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CENTRAL BANK INFORMATION OR NEO-FISHER EFFECT?

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ABSTRACT

The neo-Fisher effect and the central bank information (CBI) effect produce similar outcomes: under both, a monetary tightening triggers an increase in inflation and an expansion in real activity. Separate estimates of these effects run the risk of confounding one with the other. To disentangle these two channels, we introduce into a new-Keynesian model a permanent monetary shock that generates neo-Fisher effects and an aggregate demand shock to which the central bank responds that creates CBI effects. We estimate the model on U.S. data. We find that the neo-Fisherian shock is an important driver of inflation, while the CBI shock explains a significant fraction of movements in the nominal interest rate. The CBI shock explains little of inflation and output, but, through counterfactual exercises, we establish that this reflects the central bank's success in isolating the economy from aggregate demand disturbances. These results are shown to hold under full and imperfect information.

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1 Introduction

Neo-Fisher and central bank information (CBI) effects can occur simultaneously and can generate similar outcomes. Both can give rise to short-run increases in inflation and aggregate activity in response to a surprise increase in the policy interest rate. A natural question is which of these two mechanisms plays a larger role in explaining why sometimes interest rates, prices, and quantities all move in the same direction after a monetary disturbance. In this paper, we provide an answer to this question from the perspective of a dynamic general equilibrium model estimated using postwar U.S. data.

We construct a model with nominal and real rigidities driven by permanent and transitory monetary shocks, two preference shocks, and permanent and transitory productivity shocks. To create a central bank information channel, we assume an augmented Taylor rule whereby the central bank responds directly to one of the preference shocks in addition to the output gap and inflation. To create a neo-Fisher effect, we assume that the Taylor rule is also buffeted by permanent monetary shocks in addition to standard transitory monetary shocks.

We examine two polar information structures: in one, private agents observe all shocks individually, while in the other, agents observe only the sum of the two preference shocks and the stochastic component of the Taylor rule, but not the individual shocks that comprise them.

The main result of the paper is that both the neo-Fisher and central-bank-information effects are important drivers of macroeconomic indicators of interest. Permanent monetary shocks explain between 20 and 30 percent of the variance of inflation changes, and the preference shock to which the central bank responds in the CBI channel explains about 50 percent of movements in the interest rate. Output and inflation respond little to this preference shock, but this is a reflection of the success of the central bank at stabilizing the aggregate effects of this type of shock. When we counterfactually shut down the central bank's response to this shock by setting its coefficient in the Taylor rule equal to zero, we find that it explains about more than half of movements in inflation and about 20 percent of movements in real activity.

To the best of our knowledge, this paper is the first attempt to evaluate jointly the contributions of the neo-Fisher and the central-bank information channels. This investigation is related to two strands of the recent monetary literature, one dedicated to the neo-Fisher effect and the other to the central bank information channel. The formulation and estimation of the neo-Fisher effect adopted in this study follows Uribe (2022). The neo-Fisher effect has also been estimated in the context of empirical models among others by Uribe (2017, 2022) and Azevedo, Ritto, and Teles (2022) using data from advanced countries, García-Cicco, Goldstein, and Sturzenegger (2024) using data from advanced and emerging economies, and Schmitt-Grohé and Uribe (2022) in an open-economy setting. Lukmanova and Rabitsch (2023) estimate the neo-Fisher effect in the context of an equilibrium model with transitory but persistent monetary shocks and imperfect information. All of these studies find evidence of a significant neo-Fisher effect in advanced economies, that is, they find that a permanent or highly persistent innovation in the interest rate raises inflation and aggregate activity in the short run. Theoretical formulations of the neo-Fisher effect can be found in Schmitt-Grohé and Uribe (2010, 2012), Cochrane (2016), Williamson (2016), and Garín, Lester, and Sims (2018).

There is a large literature studying the central bank information effect. Romer and Romer (2000), Barakchian and Crowe (2013), and Campbell, Fisher, Justiniano, and Melosi (2017) provide early evidence of a central bank information advantage. Estimates of the central bank information shock include Hansen and McMahon (2016) using language analysis of central bank announcements, Kerssenfischer (2022), Cieslak and Schrimpf (2019), and Jarociński and Karadi (2020) using high-frequency movements in stock prices, and Miranda-Agrippino (2016) and Campbell, Fisher, Justiniano, and Melosi (2017) using forecast differentials between the private sector and the Federal Reserve. The macroeconomic effects of CBI shocks have been studied in Melosi (2017), Nakamura and Steinsson (2018), and Jarociński and Karadi (2020). Finally, there are studies that have raised questions about the neo-Fisher and CBI channels. See García-Schmidt and Woodford (2019) and Bouakez and Kano (2024) for papers questioning the neo-Fisher effect and Faust, Swanson, and Wright (2004) and Bauer and Swanson (2023) for papers challenging the CBI channel.

The present study connects the two branches of the monetary economics literature just described by assessing jointly the contributions of shocks that generate neo-Fisher and CBI effects. This is important because ignoring the simultaneous presence of neo-Fisher and CBI effects can lead to overestimating the influence of each channel individually.

The remainder of the paper is organized as follows. Section 2 presents the proposed model. Section 3 characterizes the signal extraction problem under imperfect information. Section 4 discusses the econometric estimation. Section 5 presents the results. Finally, section 6 presents concluding remarks.

2 The Model

The model economy features sticky prices, habit formation, permanent and transitory monetary shocks, permanent and transitory productivity shocks, and preference shocks.

2.1 Households

The economy is populated by households with preferences defined over streams of consumption and labor effort and exhibiting external habit formation. The household's lifetime utility function is

$$E_0 \sum_{t=0}^{\infty} \beta^t e^{\xi_t} \left\{ \frac{\left[(C_t - \delta \widetilde{C}_{t-1})(1 - e^{\theta} h_t)^{\chi} \right]^{1-\sigma} - 1}{1 - \sigma} \right\}, \tag{1}$$

where C_t denotes consumption, $\widetilde{C}_t$ denotes the cross-sectional average of consumption, h_t denotes hours worked, ξ_t is a preference shifter, and $\beta, \delta \in (0,1)$ and $\sigma, \chi > 0$ and θ are parameters.

To model a central bank information channel, we assume that the preference shifter ξ_t

has two components,

$$\xi_t = \xi_t^h + \xi_t^c, \tag{2}$$

which are both exogenous stochastic processes. The central bank is assumed to observe ξ_t^c and to respond to it in setting the nominal interest rate. Households and firms are assumed to observe the preference shifter ξ_t, but not its individual components ξ_t^h and ξ_t^c.

Households are subject to the budget constraint

$$P_t C_t + \frac{B_t}{1+I_t} + T_t = B_{t-1} + W_t h_t + \Phi_t, \tag{3}$$

where P_t denotes the price level, T_t denotes nominal lump-sum taxes, W_t denotes the nominal wage rate, and Φ_t denotes nominal profits received from firms. The variable B_t denotes the units of a one-period nominal discount bond purchased in period t that pays the interest rate I_t.

The consumption good C_t is assumed to be a composite of a continuum of varieties C_{it} indexed by $i \in [0,1]$ with aggregation technology

$$C_t = \left[\int_0^1 C_{it}^{1-1/\eta} di\right]^{\frac{1}{1-1/\eta}}, \tag{4}$$

where the parameter $\eta > 0$ denotes the elasticity of substitution across varieties.

