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Measuring the Stances of Monetary and Fiscal Policy

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ABSTRACT: We derive measures of the stances of monetary and fiscal policy within the framework of an empirically plausible extension of the basic New Keynesian model, and jointly estimate them for the United States using a closed form multivariate linear filter. Our theoretical analysis reveals that the neutral stance of monetary policy — as measured by the real natural rate of interest — depends on the stance of fiscal policy, which in turn depends on the composition and expected timing of structural changes in the fiscal instruments. Our empirical application finds that accounting for fiscal policy significantly alters the estimated stance of monetary policy, and that the so-called fiscal impulse is a poor proxy for the stance of fiscal policy.

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Contents

I. Introduction

The starting point for a conjunctural assessment of monetary or fiscal policy is the measurement of the current stance. Under a flexible inflation targeting regime, the theoretical macroeconomics literature has converged on the real interest rate gap as a measure of the stance of monetary policy, following Woodford (2003). Aligning practice with theory, inflation targeting central banks have widely adopted this measure of the stance of monetary policy. In contrast, no theoretical consensus has emerged around a measure of the stance of fiscal policy. Lacking clear theoretical guidance, finance ministries have tended to rely on the so-called fiscal impulse — defined as the change in the structural primary fiscal balance ratio — as an indicator of the stance of fiscal policy.

In this paper, we derive measures of the stances of monetary and fiscal policy within the framework of an empirically plausible extension of the basic New Keynesian model. While the real interest rate gap remains a measure of the stance of monetary policy, the neutral stance of monetary policy — as measured by the real natural rate of interest — depends on the stance of fiscal policy in this framework. Indeed, abstracting from fiscal policy generally yields misspecified identifying restrictions for estimating the stance of monetary policy. Moreover, the stance of fiscal policy is not proportional to the fiscal impulse, but instead depends differentially on the structural government expenditure and revenue ratios in both a forward and backward looking manner. Using a closed form multivariate linear filter, we jointly estimate these measures of the stances of monetary and fiscal policy for the United States. Based on this empirical application, we find that accounting for fiscal policy significantly alters the estimated stance of monetary policy, and that the fiscal impulse is a poor proxy for the stance of fiscal policy. We also find that the multivariate filter is much more informative for estimating the stances of monetary and fiscal policy than is its univariate counterpart.

The extensive literature on measuring the stance of monetary policy focuses on gauging its contributions to inflation and the business cycle, reflecting the inflation and output stabilization objectives of monetary policy under a flexible inflation targeting regime. As prescribed by the theoretical branch of the monetary policy stance literature revived by Woodford (2003), the empirical branch estimates the real interest rate gap based on variants of the New Keynesian model. One strand of this empirical monetary policy stance literature takes a semi-structural partial equilibrium approach, following Laubach and Williams (2003). Another takes a structural general equilibrium approach, following Smets and Wouters (2003). In contrast, the sparse literature on measuring the stance of fiscal policy focuses on either its countercyclical stabilization objective, or its debt sustainability objective. For example, Batini, Cantelmo, Melina and Villa (2021) propose a measure of the stance of fiscal policy that captures its contribution to the business cycle, whereas Polito and Wickens (2012) propose one that reflects the implied trajectory of the government debt ratio. In this paper, we extend the theoretical and empirical monetary policy stance literatures, to jointly measure the stances of monetary and fiscal policy within a unified framework. Our focus is on gauging the contributions of monetary and fiscal policy to inflation and the business cycle.

The organization of this paper is as follows. The next section extends the basic New Keynesian model to facilitate measuring the stances of monetary and fiscal policy. We then define these measures in section three, and jointly estimate them for the United States using a closed form multivariate linear filter. Finally, section four concludes.

II. The New Keynesian Model

We consider the basic New Keynesian model of a closed economy documented in Woodford (2003) and Galí (2015), extended to provide an empirically plausible framework for measuring the stances of monetary and fiscal policy. In particular, to generate inertia in inflation and persistence in output, we add partial indexation in price setting and habit persistence in consumption, following Smets and Wouters (2003). To also obtain realistic fiscal multipliers, we add credit constraints in consumption, following Galí, López-Salido and Vallés (2007). Finally, to exploit the information content of the unemployment rate when estimating the output gap, we obtain a version of Okun's law by modifying the term in the intratemporal utility function capturing disutility from work, motivated by Clark (1989).

A. Households

There exists a continuum of households indexed by $h \in [0,1]$. Households are differentiated according to whether they are credit constrained, but are otherwise identical. Credit unconstrained households of type $Z = U$ and measure ϕ^U have access to financial markets where they trade bonds and stocks, where $0 < \phi^U < 1$. In contrast, credit constrained households of type and measure ϕ^C do not have access to financial markets, where $0 < \phi^C < 1$ and $\phi^U + \phi^C = 1$. All households are originally endowed with one share of each domestic firm.

