What Do Long Data Tell Us About r^* and π^*?

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Two Empirical Questions

1. How do natural rate shocks affect output and inflation in the short and long runs?

2. Is the spike in inflation post COVID-19 driven by the permanent component of inflation?

These are 2 separate questions but they can be addressed within the same empirical framework.

Main Findings I

Question 1. How do natural rate shocks affect output and inflation in the short and long runs?

- Result. A permanent fall in the real interest rate causes a large fall in the trend of output (long run) and recession and deflation in the short run. These effects occur even outside of the ZLB.

- Why is this relevant? It poses a theoretical challenge: We have models to explain short-and long-run negative effects of falls in r^* but we lack explanations that rely neither on the ZLB being binding (secular stagnation hypothesis) nor on the assumption that output is I(2) (permanent shocks to productivity growth).

Main Findings II

Question 2. Is the spike in inflation post COVID-19 driven by the permanent component of inflation, π^*?

• Result. Between 2019 and 2021 the permanent component of inflation is estimated to have increased by 55 basis point when the model is estimated on 1900–2021 data but by 237 basis points when it is estimated on 1955–2021 data.

• Are there reasons to give credence to the long-data estimate? Yes: There are sudden inflation spikes like the one seen post COVID-19 in the long sample but not in the shorter one.

The Empirical Model

y_t = per capita output, and $\widehat{y}_t = y_t - X_t - \delta X_t^r$ its cyclical component.
π_t = inflation, and $\widehat{\pi}_t = \pi_t - X_t^m$ its cyclical component.
i_t = short rate, and $\widehat{i}_t = i_t - X_t^m - X_t^r$ its cyclical component.

Law of motion of endogenous variables and exogenous shocks:

$$\begin{bmatrix} \widehat{y}_t \\ \widehat{\pi}_t \\ \widehat{i}_t \end{bmatrix} = B \begin{bmatrix} \widehat{y}_{t-1} \\ \widehat{\pi}_{t-1} \\ \widehat{i}_{t-1} \end{bmatrix} + C \begin{bmatrix} \Delta X_t^m \\ z_t^m \\ \Delta X_t \\ z_t \\ \Delta X_t^r \end{bmatrix} ; \begin{bmatrix} \Delta X_{t+1}^m \\ z_{t+1}^m \\ \Delta X_{t+1} \\ z_{t+1} \\ \Delta X_{t+1}^r \end{bmatrix} = \rho \begin{bmatrix} \Delta X_t^m \\ z_t^m \\ \Delta X_t \\ z_t \\ \Delta X_t^r \end{bmatrix} + \Psi \begin{bmatrix} \epsilon_{t+1}^{X^m} \\ \epsilon_{t+1}^{z^m} \\ \epsilon_{t+1}^{X} \\ \epsilon_{t+1}^{z} \\ \epsilon_{t+1}^{X^r} \end{bmatrix} \tag{1}$$

Observation equations:

$$\Delta y_t = \widehat{y}_t - \widehat{y}_{t-1} + \Delta X_t + \delta \Delta X_t^r + \mu_t^y, \tag{2}$$

$$\Delta \pi_t = \widehat{\pi}_t - \widehat{\pi}_{t-1} + \Delta X_t^m + \mu_t^\pi, \tag{3}$$

$$\Delta i_t = \widehat{i}_t - \widehat{i}_{t-1} + \Delta X_t^m + \Delta X_t^r + \mu_t^i, \tag{4}$$

where $[\mu_t^y \, \mu_t^\pi \, \mu_t^i]'$ are i.i.d. measurement errors.

