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Deciphering the Neo-Fisherian Effect

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Keywords

identification, inflation, liquidity preference, neo-Fisherian effect

JEL Classification

E12, E23, E31, E43, E52

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Deciphering the Neo-Fisherian Effect[*]

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Abstract

The neo-Fisherian effect typically refers to the short-run *increase* in inflation associated with a permanent increase in the nominal interest rate. This positive comovement between the two variables is commonly viewed — and empirically identified — as being conditional on permanent monetary shocks, which are often interpreted as permanent shifts in the inflation target. Such a view, however, implies that inflation and the nominal interest rate share a common stochastic trend, a property that is hardly supported by the data, especially during episodes of stable inflation. Moreover, in countries that have adopted formal inflation targeting, changes in the inflation target occur very infrequently, if at all, calling into question the interpretation of inflation target shocks identified within standard time-series models based on quarterly data. In this paper, we propose a novel empirical strategy to detect the neo-Fisherian effect, which we apply to U.S. data. Our procedure relaxes the commonly used identifying restriction that inflation and the nominal interest rate are cointegrated, and, more importantly, is agnostic about the nature of the shock that gives rise to a neo-Fisherian effect. We find that the identified shock has no permanent effect on the nominal interest rate or inflation, but moves them in the same direction for a number of quarters. It also accounts for the bulk of their variability at any given forecasting horizon, while explaining a non-negligible fraction of output fluctuations at business-cycle frequencies. Using Bayesian techniques, we show that the data favors the interpretation of the identified shock as a liquidity preference shock rather than an inflation target shock.

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1 Introduction

The conventional view in monetary economics is that a rise in the nominal interest rates lowers inflation and the output gap in the short run, whereas an interest-rate cut does the opposite. These outcomes are consistent with the effects of transient monetary policy shocks in the standard New Keynesian model. As forcefully shown by Cochrane (2016), however, this very same model implies that a permanent increase in the nominal interest rate causes inflation to rise not only in the long run (as required by the Fisher equation), but also in the short run — a prediction that turns out to be remarkably robust across various modelling assumptions. This positive short-run comovement between inflation and the nominal interest rate has come to be known as the neo-Fisherian effect. While Cochrane (2016) considers the case of a pegged nominal interest rate, subsequent work by Uribe (2022) shows that the neo-Fisherian effect continues to be present when monetary policy follows an interest-rate rule that is subject to permanent shocks.[1] Like much of the preceding literature (e.g., Ireland, 2007; Cogley et al., 2010; Aruoba & Schorfheide, 2011), Uribe (2022) interprets these shocks as permanent exogenous shifts in the inflation target.

The presence of permanent monetary shocks implies that inflation and the nominal interest rate share a common stochastic trend, i.e., are cointegrated. This assumption underlies the empirical strategies proposed by Azevedo et al. (2022) and Uribe (2022) to test for the existence of a neo-Fisherian effect in the data. Alternatively, Lukmanova & Rabitsch (2023) attempt to directly identify inflation target shocks by including various low-frequency measures of inflation in their information set. While the assumption of cointegration between inflation and the nominal interest rate may be difficult to reject in some countries during specific periods, inflation seems to have become stationary in several countries that have adopted a credible monetary policy regime. Table 1 illustrates this point by reporting unit-root test results for U.S. inflation for the period 1953Q3–2023Q4 and the two sub-periods 1953Q3–1992Q1 and 1992Q2–2023Q4. Inflation has generally been high and volatile in the U.S. before 1992 but low and stable in the post-1992 era.[2] Overall, the results provide decisive evidence that inflation contained a unit root before 1992 but has become stationary after that date. Moreover, in the absence of announcements by the Federal Reserve regarding changes in its explicit inflation target of 2 percent, adopted in January 2012, the very notion of inflation target shocks after that date seems at least dubious (more on this below).

This paper offers novel insights into the neo-Fisherian effect, contributing to the extant literature along two lines. First, we propose a new empirical strategy to detect and measure this effect. Our

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[1] Garín et al. (2018), Uribe (2022), and Lukmanova & Rabitsch (2023) show that monetary shocks can still give rise to a neo-Fisherian effect if they are highly persistent (though not permanent).

[2] The selected break date of 1992Q1 was identified by Levin & Piger (2004) and Benati (2023) as marking a structural break in the mean of U.S. inflation. However, our results are robust to alternative dates around the selected one.

Table 1: Unit-root tests for U.S. inflation.

		Full Sample	Sub-Samples	
Test	Lag/Bandwidth Length Criterion	1954Q3–2023Q4	1954Q3–1992Q1	1992Q2–2023Q4
H_0 : Inflation has a Unit Root				
ADF	*BIC*	-3.234^{**}	-2.346	-3.395^{**}
	MBIC	-2.896^{**}	-1.815	-1.207
PP	*Newey–West*	-4.502^{***}	-3.297^{**}	-4.902^{***}
	Andrews	-4.328^{***}	-3.136^{**}	-4.579^{***}
ERS	*BIC*	-2.197^{**}	-1.521	-3.395^{***}
	MBIC	-1.974^{**}	-1.343	-1.783^{*}
NP	*BIC*	-2.180^{**}	-1.513	-3.093^{***}
	MBIC	-1.978^{*}	-1.360	-1.936^{*}
H_0 : Inflation is Stationary				
KPSS	*Newey–West*	0.395^{*}	0.465^{**}	0.205
	Andrews	0.245	0.279	0.193

Notes: ADF refers the Augmented Dickey-Fuller test (Dickey & Fuller, 1979), PP refers to the Phillips-Perron Z_t test (Phillips & Perron, 1988), ERS refers to the Elliott-Rothenberg-Stock DF-GLS test (Elliott et al., 1996), NP refers to the Ng-Perron MZ_t test (Ng & Perron, 1995), and KPSS refers to the Kwiatkowski-Phillips-Schmidt-Shin test (Kwiatkowski et al., 1992). BIC (Schwarz information criterion) and MBIC (modified Schwarz information criterion) are used to select the optimal number of lags of the dependent variable in ADF, ERS, and NP, where the maximum number of lags is set according to the Schwert criterion. Newey-West (Newey & West, 1994) and Andrews (Andrews, 1991) rules are used to determine the optimal bandwidth of the Bartlett kernel used to estimate robust standard errors in PP and KPSS. *** denotes rejection at the 1 percent level, ** denotes rejection at the 5 percent level, and * denotes rejection at the 10 percent level.

approach does not require inflation and the nominal interest rate to share a common stochastic trend, though it does not rule out this possibility. More importantly, it is agnostic about the nature of the shock that gives rise to a neo-Fisherian effect. Second, we provide theoretical arguments and empirical evidence suggesting that the positive short-run comovement between inflation and the nominal interest rate observed in the data is more likely to be driven by liquidity preference shocks than by inflation target shocks.

Our empirical strategy consists in estimating a vector auto-regression (VAR) using data on the nominal interest rate, inflation, and output, and identifying two orthogonal disturbances: a standard monetary policy shock and one that we label ‘neo-Fisherian shock’ without taking a stand on its structural interpretation. To identify the monetary policy shock, we select the linear combination of reduced-form residuals that has a transitory effect on the nominal interest rate and that satisfies the restriction that a positive realization does not raise inflation or output on impact. We then identify the neo-Fisherian shock using a Max Share approach, by selecting the linear combination of reduced-form residuals that is orthogonal to the monetary policy shock and that explains the largest fraction of the forecast-error variance of the nominal interest rate at a long but finite horizon. The latter criterion is consistent with the theoretical prediction that the neo-Fisherian effect is associated with permanent (or highly persistent) changes in the nominal interest rate. Monte Carlo simulations based on artificial data generated from a New Keynesian model show that our identification strategy is remarkably successful in recovering the true shocks both in large and small samples, regardless of whether the neo-Fisherian shock is permanent or not.

Estimation results based on U.S. data indicate that the identified neo-Fisherian shock has no permanent effect on the nominal interest rate or inflation, but moves them in the same direction for a number of quarters. In other words, the shock generates a neo-Fisherian effect, thus justifying its epithet. Positive realizations of the shock are also found to be expansionary in the short run, raising output for at least a year. Variance-decomposition results show that the neo-Fisherian shock accounts for the bulk of fluctuations in the nominal interest rate and inflation at essentially any frequency, while explaining only about 10 percent of output variability at business-cycle frequencies. Nonetheless, this shock appears to have played a more significant role during the most recent downturns, accounting for more than one-third of the decline in output growth during the Great Recession and roughly 20 percent during the COVID-19 pandemic.

The second part of the paper delves into the interpretation of the identified shock. As stated above, the common view in the empirical literature on neo-Fisherism is that the shock leading to a short-run comovement of the nominal interest rate and inflation captures exogenous shifts in the inflation target. Given that announcements about changing the inflation target are extremely infrequent events that happen once in several decades (particularly in advanced economies), it seems implausible that inflation target shocks can be extracted within VARs (or alternative time-series models) estimated using quarterly data. To elucidate the nature of the neo-Fisherian shock identified in the data, we start by showing that, in the context of a parsimonious New Keynesian economy, the effects of an (positive) inflation target shock on the nominal interest rate, inflation, and output are akin to those of a (negative) liquidity preference shock, which affects households' desire to hold safe and liquid assets. In fact, under certain parameter restrictions, the two shocks are observationally equivalent for the dynamics of inflation and output. We then use Bayesian methods to determine whether a model with liquidity preference shocks provides a better overall fit of U.S. data than does an otherwise identical model with inflation target shocks. We find that the former has a much larger marginal likelihood, thus favoring the interpretation of the neo-Fisherian shock as a liquidity preference shock.

Literature review This paper contributes to the literature on neo-Fisherism. In addition to the aforementioned papers by Cochrane (2016), Garín et al. (2018), Uribe (2022), and Lukmanova & Rabitsch (2023), studies that have examined the conditions under which the neo-Fisherian effect arises in the class of New Keynesian models include those by García-Schmidt & Woodford (2019), Amano et al. (2016), and Schmitt-Grohé & Uribe (2022). García-Schmidt & Woodford (2019) show that the neo-Fisherian effect ceases to exist when rational expectations are replaced by a learning mechanism. Amano et al. (2016) show that the neo-Fisherian effect can emerge if monetary policy deviates from the Taylor principle by committing to not responding too aggressively to off-target inflation. This in turn requires the monetary authority to use inflation to manage the real value of public debt. Finally, Schmitt-Grohé & Uribe (2022) extend the analysis of Uribe (2022) to the context of an open economy. While these papers condition the neo-Fisherian effect on inflation target shocks, we argue that, empirically, this effect is more likely to be driven by liquidity preference shocks.

Our paper is also related to the vast literature on inflation dynamics. One strand of this literature emphasizes a highly persistent stochastic component with a positive long-run mean as the fundamental characteristic of post-war U.S. inflation movements. Cogley & Sbordone (2008), Coibion & Gorodnichenko (2011), and Ascari & Sbordone (2014) show that this positive long-run mean of the inflation rate — often referred to as trend inflation — alters the shape of the log-linearized New Keynesian Phillips Curve, resulting in persistent and smooth deviations of inflation from its mean. Another strand attempts to account for the high persistence of U.S. inflation by allowing the long-run unconditional mean to vary over time. Specifically, Ireland (2007) and Cogley et al. (2010) describe the Beveridge-Nelson permanent component of the inflation rate as a stochastic inflation target set by the central bank. Aruoba & Schorfheide (2011) interpret the low-frequency movements of U.S. inflation in the 1970s and 1980s as evidence of a drifting target, which they model as a stochastic process. Kano (2023) explores the role of persistent inflation target shocks for inflation and exchange-rate dynamics in the context of a two-country New Keynesian model.

Our study also connects with the growing literature on the importance of liquidity preference shocks for aggregate fluctuations. In Christiano et al. (2003), these shocks induce households to shift from deposits to currency. In Krishnamurthy & Vissing-Jorgensen (2012), they represent stochastic changes in households' preference for safe and liquid assets. Fisher (2015) shows that this interpretation provides a micro-founded justification for the *ad hoc* risk premium shock introduced by Smets & Wouters (2007). Since positive realizations of liquidity preference shocks raise households' desire to save, but only in risk-free bonds, they lower the natural rate of interest and lead a simultaneous fall in consumption, investment, and inflation. For this reason, these shocks have sometimes been invoked to explain deep recessions, potentially characterized by liquidity traps (e.g., Bouakez et al., 2020; Cacciatore et al., 2021). Interestingly, based on an estimated model of the U.S. economy using data from 1993Q1 to 2008Q3, Campbell et al. (2016) find that liquidity preference shocks account for the largest fraction of the variance of the federal funds rate at business-cycle frequencies, thus comforting our interpretation of the source of the neo-Fisherian effect found in the data.