Each infinitely lived household h has preferences defined over consumption $C_{h,s}$ and labor supply $L_{h,s}$ represented by intertemporal utility function

$$U_{h,t} = \mathrm{E}_t \sum_{s=t}^{\infty} \beta^{s-t} u(C_{h,s}, L_{h,s}), \tag{1}$$

where E_t denotes the expectations operator conditional on information available in period t, and $0 < \beta < 1$. The intratemporal utility function is additively separable and represents external habit formation preferences in consumption,

$$u(C_{h,s}, L_{h,s}) = \frac{1}{1-1/\sigma}\left(C_{h,s} - \alpha \frac{C^Z_{s-1}}{\phi^Z}\right)^{1-1/\sigma} - \frac{\upsilon^N_s}{1+1/\eta}\left(\frac{C^Z_s}{\phi^Z} - \alpha \frac{C^Z_{s-1}}{\phi^Z}\right)^{-1/\sigma}\left(\frac{1-\chi}{1-u_s}\right)^{1/\eta}\left(\frac{L_{h,s}}{N_s}\right)^{1+1/\eta}, \tag{2}$$

where $0 \le \alpha < 1$, $\sigma > 0$, $0 < \chi < 1$ and $\eta > 0$. To neutralize the direct effect of taxation on labor supply, endogenous preference shifter υ^N_s sets disutility from labor supply proportional to aggregate real disposable income, that is $\upsilon^N_s = (1-\tau_s)Y_s$. The unemployment rate u_s measures the share of the labor force N_s in unemployment U_s, that is $u_s = U_s / N_s$, where unemployment equals the labor force less employment L_s, that is $U_s = N_s - L_s$.

The household enters period s in possession of previously purchased government bonds $B_{h,s}$ that yield interest at risk free rate i_{s-1}, and holds a diversified portfolio of shares $\{S_{h,f,s}\}_{f=0}^{1}$ in intermediate good firms that pay dividends $\{\Pi_{f,s}\}_{f=0}^{1}$. During period s, it supplies labor service $L_{h,s}$, earning labor income at nominal wage W_s. The government levies a tax on household labor income at rate τ_s. These sources of wealth are summed in household dynamic budget constraint:

$$B_{h,s+1} + \int_0^1 V_{f,s} S_{h,f,s+1} df = (1+i_{s-1})B_{h,s} + \int_0^1 (\Pi_{f,s} + V_{f,s}) S_{h,f,s} df + (1-\tau_s) W_s L_{h,s} - P_s C_{h,s}. \tag{3}$$

According to this dynamic budget constraint, at the end of period s, the household purchases bonds $B_{h,s+1}$, and a diversified portfolio of shares $\{S_{h,f,s+1}\}_{f=0}^{1}$ at prices $\{V_{f,s}\}_{f=0}^{1}$. Finally, it purchases final consumption good $C_{h,s}$ at price P_s.

Credit Unconstrained Households

In period t, the credit unconstrained household chooses state contingent sequences for consumption $\{C_{h,s}\}_{s=t}^{\infty}$, labor supply $\{L_{h,s}\}_{s=t}^{\infty}$, bond holdings $\{B_{h,s+1}\}_{s=t}^{\infty}$ and share holdings $\{\{S_{h,f,s+1}\}_{f=0}^{1}\}_{s=t}^{\infty}$ to maximize intertemporal utility function (1) subject to dynamic budget constraint (3), and terminal nonnegativity constraints $B_{h,T+1} \geq 0$ and $S_{h,f,T+1} \geq 0$ for $T \to \infty$. In equilibrium, the solutions to this utility maximization problem satisfy intertemporal optimality condition

$$\mathrm{E}_t \frac{\beta u_C(C_{h,t+1}, L_{h,t+1})}{u_C(C_{h,t}, L_{h,t})} \frac{P_t}{P_{t+1}} (1+i_t) = 1, \tag{4}$$

which equates the expected discounted value of the gross real return on government bonds to one. They also satisfy intratemporal optimality condition

$$-\frac{u_L(C_{h,t}, L_{h,t})}{u_C(C_{h,t}, L_{h,t})} = (1-\tau_t)\frac{W_t}{P_t}, \tag{5}$$

which equates the marginal rate of substitution between leisure and consumption to the after tax real wage. Finally, they satisfy intratemporal optimality condition

$$\mathrm{E}_t \frac{\beta u_C(C_{h,t+1}, L_{h,t+1})}{u_C(C_{h,t}, L_{h,t})} \frac{P_t}{P_{t+1}} \left[\frac{\Pi_{f,t+1} + V_{f,t+1}}{V_{f,t}} - (1+i_t) \right] = 0, \tag{6}$$

which equates the expected discounted values of the gross real returns on stocks and bonds.