Households choose processes $\{C_t, h_t, B_t\}_{t=0}^{\infty}$ to maximize the utility function (1) subject to the budget constraint (3) and to some borrowing limit that prevents them from engaging in Ponzi schemes. Letting $\beta^t \Lambda_t / P_t$ denote the Lagrange multiplier associated with the budget constraint (3), the first-order conditions of the household's optimization problem are

$$e^{\xi_t}(C_t - \delta \widetilde{C}_{t-1})^{-\sigma}(1 - e^{\theta} h_t)^{\chi(1-\sigma)} = \Lambda_t, \tag{5}$$

$$\frac{\chi e^{\theta}(C_t - \delta \widetilde{C}_{t-1})}{1 - e^{\theta} h_t} = \frac{W_t}{P_t}, \tag{6}$$

and

$$\Lambda_t = \beta(1 + I_t) E_t \left[\frac{\Lambda_{t+1}}{1 + \Pi_{t+1}} \right], \tag{7}$$

where $\Pi_t \equiv P_t/P_{t-1} - 1$ denotes the inflation rate in period t.

Given its desired level of consumption, C_t, the household chooses the consumption of varieties C_{it} to minimize total expenditure, $\int_0^1 P_{it} C_{it} di$, subject to the aggregation technology (4), where P_{it} denotes the nominal price of variety i. This problem delivers the following demand for individual varieties:

$$C_{it} = C_t \left(\frac{P_{it}}{P_t} \right)^{-\eta}, \tag{8}$$

where the price level P_t is given by

$$P_t \equiv \left[\int_0^1 P_{it}^{1-\eta} di \right]^{\frac{1}{1-\eta}} \tag{9}$$

and represents the minimum cost of one unit of the composite consumption good, C_t.

2.2 Firms

The firm producing variety i operates in a monopolistically competitive market and faces quadratic price adjustment costs à la Rotemberg (1982). The production technology uses labor and is buffeted by transitory and permanent productivity shocks. Specifically, output of variety i is given by

$$Y_{it} = e^{z_t} \Omega_t h_{it}^{\alpha}, \tag{10}$$

where Y_{it} denotes output of variety i in period t, h_{it} denotes labor input used in the production of variety i, z_t is a stationary productivity shock, and Ω_t is a nonstationary productivity shock. The growth rate of Ω_t is assumed to be a stationary random variable with mean g,

$$g_t = \ln\left(\frac{\Omega_t}{\Omega_{t-1}}\right) - g.$$

The expected present discounted value of real profits of the firm producing variety i expressed in units of the final good is given by

$$E_0 \sum_{t=0}^{\infty} q_t \left[\frac{P_{it}}{P_t} A_{it} - \frac{W_t}{P_t} h_{it} - \frac{\phi}{2}\Omega_t \left(\frac{P_{it}/P_{it-1}}{1+\widetilde{\Pi}_t} - 1\right)^2\right], \tag{11}$$

where A_{it} denotes the total demand for good i, $\phi > 0$ is a parameter governing the degree of price rigidity, and $q_t \equiv \beta^t \Lambda_t / \Lambda_0$ denotes a pricing kernel reflecting the assumption that households are the owners of the firms. Price adjustment costs are defined in units of the final good and are scaled by the trend component of productivity Ω_t to keep nominal rigidity from vanishing along the balanced growth path. The total demand for good i, A_{it}, includes the demand stemming from households and the demand stemming from firms to cover their price adjustment costs. Specifically, the demand for good i is given by

$$A_{it} = A_t \left(\frac{P_{it}}{P_t}\right)^{-\eta} \tag{12}$$

with

$$A_t = C_t + \frac{\phi}{2}\Omega_t \int_0^1 \left(\frac{P_{jt}/P_{jt-1}}{1+\widetilde{\Pi}_t} - 1\right)^2 dj. \tag{13}$$

The second term of this expression is nil up to first order. The variable $\widetilde{\Pi}_t$ denotes the average level of inflation around which price-adjustment costs are defined. It is predetermined in period t and is assumed to evolve over time according to

$$1 + \widetilde{\Pi}_{t+1} = (1 + \widetilde{\Pi}_t)^{\gamma_\pi} (1 + \Pi_t)^{1-\gamma_\pi}, \tag{14}$$

where the parameter $\gamma_\pi \in [0, 1]$ governs the backward-lookingness of price indexation.

The problem of the firm producing variety i is to choose processes $\{P_{it}, A_{it}, Y_{it}, h_{it}\}_{t=0}^{\infty}$ to maximize (11) subject to the demand equation (12), the production technology (10), and the requirement that demand be satisfied at the price set by the firm,

$$Y_{it} \geq A_{it}, \tag{15}$$

taking as given the processes $\widetilde{\Pi}_t$, z_t, Ω_t, A_t, W_t, P_t, and q_t.

Letting $q_t mc_{it}$ be the Lagrange multiplier associated with the demand constraint (15), the first-order conditions associated with the firm's profit maximization problem are

$$mc_{it} = \frac{W_t/P_t}{\alpha e^{z_t} \Omega_t h_{it}^{\alpha-1}} \tag{16}$$

and

$$\eta A_{it}\left(\frac{\eta-1}{\eta}\frac{P_{it}}{P_t} - mc_{it}\right) = -\phi\Omega_t \frac{P_{it}/P_{it-1}}{1+\widetilde{\Pi}_t}\left(\frac{P_{it}/P_{it-1}}{1+\widetilde{\Pi}_t} - 1\right) + \phi E_t \frac{q_{t+1}}{q_t}\Omega_{t+1}\frac{P_{it+1}/P_{it}}{1+\widetilde{\Pi}_{t+1}}\left(\frac{P_{it+1}/P_{it}}{1+\widetilde{\Pi}_{t+1}} - 1\right). \tag{17}$$

The first of these optimality conditions says that the multiplier mc_{it} represents marginal cost. The second optimality condition says that, all other things equal, if marginal revenue, $\frac{\eta-1}{\eta}\frac{P_{it}}{P_t}$, exceeds marginal cost, mc_{it}, the firm will increase prices at a rate below normal, $P_{it}/P_{it-1} < 1 + \widetilde{\Pi}_t$.

2.3 Monetary and Fiscal Policy

The monetary authority follows a Taylor-type interest-rate feedback rule buffeted by a stationary monetary shock denoted z_t^m and a nonstationary monetary shock denoted X_t^m. The nonstationary monetary shock X_t^m is meant to capture the neo-Fisher effect (Uribe, 2022). The monetary rule also includes a central-bank information channel. Specifically, the monetary authority is assumed to respond to the exogenous preference shifter ξ_t^c. Formally,

$$\frac{1+I_t}{X_t^m} = \left[\Gamma\left(\frac{1+\Pi_t}{X_t^m}\right)^{\alpha_\pi}\left(\frac{Y_t}{Y_t^n}\right)^{\alpha_y}\right]^{1-\gamma_I}\left(\frac{1+I_{t-1}}{X_{t-1}^m}\right)^{\gamma_I} e^{z_t^m+\alpha_\xi \xi_t^c}, \tag{18}$$

where Y_t denotes aggregate output, Y_t^n denotes the flexible-price or natural level of output, and Γ, α_π, α_y, α_ξ, and $\gamma_I \in [0,1)$ are parameters. The growth rate of the nonstationary monetary shock,

$$g_t^m \equiv \ln\left(\frac{X_t^m}{X_{t-1}^m}\right),$$

is assumed to be stationary.