Structure of the paper The rest of the paper is structured as follows. Section 2 describes our empirical strategy to detect the neo-Fisherian effect, and performs Monte Carlo simulations to gauge the reliability of our identification procedure. Section 3 describes the data and reports our estimation results in terms of impulse responses, forecast-error variance decomposition, and historical decomposition. Section 4 investigates the economic interpretation of the shock underlying the neo-Fisherian effect. It first discusses the near equivalence between inflation target and liquidity preference shocks. Then, it uses Bayesian techniques to show that a model with liquidity preference shocks provides a better overall fir of U.S. data than does a model with inflation target shocks. Section 5 concludes.

2 Empirical Strategy

2.1 Identification

Let $z_t = [i_t, \pi_t, y_t]'$ be a vector of observables of length T, where i_t is the nominal interest rate, π_t is inflation, and y_t is (the log of) aggregate output, and assume that z_t has the following moving-average representation (ignoring constant terms):

$$z_t = B(L)u_t,$$

where u_t is a 3×1 vector of statistical innovations, whose variance-covariance matrix is denoted by Σ. Let $\epsilon_t = [\epsilon_{m,t}, \epsilon_{n,t}, \epsilon_{y,t}]'$ be a 3×1 vector of structural innovations, where $\epsilon_{m,t}$ is a monetary policy shock, $\epsilon_{n,t}$ is a shock that has a persistent/permanent effect on the nominal interest rate — henceforth labeled neo-Fisherian shock — and $\epsilon_{y,t}$ is a shock that need not be identified. The variance-covariance matrix of ϵ_t is I_3. If a linear mapping between the statistical innovations, u_t, and the structural shocks, ϵ_t, exists, then

$$u_t = A\epsilon_t,$$

where the impact matrix, A, must be such that $AA' = \Sigma$.

Let $\tilde{A}$ denote the Cholesky decomposition of Σ. Any impact matrix $A = \tilde{A}D$, where D is an orthonormal matrix, also satisfies the requirement $AA' = \Sigma$. We identify the monetary policy shock, $\epsilon_{m,t}$, by selecting the orthonormal matrix D that satisfies the following two requirements. First, the shock does not have a permanent effect on the nominal interest rate. We implement this restriction by minimizing the sum of the squared impulse response functions of the nominal interest rate beyond a given horizon, h. This criterion ensures that the dynamic effects of a monetary policy shock on the nominal interest rate die out after h periods. Second, a positive realization of the shock does not raise inflation or output on impact. These sign restrictions reflect the widely accepted view about the short-run effects of monetary policy shocks.[3]

Let γ_j denote the jth column of D. Since the impulse vector to $\epsilon_{m,t}$ is $\tilde{A}\gamma_1$ (the first column of $\tilde{A}D$), we only need to characterize γ_1. Denote by $r_{i,\gamma_1}(k)$, $r_{\pi,\gamma_1}(k)$, and $r_{y,\gamma_1}(k)$ the impulse responses of the nominal interest rate, inflation, and output, respectively, to the impulse vector $\tilde{A}\gamma_1$ at horizon k. Our strategy to identify the monetary policy shock amounts to selecting the vector γ_1 that solves the following minimization problem:

$$\min_{\{\gamma_1\}} \sum_{k=h}^{\infty} r_{i,\gamma_1}^2(k)$$

s.t.

$$\begin{aligned}
\gamma_1^{'}\gamma_1 &= 1, \\
r_{i,\gamma_1}(1) &\geq 0, \\
r_{\pi,\gamma_1}(1) &\leq 0, \\
r_{y,\gamma_1}(1) &\leq 0.
\end{aligned}$$

The first constraint ensures that γ_1 is a column vector of an orthonormal matrix. The remaining constraints implement the sign restrictions on the responses of the nominal interest rate, inflation, and output.

Once $\epsilon_{m,t}$ is identified, we identify $\epsilon_{n,t}$ using a Max Share approach, by selecting the linear combination of reduced-form residuals that is orthogonal to $\epsilon_{m,t}$ and that explains the largest fraction of the forecast-error variance of i_t at a long but finite horizon, H.[4] This criterion reflects the theoretical prediction that the neo-Fisherian effect is associated with permanent (or highly persistent) changes in the nominal interest rate.

The k-step-ahead forecast error of vector z_t is

$$z_{t+k} - \mathbb{E}_t z_{t+k} = \sum_{l=0}^{k-1} B_l \tilde{A} D \epsilon_{t+k-l},$$

with $B_0 = I_3$. Letting $\Omega_{i,j}(h)$ denote the share of the forecast-error variance of variable i attributable to structural shock j at horizon k ($k = 1, 2...$), we have

$$\Omega_{i,j}(k) \equiv \frac{e_i^{'}\left(\sum_{l=0}^{k-1} B_l \tilde{A} D e_j e_j^{'} D^{'} \tilde{A} B_l^{'}\right) e_i}{e_i^{'}\left(\sum_{l=0}^{k-1} B_l \Sigma B_l^{'}\right) e_i} = \frac{\sum_{l=0}^{k-1} B_{i,l} \tilde{A} \gamma_j \gamma_j^{'} \tilde{A} B_{i,l}^{'}}{\sum_{l=0}^{k-1} B_{i,l} \Sigma B_{i,l}^{'}},$$

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[3] Uribe (2022) adopts a similar sign-restriction approach to identify the (transitory) monetary policy shock.

[4] The Max Share approach was first introduced by Francis et al. (2014) to identify technology shocks, and has been subsequently used by several authors to identify TFP new shocks (e.g., Kurmann & Sims, 2021; Nam & Wang, 2019; Bouakez & Kemoe, 2023, etc.).

where

$$B_{i,l} = e_i^{'} B_l, \qquad \gamma_j = De_j,$$

and e_i is a selection vector with 1 in the ith position and zero elsewhere.

Our approach to identify the neo-Fisherian shock therefore consists in selecting the vector γ_2 that solves

$$\max_{\{\gamma_2\}} \Omega_{1,2}(H) \equiv \frac{\sum_{\tau=0}^{H-1} B_{1,\tau} \tilde{A} \gamma_2 \gamma_2^{'} \tilde{A} B_{1,\tau}^{'}}{\sum_{\tau=0}^{H-1} B_{1,\tau} \Sigma B_{1,\tau}^{'}}$$

s.t.

$$\begin{aligned} \gamma_2^{'} \gamma_1 &= 0, \\ \gamma_2^{'} \gamma_2 &= 1. \end{aligned}$$

The first constraint ensures that $\epsilon_{n,t}$ is orthogonal to $\epsilon_{m,t}$, and the second constraint ensures that γ_2 is a column vector of an orthonormal matrix. In practice, we choose the truncation horizons $h = 20$ quarters and $H = 80$ quarters.

2.2 Monte Carlo simulations

Before applying our identification strategy to actual data, we evaluate its reliability both in large and small samples using Monte Carlo simulations.

2.2.1 Data generating process

Consider a simple New Keynesian economy without capital in which prices are set à la Calvo. Non-optimizing firms index their prices to past inflation. The economy features a monetary policy shock (m_t), an inflation target shock (τ_t), and a technology shock (a_t). Log-linearizing the model's equilibrium conditions around the deterministic steady state yields the following equations (a detailed description of the model is provided in the Appendix):

$$\begin{aligned} y_t &= \mathbb{E}_t y_{t+1} - (i_t - \mathbb{E}_t \pi_{t+1} - \ln \beta^{-1}), & (1) \\ \pi_t &= (1+\beta)^{-1} \left[\pi_{t-1} + \beta \mathbb{E}_t \pi_{t+1} + \lambda (y_t - a_t) \right], & (2) \\ i_t &= (1-\varrho) \ln \beta^{-1} + \varrho i_{t-1} + (1-\varrho) \left[\phi_\pi \pi_t + \phi_y (y_t - y_t^f) \right] - \left[(1-\varrho) \phi_\pi - 1 \right] \tau_t - \varrho \tau_{t-1} + m_t (3) \end{aligned}$$

where y_t is output, i_t is the nominal interest rate, π_t is the inflation rate, and $y_t^f = a_t$ is the flexible-price (or natural) level of output. The variables y_t and y_t^f are expressed as percentage deviations from their steady-state values, while i_t, π_t, m_t, τ_t, and a_t are expressed in levels. The model parameters are defined as follows: $0 < \beta < 1$ is the discount factor, $\varphi > 0$ is the inverse of the Frisch elasticity of labor supply, $\lambda \equiv \frac{(1-\theta)(1-\beta\theta)(1+\varphi)}{\theta} > 0$, with $0 < \theta < 1$ being the Calvo probability of not changing prices, $0 \leq \varrho < 1$ is the interest-smoothing parameter, and $\phi_\pi > 1$ and

$\phi_y \geq 0$ are the coefficients attached to, respectively, inflation and the output gap in the interest-rate rule.

The forcing variables follow the autoregressive processes given by

$$\begin{aligned} m_t &= \rho_m m_{t-1} + \epsilon_{m,t}, \qquad \epsilon_{m,t} \sim N(0, \sigma_m), \\ \tau_t &= \rho_\tau \tau_{t-1} + \epsilon_{\tau,t}, \qquad \epsilon_{\tau,t} \sim N(0, \sigma_\tau), \\ a_t &= \rho_a a_{t-1} + \epsilon_{a,t}, \qquad \epsilon_{a,t} \sim N(0, \sigma_a), \end{aligned}$$

where $0 \leq \rho_m, \rho_a < 1$, and $0 \leq \rho_\tau \leq 1$ to allow for the possibility of permanent inflation target shocks.[5]

To generate artificial data from the model, we assign the following standard values to its parameters: $\beta = 0.99$, $\varphi = 1$, $\theta = 0.75$, $\varrho = 0.8$, $\phi_\pi = 1.5$, and $\phi_y = 0.125$. We also set the standard deviations of the three shocks, σ_m, σ_τ, and σ_a, to 0.01. Since TFP shocks are usually found to be highly persistent, we set $\rho_a = 0.95$. Finally, to allow for a sharp distinction between transitory and persistent/permanent shifts in monetary policy, we set $\rho_m = 0$ and $\rho_\tau \in \{0.95, 1\}$. Considering both highly persistent and permanent inflation target shocks will help determine whether our identification procedure is robust regardless of whether or not inflation and the nominal interest rate share a common stochastic trend.

The theoretical impulse responses are depicted in Figure 1. The top panels of the figure show that a positive realization of $\epsilon_{m,t}$ raises the nominal interest rate while lowering inflation and output in the short run, and that these effects dissipate after about 10 quarters. These patterns rationalize the identifying restrictions imposed to pin down the monetary policy shock, discussed in Section 2. Notice that, despite its transitory effects, the shock still explains roughly 10 percent of the forecast-error variance of the nominal interest rate at long horizons, as reported in Table 2.

The dynamic responses to a positive inflation target shock are shown in the middle panels of Figure 1, for $\rho_\tau = 0.95$ and $\rho_\tau = 1$. In both cases, the shock gives rise to a neo-Fisherian effect: positive short-run comovement of inflation and the nominal interest rate. When the shock is persistent, the two variables remain higher than average for a prolonged period of time before eventually returning to their initial levels. When the shock is permanent, on the other hand, they both converge to permanently higher levels. Table 2 shows that the shock's contribution to the forecast-error variance of the nominal interest rate at the 80-quarter horizon amounts to 90 percent when $\rho_\tau = 0.95$ and reaches 99 percent when $\rho_\tau = 1$. The observation that the inflation target shock is the dominant force driving the conditional variance of the nominal interest rate at long horizons underlies our Max Share identification strategy, discussed in Section 2. Interestingly, the

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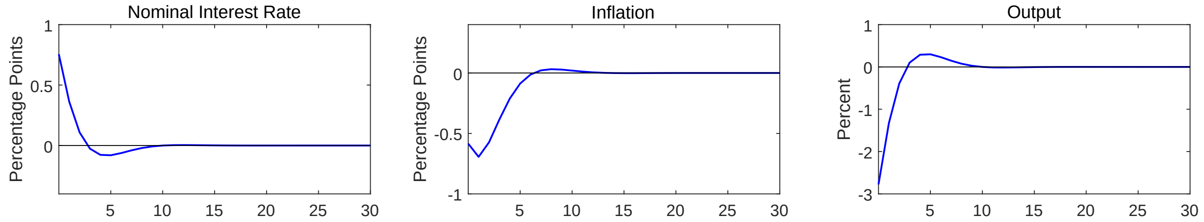
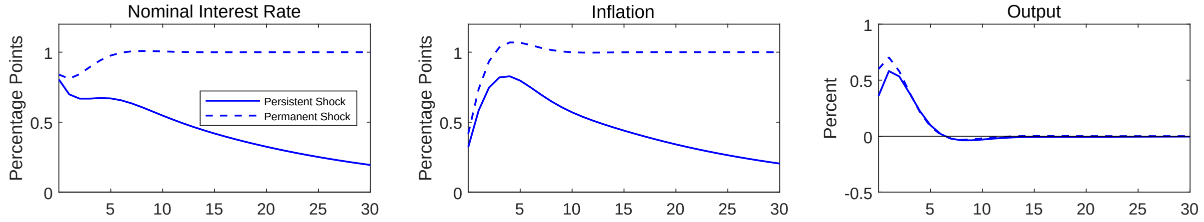
[5] When $\rho_\tau = 1$, inflation and the nominal interest rate do not have steady-state values, as their unconditional means do not exist. In this case, we solve the model by assuming that the initial values of the inflation target is equal to 0.

inflation target shock is expansionary, as output rises for about 6 quarters after the shock.

