Post-COVID Inflation: Fed beliefs and Learning

Shreeyesh Menon

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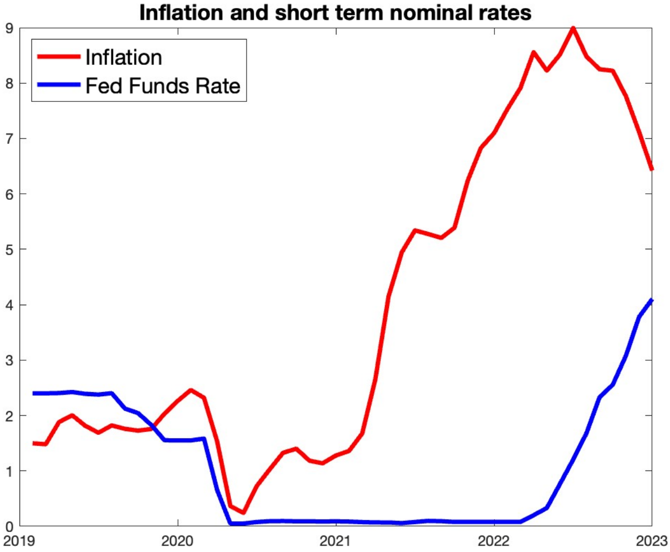
Motivation


Inflation and short term nominal rates
Inflation
Fed Funds Rate
9
8
7
6
5
4
3
2
1
0
2019
2020
2021
2022
2023

Research Questions

- Could the Fed have done better at controlling inflation by tightening sooner?
- Were the Fed's beliefs about the true dynamics of the economy correctly specified?

Overview

- I estimate a model where the central bank learns about the dynamics of the economy from data and updates its beliefs
- The central bank then sets policy based on these beliefs
- Fed estimates a Phillips curve with short term tradeoff b/w inflation and unemployment and policy that affects aggregate demand with a lag

Related Literature

Models with adaptive learning by the Central Bank have featured in work by Sargent (1999), Cogley and Sargent (2004) and Primiceri (2006) among others.

The model I discuss here is closest to Primiceri (2006) featuring a Fed using constant-gain updating for learning.

Constant Gain Learning

Consider the relationship between $\{x_t, y_t\}$ given by:

$$y_t = x_t'\beta + \epsilon_t$$

Under constant gain learning, the estimate is updated at every time step based on new observations of y_t and x_t as:

$$\hat{\beta}_t = \hat{\beta_{t-1}} + gR_{t-1}^{-1}x_t'(y_t - x_t'\hat{\beta_{t-1}})$$

$$R_t = R_{t-1} + g(x_t x_t' - R_{t-1})$$

R_t is the Covariance matrix of regressors.
'g' is the gain
e.g g=0.1 is equivalant to a rolling window regression where only the past 10 observations are used to estimate β

Policy maker's problem

Policy maker knows the true structure of the dynamics of the economy, but not the true parameters. With a welfare-maximization motive, the Fed solves:
min

$$L = E_t \sum_{t=s}^{\infty} \delta^{t-s}[(\pi_t - \pi^*)^2 + \lambda(u_t - \hat{u}_t^N)^2 + \phi(V_t - V_{t-1})^2]$$

s.t

$$\pi_s = c_{\pi,t} - \hat{\theta}(L)(u_{s-1} - \hat{u}^N_{s-1|t}) + \hat{\xi}_s$$

$$\hat{\xi}_s = \hat{\psi}_s \hat{\xi_{s-1}} + \varepsilon_s$$

$$(u_s - \hat{u}^N_{s|t}) = c_{u,t} + \hat{\rho}_t(L)(u_{s-1} - \hat{u}^N_{s-1|t}) + V_{s-1|t} + \eta_s$$

