondence of estimated and survey expectations
- λ_t jumps in 73, falls back, jumps again in 78, falls in 80, ...
- stochastic trend must be increasing through 70s, but not shown

Our private agents must learn about type (parameter), not trend (process)

Learning is hard in our regime change model: π depends on expectations

Return

An opportunistic policymaker chooses intended inflation α each period to maximize the expected objective, taking the nature of expected inflation's response to history $\{e(h_t)\}_{t=0}^{\infty}$ as given. His strategy is sequentially rational if it satisfies the first-order condition

$$\begin{aligned} 0 &= \int u(\pi_t, e_t, \varsigma_t, \tau_\alpha) g_\alpha(\pi_t|\alpha_t)\, d\pi_t \\ &\quad + (\beta_2(1-q)) \int \sum_{\varsigma_{t+1}} \varphi(\varsigma_{t+1}; \varsigma_t) V(\varsigma_{t+1}, \pi_t, h_t)\, g_\alpha(\pi_t|\alpha_t)\, d\pi_t \end{aligned}$$

where α_t is evaluated at optimal $\alpha(h_t)$, with

$$\begin{aligned} V(h_t) &= \int u(\pi_t, e_t, \varsigma_t, \tau_\alpha) g(\pi_t|\alpha_t)\, d\pi_t \\ &\quad + (\beta_2(1-q)) \int \sum_{\varsigma_{t+1}} \varphi(\varsigma_{t+1}; \varsigma_t) V(h_{t+1})\, g(\pi_t|\alpha_t)\, d\pi_t \end{aligned}$$

- Our approach to constructing equilibria (developed next) appears to be able to handle a long horizon alternative
- This extension adds a state variable, influenced by inflation outcomes
- Opportunistic type has no strategic power over expected inflation
- But it does have a sophisticated forecasting model for the states that influence inflation expectations
- It chooses its intended inflation taking these connections into account
- Such an extension of our analysis of the *committed type's* optimal decisions would deliver both optimal α and this forecasting model.

Return

- If regime changes in period t, private sector nowcast of inflation:

$$z(h_t) = \int [\rho_0 a(\rho_0, \varsigma_t) + (1-\rho_0)\alpha(\rho_0, \varsigma_t)]\, d\Xi(\rho_0|\rho(h_t))$$

- conditional on committed type: $E\pi_{t+1}|(h_t, \tau_a) =$ $\int \sum_{\varsigma_{t+1}} \varphi(\varsigma_{t+1}; \varsigma_t)\,[(1-q)\,a(h_{t+1}) + qz\,(h_{t+1})]\, g(\pi_t|a(h_t))d\pi_t$
- conditional on opportunistic type: $E\pi_{t+1}|(h_t, \tau_\alpha) =$ $\int \sum_{\varsigma_{t+1}} \varphi(\varsigma_{t+1}; \varsigma_t)\,[(1-q)\,\alpha(h_{t+1}) + qz\,(h_{t+1})]\, g(\pi_t|\alpha(h_t))d\pi_t$

Rational inflation beliefs average across two policymaker types, as above

$$e(h_t) = \beta\rho(h_t) E\pi_{t+1}|(h_t, \tau_a) + \beta(1-\rho(h_t)) E\pi_{t+1}|(h_t, \tau_\alpha)$$

Note presence of reputation (ρ) and prospective regime change (q)

Return

There is a subtlety in developing recursive Lagrangian component

$$\Psi_t = E_t \sum_{j=0}^{\infty} (\beta_a(1-q))^j \{\gamma_{t+j}[e_{t+j} - \beta E_t^p(\pi_{t+j+1})]\} \tag{13}$$

– committed type *knows* he is generating h_t

– private agents *think* opportunistic type may be generating h_t.

Using the committed type's probabilities

$$\Psi_t = \sum_{j=0}^{\infty} (\beta_a(1-q))^j \sum_{h_{t+j}} \frac{p(h_{t+j})}{p(h_t)} \gamma(h_{t+j})[e(h_{t+j}) - \beta E^p(\pi_{t+j+1}|h_{t+j})]$$

$E^p(\pi_{t+1}|h_t)$ include the probability of inflation under the alternative type. So, we undertake a "change of measure" and rewrite that part as

$$\int \sum_{\varsigma_{t+1}} \varphi(\varsigma_{t+1};\varsigma_t)[\beta(1-q)\alpha(h_{t+1}) + \beta q z(h_{t+1})]\lambda(\mathbf{h_{t+1}})g(\pi|a(h_t))d\pi$$

where $\lambda(h_{t+1})$ is the likelihood ratio $\frac{g(\pi_t|\alpha(h_t))}{g(\pi_t|a(h_t))}$