Households and firms are assumed to observe the nominal interest rate, I_t, inflation, Π_t, the output gap, Y_t/Y_t^n, and the exogenous stochastic component of the Taylor rule, which we denote $\widetilde{\Omega}_t^m$, and is given by

$$\widetilde{\Omega}_t^m \equiv X_t^{m\,1-\alpha_\pi(1-\gamma_I)} X_{t-1}^{m\;-\gamma_I} e^{z_t^m+\alpha_\xi \xi_t^c}. \tag{19}$$

However, households and firms are assumed to be unable to observe the individual components of $\widetilde{\Omega}_t^m$, namely, X_t^m, z_t^m, and ξ_t^c.

Government consumption is assumed to be nil at all times. The government's budget constraint is then given by

$$T_t + \frac{B_t}{1+I_t} = B_{t-1}.$$

Fiscal policy is assumed to be Ricardian, that is, it guarantees the intertemporal solvency of the government independently of the path of the price level.

2.4 Driving Forces

The structural shocks driving the economy, ξ_t^h, ξ_t^c, z_t^m, g_t^m, g_t, and z_t are assumed to follow AR(1) processes of the form

$$x_t = \rho_x x_{t-1} + \sigma_x \epsilon_t^x, \tag{20}$$

where ϵ_t^x is an i.i.d. random disturbance distributed $N(0,1)$, $\rho_x \in [0,1)$ is the serial correlation of x_t, and $\sigma_x > 0$ is the standard deviation of the innovation of the process, for $x = \xi^h$, ξ^c, z^m, g^m, g, and z.

2.5 Market Clearing

Clearing of the labor market requires that the demand for labor by firms equal the household's supply of labor, that is,

$$\int_0^1 h_{it} di = h_t. \tag{21}$$

Because all households are identical, so are individual and aggregate consumption per capita,

$$C_t = \widetilde{C}_t.$$

We focus attention on a symmetric equilibrium in which all firms charge the same nominal price and employ the same amount of labor, that is, an equilibrium in which h_{it} and P_{it} are the same for all $i \in [0,1]$. We then have from equations (8), (9), (10), (16), and (21) that $P_{it} = P_t$, $C_{it} = C_t$, $h_{it} = h_t$, $mc_{it} = mc_t$, and $Y_{it} = e^{z_t}\Omega_t h_t^\alpha$, for all i. Output measured in units of the final good is then given by $Y_t \equiv \left(\int_0^1 P_{it} Y_{it} di\right)/P_t = e^{z_t}\Omega_t h_t^\alpha$. As long as the nominal wage is positive, the firm will choose to satisfy the demand constraint (15) with equality, so that in equilibrium

$$Y_t = C_t + \frac{\phi}{2}\Omega_t \left(\frac{1+\Pi_t}{1+\widetilde{\Pi}_t} - 1\right)^2.$$

2.6 Equilibrium Conditions in Stationary Form

The model is driven, among other sources of variation, by two nonstationary shocks, the nonstationary productivity shock, Ω_t, and the nonstationary monetary shock, X_t^m. We express the model in terms of stationary variables by scaling all variables with stochastic trends by their respective permanent components. Under imperfect information, however, the choice of these trend components is nontrivial. The reason is that all conditional expectations in the model are taken given the private agents's information sets, which in period t include Ω_t, but not X_t^m. Thus, Ω_t can be used as a scaler to transform nonstationary real variables into stationary real variables, but X_t^m cannot be used in a similar way to transform nonstationary nominal variables into stationary ones.

To illustrate the problem with using X_t^m to transform nonstationary nominal variables into stationary ones, consider a generic expression of the form $N_t^1 = E_t N_{t+1}^2$, where N_t^1 and N_t^2 are two nominal variables that are cointegrated with X_t^m. Under full information we could use X_t^m as a scaler and define $n_t^1 = N_t^1/X_t^m$ and $n_t^2 = N_t^2/X_t^m$. Because under full information $1/X_t^m E_t N_{t+1}^2 = E_t N_{t+1}^2/X_t^m$, we can write $n_t^1 = E_t\left[n_{t+1}^2 e^{g_{t+1}^m}\right]$. However, if X_t^m is not in private agents' period-t information set, then $1/X_t^m E_t N_{t+1}^2 \neq E_t N_{t+1}^2/X_t^m$, rendering this approach to induce stationarity infeasible.

Therefore, in order to transform nonstationary nominal variables into stationary ones, we must use an observable object that is cointegrated with X_t^m. To this end, note that the exponents of X_t^m and X_{t-1}^m in the definition of the observable object $\widetilde{\Omega}_t^m$ given in equation (19) add up to $(1-\alpha_\pi)(1-\gamma_I)$. We therefore define the observable object Ω_t^m as

$$\Omega_t^m \equiv \left(\widetilde{\Omega}_t^m\right)^{\frac{1}{(1-\alpha_\pi)(1-\gamma_I)}},$$

which is cointegrated with X_t^m.

Accordingly, we use the observable exogenous variables Ω_t and Ω_t^m as the scalers to convert real and nominal nonstationary variables into stationary variables. Specifically, we create the stationary variables $c_t \equiv C_t/\Omega_t$, $y_t \equiv Y_t/\Omega_t$, $y_t^n \equiv Y_t^n/\Omega_t$, $a_t \equiv A_t/\Omega_t$, $w_t \equiv W_t/(P_t\Omega_t)$, $\lambda_t \equiv \Lambda_t \Omega_t^\sigma$, $1+\pi_t \equiv (1+\Pi_t)/\Omega_t^m$, $1+i_t \equiv (1+I_t)/\Omega_t^m$, and $1+\widetilde{\pi}_t \equiv (1+\widetilde{\Pi}_t)/\Omega_{t-1}^m$. Let $g_t^{\omega m} \equiv \ln\left(\frac{\Omega_t^m}{\Omega_{t-1}^m}\right)$ be the growth rate of Ω_t^m, so that

$$g_t^{\omega m} = \frac{g_t^m[1-\alpha_\pi(1-\gamma_I)] - g_{t-1}^m\gamma_I + z_t^m - z_{t-1}^m + \alpha_\xi(\xi_t^c - \xi_{t-1}^c)}{(1-\alpha_\pi)(1-\gamma_I)}. \tag{22}$$

We can then write equilibrium conditions (5)–(7), (10), and (13)–(18), respectively, as

$$\lambda_t = e^{\xi_t}\left(c_t - \delta\frac{c_{t-1}}{e^{g_t+g}}\right)^{-\sigma}\left(1 - e^{\theta}h_t\right)^{\chi(1-\sigma)}, \tag{23}$$

$$\frac{\chi e^{\theta}\left(c_t - \delta\frac{c_{t-1}}{e^{g_t+g}}\right)}{1 - e^{\theta}h_t} = w_t, \tag{24}$$

$$\lambda_t = \beta(1+i_t)E_t\left[\frac{\lambda_{t+1}}{1+\pi_{t+1}}e^{-g_{t+1}^{\omega m}-\sigma(g_{t+1}+g)}\right], \tag{25}$$

$$y_t = e^{z_t}h_t^{\alpha}, \tag{26}$$

$$a_t = c_t + \frac{\phi}{2}\left(\frac{1+\pi_t}{1+\widetilde{\pi}_t}e^{g_t^{\omega m}} - 1\right)^2, \tag{27}$$

$$1+\widetilde{\pi}_{t+1} = [(1+\widetilde{\pi}_t)e^{-g_t^{\omega m}}]^{\gamma_m}(1+\pi_t)^{1-\gamma_m}, \tag{28}$$