Monetary Policy Shock



Inflation Target Shock



Technology Shock

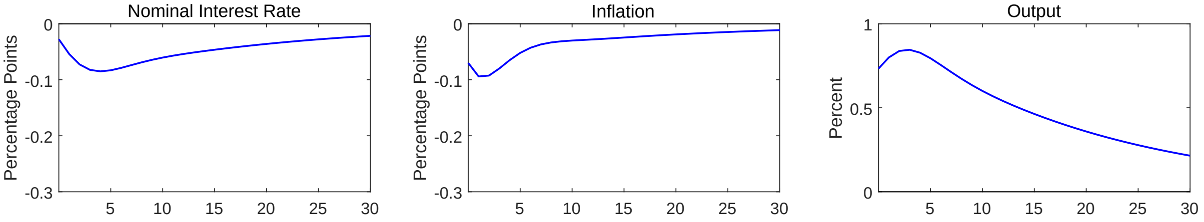


Figure 1: Theoretical impulse responses.

Notes: The figure shows the theoretical impulse responses to monetary policy, inflation target, and technology shocks. The responses of the nominal interest rate and inflation are expressed in percentage-point deviations from their pre-shock levels. The response of output is expressed as percentage deviation from its pre-shock level. In all cases, the size of the shock is 1 percent. For the inflation target shock, the solid lines represent the case of a persistent shock ($\rho_\tau = 0.95$), while the dashed lines represent the case of a permanent shock ($\rho_\tau = 1$).

Finally, the bottom panels of Figure 1 show that a positive technology shock raises output while lowering inflation and the nominal interest rate. This negative comovement between output and inflation violates the sign restrictions we impose to identify the monetary policy shock, thus ensuring that the latter is not confounded by changes in technology. On the other hand, the technology shock leads to positive comovement between the nominal interest rate and inflation. However, the response of the nominal interest rate is smaller (in absolute value) at any given horizon than that triggered by an inflation target shock, both when $\rho_\tau = 0.95$ and when $\rho_\tau = 1$. The share of the forecast-error variance of the nominal interest rate accounted for by the technology shock does not exceed 1 percent, even at long horizons. This observation greatly alleviates the concern that technological disturbances confound the identification of the neo-Fisherian shock.

Table 2: Theoretical (model-based) variance decomposition.

		Horizon					
		$k = 1$	$k = 4$	$k = 8$	$k = 16$	$k = 32$	$k = 80$
		Monetary Policy Shock					
Nominal Interest Rate	$\rho_\tau = 0.95$	0.468	0.259	0.162	0.110	0.092	0.088
	$\rho_\tau = 1$	0.447	0.198	0.098	0.047	0.023	0.009
Inflation	$\rho_\tau = 0.95$	0.760	0.557	0.249	0.175	0.147	0.142
	$\rho_\tau = 1$	0.656	0.326	0.159	0.082	0.042	0.017
Output	$\rho_\tau = 0.95$	0.920	0.734	0.624	0.538	0.495	0.485
	$\rho_\tau = 1$	0.896	0.710	0.607	0.525	0.484	0.476
		Inflation Target Shock					
Nominal Interest Rate	$\rho_\tau = 0.95$	0.532	0.735	0.829	0.880	0.898	0.901
	$\rho_\tau = 1$	0.553	0.797	0.897	0.949	0.974	0.990
Inflation	$\rho_\tau = 0.95$	0.229	0.433	0.744	0.819	0.847	0.853
	$\rho_\tau = 1$	0.335	0.667	0.836	0.915	0.957	0.983
Output	$\rho_\tau = 0.95$	0.020	0.068	0.061	0.052	0.048	0.047
	$\rho_\tau = 1$	0.042	0.099	0.086	0.074	0.068	0.067
		Technology Shock					
Nominal Interest Rate	$\rho_\tau = 0.95$	0.000	0.006	0.009	0.010	0.010	0.011
	$\rho_\tau = 1$	0.001	0.004	0.005	0.004	0.003	0.001
Inflation	$\rho_\tau = 0.95$	0.011	0.010	0.007	0.006	0.006	0.081
	$\rho_\tau = 1$	0.009	0.007	0.005	0.003	0.001	0.001
Output	$\rho_\tau = 0.95$	0.060	0.198	0.315	0.410	0.457	0.467
	$\rho_\tau = 1$	0.062	0.191	0.307	0.401	0.448	0.458

Notes: The table reports the theoretical fractions of the k-step ahead forecast-error variance of each variable attributed to each of the structural shocks. The fractions may not add up to 1 due to rounding.

2.2.2 Results

Using model (1)–(3) as a data-generating process, we simulate 2000 sequences $\{i_t, \pi_t, y_t\}_{t=1}^{T}$ of length T. We consider both a large sample ($T = 10,000$) and a small sample ($T = 275$). The latter roughly corresponds to the number of observations used in our empirical analysis, discussed in the next section. In each case, the resulting sample is obtained after discarding the first 100 observations to ensure that the results do not depend on initial conditions. As stated above, the artificial series are generated both under the assumptions that the inflation target shock is persistent ($\rho_\tau = 0.95$) and permanent ($\rho_\tau = 1$).

For each Monte Carlo replication, we estimate a VAR(3) using the synthetic series $i_t, \pi_t,$ and y_t, and identify the monetary policy and inflation target shocks using the identification procedure described in Section 2. The results are shown in Figures 2 and 3 for $T = 10,000$ and in Figures 4 and 5 for $T = 275$. In each figure, the dashed lines represent the true (model-based) responses, the solid lines represent the estimated median responses across the 2000 replications, the dark and light shaded areas represent, respectively, the 84 and 95 percent confidence bands. Table 3 reports the estimated median forecast-error variance decomposition.

Consider first the results for $T = 10,000$, which illustrate the asymptotic properties of our estimates. The top panels of Figures 2 and 3 show that our identification procedure yields unbiased estimates of the effects of the monetary policy shock, regardless of whether the data are driven by persistent or permanent inflation target shocks. The estimated effects of the inflation target shock on the nominal interest rate and inflation are also unbiased, but that on output exhibits very small downward bias when the shock is persistent. In all cases, the estimated confidence bands are extremely narrow, indicating very little variability of the estimates. In addition, Table 3 shows that the estimated forecast-error variance decomposition is nearly identical to its model-based counterpart. These results suggest that, asymptotically, our identification procedure is remarkably successful at recovering the true structural shocks, including the neo-Fisherian one.

Next, consider the results for $T = 275$. Our procedure again performs very well in extracting the true monetary policy shock and in estimating its effects with precision, as shown in the top panels of Figures 4 and 5. The estimated effects of the inflation target shock on the nominal interest rate and inflation are biased downward at long horizons when the true shock is permanent (see the bottom panels of Figure 5), but in all cases, the theoretical responses lie within the estimated 95 percent confidence intervals. The estimated variance decomposition is also considerably similar to its theoretical counterpart, irrespective of whether the true inflation target shock is persistent or permanent.

Based on these results, we deem our identification procedure reliable not only in large samples but also in small samples of the size typically used in times-series analysis with aggregate data.

Robustness To check the robustness of our identification method, we also generate artificial data under the following alternative assumptions about the model economy: (i) non-optimizing firms index their prices to the past level of the inflation target (rather than to past inflation), (ii) technology shocks are permanent (rather than persistent), and (iii) monetary policy shocks are mildly autocorrelated, with $\rho_m = 0.5$ (rather than being i.i.d.). In all cases, our identification strategy performs remarkably well in recovering the true shocks. To conserve space, the results are not reported but are available upon request.

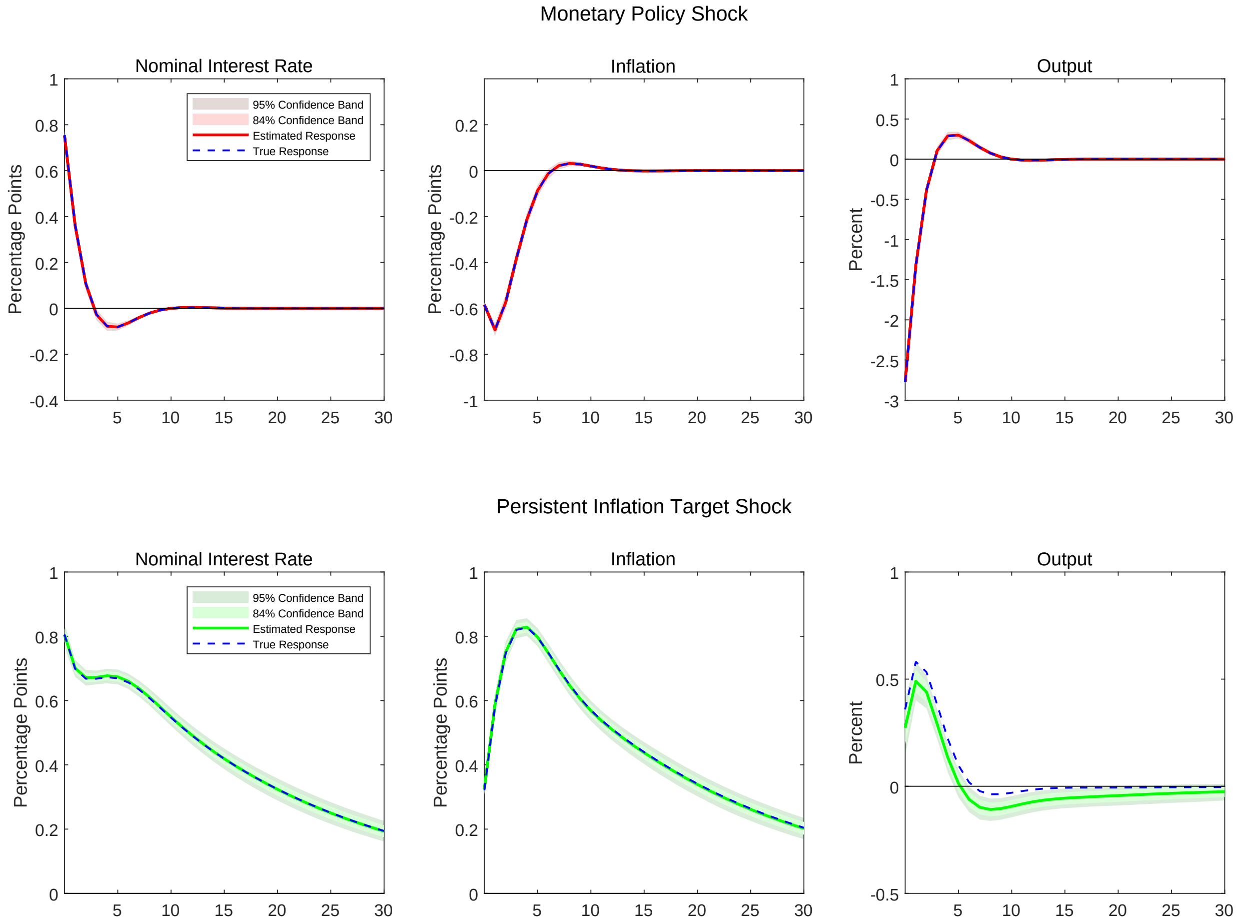


Figure 2: Simulation results: Impulse responses estimated using artificial data with a persistent inflation target shock (large sample).

Notes: The figure shows the impulse responses to monetary policy and inflation target shocks estimated within a three-equation VAR using artificial data generated from a simple New Keynesian model. The series used in estimation are those of the nominal interest rate, inflation, and output, each including 10,000 observations. The responses of the nominal interest rate and inflation are expressed in percentage-point deviations from their pre-shock levels. The response of output is expressed as percentage deviation from its pre-shock level. The dark and light shaded areas represent, respectively, the 84 and 95 percent confidence bands based on 2000 draws. The solid lines are the median impulse responses. The dashed lines are the theoretical (true) responses.