$s \geq t+1$

True Model

Phillips Curve

$$\pi_t = \pi^* - \theta(L)(u_{t-1} - u_{t-1}^N) + \xi_t$$

Cost-push shocks

$$\xi_t = \psi\xi_{t-1} + \varepsilon_t$$

Aggregate Demand

$$(u_t - u_t^N) = \rho(L)(u_{t-1} - u_{t-1}^N) + V_{t-1} + \eta_t$$

Evolution of u_t^N

$$u_t^N = (1-\gamma)u^* + \gamma u_{t-1}^N + \tau_t$$

Updating Beliefs : $\hat{u_t^N}$

Policy-maker's assumption: unemployment on average equals its natural rate

Conditional on the observed inflation, estimate of the natural rate is evaluated using a constant-gain updation:

$$\hat{u^N_{t|t}} = \widehat{u^N_{t-1|t-1}} + g_N(u_t - \widehat{u^N_{t-1|t-1}})$$

Updating Beliefs: Model parameters

Using the estimate of u_t^N, the parameters of the model can be updated in a constant gain setup as:

$$\begin{aligned}\hat{\beta}_t^i &= \hat{\beta}_{t-1}^i + gR_{i,t-1}^{-1}x_t^i\left(y_t^i - x_t^{i\prime}\hat{\beta}_{t-1}^i\right), \\ R_{i,t} &= R_{i,t-1} + g\left(x_t^i x_t^{i\prime} - R_{i,t-1}\right), \qquad i = \{\pi, u\},\end{aligned}$$

$$\hat{\xi}_t = \pi_t - x_t^{\pi\prime}\hat{\beta_{t-1}^{\pi}}$$

$$\hat{\psi}_t = \hat{\psi_{t-1}} + \frac{g\hat{\xi_{t-1}}}{R_{\xi,t-1}}(\hat{\xi}_t - \hat{\psi_{t-1}}\hat{\xi_{t-1}})$$

Optimal Policy

- Conditional on beliefs about the model parameters and data $(u_{1:t}, \pi_{1:t})$, the system can be solved as a Linear Quadratic Control problem.
- In general a system given by:

$$x_{t+1} = Ax_t + Bv_t + \varepsilon_t$$

Optimal solution (i.e a sequence of $v_{t,t+1,\ldots}$)

- where v_t is the vector of control variables e.g. the policy rate
- under a loss function of the form

$$L = \sum_{s=t}^{\infty} (x_s' Q x_s + v_s' R v_s)$$

Optimal Policy (contd...)

- is given by

$$v_t = -Gx_t$$

  where G(.) is a nonlinear function of the estimated model parameters and data.

- Where the state vector $x_t = [\pi_t - \pi^*, \pi_{t-1} - \pi^*, u_t - \hat{u_t^N}, u_{t-1} - \hat{u_{t-1}^N}, 1, \hat{\xi_t}, \hat{\xi_{t-1}}, V_{t-1}]$

Policy maker's problem

min

$$L = E_t \sum_{t=s}^{\infty} \delta^{t-s}[(\pi_t - \pi^*)^2 + \lambda(u_t - \hat{u}_t^N)^2 + \phi(V_t - V_{t-1})^2]$$

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$s \geq t+1$

Data

- For estimation, I use monthly data from Jan 1948-Dec 2022
- I use data from 1948:01-1962:12 to form the initial beliefs and then estimate the model forward from 1963 onwards.

For estimation, I use monthly data from Jan 1948-Dec 2022.

Tuning Parameters

- I follow Primiceri (2006) and set $\lambda = 1$, giving equal weight to unemployment and inflation gaps
- Set g=0.030 and g_N=0.015 as typical in literature (0.01-0.04)
- Persistence of u_t^N set as $\gamma = 0.99$, unconditional mean $u* = 5.8$ (mean unemployment during this period)

For estimation, I use monthly data from Jan 1948-Dec 2022.

Estimating the "true" DGP and filtered u_t^N and ξ_t

- Conditional on observed data, Fed forms its beliefs about the parameters of perceived laws of motion using constant gain updating
- Conditional on beliefs and data, Fed decides the optimal policy by solving the control problem
- Given the value of parameters and the Fed's policy, a Kalman filter recovers the series u_t^N, ξ_t (cost push shocks) and the Likelihood
- The "true" parameters are estimated by maximizing likelihood given observations on π_t and u_t