Credit Constrained Households

In period t, the credit constrained household chooses state contingent sequences for consumption $\{C_{h,s}\}_{s=t}^{\infty}$ and labor supply $\{L_{h,s}\}_{s=t}^{\infty}$ to maximize intertemporal utility function (1) subject to dynamic budget constraint (3) and the financial market access restrictions. In equilibrium, the solutions to this utility maximization problem satisfy household static budget constraint

$$P_t C_{h,t} = \Pi_t + (1-\tau_t) W_t L_{h,t}, \tag{7}$$

which equates consumption expenditures to disposable income. They also satisfy intratemporal optimality condition

$$-\frac{u_L(C_{h,t}, L_{h,t})}{u_C(C_{h,t}, L_{h,t})} = (1-\tau_t)\frac{W_t}{P_t}, \tag{8}$$

which equates the marginal rate of substitution between leisure and consumption to the after tax real wage.

B. Firms

There exists a continuum of monopolistically competitive intermediate good firms indexed by $f \in [0,1]$ that supply differentiated intermediate output goods, but are otherwise identical. Each intermediate good firm f sells shares to credit unconstrained households at price $V_{f,t}$.

Acting in the interests of its shareholders, the intermediate good firm maximizes its pre-dividend stock market value, which in equilibrium equals the expected discounted value of current and future dividend payments:

$$\Pi_{f,t} + V_{f,t} = \mathrm{E}_t \sum_{s=t}^{\infty} \frac{\beta^{s-t}\lambda_s^U}{\lambda_t^U} \Pi_{f,s}. \tag{9}$$

Shares entitle households to dividend payments equal to net profits $\Pi_{f,s}$, defined as after tax earnings:

$$\Pi_{f,s} = (1-\tau_s)(P_{f,s}Y_{f,s} - W_s L_{f,s}). \tag{10}$$

Earnings equal revenues from sales of differentiated intermediate output good $Y_{f,s}$ at price $P_{f,s}$ minus expenditures on labor service $L_{f,s}$. The government levies a tax on corporate earnings at rate τ_s.

The intermediate good firm rents labor service $L_{f,s}$ given productivity coefficient A_s to produce differentiated intermediate output good $Y_{f,s}$ according to production function

$$Y_{f,s} = A_s (L_{f,s})^{\phi^Y}, \tag{11}$$

where $A_s > 0$. This production function is homogeneous of degree ϕ^Y, where $\phi^Y > 0$.

In period t, the intermediate good firm chooses a state contingent sequence for employment $\{L_{f,s}\}_{s=t}^{\infty}$ to maximize pre-dividend stock market value (9) subject to production function (11). This value maximization problem yields necessary first order condition

$$\Phi_{f,t} = \frac{1-\tau_t}{\phi^Y} \frac{W_t L_{f,t}}{P_t Y_{f,t}}, \tag{12}$$

where $P_s \Phi_{f,s}$ denotes the Lagrange multiplier associated with the period s production technology constraint. This necessary first order condition equates real marginal cost $\Phi_{f,t}$ to the ratio of the after tax real wage to the marginal product of labor.

There exist a large number of perfectly competitive firms that combine differentiated intermediate output goods $Y_{f,t}$ supplied by intermediate good firms to produce final output good Y_t according to production function

$$Y_t = \left[\int_0^1 (Y_{f,t})^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}}, \tag{13}$$

where $\theta > 1$. The final good firm maximizes profits derived from production of the final output good with respect to inputs of intermediate output goods, implying demand functions:

$$Y_{f,t} = \left(\frac{P_{f,t}}{P_t} \right)^{-\theta} Y_t. \tag{14}$$

Since the production function exhibits constant returns to scale, in equilibrium the final good firm earns zero profit, implying aggregate price index:

$$P_t = \left[\int_0^1 (P_{f,t})^{1-\theta} df \right]^{\frac{1}{1-\theta}}. \tag{15}$$

Clearing of the final output good market requires that production of the final output good equal the total demand of households and the government, that is $Y_t = C_t + G_t$.

In an extension of the model of nominal price rigidity proposed by Calvo (1983) following Smets and Wouters (2003), each period a randomly selected fraction $1-\omega$ of intermediate good firms adjust their price optimally, where $0 \le \omega < 1$. The remaining fraction ω of intermediate good firms adjust their price to account for past inflation according to partial indexation rule

$$P_{f,t} = \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\gamma} \left(\frac{\bar{P}_{t-1}}{\bar{P}_{t-2}} \right)^{1-\gamma} P_{f,t-1}, \tag{16}$$

where $0 \leq \gamma \leq 1$. If the intermediate good firm can adjust its price optimally in period t, then it does so to maximize pre-dividend stock market value (9) subject to production function (11), intermediate output good demand function (14), and the assumed form of nominal price rigidity. We consider a symmetric equilibrium under which all intermediate good firms that adjust their price optimally in period t choose a common price P_t^* given by necessary first order condition:

$$\frac{P_t^*}{P_t} = \frac{\theta}{\theta-1} \frac{\mathrm{E}_t \sum_{s=t}^{\infty} (\omega)^{s-t} \frac{\beta^{s-t}\lambda_s^U}{\lambda_t^U} \Phi_{t,s} \left[\left(\frac{P_{t-1}}{P_{s-1}}\right)^{\gamma} \left(\frac{\bar{P}_{t-1}}{\bar{P}_{s-1}}\right)^{1-\gamma} \frac{P_s}{P_t} \right]^{\theta} P_s Y_s}{\mathrm{E}_t \sum_{s=t}^{\infty} (\omega)^{s-t} \frac{\beta^{s-t}\lambda_s^U}{\lambda_t^U} (1-\tau_s) \left[\left(\frac{P_{t-1}}{P_{s-1}}\right)^{\gamma} \left(\frac{\bar{P}_{t-1}}{\bar{P}_{s-1}}\right)^{1-\gamma} \frac{P_s}{P_t} \right]^{\theta-1} P_s Y_s}. \tag{17}$$

This necessary first order condition equates the expected present value of marginal revenue to the expected present value of marginal cost. Aggregate price index (15) equals an average of the price set by the fraction $1-\omega$ of intermediate good firms that adjust their price optimally in period t, and the average of the prices set by the remaining fraction ω of intermediate good firms that adjust their price according to partial indexation rule (16):

$$P_t = \left\{ (1-\omega)(P_t^*)^{1-\theta} + \omega \left[\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma} \left(\frac{\bar{P}_{t-1}}{\bar{P}_{t-2}}\right)^{1-\gamma} P_{t-1} \right]^{1-\theta} \right\}^{\frac{1}{1-\theta}}. \tag{18}$$

Since those intermediate good firms able to adjust their price optimally in period t are selected randomly from among all intermediate good firms, the average price set by the remaining intermediate good firms equals the value of the aggregate price index that prevailed during period $t-1$, rescaled to account for past inflation.

C. The Government

The government consists of a monetary authority that conducts monetary policy, and a fiscal authority that conducts fiscal policy.

The Monetary Authority

The monetary authority implements monetary policy through control of the nominal interest rate according to a monetary policy rule exhibiting partial adjustment dynamics of the form

$$i_t - \tilde{i}_t = \rho(i_{t-1} - \tilde{i}_{t-1}) + (1-\rho)\left[\xi^{\pi}(\pi_t - \pi) - \phi^{Y}\xi^{u}(u_t - \chi)\right], \tag{19}$$

where $0 \leq \rho < 1$, $\xi^{\pi} > 1$ and $\xi^{u} \geq 0$. As specified, the deviation of the nominal interest rate from its flexible price equilibrium value depends on a weighted average of its past deviation and its desired deviation, which in turn is increasing in the contemporaneous deviation of inflation from its target value, and is decreasing in the contemporaneous deviation of the unemployment rate from its flexible price equilibrium value. In flexible price equilibrium, this monetary policy rule reduces to $\tilde{\pi}_t = \pi$.

The Fiscal Authority

The fiscal authority enters period t with previously accumulated government debt D_t, which subsequently evolves according to government dynamic budget constraint

$$D_{t+1} = (1+i_{t-1})D_t - PB_t, \tag{20}$$

where clearing of the government bond market requires that $B_{t+1} = D_{t+1}$. The primary fiscal balance PB_t equals tax revenues T_t less government expenditures, that is $PB_t = T_t - P_t G_t$. During period t, the fiscal authority levies taxes on corporate earnings and household labor income at rate τ_t:

$$T_t = \int_0^1 \tau_t (P_{f,t} Y_{f,t} - W_t L_{f,t}) df + \int_0^1 \tau_t W_t L_{h,t} dh. \tag{21}$$

In equilibrium $T_t = \tau_t P_t Y_t$, corresponding to the case of proportional output taxation, which as discussed in Romer (2019) is a reasonable approximation for many economies. Finally, the fiscal authority purchases public consumption good G_t at price P_t.

The fiscal authority implements fiscal policy by setting the government expenditure ratio and output tax rate as prescribed by fiscal policy rules exhibiting partial adjustment dynamics. Let g_t denote the government expenditure ratio, pb_t the primary fiscal balance ratio, and d_{t+1} the government debt ratio, where $g_t = G_t / Y_t$, $pb_t = PB_t / P_t Y_t$ and $d_{t+1} = D_{t+1} / P_t Y_t$. The fiscal expenditure rule satisfies

$$g_t - g = \rho(g_{t-1} - g) + (1-\rho)\left[\phi^Y \zeta^u (u_t - \chi) - \zeta^d (d_{t+1} - d)\right], \tag{22}$$

where $\zeta^u \geq 0$ and $\zeta^d > 0$. As specified, the deviation of the government expenditure ratio from its steady state equilibrium value depends on a weighted average of its past deviation and its desired deviation, which in turn is increasing in the contemporaneous deviation of the unemployment rate from its flexible price equilibrium value, and is decreasing in the contemporaneous deviation of the government debt ratio from its steady state equilibrium value. The fiscal revenue rule satisfies:

$$\tau_t - \tau = \rho(\tau_{t-1} - \tau) + (1-\rho)\zeta^d (d_{t+1} - d). \tag{23}$$

As specified, the deviation of the output tax rate from its steady state equilibrium value depends on a weighted average of its past deviation and its desired deviation, which in turn is increasing in the contemporaneous deviation of the government debt ratio from its steady state equilibrium value.