Returning to (9), we can write it as

$$\Psi_t = E_t^c[\sum_{j=0}^{\infty}(\beta_a(1-q))^j \psi_{t+j}]$$

$$\psi_t \equiv \gamma_t e_t - \frac{\beta}{\beta_a(1-q)}\gamma_{t-1}\{\rho_{t-1}[(1-q)a_t + qz_t] + (1-\rho_{t-1})\lambda_t[(1-q)\alpha_t + qz_t]\}$$

This expression captures past commitments about current state-contingent decisions as relevant to past inflation expectations, including the predetermined λ_t . Note that at the start of the regime, when $t = 0$, $\gamma_{t-1} = 0$ by assumption. The initial condition on reputation specifies ρ_0. Defining a pseudo state proportional to $\gamma_{t-1}\rho_{t-1}$ and eliminating λ using Bayes' rule, ψ may be rewritten to reduce state variables and clutter as $\psi_t = \gamma_t e_t - \mu_t\{(1-q)a_t + qz_t] + \frac{(1-\rho_t)}{\rho_t}[(1-q)\alpha_t + qz_t]\}$. Return

Public Perfect Bayesian Equilibrium

Define public history: $h_t = \{h_{t-1}, \pi_{t-1}, \varsigma_t\}$

Definition

A Public Perfect Bayesian Equilibrium is a set of functions $\{z(h_t), e(h_t), \rho(h_t), \alpha(h_t), a(h_t)\}_{t=0}^{\infty}$ such that in each history:
(i) given $\alpha(h_t)$, $a(h_t)$, and $\rho(h_t)$, the private sector's nowcast of inflation conditional on a replacement $z(h_t)$ satisfies (8);
(ii) given the policymaker's strategies, $\alpha(h_t)$, $a(h_t)$, and $z(h_t)$, the private sector's belief function $\rho(h_{t+1})$ is updated according to (4); and its expected inflation function $e(h_t)$ satisfies (5);
(iii) given the expected inflation function, $e(h_t)$, the action of the opportunistic type policymaker $\alpha(h_t)$ maximizes his expected payoff (6); and, at the start of a regime (t=0),
(iv) the strategy for the committed type policymaker $\{a(h_t)\}_{t=0}^{\infty}$ maximizes his expected payoff (8), taking into account the strategic power of $\{a(h_t)\}_{t=0}^{\infty}$ on $\{e(h_t)\}_{t=0}^{\infty}$.

Return

Modeling Strategy

Why nonstandard? why so complicated?

The standard recipe for optimal policy design proceeds as follows within a static model with two tyes of policymakers that have objectives $\underline{u}(a, e, \tau_a)$ and $\underline{u}(\alpha, e, \tau_\alpha)$. First, assume that the expected rate of inflation, e, is based on the private sector's assumed inflation actions $\widehat{a}$ and $\widehat{\alpha}$ for the committed and alternative types respectively, together with the probability that it attaches to inflation being generated by each type.

$$e(\rho, \widehat{a}, \widehat{\alpha}) = (1 - \rho)\widehat{a} + (1 - \rho)\widehat{\alpha}$$

Second, compute the best response of alternative policy to expectations, $\alpha(\rho, e)$, perhaps by using a first order condition $\frac{\partial}{\partial \alpha}\underline{u}(\alpha, e, \tau_\alpha) = 0$. Third, imposing $\widehat{\alpha} = \alpha(e, \rho)$, determine $e(\rho, \widehat{a}) = e(\rho, a, \alpha(e, \rho))$. Fourth, confronting the committed type with this consistent set of expectations, the policy a that maximize $\underline{u}(a, e(\rho, a), \tau_a)$. The result will be an equilibrium function $a(\rho)$ that can be used to construct $\alpha(\rho)$ and $e(\rho)$, Our principal agent approach doesn't require this sequence of expectations function constructions. Instead, we maximize the objective

$$\max_{a,\alpha,e} \underline{u}(a, e, \tau_a)$$

subject to a rational expectations constraint

$$e = \rho a + (1 - \rho)\alpha$$

and the implementation constraint, which can be expressed as $\alpha = \arg\max_{\widetilde{\alpha}} \underline{u}(\widetilde{\alpha}, e, \tau_\alpha)$ and in various other ways including the best response function $\alpha - \pi^* = A(e - \pi^*) + \iota$.