Estimates

Parameter	Estimate	Description
$\theta_{true}(1)$	-0.067^{**} (0.022)	Slope of the Phillips curve
$\theta_{true}(2)$	-0.0262^{*} (0.017)	
σ_{ε}^2	0.9741^{**} (0.371)	Variance of disturbances to the cost-push shocks (ξ_t)
σ_{η}^2	0.1498^{***} (0.066)	Variance of disturbances to aggregate demand
ψ_{true}	0.9910^{**} (0.413)	Persistence of cost-push shocks
ϕ	2.644 (1.732)	Fed's loading on the smoothing term in the loss function

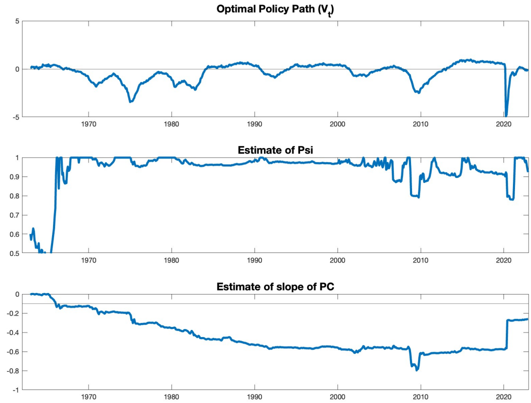


Figure: Evolution of Fed's beliefs

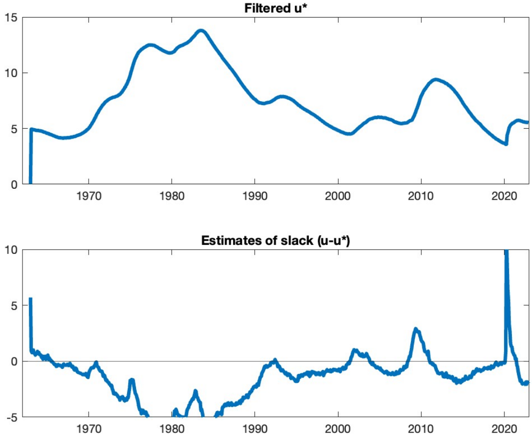


Figure: Natural rate and economic slack

Counterfactual: Fully informed Fed

- In the next exercise, I look at what would happen if Fed had full-information of the model parameters and the shocks that hit the economy.
- I set Fed's beliefs equal to the corresponding "true" values of the

Policy path under a fully informed Fed

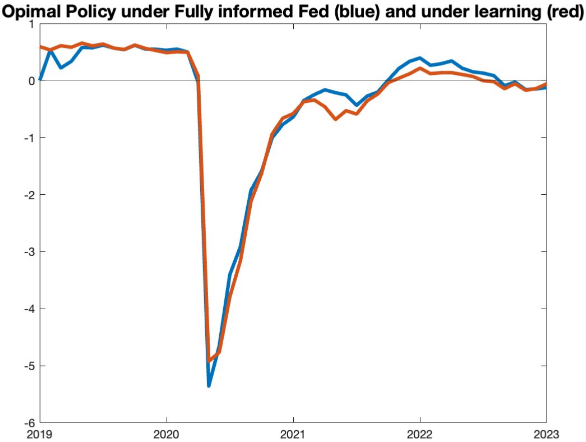


Figure: Counterfactual path

What path would inflation take under a fully informed Fed?

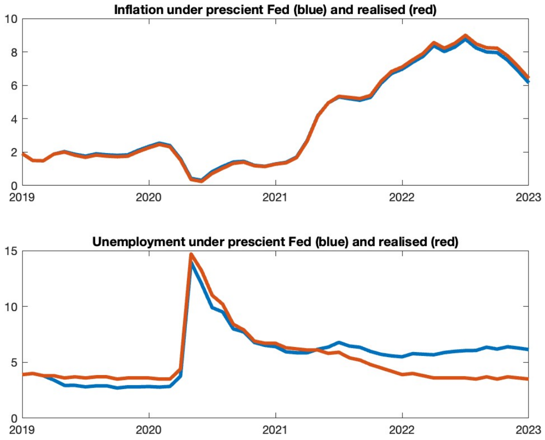
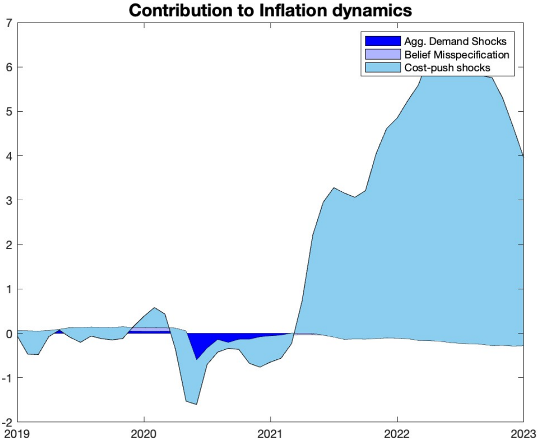