$$y_t = a_t, \tag{29}$$

$$\mathrm{mc}_t = \frac{w_t}{\alpha e^{z_t}h_t^{\alpha-1}}, \tag{30}$$

$$\begin{aligned}\left(\frac{\eta-1}{\eta} - mc_t\right)a_t \;=\;& \frac{\phi}{\eta}\beta E_t e^{(1-\sigma)(g_{t+1}+g)}\frac{\lambda_{t+1}}{\lambda_t}\frac{1+\pi_{t+1}}{1+\widetilde{\pi}_{t+1}}e^{g_{t+1}^{\omega m}}\left(\frac{1+\pi_{t+1}}{1+\widetilde{\pi}_{t+1}}e^{g_{t+1}^{\omega m}} - 1\right)\\ &-\frac{\phi}{\eta}\frac{1+\pi_t}{1+\widetilde{\pi}_t}e^{g_t^{\omega m}}\left(\frac{1+\pi_t}{1+\widetilde{\pi}_t}e^{g_t^{\omega m}} - 1\right),\end{aligned} \tag{31}$$

and

$$1+i_t = \left[\Gamma(1+\pi_t)^{\alpha_\pi}\left(\frac{y_t}{y_t^n}\right)^{\alpha_y}\right]^{1-\gamma_I}\left(\frac{1+i_{t-1}}{e^{g_t^{\omega m}}}\right)^{\gamma_I}. \tag{32}$$

The detrended flexible-price level of output, y_t^n, is given by the solution of equations (24), (26), and (30) evaluated at $c_t = y_t^n$ and $mc_t = (\eta - 1)/\eta$, for all t. This yields y_t^n implicitly as

$$\frac{\chi e^{\theta}\left(y_t^n - \delta \frac{y_{t-1}^n}{e^{g_t + g}}\right)}{1 - e^{\theta}(y_t^n e^{-z_t})^{1/\alpha}} = \frac{\eta - 1}{\eta} \alpha e^{z_t/\alpha} \left(y_t^n\right)^{(\alpha-1)/\alpha}. \tag{33}$$

Note that y_t^n depends on the productivity shocks z_t and g_t, but not on preference or monetary shocks, so it is observable even under imperfect information.

We are ready to define a competitive equilibrium under full information:

Definition 1 (Equilibrium Under Full Information) *An equilibrium under full information is a set of processes c_t, h_t, λ_t, w_t, i_t, π_t, $\tilde{\pi}_t$, y_t, y_t^n, a_t, mc_t, $g_t^{\omega m}$, and ξ_t satisfying (2) and (22)–(33), given stochastic processes ξ_t^h, ξ_t^c, z_t, g_t, z_t^m, and g_t^m, and the initial conditions c_{-1}, y_{-1}^n, $\tilde{\pi}_0$, i_{-1}, g_{-1}^m, z_{-1}^m, and ξ_{-1}^c.*

We now turn to the characterization of the equilibrium under imperfect information.

3 Signal Extraction

Under imperfect information, agents must form conditional expectations about future values of endogenous and exogenous variables, based on the current position of the observable states of the economy and knowledge of the law of motion of the unobserved exogenous states ξ_t^h, ξ_t^c, z_t^m, and g_t^m. To solve this signal extraction problem, we proceed as follows. Let $\boldsymbol{y}_t = [h_t \;\; y_t \;\; y_t^n \;\; w_t \;\; mc_t \;\; \lambda_t \;\; \pi_t \;\; a_t \;\; i_t]'$ be the vector of controls, $\boldsymbol{v}_t = [c_{t-1} \;\; y_{t-1}^n \;\; \tilde{\pi}_t \;\; i_{t-1} \;\; z_t \;\; g_t]'$, the vector of endogenous states and observable exogenous states, and

$$\boldsymbol{o}_t = \begin{bmatrix} \xi_t \\ g_t^{\omega m} \end{bmatrix} \tag{34}$$

the vector of observable exogenous states used to extract information about the current and future expected positions of the unobservable exogenous states ξ_t^h, ξ_t^c, z_t^m, and g_t^m.

Let the lengths of $\boldsymbol{y}_t$, $\boldsymbol{v}_t$, and $\boldsymbol{o}_t$ be n_y, n_v and n_o. Linearize the equilibrium conditions (23)-(33). The resulting linearized expressions together with the AR(1) processes for the observed exogenous states included in $\boldsymbol{v}_t$ (i.e., z_t and g_t) can be written as

$$\mathcal{A}\, E_t \begin{bmatrix} \hat{\boldsymbol{y}}_{t+1} \\ \hat{\boldsymbol{v}}_{t+1} \\ \boldsymbol{o}_{t+1} \end{bmatrix} = \mathcal{B} \begin{bmatrix} \hat{\boldsymbol{y}}_{t} \\ \hat{\boldsymbol{v}}_{t} \\ \boldsymbol{o}_{t} \end{bmatrix}, \tag{35}$$

where hatted variables refer to deviations from steady-state values. (The vector $\boldsymbol{o}_t$ is not hatted, as its steady-state value is zero, so it is already expressed in deviations from steady state.)

The system (35) has $n_y + n_v$ equations and $n_y + n_v + n_o$ variables. Let $\boldsymbol{u}_t \equiv [\xi^h_t \;\; \xi^c_t \;\; \xi^c_{t-1} \;\; z^m_t \;\; z^m_{t-1} \;\; g^m_t \; g^m_{t-1}]'$ be the vector of unobserved exogenous states with length n_u. Then, from the law of motion of the exogenous driving forces given in (20) we have that

$$\boldsymbol{u}_{t+1} = F\boldsymbol{u}_t + B\boldsymbol{\epsilon}^u_{t+1} \tag{36}$$

and from equations (2), (22), and (34) we have that

$$\boldsymbol{o}_t = H'\boldsymbol{u}_t \tag{37}$$

with

$$F = \begin{bmatrix} \rho_{\xi h} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \rho_{\xi c} & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \rho_{zm} & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \rho_{gm} & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}, \quad B = \begin{bmatrix} \sigma_{\xi h} & 0 & 0 & 0 \\ 0 & \sigma_{\xi c} & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & \sigma_{zm} & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \sigma_{gm} \\ 0 & 0 & 0 & 0 \end{bmatrix},$$

$$H' = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{\alpha_\xi}{a} & -\frac{\alpha_\xi}{a} & \frac{1}{a} & -\frac{1}{a} & \frac{a+\gamma_I}{a} & \frac{-\gamma_I}{a} \end{bmatrix}, \quad \text{and} \quad \boldsymbol{\epsilon}_t^u = \begin{bmatrix} \epsilon_t^{\xi h} \\ \epsilon_t^{\xi c} \\ \epsilon_t^{zm} \\ \epsilon_t^{gm} \end{bmatrix},$$

where $a \equiv (1-\alpha_\pi)(1-\gamma_I)$. Let $\boldsymbol{\eta}_t \equiv E_{t-1}\boldsymbol{u}_t$ be the expected value of $\boldsymbol{u}_t$ conditional on $\boldsymbol{o}_{t-1}$. Then, applying the Kalman filter yields

$$\boldsymbol{\eta}_{t+1} = (F - KH')\boldsymbol{\eta}_t + K\boldsymbol{o}_t \tag{38}$$

and

$$E_t\boldsymbol{o}_{t+1} = H'\boldsymbol{\eta}_{t+1}, \tag{39}$$

where $K = FPH(H'PH)^{-1}$ is the Kalman gain, $P = F[P - PH(H'PH)^{-1}H'P]F' + Q$ is the steady-state mean square error of $\boldsymbol{\eta}_{t+1}$ expressed implicitly as a Ricatti equation, and $Q \equiv BB'$ is the variance-covariance matrix of the innovation $B\boldsymbol{\epsilon}_t^u$. Equation (38) gives the law of motion of agents' expectation of the position of the latent exogenous state vector $\boldsymbol{u}_t$. This expectation changes over time as information about the observable state $\boldsymbol{o}_t$ arrives. Equation (39) expresses the expected value of the observable state in period $t+1$, $E_t\boldsymbol{o}_{t+1}$, as a function of the expected position of the vector of unobservable states in $t+1$, $\boldsymbol{\eta}_{t+1}$.