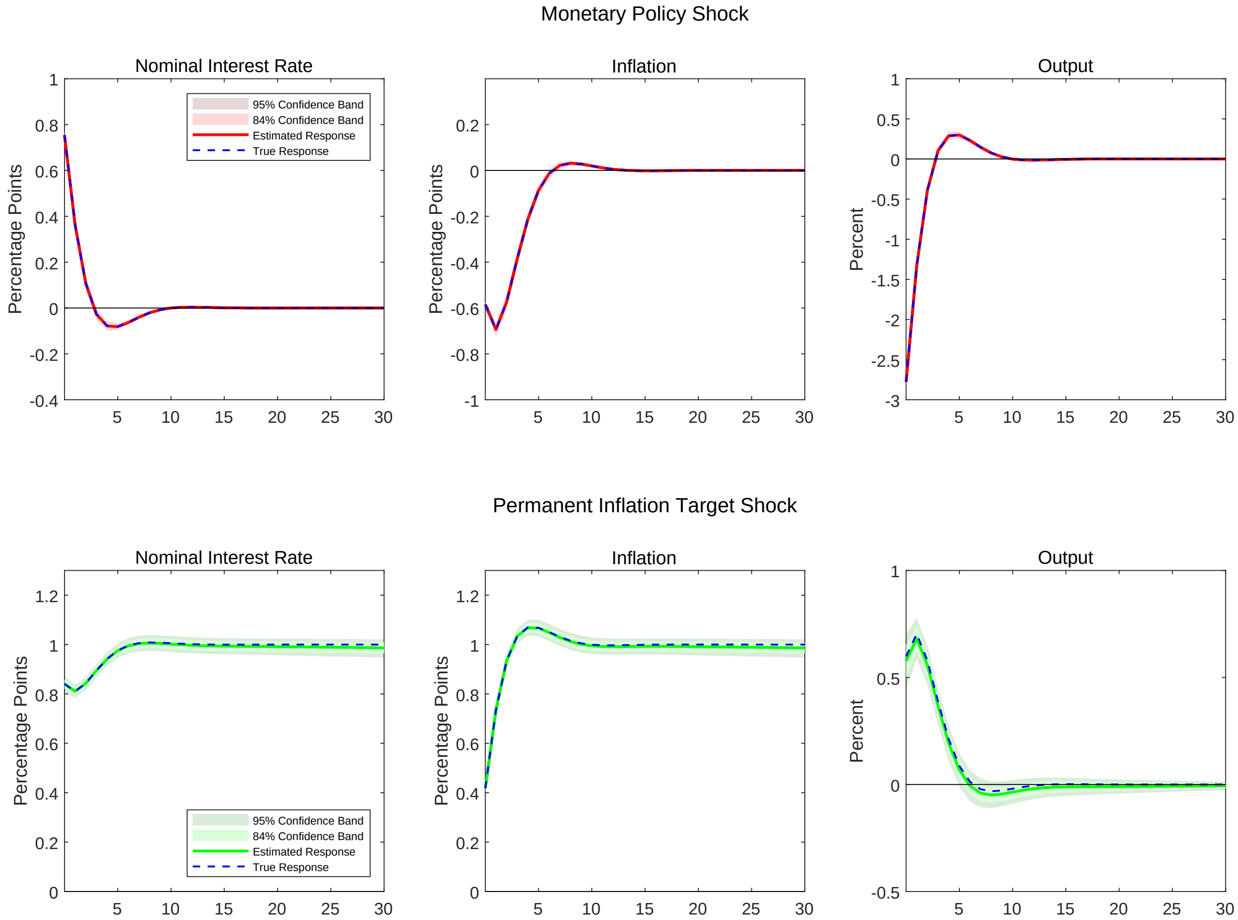


Figure 3: Simulation results: Impulse responses estimated using artificial data with a permanent inflation target shock (large sample).

Notes: The figure shows the impulse responses to monetary policy and inflation target shocks estimated within a three-equation VAR using artificial data generated from a simple New Keynesian model. The series used in estimation are those of the nominal interest rate, inflation, and output, each including 10,000 observations. The responses of the nominal interest rate and inflation are expressed in percentage-point deviations from their pre-shock levels. The response of output is expressed as percentage deviation from its pre-shock level. The dark and light shaded areas represent, respectively, the 84 and 95 percent confidence bands based on 2000 draws. The solid lines are the median impulse responses. The dashed lines are the theoretical (true) responses.

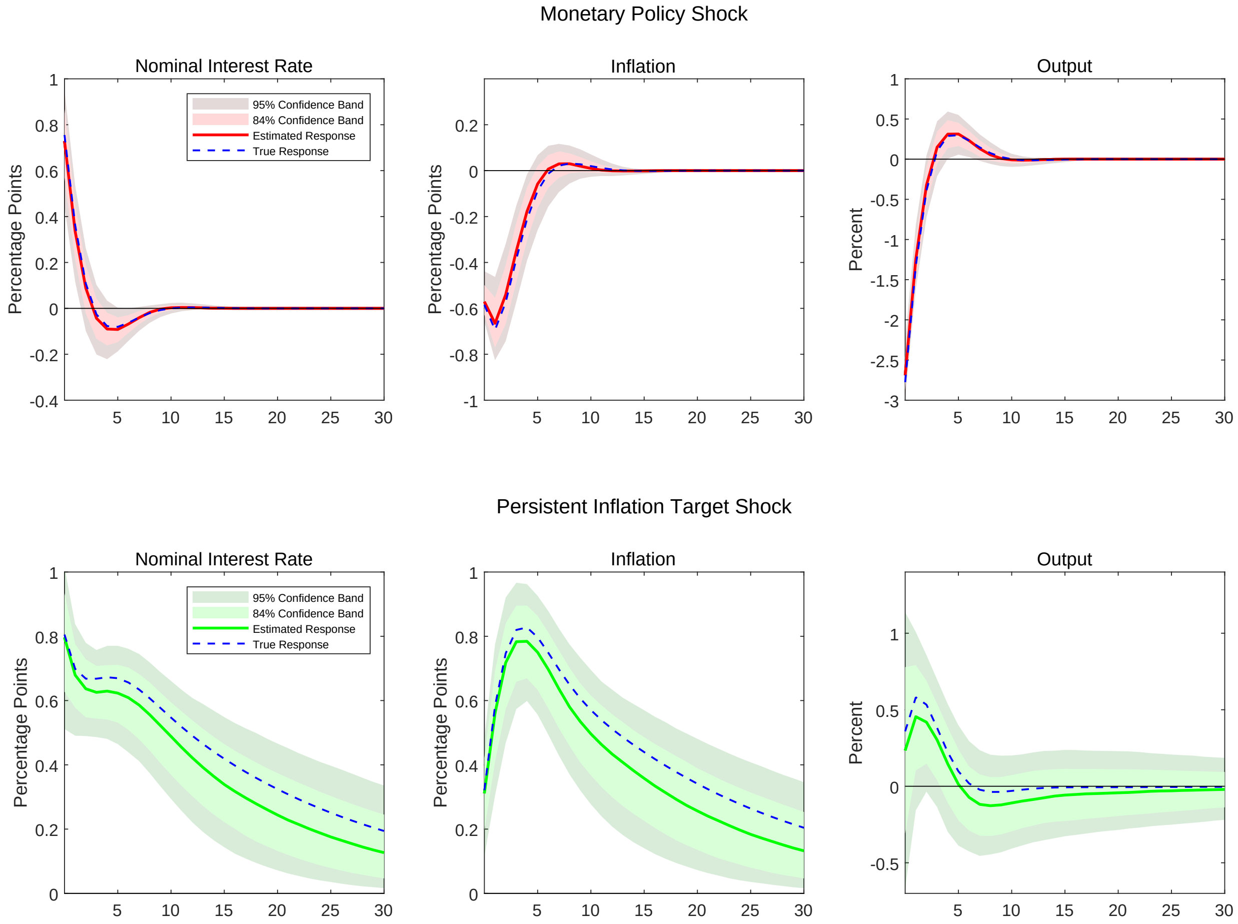


Figure 4: Simulation results: Impulse responses estimated using artificial data with a persistent inflation target shock (small sample).

Notes: The figure shows the impulse responses to monetary policy and inflation target shocks estimated within a three-equation VAR using artificial data generated from a simple New Keynesian model. The series used in estimation are those of the nominal interest rate, inflation, and output, each including 275 observations. The responses of the nominal interest rate and inflation are expressed in percentage-point deviations from their pre-shock levels. The response of output is expressed as percentage deviation from its pre-shock level. The dark and light shaded areas represent, respectively, the 84 and 95 percent confidence bands based on 2000 draws. The solid lines are the median impulse responses. The dashed lines are the theoretical (true) responses.

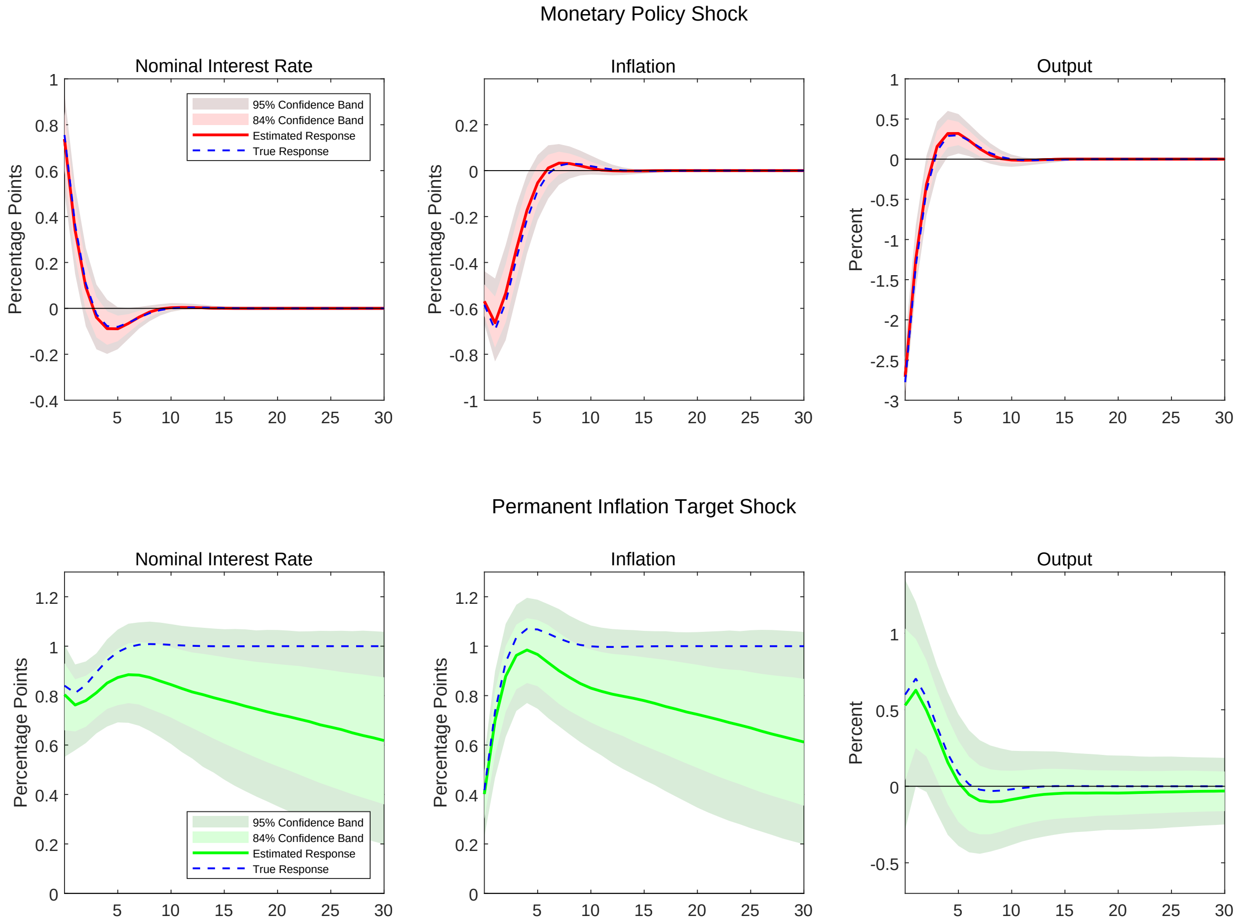


Figure 5: Simulation results: Impulse responses estimated using artificial data with a permanent inflation target shock (small sample).