Figure: Counterfactual path

Contributing factors to inflation surge



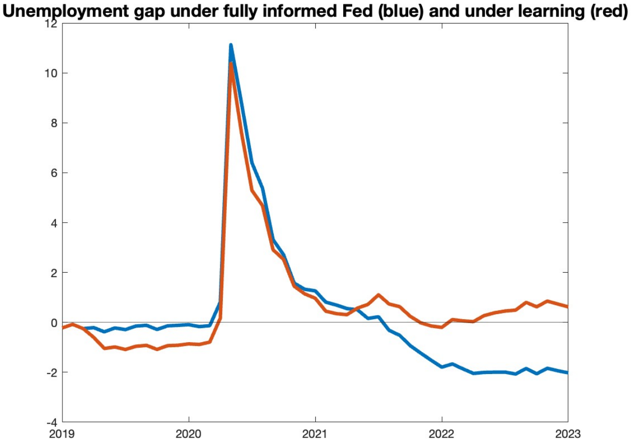


Figure: True Unemployment Gap (Learning) vs Full information benchmark

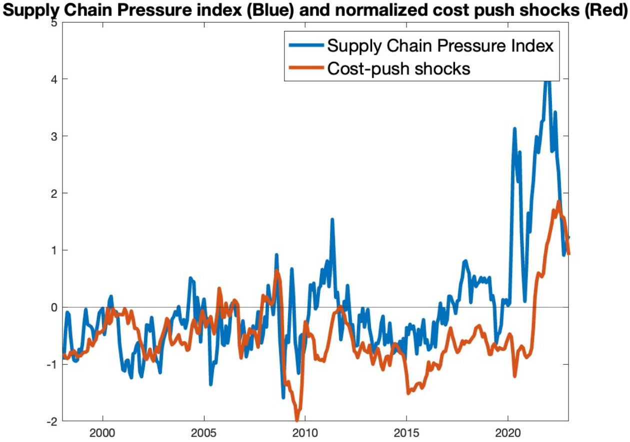


Figure: Cost-push shocks and Supply Chain pressures

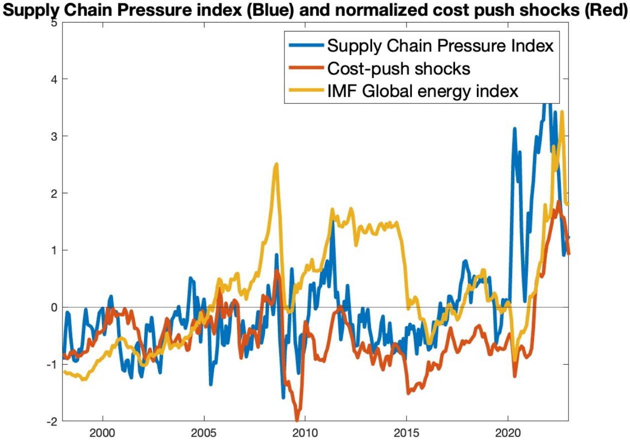


Figure: Cost-push shocks, Supply Chain pressures and Energy prices

Relationship between estimated cost push shocks and supply shocks

$$\xi_t \sim GSCPI_t + IMF\_Energy_t$$

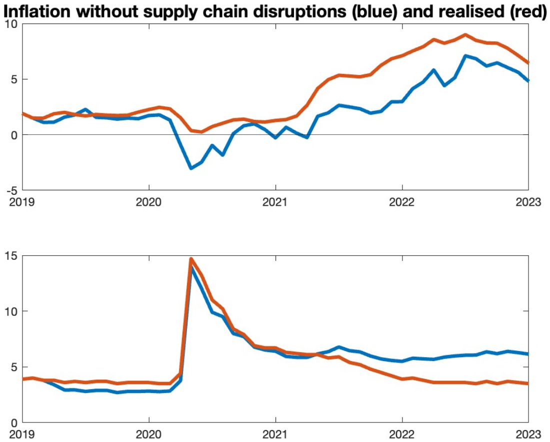
	Coefficient Estimate (SE)
Constant	-0.5464***
	(0.0293)
GSCPI	0.2509***
	(0.0302)
IMF Energy Index	0.2211***
	(0.0316)
R^2	0.376
N	300