Key trade-off for the committed type

When private sector rationally expects future equilibrium decision rules $a^*(\varsigma', \rho', \mu')$, $\alpha^*(\varsigma', \rho', \mu')$, $z^*(\varsigma', \rho')$,

there is an operational expectation function

$$e = e(\delta, \mu'; \varsigma, \rho) \tag{14}$$

so that committed type chooses e by via (δ, μ')

- $\delta = a - \alpha$ determines ρ': building reputation
- μ': managing expectation

Return

Reduced recursive optimization

Using operational expectation function:

$$W(\varsigma, \rho, \mu) = \max_{\delta, \mu'} u(\delta, \mu') + \mu\omega(\delta, \mu') + \beta_a (1-q)\, \Omega(\delta, \mu') \tag{15}$$

where $e = e(\delta, \mu'; \varsigma, \rho)$, $\alpha = Ae + B(\varsigma)$, $a = \alpha + \delta$ and

$$\begin{aligned}
u(\delta, \mu') &= \underline{u}(a, e, \varsigma, \tau = 1) && (16)\\
\omega(\delta, \mu') &= -\frac{1}{\rho}\left[(1-q)\,\alpha + qz(\varsigma, \rho)\right] - (1-q)\,\delta && (17)\\
\Omega(\delta, \mu') &= \int \sum_{\varsigma'} \varphi(\varsigma'; \varsigma)\, U^*(\varsigma', b(\varepsilon_a, \varepsilon_a + \delta, \rho), \mu')\, \phi(\varepsilon_a) d\varepsilon_a && (18)
\end{aligned}$$

with $U^*(\varsigma, \rho, \mu) = W(\varsigma, \rho, \mu) - \mu\omega^*(\varsigma, \rho, \mu)$ and $\omega^*(\varsigma, \rho, \mu) = \omega(\delta^*, \mu'^*)$.

Return

Modeling Strategy

Why nonstandard? why so complicated?

There is likely only a modest gain or none in the static context described here. However, as shown in this paper, the principal agent approach makes it possible for us to determine **a recursive dynamic equilibrium when inflation expectations link periods together**. Further, it both **identifies the relevant state variables** for our committed type and provides a **Bellman-like program for computing optimal outcomes** $a(s), \alpha(s)$ and $e(s)$ in a setting where an **evolving reputation** ρ is an element of the state vector. We have developed a powerful approach that **simplifies** the analysis of many environments of interest.

Return

Optimal intended inflation with commitment

Recursive optimal policy problem: actually very familiar

- Without reputation dynamics or opportunistic type or replacement and assuming same discount factor $\beta = \beta_a$ so that $\mu' = \gamma$

$$W(\varsigma, \mu) = \min_{\gamma} \max_{a,e} \{u(a, e, \varsigma) - \mu a + \gamma e + \beta \sum_{\varsigma'} \varphi(\varsigma'; \varsigma) W(\varsigma', \mu')$$

- Solution: standard NK optimal policy, expectations management
  - lagged multiplier $(\mu_t = \gamma_{t-1})$ captures past commitments
  - linear first order conditions govern optimal (a, e, γ) with states ς, μ
  - multiplier evolves according to $\mu' = \gamma(\varsigma, \mu)$
- Feature: startup inflation (from initial $\mu = 0$ but choked off by rising μ)
  - eliminated by analysts employing "timeless perspective"
  - necessary given our emphasis on "regime change": new policymakers!

Return

Solving the model

using an approach motivated by potential nonlinearities

With a set of guessed functions $z(\varsigma, \rho)$, $a(\varsigma, \rho, \mu), \alpha(\varsigma, \rho, \mu)$ and $U(\rho, \eta, \varsigma)$,

1. obtain an operational expectation function $e(\delta, \mu'; \varsigma, \rho)$ and the expected continuation function $\Omega(\delta, \mu'; \varsigma, \rho)$;
2. use $\alpha = Ae + B(\varsigma)$ to determine $\alpha(\delta, \mu'; \varsigma, \rho)$ and $a(\delta, \mu'; \varsigma, \rho)$;
3. evaluate the committed type's payoff as in (15) for each pair (δ, μ');
4. identify (δ, μ') maximizing committed type's payoff for each (ς, ρ, μ);
5. use optimal (δ, μ') to update guessed functions.

Iterate until the policy functions converge.