Notes: The figure shows the impulse responses to monetary policy and inflation target shocks estimated within a three-equation VAR using artificial data generated from a simple New Keynesian model. The series used in estimation are those of the nominal interest rate, inflation, and output, each including 275 observations. The responses of the nominal interest rate and inflation are expressed in percentage-point deviations from their pre-shock levels. The response of output is expressed as percentage deviation from its pre-shock level. The dark and light shaded areas represent, respectively, the 84 and 95 percent confidence bands based on 2000 draws. The solid lines are the median impulse responses. The dashed lines are the theoretical (true) responses.

Table 3: Simulation results: Fractions of forecast-error variance attributed to monetary policy and inflation target shocks estimated using artificial data.

		Horizon					
Panel A: $\rho_\tau = 0.95$		$k = 1$	$k = 4$	$k = 8$	$k = 16$	$k = 32$	$k = 80$
		Monetary Policy Shock					
	Theoretical	0.468	0.259	0.162	0.110	0.092	0.088
Nominal Interest Rate	Estimated (Large Sample)	0.466	0.257	0.161	0.110	0.092	0.088
	Estimated (Small Sample)	0.439	0.249	0.167	0.120	0.102	0.097
	Theoretical	0.760	0.557	0.249	0.175	0.147	0.142
Inflation	Estimated (Large Sample)	0.761	0.434	0.250	0.175	0.148	0.143
	Estimated (Small Sample)	0.732	0.412	0.244	0.181	0.156	0.151
	Theoretical	0.920	0.734	0.624	0.538	0.495	0.485
Output	Estimated (Large Sample)	0.921	0.734	0.624	0.538	0.495	0.486
	Estimated (Small Sample)	0.884	0.705	0.608	0.531	0.497	0.489
		Inflation Target Shock					
	Theoretical	0.532	0.735	0.829	0.880	0.898	0.901
Nominal Interest Rate	Estimated (Large Sample)	0.531	0.741	0.838	0.889	0.907	0.910
	Estimated (Small Sample)	0.524	0.718	0.810	0.861	0.872	0.870
	Theoretical	0.229	0.433	0.744	0.819	0.847	0.853
Inflation	Estimated (Large Sample)	0.235	0.564	0.748	0.822	0.849	0.854
	Estimated (Small Sample)	0.216	0.537	0.723	0.788	0.806	0.804
	Theoretical	0.020	0.068	0.061	0.052	0.048	0.047
Output	Estimated (Large Sample)	0.009	0.046	0.040	0.038	0.037	0.037
	Estimated (Small Sample)	0.020	0.062	0.066	0.079	0.089	0.095
Panel B: $\rho_\tau = 1$							
		Monetary Policy Shock					
	Theoretical	0.447	0.198	0.098	0.047	0.023	0.009
Nominal Interest Rate	Estimated (Large Sample)	0.445	0.197	0.098	0.047	0.023	0.009
	Estimated (Small Sample)	0.433	0.200	0.108	0.059	0.036	0.024
	Theoretical	0.656	0.326	0.159	0.082	0.042	0.017
Inflation	Estimated (Large Sample)	0.657	0.326	0.160	0.083	0.042	0.017
	Estimated (Small Sample)	0.628	0.312	0.162	0.094	0.058	0.040
	Theoretical	0.896	0.710	0.607	0.525	0.484	0.476
Output	Estimated (Large Sample)	0.897	0.711	0.609	0.527	0.486	0.477
	Estimated (Small Sample)	0.865	0.685	0.595	0.529	0.497	0.481
		Inflation Target Shock					
	Theoretical	0.553	0.797	0.897	0.949	0.974	0.990
Nominal Interest Rate	Estimated (Large Sample)	0.554	0.799	0.898	0.950	0.975	0.990
	Estimated (Small Sample)	0.516	0.747	0.856	0.918	0.946	0.960
	Theoretical	0.335	0.667	0.836	0.915	0.957	0.983
Inflation	Estimated (Large Sample)	0.335	0.667	0.836	0.915	0.957	0.982
	Estimated (Small Sample)	0.313	0.630	0.796	0.876	0.920	0.942
	Theoretical	0.042	0.099	0.086	0.074	0.068	0.067
Output	Estimated (Large Sample)	0.039	0.092	0.079	0.069	0.064	0.063
	Estimated (Small Sample)	0.034	0.092	0.095	0.102	0.112	0.130

Note: The table reports the median fraction (across 2000 bootstrap replications) of the k-step ahead forecast-error variance of each variable due to monetary policy and inflation target shocks.

3 Empirical Evidence

In this section, we use our empirical strategy to estimate the dynamic effects of neo-Fisherian shocks and their relative contribution to aggregate fluctuations in the U.S.

3.1 Data

We use quarterly U.S. data spanning the period 1954Q3–2023Q4. The nominal interest rate is measured by the federal funds rate, expressed in percent per year. Inflation is measured by the growth rate of the GDP deflator, expressed in percent per year. Output is measured by annualized real GDP (chained 2017 dollars, seasonally adjusted) divided by the civilian non-institutional population 16 years of age and older, and expressed in logarithm. All the series are retrieved from the FRED database.

3.2 Results

Below, we discuss our empirical findings based on our agnostic identification strategy. The results are based on a VAR(3) but are robust to higher lag orders.

3.2.1 Impulse responses

Figure 6 shows the impulse responses to the identified monetary policy and neo-Fisherian shocks. The dark and light shaded areas represent, respectively, the 84 and 95 percent bias-corrected bootstrap confidence intervals, computed using Kilian (1998)'s procedure with 2000 replications. The solid lines represent the median responses.

Consistently with the imposed sign restrictions, a positive realization of the monetary policy shock raises the nominal interest rate but lowers inflation and output on impact (see the top panels of Figure 6). These two variables remain below their pre-shock levels for a prolonged period of time. Thus, although the sign-restriction approach — by construction — prevents the occurrence of a price puzzle on impact, the estimated response of inflation does not exhibit such a puzzle at subsequent horizons.

The impulse responses to the neo-Fisherian shock are depicted in the bottom panels of Figure 6. A positive realization of the shock leads to a persistent and hump-shaped increase in the nominal interest rate, which, however, ultimately returns to its initial level. Inflation also rises persistently in response to the shock, though its response is not as persistent as that of the nominal interest rate and lacks the hump-shaped pattern. These observations suggest that the data do not support the existence of a shock that raises permanently both the nominal interest rate and inflation. Finally, the identified neo-Fisherian shock is expansionary in the short run, as it raises aggregate output for at least a year.

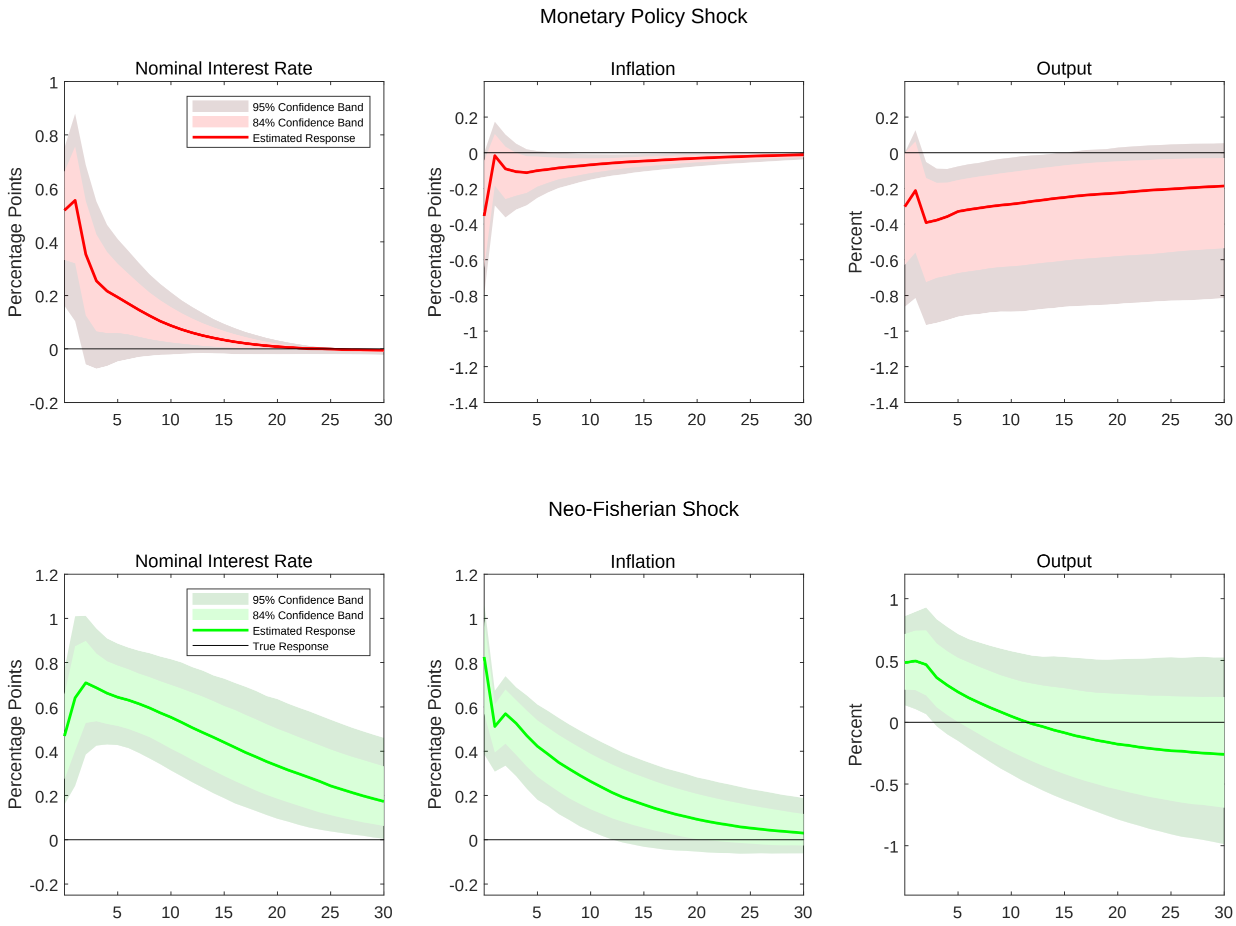


Figure 6: Estimated impulse responses.

Notes: The figure shows the impulse responses to monetary policy and neo-Fisherian shocks estimated within a three-equation VAR using U.S. data. The series used in estimation are those of the nominal interest rate, inflation, and output. The responses of the nominal interest rate and inflation are expressed in percentage-point deviations from their pre-shock levels. The response of output is expressed as percentage deviation from its pre-shock level. The dark and light shaded areas represent, respectively, the 84 and 95 percent bias-corrected bootstrap confidence intervals, computed using Kilian (1998)'s procedure with 2000 replications. The solid lines represent the median responses.

3.2.2 Variance decomposition

By assumption, our identification strategy requires that the neo-Fisherian shock accounts for the bulk of the forecast-error variance of the nominal interest rate at the 80-quarter horizon. But how large is the contribution of this shock to the conditional variance of not only the interest rate, but also inflation and output at short horizons and at business-cycle frequencies?

Table 4 reports the median fractions (across 2000 bootstrap replications) of the forecast-error variance attributed to monetary policy and neo-Fisherian shocks at various horizons. The neo-Fisherian shock turns out to be important in explaining movements in the nominal interest at any given horizon, with a contribution that amounts to roughly 40 percent at the one-quarter horizon but that keeps increasing with the horizon. The monetary policy shock explains essentially the remainder of the forecast-error variance of the nominal interest rate, but its contribution dwindles as the horizon increases. The neo-Fisherian shock also proves to be the main driver of movements in inflation, accounting for more than 57 percent of its conditional variance at the one-quarter horizon and roughly 68 percent at business-cycle frequencies. In contrast, the contribution of the monetary policy shock to the conditional variance of inflation never exceeds 10 percent at any given horizon. Finally, the neo-Fisherian shock does not seems to play a major role in driving fluctuations in aggregate output, though it still accounts for more than 10 percent of its conditional variance at business-cycle frequencies. Overall, these results indicate that the neo-Fisherian shock is the principal source of fluctuations in nominal variables, while being responsible for a non-negligible fraction of output variability.

Table 4: Fractions of forecast-error variance attributed to monetary policy and neo-Fisherian shocks.

	Horizon					
	$k = 1$	$k = 4$	$k = 8$	$k = 16$	$k = 32$	$k = 80$
	Monetary Policy Shock					
Nominal Interest Rate	0.503	0.292	0.206	0.143	0.114	0.104
Inflation	0.102	0.065	0.058	0.058	0.059	0.057
Output	0.090	0.105	0.107	0.088	0.060	0.036
	Neo-Fisherian Shock					
Nominal Interest Rate	0.397	0.604	0.722	0.797	0.818	0.808
Inflation	0.567	0.668	0.685	0.684	0.680	0.676
Output	0.234	0.198	0.132	0.096	0.106	0.118

Note: The table reports the median fractions (across 2000 bootstrap replications) of the k-step ahead forecast-error variance of each variable due to monetary policy and neo-Fisherian shocks.