The system consisting of (35), (38), and (39) has $n_y + n_v + n_o + n_u$ equations and also $n_y + n_v + n_o + n_u$ unknowns. Solving this system taking $\hat{\boldsymbol{v}}_t$, $\boldsymbol{\eta}_t$, and $\boldsymbol{o}_t$ as states and $\hat{\boldsymbol{y}}_t$ as controls yields

$$\boldsymbol{x}_{t+1} = h_x\boldsymbol{x}_t + \Sigma\boldsymbol{\epsilon}_{t+1} \tag{40}$$

and

$$\hat{\boldsymbol{y}}_t = g_x\boldsymbol{x}_t, \tag{41}$$

where $\boldsymbol{x}_t \equiv [\hat{\boldsymbol{v}}_t'\,\boldsymbol{\eta}_t'\,\boldsymbol{o}_t']'$, $\boldsymbol{\epsilon}_t = [\epsilon_t^z \;\; \epsilon_t^g]'$, and Σ contains the standard deviations of the elements of $\boldsymbol{\epsilon}_t$ in the corresponding positions. Let n_ϵ be the length of $\boldsymbol{\epsilon}_t$.

Finally, to express the evolution of this system in terms of its exogenous state $\boldsymbol{u}_t$, use equations (36) and (37) to eliminate $\boldsymbol{o}_t$ from (40) and (41). To this end, partition h_x, g_x, and Σ as

$$h_x = \begin{bmatrix} h_x^{11} & h_x^{12} \\ h_x^{21} & h_x^{22} \end{bmatrix}, \quad g_x = \begin{bmatrix} g_x^1 & g_x^2 \end{bmatrix}, \quad \text{and } \Sigma = \begin{bmatrix} \Sigma^1 \\ \Sigma^2 \end{bmatrix},$$

with h_x^{11} of size $n_v + n_u$ by $n_v + n_u$, g_x^1 of size n_y by $n_v + n_u$, and Σ^1 of size $n_v + n_u$ by n_ϵ. Then, the equilibrium evolution of all variables in the model can be written as

$$\boldsymbol{X}_{t+1} = H_x \boldsymbol{X}_t + C \boldsymbol{\mu}_{t+1}$$

and

$$\hat{\boldsymbol{y}}_t = G_x \boldsymbol{X}_t,$$

where $\boldsymbol{X}_t \equiv [\hat{\boldsymbol{v}}_t' \, \boldsymbol{\eta}_t' \, \boldsymbol{u}_t']'$, $\boldsymbol{\mu}_t = [\boldsymbol{\epsilon}_t' \; \boldsymbol{\epsilon}_t^{u\prime}]'$, and

$$H_x = \begin{bmatrix} h_x^{11} & h_x^{12} H' \\ \emptyset & F \end{bmatrix}, \quad C = \begin{bmatrix} \Sigma^1 & \emptyset \\ \emptyset & B \end{bmatrix}, \quad \text{and} \quad G_x = \begin{bmatrix} g_x^1 & g_x^2 H' \end{bmatrix}.$$

We now proceed to estimate the model and characterize its equilibrium properties.

4 Estimation

We follow the standard practice of calibrating some parameters and estimating others. We estimate the parameters defining all stochastic processes, the parameters defining price stickiness and habit formation, and all policy parameters. The remaining parameters are calibrated.

Table 1 summarizes the calibration. The time unit is one quarter. The calibrated parameters take standard values in business-cycle analysis. We set the steady-state of the growth rate of the nonstationary productivity shock, g, to 0.0041, which is consistent with an average

Table 1: Calibrated Parameters

Parameter	Value	Description
g	0.0041	mean output growth rate
σ	2	inverse of intertemp. elast. subst.
β	0.9982	subjective discount factor
η	6	intratemporal elast. of subst.
α	0.75	labor semielast. of output
θ	0.4055	preference parameter

Note. The time unit is one quarter.

growth rate of output per capita of about 1.7 percent per year over the postwar period; the inverse of the intertemporal elasticity of consumption substitution, σ, to 2; the steady-state real interest rate to 4 percent per year, which implies a growth-adjusted discount factor, $\beta e^{-\sigma g}$, of 0.99 per year and a value of β of 0.9982; the labor elasticity of output, α, to 0.75; the elasticity of substitution across good varieties, η, to 6; the steady-state share of time allocated to work, h, to 1/3; and the labor supply elasticity holding consumption constant, $(1-e^{\theta}h)/(e^{\theta}h)$, to 1. The last two restrictions imply that the preference parameter θ equals $-\ln(2h) = 0.4055$.

We estimate the remaining parameters under full and imperfect information using Bayesian techniques. The estimation uses U.S. data covering the period 1961:Q3 to 2019:Q4. We leave the Covid-19 years out of the sample as they were arguably driven by extraordinary shocks not included in the model. The data used in the estimation contains observations on the growth rate of real GDP per capita, $\Delta \ln Y_t$, the change in the nominal interest rate, proxied by the Federal Funds rate, ΔI_t, and the interest-rate inflation differential, $I_t - \Pi_t$, where Π_t is proxied by the growth rate of the implicit GDP deflator. The estimation is based on 1 million draws from the posterior distribution using the Metropolis-Hastings sampler, after burning 50 million draws. Table 2 provides a summary of the prior and posterior distributions of the estimated parameters.

The serial correlations of all exogenous shocks are given beta prior distributions with mean 0.5 and standard deviation 0.2, except for those of the growth rates of the nonstationary shocks, g_t and g_t^m, which are given prior means of 0.3. The standard deviations of all shocks are given gamma distributions with mean and standard deviation 0.01 (or 1 percent), except for those of the monetary shocks z_t^m and g_t^m, which are given means and standard deviations that are 4 times smaller (0.0025), as they are frequency dependent.

Consider now the prior distributions of the parameters of the Taylor rule. The coefficients associated with inflation, the output-gap, and interest-rate smoothing are assigned standard values. Specifically, the inflation coefficient, α_π, has a gamma distribution with mean 1.5 and standard deviation 0.25. The output-gap coefficient, α_y, has a gamma distribution with mean 0.125 and standard deviation 0.1. And the interest-rate smoothing parameter, γ_I, has a uniform distribution with support [0 1]. The parameter governing the central bank information channel, α_ξ, has the same prior distribution as the output-gap coefficient, namely, a gamma distribution with mean 0.125 and standard deviation 0.1. This is motivated by the fact that, like α_y, the coefficient α_ξ represents the central bank's response to a measure of aggregate activity.

Finally, the coefficient governing price stickiness, π, has a gamma prior distribution with mean 50 and standard deviation 20, and the parameters governing habit formation, δ, and price indexation, γ_π, have uniform prior distributions with support [0 1].

As is common in estimated macroeconomic models, a number of parameters are imprecisely estimated. However, the estimation provides informative posteriors for the novel feature of the model, namely, the central bank information channel. In particular, this is the case for both the central bank's response to the unobserved component of the demand shock, α_ξ, and for the parameters defining the law of motion of this shock, ρ_{ξ^c} and σ_{ξ^c}. It also yields precise estimates for the parameters governing the propagation of shocks, specifically the price stickiness parameter, ϕ, and the habit formation parameter, δ.