Return

PC slope, weight on output gap variability

- π is percent qar and x is a percent deviation.
- $\kappa = 0.08$ implies a relatively flat Phillips curve, consistent with
  - estimates from 1950s and 1960s
  - modern cost-based estimates if low marginal cost elasticity (wrt x)
- $\vartheta_x = 0.1$ translates to $(\bar{\pi} - \pi^*)^2 + 1.6\,(x - x^*)^2$ in annual inflation $\bar{\pi}$

Return to CalibTable

Discrete States and Transition

$$\Theta_t \in \{(\theta_t = 0, \tau_t = 1), (\theta_t = 0, \tau_t = 0), (\theta_t = 1, \phi_t = 1, \tau_t = 1),$$
$$(\theta_t = 1, \phi_t = 1, \tau_t = 0), (\theta_t = 1, \phi_t = 0, \tau_t = 1), (\theta_t = 1, \phi_t = 0, \tau_t = 0)\}$$

with transition prob matrix $P_{i,j} = Pr(\Theta_t = j | \Theta_{t-1} = i)$:

$$\begin{bmatrix} 1-q & 0 & \delta_\rho b_{t-1}^{i=1} q & \delta_\rho (1 - b_{t-1}^{i=1}) q & (1-\delta_\rho)\overline{\rho} q & (1-\delta_\rho)(1-\overline{\rho}) q \\ 0 & (1-q) & \delta_\rho b_{t-1}^{i=2} q & \delta_\rho (1 - b_{t-1}^{i=2}) q & (1-\delta_\rho)\overline{\rho} q & (1-\delta_\rho)(1-\overline{\rho}) q \\ 1-q & 0 & \delta_\rho b_{t-1}^{i=3} q & \delta_\rho (1 - b_{t-1}^{i=3}) q & (1-\delta_\rho)\overline{\rho} q & (1-\delta_\rho)(1-\overline{\rho}) q \\ 0 & (1-q) & \delta_\rho b_{t-1}^{i=4} q & \delta_\rho (1 - b_{t-1}^{i=4}) q & (1-\delta_\rho)\overline{\rho} q & (1-\delta_\rho)(1-\overline{\rho}) q \\ 1-q & 0 & \delta_\rho b_{t-1}^{i=5} q & \delta_\rho (1 - b_{t-1}^{i=5}) q & (1-\delta_\rho)\overline{\rho} q & (1-\delta_\rho)(1-\overline{\rho}) q \\ 0 & (1-q) & \delta_\rho b_{t-1}^{i=6} q & \delta_\rho (1 - b_{t-1}^{i=6}) q & (1-\delta_\rho)\overline{\rho} q & (1-\delta_\rho)(1-\overline{\rho}) q \end{bmatrix}$$

where $b_{t-1}^i := b(\varsigma_{t-1}, \rho_{t-1}, \mu_{t-1}, \pi_{t-1} | \Theta_{t-1} = i)$

Return

During the 1960s and 1970s, the Federal Reserve's ***short run focus*** *led to increasing inflation. As inflation increased, so too did expectations of future inflation, which led to monetary policy actions that repeatedly raised inflation until it reached over 10 percent. The Fed's* ***reputation*** *for being committed to bringing about low inflation fell over this period and its announcements of anti-inflation plans had* ***reduced credibility****.*

1.6 Results compatible with a simple narrative

Disinflation and Stabilization

When the conquest of inflation became a priority around 1980, inflation expectations were stubborn and the Fed had to take especially ***tough policy actions so as to enhance its reputation****. Even though inflation fell to about 2 percent in the late 1980s, issues of imperfect credibility continued to be of importance as the Fed worked to reduce inflation expectations that were about 2 percent higher than actual inflation, in part due to the potential return to earlier policy behavior. By the early 2000s, the Fed's* ***reputation for being committed to low and stable inflation*** *was substantially enhanced, with its policies yielding actual and expected inflation in the 2 percent range.*

Return

What we are not studying in this paper: signaling

but we use perspective developed in earlier research

- Our committed policymaker chooses intended inflation a
  - action assumed not directly observable
  - can issue message $m = a$ and carry through on it
- Our alternative policymaker must also announce $m = a$
- The unique signaling equilibrium
  - developed with small modification of M-OF-P
  - strategic power of $m = a$ over expectations
  - corresponds to our optimal policy
- Lu (JET 2013)
  - tax model with two optimizing policymaker types
  - contains confiscation incentives as in Phelan (JET 2006)
  - proves results just described
  - establishes no mixed strategy announcement equilibria