3.2.3 Historical decomposition

Further insights into the relative importance of the neo-Fisherian shock in accounting for fluctuations in the nominal interest rate, inflation, and output can be gained by inspecting their historical decomposition. Figure 7 depicts the median time paths (across 2000 bootstrap replications) of these variables simulated from the estimated VAR under the assumption that the neo-Fisherian shock is the only stochastic disturbance driving the data. For ease of visualization, output is expressed in growth-rate terms, and the actual series are superimposed on the simulated ones. Table 5 reports the correlations and variance ratios between the actual and simulated series.

Figure 7 shows that the simulated series of the nominal interest rate and especially of inflation track very closely their actual counterparts. The correlation between the simulated and actual series amounts to 0.84 for the nominal interest rate and 0.97 for inflation. In each case, the simulated series is roughly 80 percent as volatile as the actual one. These observations confirm that the neo-Fisherian shock has been the dominant source of fluctuations in these variables.

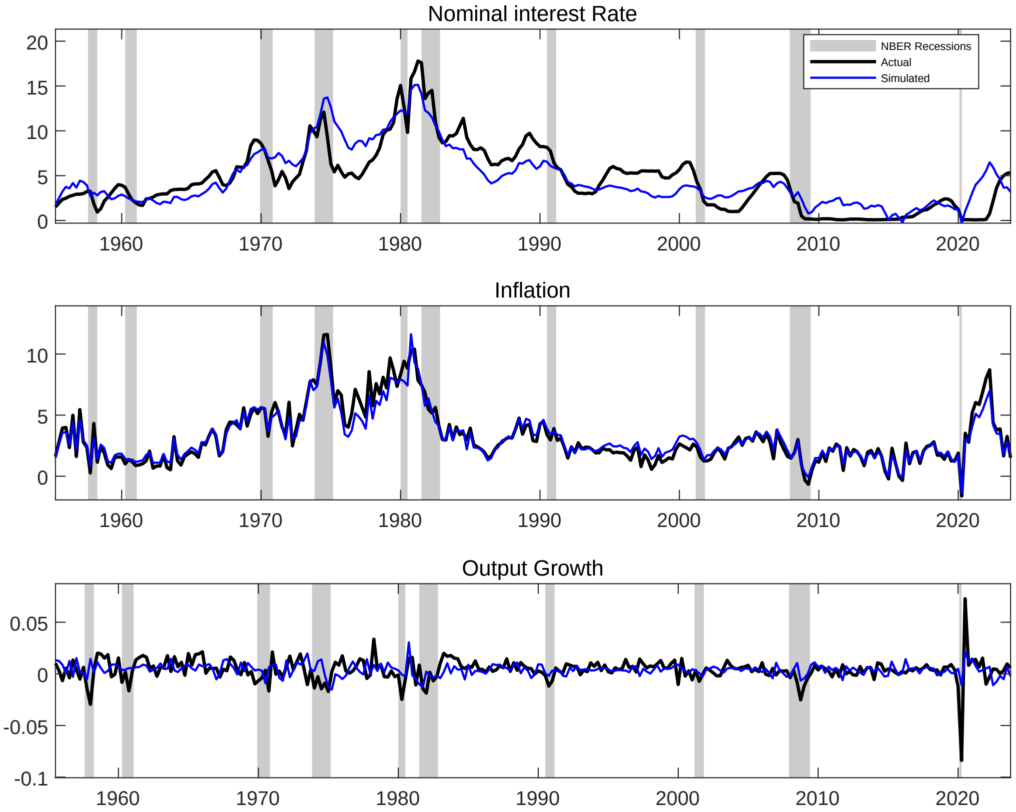


Figure 7: Historical decomposition.

Notes: The figure shows the actual series (thick black lines) and the ones simulated from the VAR assuming that the neo-Fisherian shock is the only disturbance generating the data (thin blue lines). Each simulated data point is the median across 2000 bootstrap replications. The shaded areas indicate the dates of the U.S. recessions identified by the NBER.

On the other hand, the simulated series of output growth is weakly correlated with — and much smoother than — the actual one, suggesting that the neo-Fisherian shock has played a limited role in accounting for output fluctuations on average. Nonetheless, this shock appears to have played a more significant role during the most recent downturns, accounting for more than one-third of the decline in output growth during the Great Recession and roughly 20 percent during the COVID-19 pandemic. Intuitively, in normal times, where monetary authorities operate away from the effective lower bound (ELB) on the policy rate, the positive comovement between inflation and the nominal interest rate induced by the neo-Fisherian shock leads to modest variation in the real interest rate and thus in economic activity. In contrast, during severe recessions that drive the policy rate to its ELB, as was the case during the Great Recession and the COVID-19 pandemic, the partial adjustment of the nominal interest rate prompts a more substantial change in the real interest rate.

Table 5: Correlations and variance ratios between the simulated and actual series.

	Correlation	Variance Ratio
Nominal Interest Rate	0.840	0.775
Inflation	0.969	0.792
Output Growth	0.253	0.289

Notes: The table reports the median (across 2000 bootstrap replications) correlations and variance ratios between the simulated and actual series. The former are constructed from the VAR under the assumption that the neo-Fisherian shock is the only disturbance generating the data.

4 What is being Identified?

The consensual view in the literature on neo-Fisherism is that the shock leading to a positive comovement of the nominal interest rate and inflation captures exogenous shifts in monetary policy that are highly persistent or even permanent. Often, such policy shifts are construed as changes in the inflation target (e.g., Garín et al., 2018; Uribe, 2022). Given that announcements about changing the inflation target are extremely infrequent events that happen once in several decades (particularly in advanced economies), it seems implausible that inflation target shocks can be extracted within VARs (or alternative time-series models) estimated using quarterly data. In this section, we offer an alternative interpretation of the neo-Fisherian shock identified in the data.

4.1 Inflation target shocks vs liquidity preference shocks

Let us amend the utility function in the benchmark economy by assuming that households' preferences depend on the real value of risk-free bonds, as in Krishnamurthy & Vissing-Jorgensen (2012). More specifically, the representative household maximizes

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\ln(C_t) - \psi \frac{{N_t}^{1+\varphi}}{1+\varphi} + \zeta_t V\left(\frac{\mathcal{B}_t}{P_t}\right) \right], \tag{4}$$

where $\mathcal{B}_t$ is a stock of one-period riskless nominal bonds that mature in period t, $V(\cdot)$ is increasing and concave in $\frac{\mathcal{B}_t}{P_t}$ and is such that $V(0) = 0$ and $V'(0) = 1$, and ζ_t is an exogenous shock that evolves according to the following process:

$$\zeta_t = \rho_\zeta \zeta_{t-1} + \epsilon_{\zeta,t}, \qquad \epsilon_{\zeta,t} \sim N(0, \sigma_\zeta),$$

where $0 < \rho_\zeta < 1$. Positive realizations of $\epsilon_{\zeta,t}$ therefore imply that the representative household values the liquidity and safety of risk-free assets. Accordingly, we shall refer to ζ_t as a liquidity preference shock. In this model, the Euler equation becomes

$$\frac{1}{C_t} = \beta(1+i_t)\mathbb{E}_t \left[\frac{1}{(1+\pi_{t+1})C_{t+1}} \right] + \zeta_t V'\left(\frac{\mathcal{B}_t}{P_t}\right). \tag{5}$$

Equation (5) implies that an increase in ζ_t lowers the marginal disutility of saving in the risk-free bond $\left(\frac{1}{C_t} - \zeta_t V'\left(\frac{\mathcal{B}_t}{P_t}\right)\right)$, thus increasing the incentive to save. As a result, the natural rate of interest falls. With flexible prices, this does not affect consumption (and output) in equilibrium. With sticky prices, however, and to the extent that monetary policy is sub-optimal, the nominal interest rate does not fall sufficiently to replicate the flexible-price allocation, leading to a fall in consumption and output. This contraction in turn lowers inflation (see Bouakez et al., 2020). Conversely, a negative realization of the liquidity preference shock raises the nominal interest rate, output, and inflation, just as does an exogenous increase in the inflation target.

In order to show the similarity between the effects of liquidity preference and inflation target shocks, let us abstract from monetary policy and technology shocks and from interest-rate smoothing (by setting $\varrho = 0$), and assume for simplicity that steady-state output is normalized to 1.[6] The log-linearized model therefore becomes

$$\begin{aligned} y_t &= \mathbb{E}_t y_{t+1} - (i_t - \mathbb{E}_t \pi_{t+1}) - \zeta_t, && (6) \\ \pi_t &= (1+\beta)^{-1} (\pi_{t-1} + \beta \mathbb{E}_t \pi_{t+1} + \lambda y_t), && (7) \\ i_t &= \phi_\pi \pi_t + \phi_y y_t - (\phi_\pi - 1)\, \tau_t. && (8) \end{aligned}$$

It is straightforward to see that

$$\begin{aligned} \frac{dy_{t+j}}{d\zeta_t} &= -(\phi_\pi - 1) \frac{dy_{t+j}}{d\tau_t}, \qquad j = 0, 1... \\ \frac{d\pi_{t+j}}{d\zeta_t} &= -(\phi_\pi - 1) \frac{d\pi_{t+j}}{d\tau_t}, \qquad j = 0, 1... \\ \frac{di_{t+j}}{d\zeta_t} &= -(\phi_\pi - 1) \left(\frac{di_{t+j}}{d\tau_t} + \phi_\pi - 1\right), \qquad j = 0, 1... \end{aligned}$$

Thus, to the extent that τ_t and ζ_t are equally persistent, the responses of output and inflation to a positive realization of $\epsilon_{\tau,t}$ are proportional (thus identical in shape) to their responses to a negative realization of $\epsilon_{\zeta,t}$. In the special case where $\rho_\zeta = \rho_\tau$ and $\sigma_\zeta = (\phi_\pi - 1)\, \sigma_\tau$, one can easily see that a model with liquidity preference shocks would be observationally equivalent to a model with inflation target shocks with respect to the dynamics of output and inflation. On the other hand, while the liquidity preference shock always gives rise to a short-run positive comovement between the nominal interest and inflation rates (i.e., a neo-Fisherian effect), the inflation target shock does so only when it is sufficiently persistent. Figure 8 illustrates these predictions for $\rho_\tau = \rho_\zeta \in \{0, 0.95\}$.

In the more general case where $\varrho > 0$, the dynamic responses to a liquidity preference shock are no longer affine functions of those implied by an inflation target shock. However, as is depicted in

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[6] At the steady state, $Y = \left[\frac{1}{\psi}\left(\frac{\nu-1}{\nu}\right)\right]^{\frac{1}{1+\varphi}}$. Setting ψ to $\frac{\nu}{\nu-1}$ ensures that $Y = 1$.