D. Equilibrium

A rational expectations equilibrium in this New Keynesian model of a closed economy consists of state contingent sequences of allocations for households and firms that solve their constrained optimization problems given prices and policies, together with a state contingent sequence of allocations for the government that satisfies its policy rules and constraint given prices, with supporting prices such that all markets clear.

Let $\hat{x}_t$ denote the deviation of variable x_t from its steady state equilibrium value $\overline{x}_t$. Analytically linearizing the equilibrium conditions of our New Keynesian model around a stationary deterministic steady state equilibrium, and consolidating them by substituting out intermediate variables, yields

$$\hat{\pi}_t = \frac{\gamma}{1+\gamma\beta}\hat{\pi}_{t-1} + \frac{\beta}{1+\gamma\beta}\mathrm{E}_t \hat{\pi}_{t+1} - \frac{(1-\omega)(1-\omega\beta)}{\omega(1+\gamma\beta)}\hat{u}_t, \tag{24}$$

$$\hat{y}_t = \frac{\alpha}{1+\alpha}\hat{y}_{t-1} + \frac{1}{1+\alpha}\mathrm{E}_t\hat{y}_{t+1} - \sigma\frac{1-\alpha}{1+\alpha}\left[\hat{r}_t - \frac{1}{\sigma}\frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{\mathrm{E}_t(\phi^C\Delta\hat{\tau}_{t+1} - \Delta\hat{g}_{t+1}) - \alpha(\phi^C\Delta\hat{\tau}_t - \Delta\hat{g}_t)}{1-\alpha}\right], \quad (25)$$

$$\hat{u}_t = -\frac{1}{\phi^Y}\left[\hat{y}_t - (\hat{a}_t + \phi^Y\hat{n}_t)\right], \quad (26)$$

$$\hat{i}_t - \hat{\tilde{i}}_t = \rho(\hat{i}_{t-1} - \hat{\tilde{i}}_{t-1}) + (1-\rho)(\xi^\pi\hat{\pi}_t - \phi^Y\xi^u\hat{u}_t), \quad (27)$$

$$\hat{g}_t = \rho\hat{g}_{t-1} + (1-\rho)(\phi^Y\zeta^u\hat{u}_t - \zeta^d\hat{d}_{t+1}), \quad (28)$$

$$\hat{\tau}_t = \rho\hat{\tau}_{t-1} + (1-\rho)\zeta^d\hat{d}_{t+1}, \quad (29)$$

$$\hat{d}_{t+1} = \frac{1}{\beta}\hat{d}_t - (\hat{\tau}_t - \hat{g}_t), \quad (30)$$

where the real interest rate $\hat{r}_t$ is defined as $\hat{r}_t = \hat{i}_t - \mathrm{E}_t\hat{\pi}_{t+1}$, while the inflation rate $\hat{\pi}_t$ is defined as $\hat{\pi}_t = \hat{p}_t - \hat{p}_{t-1}$, and lowercase variables denote the natural logarithms of their uppercase counterparts. This steady state equilibrium features zero inflation, productivity growth, labor force growth, and government debt. Closing the model requires determining the flexible price equilibrium value of the nominal interest rate. This in turn requires decomposing all variables into deviations from their flexible price equilibrium values, and deviations of these flexible price equilibrium values from their steady state equilibrium values.

Let $\hat{\hat{x}}_t$ denote the deviation of variable x_t from its flexible price equilibrium value $\tilde{x}_t$ which obtains when $\omega = 0$, otherwise referred to as its natural or potential value. Our linearized New Keynesian model may be restated as

$$\hat{\hat{\pi}}_t = \frac{\gamma}{1+\gamma\beta}\hat{\hat{\pi}}_{t-1} + \frac{\beta}{1+\gamma\beta}\mathrm{E}_t\hat{\hat{\pi}}_{t+1} + \frac{(1-\omega)(1-\omega\beta)}{\omega(1+\gamma\beta)}\frac{1}{\phi^Y}\hat{\hat{y}}_t, \quad (31)$$

$$\hat{\hat{y}}_t = \frac{\alpha}{1+\alpha}\hat{\hat{y}}_{t-1} + \frac{1}{1+\alpha}\mathrm{E}_t\hat{\hat{y}}_{t+1} - \sigma\frac{1-\alpha}{1+\alpha}\left[\hat{\hat{r}}_t - \frac{1}{\sigma}\frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{\mathrm{E}_t(\phi^C\Delta\hat{\hat{\tau}}_{t+1} - \Delta\hat{\hat{g}}_{t+1}) - \alpha(\phi^C\Delta\hat{\hat{\tau}}_t - \Delta\hat{\hat{g}}_t)}{1-\alpha}\right], \quad (32)$$