Data and Estimation

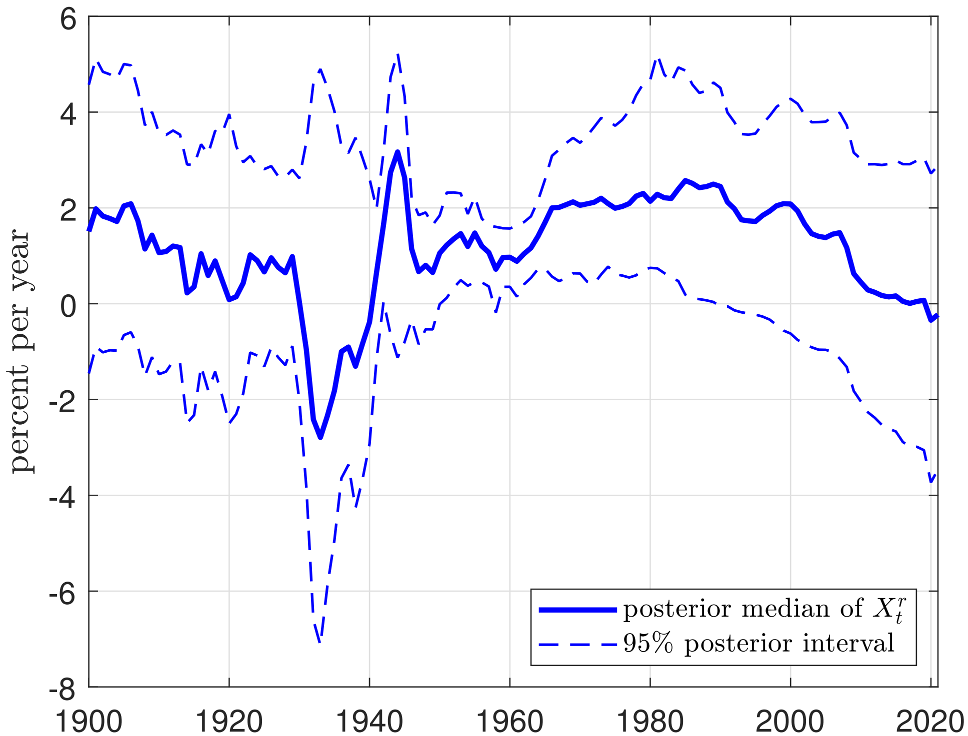
• Annual U.S. data from 1900 to 2021 on

– real GDP per capita
– consumer price inflation
– and the short-term nominal interest rate.

• Bayesian estimation. Random Walk Metropolis-Hastings algorithm to obtain 50 million draws from the posterior distribution of the estimated parameter vector.

Natural Rate Supercycles

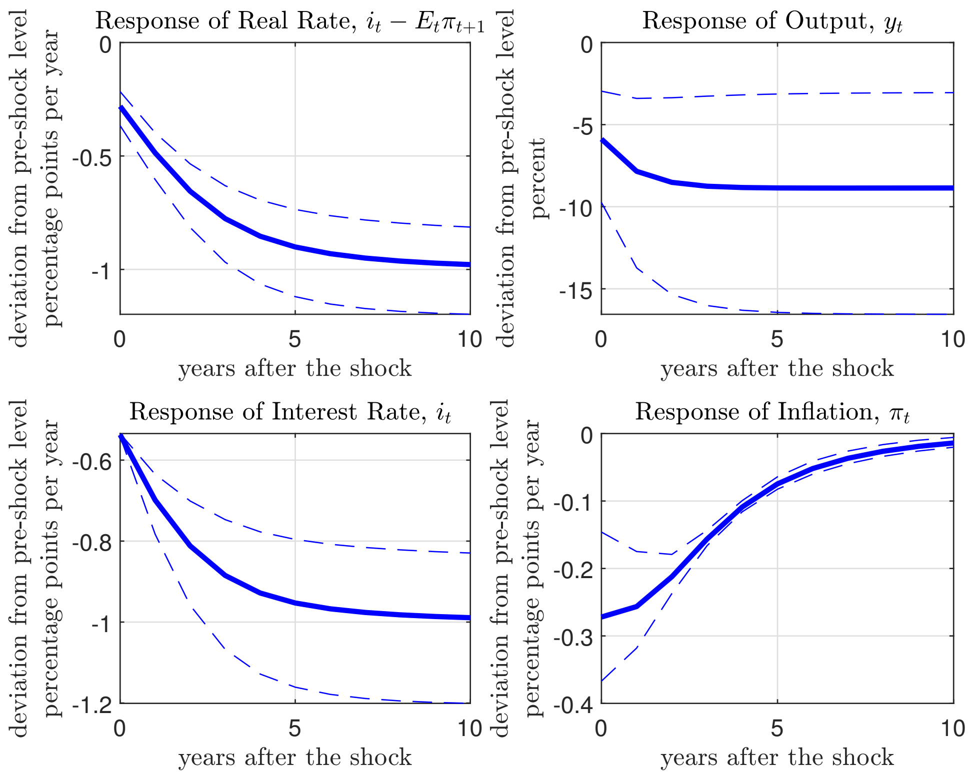
The Natural Rate of Interest, r^*: 1900–2021



Notes. The variable X_t^r is computed by two-sided Kalman smoothing. It is normalized by adding a constant to match the observed sample mean of $i_t - \pi_{t+1}$ (1.15 percent per year). The solid line is the posterior median of X_t^r and the broken lines indicate the 2.5th and 97.5th posterior percentile of X_t^r, respectively. These statistics are computed using 100,000 randomly picked draws from an MCMC chain of length 50 million.

Question 1: How do natural rate shocks affect output and inflation in the short and long runs?