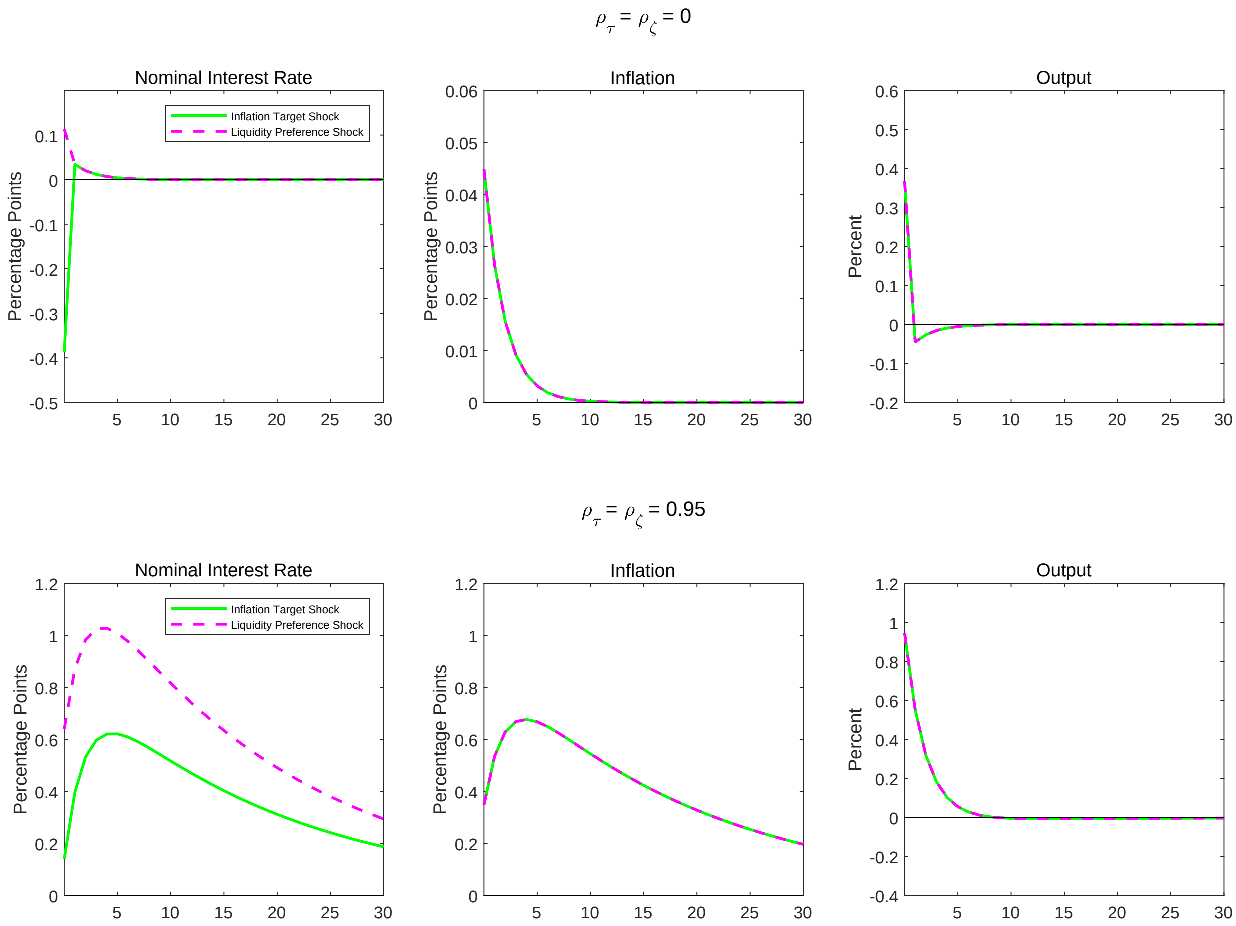

Figure 8: Impulse responses to inflation target and liquidity preference shocks without interest-rate smoothing ($\varrho = 0$).

Notes: The figure shows the impulse responses to a positive inflation target shock and to a negative liquidity preference shock with $\varrho = 0$. The two shocks are i.i.d ($\rho_\tau = \rho_\zeta = 0$) in the top panels and are equally persistent ($\rho_\tau = \rho_\zeta = 0.95$) in the bottom panels. The size of the inflation target shock is equal to 1 percent and that of the liquidity preference shock is equal to $(\phi_\pi - 1)$ percent, where $\phi_\pi = 1.5$. The responses of the nominal interest rate and inflation are expressed in percentage-point deviations from their pre-shock levels. The response of output is expressed as percentage deviation from its pre-shock level.

Figure 9, where we assume that $\varrho = 0.8$ and $\rho_\zeta = \rho_\tau = 0.95$, the two shocks still lead to a positive comovement of the nominal interest rate, inflation, and output, consistently with the empirical findings. Interestingly, the response of the nominal interest rate to a negative liquidity preference shock exhibits the same hump-shaped pattern observed in the data, unlike the response triggered by an inflation target shock, which is rather monotonic.

These arguments, along with the observation that there have not been explicit announcements about persistent/permanent changes in the U.S. inflation target since its implementation, suggest that the neo-Fisherian effect measured in the data is more likely to be due to persistent liquidity preference shocks rather than to long-lasting exogenous shifts in U.S. monetary policy. The next section provides formal support to this conjecture.

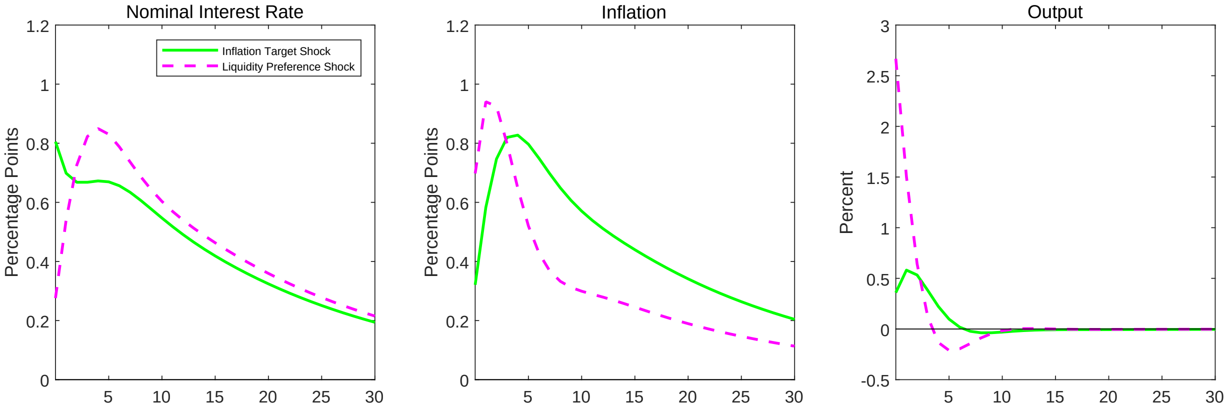

Figure 9: Impulse responses to inflation target and liquidity preference shocks with interest-rate smoothing ($\varrho = 0.8$).

Notes: The figure shows the impulse responses to a positive inflation target shock and to a negative liquidity preference shock with $\varrho = 0.8$. The two shocks are equally persistent ($\rho_\zeta = \rho_\tau = 0.95$). The size of the inflation target shock is equal to 1 percent and that of the liquidity preference shock is equal to $(\phi_\pi - 1)$ percent, where $\phi_\pi = 1.5$. The responses of the nominal interest rate and inflation are expressed in percentage-point deviations from their pre-shock levels. The response of output is expressed as percentage deviation from its pre-shock level.

4.2 Which story best fits the data? A Bayesian perspective

In this section, we use Bayesian methods to determine whether a model with liquidity preference shocks (henceforth referred to as the LP model) provides a better overall fit of U.S. data than does an otherwise identical model with inflation target shocks (henceforth referred to as the IT model). In the Appendix, we provide a detailed description of the two models, and derive the corresponding three log-linear equations characterizing the dynamics of output, inflation, and the nominal interest rate. These are given by equations (A.8)–(A.10) for the IT model and equations (A.11)–(A.13) for the LP model. Notice that the two models are equally parsimonious and share the same deep parameters.

Both models are estimated using Bayesian methods. To do so, we use quarterly data on the nominal interest rate, inflation, and output growth. From the solution of each model, we derive the state-space representation and apply the Kalman filter to construct the likelihood function $L(z^T|\Theta)$, where z^T is the vector of observables and Θ is the vector of structural parameters (see the Appendix for details). Let $p(\Theta)$ denote a prior probability of the structural parameters. Then, by Bayes' law, $p(\Theta|z^T) \propto p(\Theta)L(z^T|\Theta)$, where $p(\Theta|z^T)$ is the posterior distribution. We estimate the latter using the Random-Walk Metropolis-Hastings (RW-MH) algorithm with 1 million draws.

Table 6 summarizes our Bayesian analysis of the two models. The second, third, and fourth columns of the table report the prior distributions of the structural parameters listed in the first column. Our prior configuration is quite standard and follows closely that chosen by Uribe (2022).

In particular, we assume that ρ_m follows a Beta distribution with mean 0.3 and a standard deviation of 0.2, and ρ_τ and ρ_ζ follow a Beta distribution with mean 0.7 and a standard deviation of 0.2.

Table 6: Prior and posterior distributions of the structural parameters.

	Prior Distribution			Posterior Distribution					
				IT Model			LP Model		
Parameter	Distribution	Mean	S.D.	Mean	S.D.	HPD	Mean	S.D.	HPD
β	BETA	0.990	0.005	0.991	0.004	[0.983 0.998]	0.990	0.004	[0.981 0.998]
η	GAMMA	1.000	0.200	1.054	0.033	[0.992 1.109]	1.041	0.031	[0.983 1.095]
θ	BETA	0.500	0.200	0.545	0.020	[0.503 0.579]	0.458	0.017	[0.428 0.489]
ϱ	BETA	0.700	0.200	0.863	0.015	[0.833 0.887]	0.583	0.057	[0.501 0.689]
ϕ_π	GAMMA	1.500	0.250	2.424	0.034	[2.365 2.482]	2.332	0.073	[2.238 2.495]
ϕ_y	GAMMA	0.125	0.100	0.056	0.024	[0.007 0.103]	0.125	0.029	[0.073 0.186]
ρ_a	BETA	0.700	0.200	0.999	0.000	[0.996 1.000]	0.996	0.003	[0.988 1.000]
ρ_m	BETA	0.300	0.200	0.421	0.048	[0.337 0.483]	0.436	0.079	[0.286 0.539]
ρ_τ	BETA	0.700	0.200	0.988	0.007	[0.976 0.999]	–	–	–
ρ_ζ	BETA	0.700	0.200	–	–	–	0.929	0.017	[0.898 0.964]
σ_a	INVGAMMA	0.010	0.010	0.012	0.004	[0.011 0.013]	0.011	0.003	[0.010 0.012]
σ_m	INVGAMMA	0.010	0.010	0.002	0.004	[0.002 0.003]	0.004	0.003	[0.003 0.004]
σ_τ	INVGAMMA	0.010	0.010	0.002	0.004	[0.002 0.003]	–	–	–
σ_ζ	INVGAMMA	0.010	0.010	–	–	–	0.002	0.003	[0.001 0.002]
Log Marginal Likelihood				-75.011			-13.351		

Notes: The posterior distributions are constructed using 1 million Monte Carlo Markov Chain (MCMC) draws from the RW-MH posterior sampler with 100,000 burn-in draws. HPD denotes the 95 percent Bayesian highest probability density interval. The log marginal likelihoods are estimated from the MCMC draws using Geweke (1999)'s harmonic mean estimator.

The fifth, sixth, and seventh columns of Table 6 display the posterior means, posterior standard deviations, and 95 percent highest probability density (HPD) intervals of the structural parameters of the IT model, while the eighth, ninth, and tenth columns report those of the LP model, respectively. The two models lead to almost identical posterior inferences regarding the common structural parameters, the only exceptions being that the IT model infers a larger Calvo probability and a larger degree of interest-rate smoothing than does the LP model. Importantly, the inflation target shock is estimated to be nearly permanent, unlike the liquidity preference shock; the posterior means of ρ_τ and ρ_ζ are 0.988 and 0.929, and the corresponding upper bounds of the 95 percent HPD intervals are 0.999 and 0.964, respectively.

The last raw of Table 6 reports the log marginal likelihoods of the two models, which are estimated using Geweke (1999)'s harmonic mean estimator. They are equal to -75.011 and -13.351 for the IT and LP models, respectively. According to Kass & Raftery (1995), this difference in the marginal likelihoods implies very strong evidence in favor of the LP model against the IT model.

5 Conclusion

Existing empirical studies estimate the neo-Fisherian effect under the assumption that the underlying shock is a permanent shit in monetary policy, often interpreted as a lasting exogenous change in the inflation target. In this paper, we have proposed an alternative empirical strategy to detect and measure such an effect, which is agnostic about the persistence and nature of the shock that generates it. Monte Carlo simulations based on artificial data confirm that our approach is robustly reliable. Applying our methodology to U.S. data, we find strong evidence of a neo-Fisherian effect. The underlying shock, however, is found to persistent but not permanent, causing inflation and the nominal interest rate to eventually return to their pre-shock levels. The identified shock proves to be the main driver of these two variables at any given frequency, while accounting for a non-negligible fraction of output variability at business-cycle frequencies.

We have then provided theoretical and empirical arguments that advocate for the interpretation of the identified shock as a liquidity preference shock rather than an inflation target shock. While the two disturbances imply similar dynamics of the nominal interest rate, inflation, and output, Bayesian analysis indicates that a model with liquidity preference shocks is better supported by the data than an otherwise identical model with inflation target shocks.

Given the importance of liquidity preference shocks in accounting for interest-rate variability, it is plausible to believe that they also play a significant role in explaining exchange-rate movements. Extending our analysis to the context of an open economy would help shed light on this conjecture. We leave this inquiry for future research.

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A Appendix

Model with inflation target shocks (IT model)

The representative household in this economy has the following expected lifetime utility:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\ln(C_t) - \psi \frac{{N_t}^{1+\varphi}}{1+\varphi} \right],$$

where C_t is a consumption basket, N_t is hours worked, $0 < \beta < 1$ is the subjective discount factor, $\psi > 0$ is a utility shifter, and $\varphi > 0$ is the Frisch elasticity of labor supply.