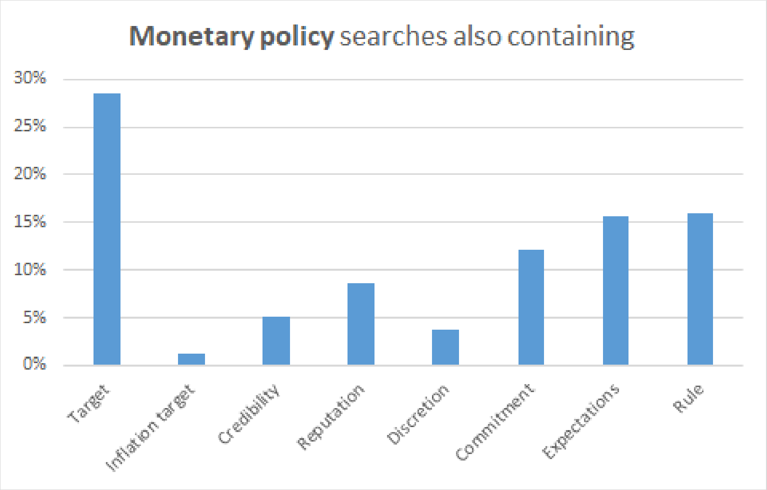
Return

Interest Rates

- The behavior of interest rates is central to many macro policy analyses
- For example, Andy Levin and John Taylor view the Great Inflation as the result of policy mistakes: "getting behind the curve"
- Given our approach, a first step is to look at the behavior of real rates constructed by subtracting SPF expected inflation from nominal rates
- During 1969-2005, it has been pretty standard to think about a 2% real rate as dividing "loose policy" from "tight policy"
- That's the real part of the intercept (r*) in a standard Taylor rule

Googling: policy, reputation and commitment

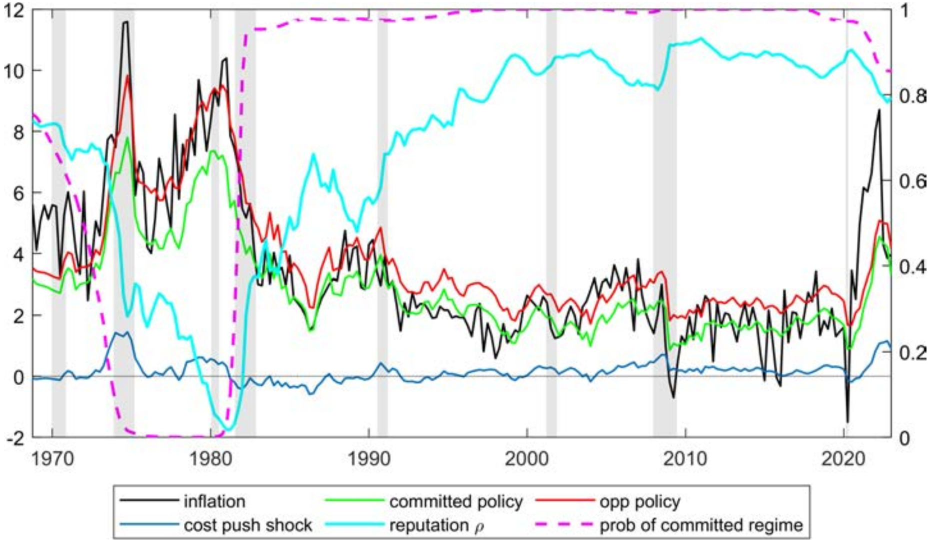
- 52 million hits for "monetary policy"
- Reputation in 9%; Commitment in 12%



Googling: policy, reputation and commitment

- 2 hits for **estimated reputation**, both linked to inflation: one is to the 1994 thesis of Axel Weber, later head of the Bundesbank etc
- 200 hits for **estimated credibility**, more diffuse in topics with many about exchange rate regimes