$$\hat{\hat{u}}_t = -\frac{1}{\phi^Y}\hat{\hat{y}}_t, \quad (33)$$

$$\hat{\hat{i}}_t = \rho\hat{\hat{i}}_{t-1} + (1-\rho)(\xi^\pi\hat{\hat{\pi}}_t + \xi^u\hat{\hat{y}}_t), \quad (34)$$

$$\hat{\tilde{r}}_t = \frac{1}{\sigma}\left[\frac{\mathrm{E}_t\Delta\hat{\tilde{y}}_{t+1} - \alpha\Delta\hat{\tilde{y}}_t}{1-\alpha} + \frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{\mathrm{E}_t(\phi^C\Delta\hat{\tilde{\tau}}_{t+1} - \Delta\hat{\tilde{g}}_{t+1}) - \alpha(\phi^C\Delta\hat{\tilde{\tau}}_t - \Delta\hat{\tilde{g}}_t)}{1-\alpha}\right], \quad (35)$$

$$\hat{\hat{g}}_t = \rho\hat{\hat{g}}_{t-1} - (1-\rho)(\zeta^u\hat{\hat{y}}_t + \zeta^d\hat{\hat{d}}_{t+1}),\ \hat{\tilde{g}}_t = \rho\hat{\tilde{g}}_{t-1} - (1-\rho)\zeta^d\hat{\tilde{d}}_{t+1}, \quad (36)$$

$$\hat{\hat{\tau}}_t = \rho\hat{\hat{\tau}}_{t-1} + (1-\rho)\zeta^d\hat{\hat{d}}_{t+1},\ \hat{\tilde{\tau}}_t = \rho\hat{\tilde{\tau}}_{t-1} + (1-\rho)\zeta^d\hat{\tilde{d}}_{t+1}, \quad (37)$$

$$\hat{\hat{d}}_{t+1} = \frac{1}{\beta}\hat{\hat{d}}_t - (\hat{\hat{\tau}}_t - \hat{\hat{g}}_t),\ \hat{\tilde{d}}_{t+1} = \frac{1}{\beta}\hat{\tilde{d}}_t - (\hat{\tilde{\tau}}_t - \hat{\tilde{g}}_t), \quad (38)$$

where the real interest rate gap $\hat{\hat{r}}_t$ satisfies $\hat{\hat{r}}_t = \hat{\hat{i}}_t - \mathrm{E}_t\hat{\hat{\pi}}_{t+1}$, while the real natural rate of interest $\hat{\tilde{r}}_t$ satisfies $\hat{\tilde{r}}_t = \hat{\tilde{i}}_t - \mathrm{E}_t\hat{\tilde{\pi}}_{t+1}$ with $\hat{\tilde{\pi}}_t = 0$, and potential output satisfies $\hat{\tilde{y}}_t = \hat{a}_t + \phi^Y\hat{n}_t$. This model consists of: i) a Phillips curve dynamically relating the inflation gap to the output gap; ii) an Euler equation dynamically relating the output gap to the real interest rate gap and changes in the fiscal instrument gaps; iii) a version of Okun's law statically relating the unemployment rate gap to the output gap; iv) a Taylor rule dynamically relating the nominal policy interest rate gap to the inflation and output gaps; v) a natural rate relationship dynamically relating the real natural rate of interest to potential output growth and structural changes in the fiscal instruments; vi) a fiscal expenditure rule dynamically relating the government expenditure ratio to the output gap and the government debt ratio; vii) a fiscal revenue rule dynamically relating the output tax rate to the government debt ratio; and viii) a government budget constraint dynamically relating the government debt ratio to the primary fiscal balance ratio.

III. Measuring the Stances of Monetary and Fiscal Policy

Having extended the basic New Keynesian model to facilitate measuring the stances of monetary and fiscal policy, we proceed to define these measures, and to jointly estimate them for the United States using a closed form multivariate linear filter. Our proposed measures of the stances of monetary and fiscal policy capture the contributions of these policies to inflation and the business cycle, from both their systematic and unsystematic components.

A. Theory

As discussed in Woodford (2003), in the basic New Keynesian model of a closed economy, the real interest rate gap is a measure of the stance of monetary policy. In this framework, a negative real interest rate gap generates inflationary pressure by raising output above potential, and the stance of monetary policy is said to be expansionary, or alternatively loose or accommodative. In contrast, a positive real interest rate gap generates disinflationary pressure by lowering output below potential, and the stance of monetary policy is said to be contractionary, or alternatively tight or restrictive. Accordingly, the real natural rate of interest is a measure of the neutral stance of monetary policy in this framework, relative to which its contributions to inflation and the business cycle can be gauged. To operationalize these real concepts, they are often translated into nominal equivalents.