The consumption basket consists of a Dixit–Stiglitz aggregator of a continuum of final goods, each of which is produced by a monopolistically competitive firm:

$$C_t = \left(\int_0^1 C_t(\iota)^{\frac{\nu-1}{\nu}} d\iota \right)^{\frac{\nu}{\nu-1}}$$

where $C_t(\iota)$ is the consumption demand for a particular final good indexed by $\iota \in [0, 1]$, and $\nu > 1$ represents the price elasticity of demand.

The static cost minimization problem of the representative household yields the demand function for each final good. Given the price of final good ι, $P_t(\iota)$, the demand function is

$$C_t(\iota) = \left(\frac{P_t(\iota)}{P_t} \right)^{-\nu} C_t,$$

where P_t is the aggregate price level, which satisfies

$$P_t = \left(\int_0^1 P_t(\iota)^{1-\nu} d\iota \right)^{\frac{1}{1-\nu}}.$$

The household maximizes its expected lifetime utility subject to the following budget constraint:

$$\mathcal{B}_t + P_t C_t \leq (1 + i_{t-1}) B_{t-1} + \mathcal{W}_t N_t + \mathcal{D}_t,$$

where $\mathcal{B}_t$, i_t, $\mathcal{W}_t$, and $\mathcal{D}_t$ denote nominal bond holdings, the nominal interest rate, the nominal wage, and nominal dividends from monopolistically competitive firms, respectively. The first-order necessary conditions associated with this maximization problem are

$$\frac{1}{C_t} = \beta (1 + i_t) \mathbb{E}_t \frac{1}{(1 + \pi_{t+1}) C_{t+1}}, \tag{A.1}$$

and

$$\psi N_t^{\varphi} = \frac{W_t}{C_t}, \tag{A.2}$$

where $\pi_t \equiv \frac{P_t}{P_{t-1}} - 1$ is the inflation rate between $t-1$ and t, and $W_t \equiv \frac{\mathcal{W}_t}{P_t}$ is the real wage.

Firm ι produces its final good using the production technology

$$Y_t(\iota) = e^{a_t} N_t(\iota),$$

where a_t denotes labor productivity (or technology), which is governed by the following process:

$$a_t = \rho_a a_{t-1} + \epsilon_{a,t}, \qquad \epsilon_{a,t} \sim N(0, \sigma_a),$$

where $0 \leq \rho_a < 1$. Given the production function above, the economy's average real marginal cost is

$$MC_t = \frac{W_t}{e^{a_t}}. \tag{A.3}$$

Final-good-producing firm set prices à la Calvo: in each period, a given firm resets its optimal price with probability $0 \leq 1 - \theta < 1$. Firms that cannot optimally reset prices fully index their current prices to past inflation. Let $\mathcal{P}_t$ denote the optimal reset price at time t. A firm that gets to reset its price at time t solves the following problem:

$$\max_{\mathcal{P}_t} \mathbb{E}_t \sum_{i=0}^{\infty} \theta^i Q_{t,t+i} \left\{\mathcal{P}_t - \mathcal{MC}_{t+i}\right\} C_{t+i|i},$$

where $Q_{t,t+i} \equiv \beta^i (C_t/C_{t+i})(P_t/P_{t+i})$ is the stochastic discount factor for nominal payoffs, $C_{t+i|i} \equiv \left(\frac{\mathcal{P}_t}{P_{t+i}}\right)^{-\nu} C_{t+i}$, and $\mathcal{MC}_{t+i}$ is the the economy's average nominal marginal cost. The FONC for the optimal price is

$$\mathcal{P}_t = \frac{\nu}{\nu - 1} \frac{\mathbb{E}_t \sum_{i=1}^{\infty} \theta^i Q_{t,t+i} \mathcal{MC}_{t+i} C_{t+i|i}}{\mathbb{E}_t \sum_{i=1}^{\infty} \theta^i Q_{t,t+i} C_{t+i|i}}. \tag{A.4}$$

Given the optimal price, the price index, P_t, follows the law of motion:

$$P_t^{1-\nu} = (1-\theta)\mathcal{P}_t^{1-\nu} + \theta[P_{t-1}(1+\pi_{t-1})]^{1-\nu}. \tag{A.5}$$

As in Uribe (2022), we assume that monetary policy is determined by a generalized Taylor rule that allows for stochastic variations in the inflation target, τ_t. More specifically, the central bank sets the short-term nominal interest rate according to

$$\left(\frac{1+i_t}{1+\tau_t}\right) = \left(\frac{1+i_{t-1}}{1+\tau_{t-1}}\right)^{\varrho} \left[\frac{1}{\beta}\left(\frac{1+\pi_t}{1+\tau_t}\right)^{\phi_\pi} \left(\frac{Y_t}{Y_t^f}\right)^{\phi_y}\right]^{1-\varrho} e^{m_t}, \tag{A.6}$$

where $0 \leq \varrho < 1$, $\phi_\pi > 1$, $\phi_y \geq 0$, Y_t/Y_t^f is the output gap, defined as the difference between actual output and its flexible-price counterpart, Y_t^f, and m_t is a monetary policy shock. The processes governing the evolution of m_t and τ_t are given by

$$\begin{aligned} m_t &= \rho_m m_{t-1} + \epsilon_{m,t}, \qquad \epsilon_{m,t} \sim N(0, \sigma_m), \\ \tau_t &= \rho_\tau \tau_{t-1} + \epsilon_{\tau,t}, \qquad \epsilon_{\tau,t} \sim N(0, \sigma_\tau), \end{aligned}$$

where $0 \leq \rho_m < 1$, and $0 \leq \rho_\tau \leq 1$.

Let $N_t \equiv \int_0^1 N_t(\iota) d\iota$ denote aggregate labor and $\Delta_t \equiv \int_0^1 \left(\frac{P_t(\iota)}{P_t}\right)^{-\nu} d\iota$. Then, we can write

$$\Delta_t Y_t = A_t N_t. \tag{A.7}$$

Consider a deterministic steady state in which real variables are constant, and let variables without a time subscript denote steady-state values and lower-case variables denote percentage deviations of their upper-case counterparts from their steady-state values (e.g., $y_t = \frac{Y_t - Y}{Y} \approx \ln Y_t - \ln Y$). Imposing the resource constraint $Y_t = C_t$, using (A.2), (A.3), and (A.7) to substitute for MC_t in (A.4), and log-linearizing the equilibrium conditions around the deterministic steady state, the dynamics of output, inflation, and the nominal interest rate can be summarized by the following equations:

$$y_t = \mathbb{E}_t y_{t+1} - (i_t - \mathbb{E}_t \pi_{t+1} - \ln \beta^{-1}), \tag{A.8}$$

$$\pi_t = (1+\beta)^{-1} \left[\pi_{t-1} + \beta \mathbb{E}_t \pi_{t+1} + \lambda \left(y_t - a_t\right)\right], \tag{A.9}$$

$$i_t = (1-\varrho) \ln \beta^{-1} + \varrho i_{t-1} + (1-\varrho) \left[\phi_\pi \pi_t + \phi_y (y_t - y_t^f)\right] - \left[(1-\varrho)\,\phi_\pi - 1\right] \tau_t - \varrho \tau_{t-1} + m_t, \tag{A.10}$$

where $\lambda \equiv \frac{(1-\theta)(1-\beta\theta)(1+\varphi)}{\theta} > 0$ and $y_t^f = a_t$.

Model with liquidity preference shocks (LP model)

In the LP model, we abstract from stochastic variations in the inflation target by assuming $\tau_t = \tau = 0$ for all t. Moreover, we assume that the expected lifetime utility function is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\ln(C_t) - \psi \frac{N_t{}^{1+\varphi}}{1+\varphi} + \zeta_t V\left(\frac{\mathcal{B}_t}{P_t}\right)\right],$$

where $V(\cdot)$ is increasing and concave in $\frac{\mathcal{B}_t}{P_t}$ and is such that $V(0) = 0$ and $V^{'}(0) = 1$, and ζ_t is a liquidity preference shock that evolves according to the following process:

$$\zeta_t = \rho_\zeta \zeta_{t-1} + \epsilon_{\zeta,t}, \qquad \epsilon_{\zeta,t} \sim N(0, \sigma_\zeta),$$

where $0 < \rho_\zeta < 1$.

In this case, the Euler equation becomes

$$\frac{1}{C_t} = \beta(1+i_t)\mathbb{E}_t\left[\frac{1}{(1+\pi_{t+1})C_{t+1}}\right] + \zeta_t V'\left(\frac{\mathcal{B}_t}{P_t}\right),$$

while the rest of the FONCs are identical to those of the IT model. The two models also share the same steady state.

The log-linearized LP model is given by

$$\begin{aligned} y_t &= \mathbb{E}_t y_{t+1} - (i_t - \mathbb{E}_t \pi_{t+1} - \ln \beta^{-1}) - \zeta_t, &\text{(A.11)} \\ \pi_t &= (1+\beta)^{-1} \left[\pi_{t-1} + \beta \mathbb{E}_t \pi_{t+1} + \lambda (y_t - a_t)\right], &\text{(A.12)} \\ i_t &= (1-\varrho) \ln \beta^{-1} + \varrho i_{t-1} + (1-\varrho) \left[\phi_\pi \pi_t + \phi_y (y_t - y_t^f)\right] + m_t. &\text{(A.13)} \end{aligned}$$

Construction of the likelihood function

Let $\mathcal{M} = \{\text{IT, LP}\}$ denote the linear rational expectations model under consideration and x_t denote a 9×1 unobserved state column vector defined as

$$x_t \equiv \begin{cases} [y_t, \pi_t, i_t, \mathbb{E}_t y_{t+1}, \mathbb{E}_t \pi_{t+1}, m_t, \tau_t, a_t, \pi_{t-1}]' & if\ \mathcal{M} = \text{IT} \\ [y_t, \pi_t, i_t, \mathbb{E}_t y_{t+1}, \mathbb{E}_t \pi_{t+1}, m_t, \zeta_t, a_t, \pi_{t-1}]' & if\ \mathcal{M} = \text{LP} \end{cases}.$$

Furthermore, let ϵ_t and η_t denote 3×1 random vectors consisting of the structural shocks and rational expectations errors, respectively:

$$\epsilon_t \equiv \begin{cases} [\epsilon_{m,t}, \epsilon_{\tau,t}, \epsilon_{a,t}]' & if\ \mathcal{M} = \text{IT} \\ [\epsilon_{m,t}, \epsilon_{\zeta,t}, \epsilon_{a,t}]' & if\ \mathcal{M} = \text{LP} \end{cases},$$

and

$$\eta_t \equiv [y - \mathbb{E}_{t-1} y_t,\ \pi_t - \mathbb{E}_{t-1} \pi_t]'.$$

The vector of structural shocks, ϵ_t, is assumed to be normally distributed, with a zero mean and a diagonal variance-covariance matrix Σ: $\epsilon_t \sim i.i.d.N(0, \Sigma)$ with $diag(\Sigma) \equiv [\sigma_m, \sigma_\tau, \sigma_a]'$.

For each model, the equilibrium conditions can be written as

$$G_0(\Theta) x_t = G_1(\Theta) x_{t-1} + Q(\Theta) \eta_t + R(\Theta) \epsilon_t,$$

where G_0, G_1, Q, and R are coefficient matrices and Θ is the vector of structural parameters. Applying Sims (2002)'s QZ algorithm to the system above yields a unique solution as the following stationary transition equation of the state vector:

$$x_t = F(\Theta) x_{t-1} + \Phi(\Theta) \epsilon_t, \tag{A.14}$$

where F and Φ are conformable coefficient matrices.

Let z_t denote the information set that consists of the nominal interest rate, inflation, and the growth rate of output:

$$z_t \equiv [i_t,\ \pi_t, \Delta y_t]'.$$

Assuming that all the shocks follow stationary processes, it is straightforward to show that the demeaned information set $\tilde{z}_t \equiv z_t - \mathbb{E}z_t$ is linearly related to the unobservable state vector x_t via

$$\tilde{z}_t = \Xi x_t, \tag{A.15}$$

where Ξ is a conformable coefficient matrix. Equations (A.14) and (A.15) jointly constitute a state-space representation of each of the two models.

Given the data set $z^T \equiv \{z_t\}_{t=0}^T$, we construct the likelihood $L(z^T|\Theta)$ of each model by applying the Kalman filter to the state-space representation (A.14)–(A.15). Let $p(\Theta)$ denote a prior probability of the structural parameters. Then, by Bayes' law, $p(\Theta|z^T) \propto p(\Theta)L(z^T|\Theta)$, where $p(\Theta|z^T)$ is the posterior distribution. The latter is simulated using the Random-Walk Metropolis-Hastings algorithm.