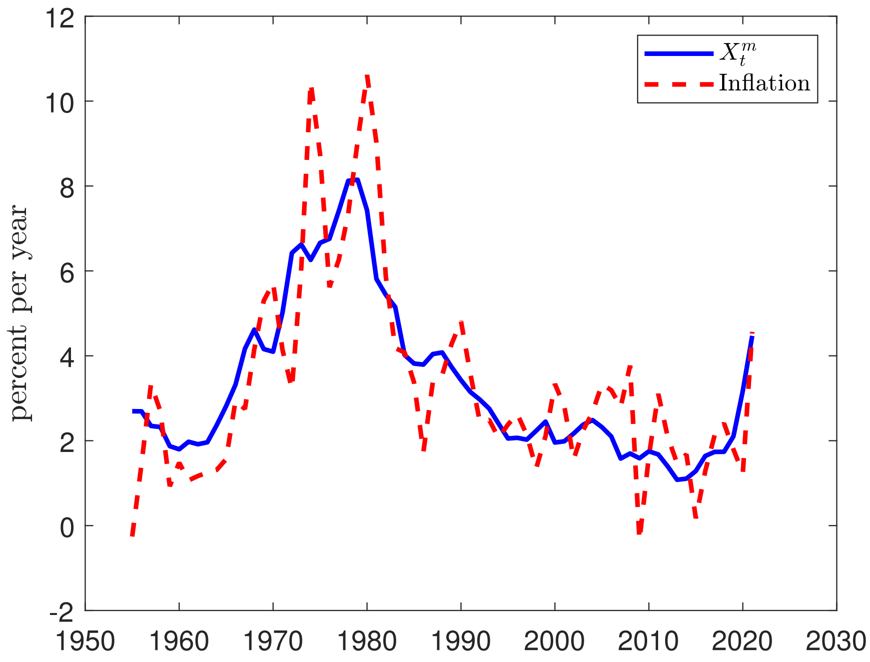
Impulse Response to a Decline in X_t^r



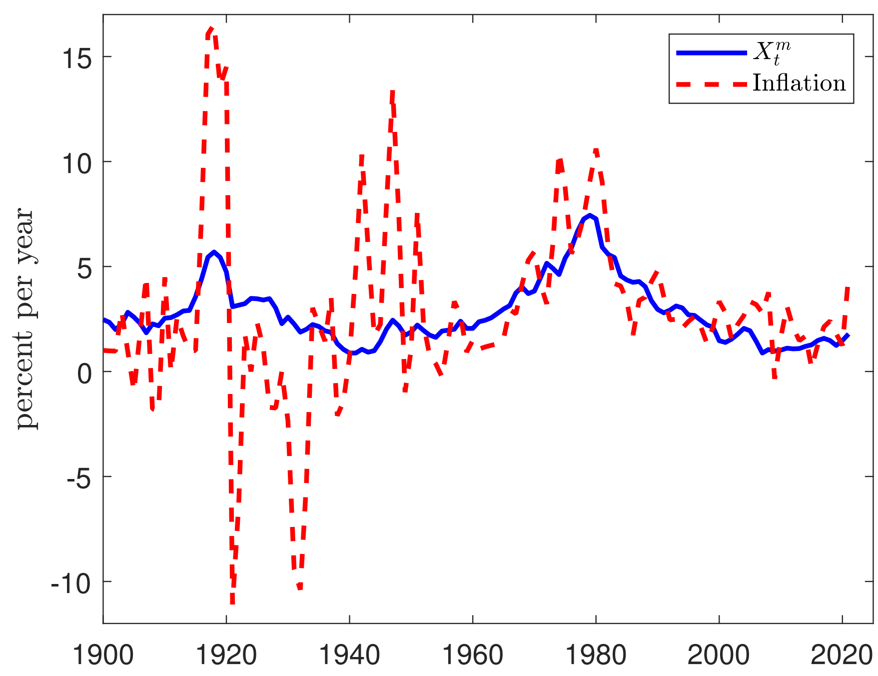
Notes. Solid lines display the posterior mean response to a negative natural rate shock (a decrease in X_t^r) that lowers the real interest rate by 1 annual percentage point in the long run. Broken lines are asymmetric 95-percent confidence bands computed using the Sims-Zha (1999) method from 100,000 randomly picked draws from an MCMC chain of length 50 million. Impulse responses and confidence bands are conditional on $\delta > 0$.

Question 2: Is the spike in inflation post COVID-19 driven by the permanent component of inflation?

1955–2021 Sample



1900–2021 Sample



Notes. X_t^m is computed by smoothing using the Kalman filter at the posterior mean of the vector of estimated parameters and is normalized by adding a constant to match the sample mean of inflation.

Conclusion

We formulate a semi-structural model with SVAR and DSGE features and estimate it on US data from 1900 to 2021 to address 2 separate questions:

• What happens with observed macroeconomic aggregates in the short and long runs in response to a change in the permanent component of the real interest rate?
— We find that a permanent fall in the real interest rate produces a large fall in output trend and recession and deflation in the short run. These effects are present even outside of the ZLB, which poses a theoretical challenge.

• To what extent was the inflation spike post COVID-19 driven by its permanent component?
— We find that if one includes the pre-war sample in the estimation, which is rich in inflation spikes, the permanent component explains a small fraction of the post-COVID-19 inflation.