Interestingly, the posterior estimates are virtually identical whether the estimation is conducted under full or imperfect information. Thus, in the analysis that follows, differences

Table 2: Prior and Posterior Parameter Distributions

	Prior Distribution			Posterior Distribution			
				Full Information		Imperfect Information	
Parameter	Distribution	Mean	Std	Mean	Std	Mean	Std
ϕ	Gamma	50	20	96.1	25.9	96.7	26.1
α_π	Gamma	1.5	0.25	1.55	0.226	1.55	0.232
α_y	Gamma	0.125	0.1	0.0863	0.0629	0.0889	0.0681
α_ξ	Gamma	0.125	0.1	0.0657	0.0199	0.0736	0.0253
ρ_{ξ^h}	Beta	0.5	0.2	0.567	0.197	0.601	0.188
ρ_{ξ^c}	Beta	0.5	0.2	0.916	0.0289	0.907	0.0423
ρ_{z^m}	Beta	0.5	0.2	0.484	0.212	0.54	0.212
ρ_{g^m}	Beta	0.3	0.2	0.238	0.163	0.265	0.18
σ_{ξ^h}	Gamma	0.01	0.01	0.0101	0.00433	0.0111	0.00547
σ_{ξ^c}	Gamma	0.01	0.01	0.0248	0.00577	0.0234	0.00594
σ_{z^m}	Gamma	0.0025	0.0025	0.00061	0.000384	0.000631	0.000387
σ_{g^m}	Gamma	0.0025	0.0025	0.000889	0.000426	0.000842	0.000422
γ_π	Uniform	0.5	0.289	0.296	0.16	0.339	0.17
γ_I	Uniform	0.5	0.289	0.217	0.111	0.18	0.0834
δ	Uniform	0.5	0.289	0.353	0.081	0.333	0.0794
ρ_z	Beta	0.5	0.2	0.482	0.196	0.484	0.193
ρ_g	Beta	0.3	0.2	0.195	0.0968	0.19	0.0944
σ_z	Gamma	0.01	0.01	0.00162	0.00128	0.00159	0.00129
σ_g	Gamma	0.01	0.01	0.00791	0.00104	0.00795	0.00106
R_{11}	Uniform	3.16e-06	1.82e-06	3.92e-06	1.72e-06	3.95e-06	1.74e-06
R_{22}	Uniform	2.1e-06	1.21e-06	3.71e-06	3.06e-07	3.72e-06	3.02e-07
R_{33}	Uniform	2.49e-07	1.44e-07	2.32e-07	1.4e-07	2.34e-07	1.41e-07
χ				0.98	0.133	0.95	0.124

Note. The time unit is one quarter. The posterior distribution of χ is derived from the corresponding distribution of δ. The parameters R_{ii}, for $i = 1 : 3$ are the diagonal elements of the variance-covariance matrix of measurement errors.

in the model's predictions under these two information structures can largely be attributed to the impact of informational frictions on the behavior of private agents.

5 Results

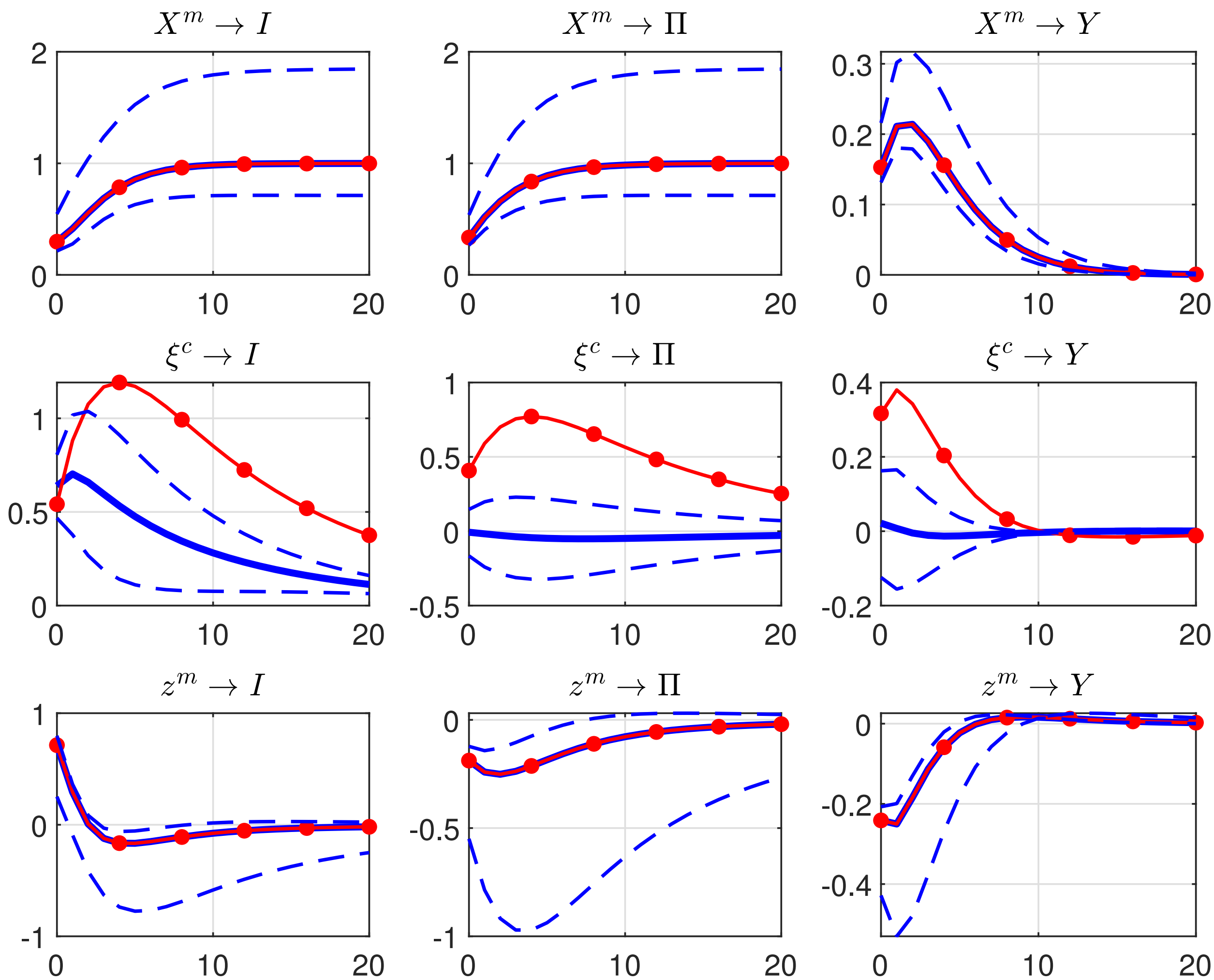
This section characterizes the macroeconomic consequences of permanent monetary shocks and the central bank information channel. It begins with the full information environment and then turns to the one with imperfect information.

5.1 Full Information

Under full information, households and firms can observe separately all shocks buffeting the economy, that is, the stationary and nonstationary productivity shocks, z_t and g_t, the two demand shocks, ξ_t^h and ξ_t^c, and the stationary and nonstationary monetary shocks, z_t^m and X_t^m.