Full Sample Fit Return



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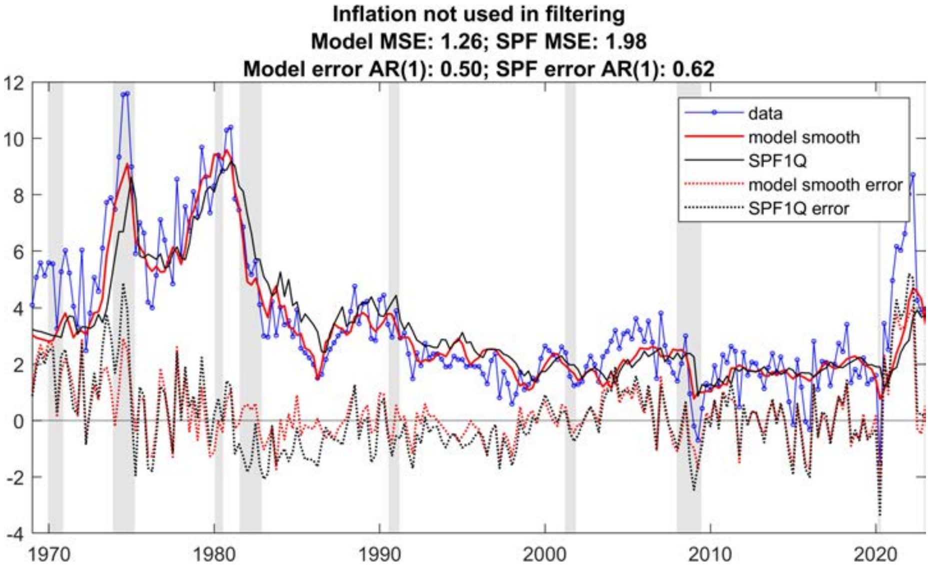

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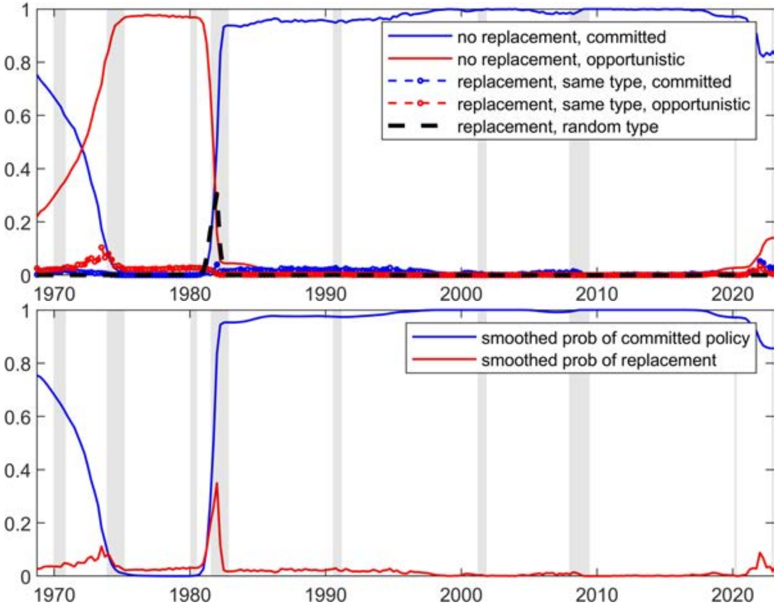

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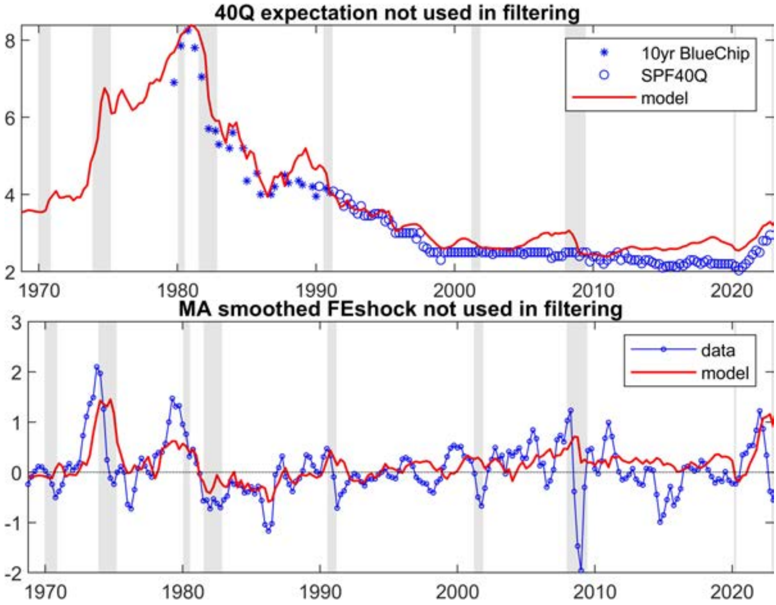

Untargeted inflation: filtered result Return