In our extension of the basic New Keynesian model to incorporate fiscal policy, the real interest rate gap remains a measure of the stance of monetary policy, and the real natural rate of interest is still a measure of the neutral stance of monetary policy. However, in this framework the real interest rate gap drives the output and inflation gaps alongside automatic fiscal stabilizers, which we associate with changes in the fiscal instrument gaps. Moreover, the real natural rate of interest depends not only on potential output growth, but also on the stance of fiscal policy, which we associate with structural changes in the fiscal instruments. Indeed, since potential output is exogenous in this framework, a tightening of the stance of fiscal policy translates one for one into a reduction in the real natural rate of interest, and vice versa.

Definition 1. Let mp_t denote the stance of monetary policy, fp_t the stance of fiscal policy, and fs_t automatic fiscal stabilizers, all measured in monetary policy stance equivalent units. Given $mp_t = \hat{\hat{r}}_t$, we define:

$$\begin{aligned} fp_t &\equiv -\frac{1}{\sigma}\frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{\mathrm{E}_t(\phi^C\Delta\hat{\bar{\tau}}_{t+1}-\Delta\hat{\bar{g}}_{t+1})-\alpha(\phi^C\Delta\hat{\bar{\tau}}_t-\Delta\hat{\bar{g}}_t)}{1-\alpha} \\ &= \frac{1}{\sigma}\frac{1+\alpha}{1-\alpha}\frac{1}{1-\phi^C}\frac{1}{1-\tau}\left[(\phi^C\hat{\bar{\tau}}_t-\hat{\bar{g}}_t)-\frac{\alpha}{1+\alpha}(\phi^C\hat{\bar{\tau}}_{t-1}-\hat{\bar{g}}_{t-1})-\frac{1}{1+\alpha}\mathrm{E}_t(\phi^C\hat{\bar{\tau}}_{t+1}-\hat{\bar{g}}_{t+1})\right], \end{aligned} \tag{39}$$

$$\begin{aligned} fs_t &\equiv \frac{1}{\sigma}\frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{\mathrm{E}_t(\phi^C\Delta\hat{\hat{\tau}}_{t+1}-\Delta\hat{\hat{g}}_{t+1})-\alpha(\phi^C\Delta\hat{\hat{\tau}}_t-\Delta\hat{\hat{g}}_t)}{1-\alpha} \\ &= -\frac{1}{\sigma}\frac{1+\alpha}{1-\alpha}\frac{1}{1-\phi^C}\frac{1}{1-\tau}\left[(\phi^C\hat{\hat{\tau}}_t-\hat{\hat{g}}_t)-\frac{\alpha}{1+\alpha}(\phi^C\hat{\hat{\tau}}_{t-1}-\hat{\hat{g}}_{t-1})-\frac{1}{1+\alpha}\mathrm{E}_t(\phi^C\hat{\hat{\tau}}_{t+1}-\hat{\hat{g}}_{t+1})\right]. \end{aligned} \tag{40}$$

This measure of the stance of fiscal policy is not proportional to the so-called fiscal impulse — defined as the change in the structural primary fiscal balance ratio — under any permissible set of parameter restrictions in our New Keynesian model.[1] Nonetheless, these concepts are related. In particular, the stance of fiscal policy in our model is proportional to the deviation of the contemporaneous weighted structural primary fiscal balance ratio from a weighted average of its past and expected future values. Reflecting the dynamic properties of the Euler equation, this measure of the stance of fiscal policy is both backward and forward looking, whereas the fiscal impulse is a purely backward looking concept. Indeed, since the habit persistence parameter α satisfies $0 \leq \alpha < 1$, our measure of the stance of fiscal policy is more forward than backward looking. Moreover, in the weighted structural primary fiscal balance ratio, the relative weight on the structural fiscal revenue ratio equals the credit constrained household share parameter ϕ^C, which satisfies $0 < \phi^C < 1$. This accords with the empirical regularity that revenue based fiscal measures have smaller output multipliers than expenditure based measures, as discussed in the survey paper by Whalen and Reichling (2015). Parallel considerations apply to our measure of automatic fiscal stabilizers.

In our New Keynesian model, abstracting from fiscal policy yields misspecified identifying restrictions for estimating the stance of monetary policy, unless automatic fiscal stabilizers and the stance of fiscal policy are both always zero. Indeed, the stance of monetary policy enters the Euler equation alongside automatic fiscal stabilizers, while the neutral stance of monetary policy depends on the stance of fiscal policy. These theoretical predictions matter, because estimating unobserved variables conditional on misspecified identifying restrictions generally results in biases.

B. Estimation

Consider a vector stochastic process $\{\{y_{i,t}\}_{i=1}^{N}\}_{t=1}^{T}$ of dimension N that is observed for T periods. Suppose that this vector stochastic process is additively separable into cyclical and trend components, that is $y_{i,t} = \hat{y}_{i,t} + \bar{y}_{i,t}$.