Figure 1 displays impulse response functions to X_t^m, ξ_t^c, and z_t^m under full information. The permanent monetary shock produces a significant neo-Fisher effect: In response to an innovation in X_t^m that increases the nominal interest rate and inflation by 1 annual percentage point in the long run, the interest rate, inflation, and output all increase in the short run. Just two quarters after the shock, inflation is already halfway to its higher long-run value. Output rises by 15 basis point on impact, reaches a peak of 20 basis points two quarters after the shock and then converges to its pre-shock level gradually over time. The intuition behind this result is as follows. When the innovation in X_t^m is revealed, firms know that inflation will be higher in the long run, as an increase in X_t^m is akin to an increase in the central bank's inflation target. Because firms face price adjustment costs, it pays for them to start increasing prices already in the short run. Inflation actually adjusts faster than the interest rate in the short run, which causes a fall in the real interest rate and consequently an expansion in aggregate activity.

Figure 1: Estimated Impulse Responses Under Full Information



Notes. The horizontal axes measure quarters after the shock. Solid lines are posterior means, dashed lines are 95% asymmetric error bands computed using the Sims-Zha (1999) method, and circled lines are posterior means restricting $\alpha_\xi = 0$ without reestimation. Inflation, Π_t, and the nominal interest rate, I_t, are deviations from pre-shock levels and are expressed in percentage points per year. Output, Y_t, is measured in percent deviations from trend. The size of the permanent monetary shock X_t^m is set so as to increase the nominal interest rate by 1 annual percentage point in the long run on average. The size of the transitory monetary shock z_t^m is 1 annual percentage point on impact. And the size of the demand shock ξ_t^c is one standard deviation.

The estimated model also predicts a significant central-bank information channel of monetary policy, as the central bank actively stabilizes demand shocks: Figure 1 shows that in response to a one-standard-deviation innovation in ξ_t^c, the policy rate increases by 64 basis points and reaches a peak of 70 basis points one quarter after the shock. Neither inflation nor output respond significantly to the demand shock. But this is a reflection of the central bank successfully stabilizing the economy in response to this type of disturbance.

To see this, Figure 1 also displays (with circled lines) the economy's response to a ξ_t^c shock under the assumption that the central bank does not respond directly to this type of disturbance, that is, when α_ξ is restricted to be zero. In this case, the demand shock causes a large increase in inflation and output. Interestingly, the interest rate increases almost twice as much in the absence of a central bank information channel than in its presence. This is because when $\alpha_\xi = 0$, the increases in inflation and output call for large increases in the policy rate through the standard systematic components of the Taylor rule.

The virtually complete stabilization of output and inflation in response to demand shocks brings the economy closer to the outcome that would obtain under full price flexibility (i.e., a mute output response), suggesting that the estimated positive value of the policy coefficient α_ξ could be conducive to a more efficient allocation. This is because responding directly to demand shocks allows the central bank to raise the real interest rate in line with the increase in the natural rate triggered by the demand shock, while keeping inflation and output close to their target values, something that is impossible to do under a standard Taylor rule.

Under full information, a monetary tightening stemming from an increase in the transitory monetary shock z_t^m produces conventional effects, namely, a fall in inflation and output.

Table 3 displays the variance decomposition of the variables of interest. According to the estimated model, both the neo-Fisher effect and the central-bank information effect are relevant drivers of the data. The permanent monetary shock, X_t^m, is important in explaining inflation, accounting for one third of the variance of changes in Π_t. The central bank information shock ξ_t^c plays a key role along a different dimension. It primarily drives

Table 3: Variance Decomposition Under Full Information

Shock	α_ξ Estimated			$\alpha_\xi = 0$		
	ΔI_t	$\Delta \Pi_t$	ΔY_t	ΔI_t	$\Delta \Pi_t$	ΔY_t
Permanent Monetary Shock, g_t^m	6.0	33.2	1.8	5.6	15.1	1.5
Central Bank Information Shock, ξ_t^c	52.9	6.8	1.5	56.1	57.2	17.9
Transitory Interest-Rate Shock, z_t^m	8.6	4.0	1.3	7.9	1.8	1.0
Preference Shock, ξ_t^h	25.4	44.0	25.5	23.8	20.8	21.8
Transitory Productivity Shock, z_t	4.7	7.8	1.6	4.4	3.3	1.3
Permanent Productivity Shock, g_t	2.5	4.3	68.3	2.3	1.9	56.5

Notes. Posterior means, in percent. The variables ΔI_t, $\Delta \Pi_t$, and ΔY_t denote the change in the nominal interest rate, the change in the inflation rate, and the output growth rate.

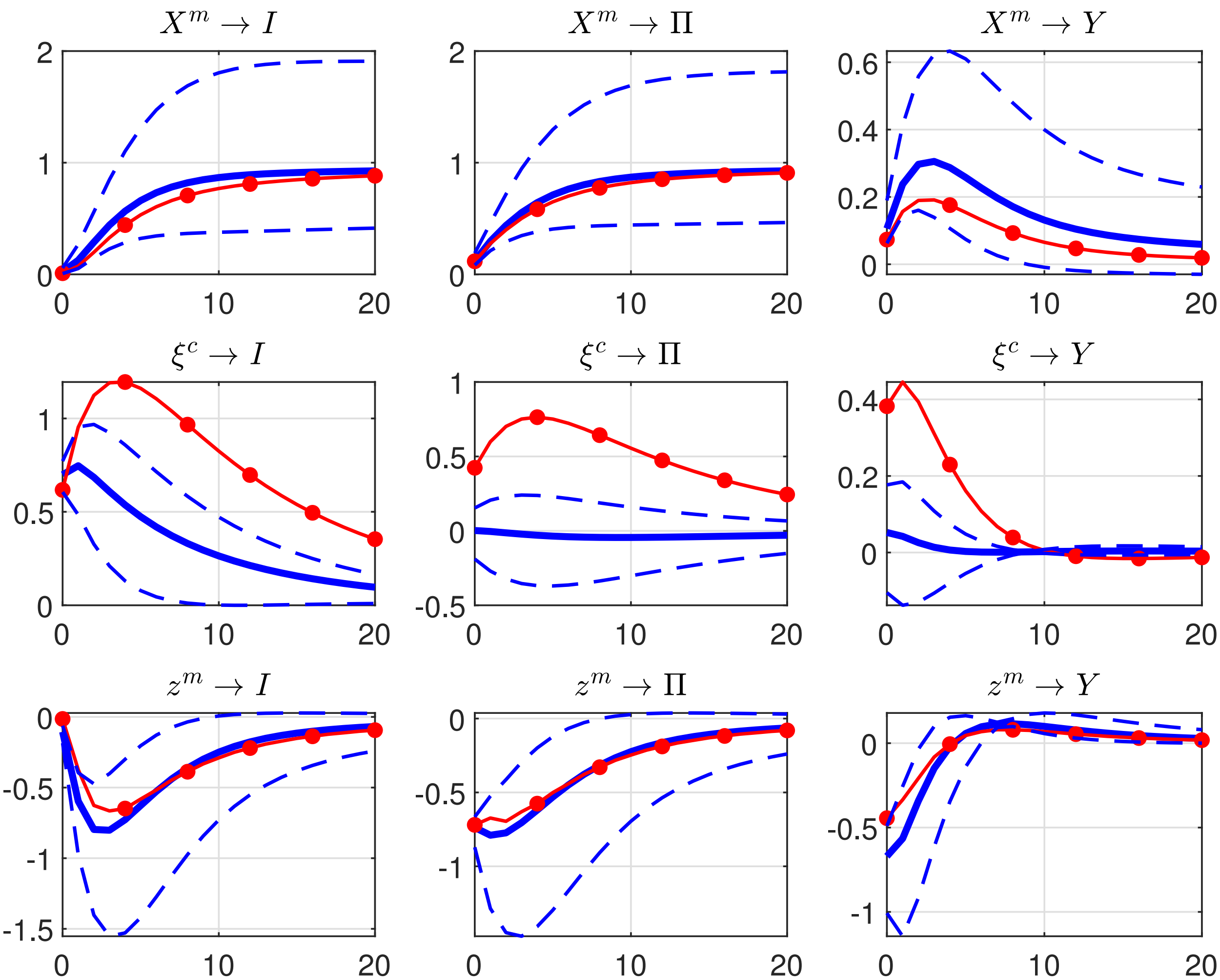
Table 4: Variance Decomposition Under Imperfect information