Note: $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$

Expected path of inflation without COVID supply chain disruption

- In the next exercise, I use the relationship between the cost push shocks and the supply chain pressures to see what would happen if we did not experience unusual supply chain disruptions post-pandemic.
- For this, I construct a counterfactual series of cost-push shocks using values of supply chain pressure index sampled from the pre-pandemic period
- I then calculate the expected path of inflation taking this series of cost push shocks and estimated model parameters as given under a fully informed Fed

Expected path of inflation without COVID supply chain disruption



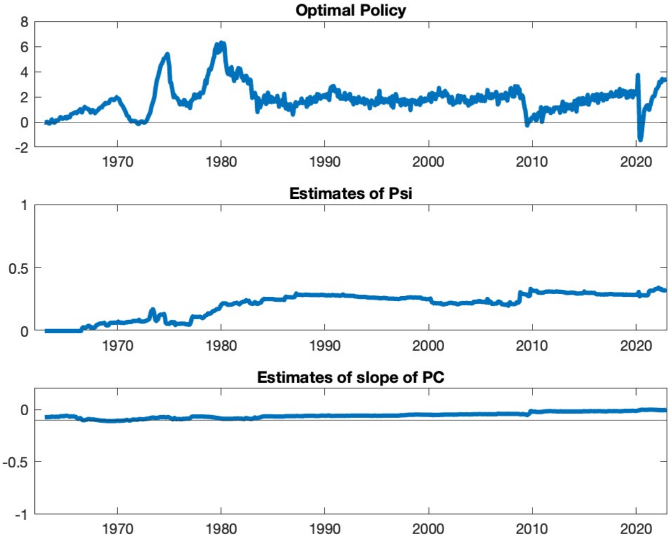
Findings

- Under full information, Fed would have raised rates higher and sustained unemployment closer to the natural rate (currently there is a gap of -2%)
- Owing to a flat Phillips curve, the cost of disinflation would have been large

Future work

- Estimate the model with an Expectations-augmented Phillips Curve
- Following Bernanke and Blanchard (2022 Working Paper), estimate aggregate demand using vacancy-unemployment ratio (v/u)
- Model with Time Varying parameters

With Adaptive Inflation expectations



Estimates of real interest rates during this period

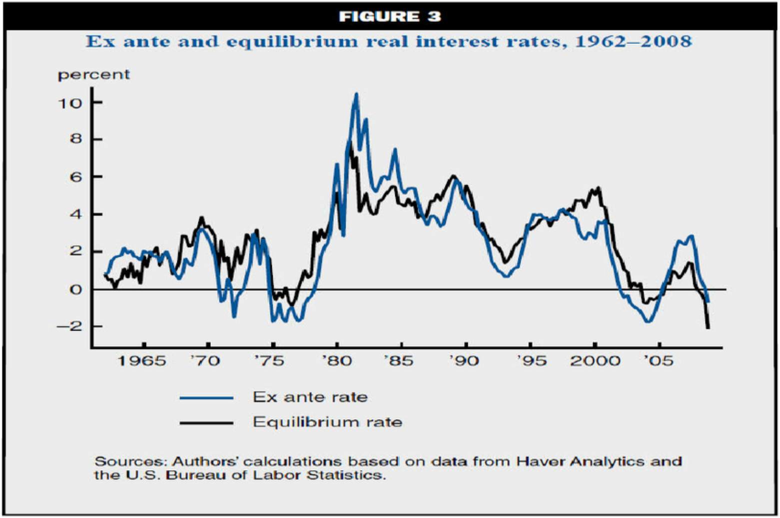


Figure: Estimates of r (proxied by V_t in the model)

Policy variable V_t under fully adaptive inflation expectations