Shock	α_ξ Estimated			$\alpha_\xi = 0$		
	ΔI_t	$\Delta \Pi_t$	ΔY_t	ΔI_t	$\Delta \Pi_t$	ΔY_t
Permanent Monetary Shock, g_t^m	3.8	19.6	2.3	3.7	9.7	1.1
Central Bank Information Shock, ξ_t^c	61.3	6.7	2.0	68.4	62.6	25.7
Transitory Interest-Rate Shock, z_t^m	5.3	23.7	6.7	5.3	8.2	2.4
Preference Shock, ξ_t^h	22.6	39.4	15.9	15.7	14.8	7.7
Transitory Productivity Shock, z_t	4.9	7.3	1.5	4.9	3.3	1.3
Permanent Productivity Shock, g_t	2.1	3.2	71.7	2.0	1.5	61.9

Notes. Posterior means, in percent. The variables ΔI_t, $\Delta \Pi_t$, and ΔY_t denote the change in the nominal interest rate, the change in the inflation rate, and the output growth rate.

movements in the nominal interest rate, explaining half of the variance of changes in I_t. This shock has a minor role in explaining movements in inflation and output. However, as explained in the analysis of impulse responses, this is due to the central bank's success in stabilizing the economy in response to demand shocks: The last three columns of Table 3 display the variance decomposition when α_ξ is restricted to be 0, that is, when the central bank does not respond directly to the demand shock ξ_t^c. In this case, ξ_t^c explains 57 percent of changes in inflation and 17 percent of changes in output.

Figure 2: Estimated Impulse Responses Under Imperfect Information



Notes. The horizontal axes measure quarters after the shock. Solid lines are posterior means, dashed lines are 95% asymmetric error bands computed using the Sims-Zha (1999) method, and circled lines are posterior means restricting $\alpha_\xi = 0$ without reestimation. Inflation, Π_t, and the nominal interest rate, I_t, are deviations from pre-shock levels and are expressed in percentage points per year. Output, Y_t, is measured in percent deviations from trend. The size of the permanent monetary shock X_t^m is set so as to increase the nominal interest rate by 1 annual percentage point in the long run on average. The size of the transitory monetary shock z_t^m is 1 annual percentage point on impact. And the size of the demand shock ξ_t^c is one standard deviation.

5.2 Imperfect Information

Under imperfect information, private agents observe the stochastic component of the Taylor rule, $\widetilde{\Omega}_t^m \equiv X_t^{m\,1-\alpha_\pi(1-\gamma_I)} X_{t-1}^{m\;\;-\gamma_I} e^{z_t^m+\alpha_\xi \xi_t^c}$, but not the individual shocks that drive it, namely, the two monetary shocks, X_t^m and z_t^m, and the demand shock ξ_t^c. Similarly, under imperfect information private agents observe the preference shifter ξ_t, but not separately its two components ξ_t^h and ξ_t^c. As it turns out, however, the equilibrium dynamics are not too different relative to the perfect information case.

Figure 2 displays impulse responses to X_t^m, ξ_t^c, and z_t^m under imperfect information. An increase in the permanent monetary shock continues to produce a significant neo-Fisher effect, as the interest rate, inflation, and output all increase in the short run in response to an increase in X_t^m. Quantitatively, the reaction of the nominal interest rate on impact is somewhat more muted, but overall the economy continues to reach its long-run position relatively quickly and the expansionary effect on output is little changed.

A positive innovation in the demand shock ξ_t^c continues to produce a significant and persistent tightening, and the monetary authority achieves a virtually perfect stabilization of inflation and output. When we counterfactually shut down the central bank's reaction to ξ_t^c by setting α_ξ to zero, both inflation and output display large and significant increases, just as under full information.

A noticeable difference with the full information case is the response to a stationary monetary shock z_t^m, especially the response of the nominal interest rate. Under imperfect information, when z_t^m goes up, private agents know that the increase in the exogenous component of the Taylor rule is not due to a demand shock, since they know that ξ_t did not move. So they are sure that they are in the presence of a monetary shock. But they are not sure whether the monetary innovation is a stationary or a permanent one. Since the exogenous component of the Taylor rule, $\widetilde{\Omega}_t^m \equiv X_t^{m\,1-\alpha_\pi(1-\gamma_I)} X_{t-1}^{m\;\;-\gamma_I} e^{z_t^m+\alpha_\xi \xi_t^c}$, is increasing in z_t^m but decreasing in X_t^m, agents think that the economy could have been hit either with an increase in z_t^m or with a decrease in X_t^m. Both of these possibilities tend to produce falls in inflation and output. So the transition in response to an increase in z_t^m is characterized by paths of Π_t and Y_t below trend. The response of the interest rate is ambiguous, because an increase in z_t^m induces an increase in I_t, whereas a fall in X_t^m induces a decrease.

Table 4 displays a variance decomposition under imperfect information. Movements in X_t^m explain about 20 percent of the variance of inflation changes, suggesting that the permanent monetary shock continues to be an important driver of inflation, though less so than under full information. The central bank information channel is somewhat stronger under imperfect information. Now, the demand shock ξ_t^c explains 61 percent of movements in the nominal interest rate, up from 53 percent under full information. As under full information, this shock contributes relatively little to explaining movements in inflation and output, but this is due to its success in isolating the economy from this type of disturbances. When we counterfactually shut down the central bank's response to demand shocks, this source of disturbance becomes the main driver of inflation and a significant driver of aggregate activity.

6 Conclusion

The neo-Fisher effect and the central-bank information effect produce similar outcomes: under both, a monetary tightening triggers an increase in inflation and an expansion in real activity. Separate estimates of these effects run the risk of confounding one with the other. In this paper we present the first attempt to jointly estimate the two effects. To this end, we incorporate into a dynamic general equilibrium model with nominal and real rigidities permanent monetary shocks—the neo-Fisherian channel—and an interest-rate feedback rule that responds directly to an aggregate demand shock in addition to inflation and output—the central bank information channel. We estimate the model using U.S. data on interest rates, inflation, and output over the postwar period.

The estimated model suggests that both the neo-Fisher shock and the central-bank information shock are relevant drivers of the U.S. economy. Permanent monetary shocks explain a significant fraction of movements in inflation, and the demand shock to which the monetary authority responds explains a large share of variations in the nominal interest rate. In equilibrium, this demand shock does not explain much of the volatility of inflation or output. However, through counterfactual exercises we establish that this is a reflection of the CBI channel's success in stabilizing the aggregate effects of this type of disturbance.

The estimated model predicts that through its direct response to aggregate shocks, the central bank brings the real allocation closer to the one that would arise under flexible prices. This finding suggests that the central-bank information channel could be conducive to a more efficient outcome. A promising line of investigation is ascertaining precisely how much closer the direct response of central banks to aggregate disturbances—of which the current formulation of the CBI channel is just one example—can bring the economy to the efficiency frontier. We leave this task for future work.

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