We define the Generalized Multivariate Linear Filter (GMLF) as that trend component estimator $\{\{\bar{y}_{i,t|T}\}_{i=1}^{N}\}_{t=1}^{T}$ which minimizes objective function:

$$\begin{aligned} S(\{\{\bar{y}_{i,t}\}_{i=1}^{N}\}_{t=1}^{T}) &= \sum_{i=1}^{N}\sum_{t=1}^{T}\hat{y}_{i,t}^2 + \sum_{i=1}^{N}\sum_{d=1}^{D}\lambda_{d,i}^2\sum_{t=d+1}^{T}(\Delta^d\bar{y}_{i,t})^2 \\ &+\sum_{g=1}^{G}\gamma_g^2\sum_{t=P_1+1}^{T-P_2}\left(\sum_{i=1}^{N}\sum_{p=-P_1}^{P_2}\phi_{g,i,p}\hat{y}_{i,t+p}\right)^2 + \sum_{h=1}^{H}\psi_h^2\sum_{t=Q_1+1}^{T-Q_2}\left(\sum_{i=1}^{N}\sum_{q=-Q_1}^{Q_2}\theta_{h,i,q}\bar{y}_{i,t+q}\right)^2. \end{aligned} \tag{41}$$

This minimization problem strikes a balance between minimizing the sum of squares of the cyclical components and the sum of squares of the ordinary difference of variable specific order d_i of the trend components, where $\lambda_{d,i} = 0$ for all $d \neq d_i$. As $\lambda_{d,i}$ increases, the estimated trend component becomes smoother, converging to a deterministic polynomial of degree $d_i - 1$ in the limit as $\lambda_{d,i} \to \infty$. We therefore recommend choosing the minimum value of d_i for which $\{\Delta^{d_i-1}y_{i,t}\}_{t=d_i}^{T}$ does not exhibit a long run trend for all $i = 1,\ldots,N$. This minimization problem also quadratically penalizes the deviations of G linearly independent dynamic linear combinations of up to lag order P_1 and lead order P_2 of the cyclical components from zero, and H linearly independent dynamic linear combinations of up to lag order Q_1 and lead order Q_2 of the trend components from zero, where $G \leq N$ and $H \leq N$. As γ_g or ψ_h increases, the estimated cyclical or trend components more closely satisfy the stochastic linear restriction imposed on their comovement, which becomes deterministic in the limit as $\gamma_g \to \infty$ or $\psi_h \to \infty$, respectively.

[1] In our model, the fiscal impulse fi_t satisfies $fi_t = \Delta\hat{\bar{\tau}}_t - \Delta\hat{\bar{g}}_t$.

Proposition 1. Let $\bar{\boldsymbol{Y}}_{|T}$ denote the Generalized Multivariate Linear Filter (GMLF). Using matrix notation, objective function (41) may be expressed as

$$\begin{aligned} S(\bar{\boldsymbol{Y}}) &= \operatorname{Tr}(\hat{\boldsymbol{Y}}^{\mathsf{T}}\hat{\boldsymbol{Y}}) + \sum_{d=1}^{D}\operatorname{Tr}\left((\boldsymbol{\Delta}^{d}\bar{\boldsymbol{Y}}\boldsymbol{\Lambda}_{d})^{\mathsf{T}}(\boldsymbol{\Delta}^{d}\bar{\boldsymbol{Y}}\boldsymbol{\Lambda}_{d})\right) \\ &+ \operatorname{Tr}\left(\left(\sum_{p=-P_1}^{P_2}\boldsymbol{L}_{\boldsymbol{P}}^{p}\hat{\boldsymbol{Y}}\boldsymbol{\Phi}_{p}\boldsymbol{\Gamma}\right)^{\mathsf{T}}\left(\sum_{p=-P_1}^{P_2}\boldsymbol{L}_{\boldsymbol{P}}^{p}\hat{\boldsymbol{Y}}\boldsymbol{\Phi}_{p}\boldsymbol{\Gamma}\right)\right) + \operatorname{Tr}\left(\left(\sum_{q=-Q_1}^{Q_2}\boldsymbol{L}_{\boldsymbol{Q}}^{q}\bar{\boldsymbol{Y}}\boldsymbol{\Theta}_{q}\boldsymbol{\Psi}\right)^{\mathsf{T}}\left(\sum_{q=-Q_1}^{Q_2}\boldsymbol{L}_{\boldsymbol{Q}}^{q}\bar{\boldsymbol{Y}}\boldsymbol{\Theta}_{q}\boldsymbol{\Psi}\right)\right), \end{aligned} \tag{42}$$

where

$$\boldsymbol{Y} = \begin{bmatrix} y_{1,1} & \cdots & y_{N,1} \\ \vdots & \ddots & \vdots \\ y_{1,T} & \cdots & y_{N,T} \end{bmatrix},\ \boldsymbol{\Lambda}_d = \begin{bmatrix} \lambda_{d,1} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \lambda_{d,N} \end{bmatrix},\ \boldsymbol{\Phi}_p = \begin{bmatrix} \phi_{1,1,p} & \cdots & \phi_{G,1,p} \\ \vdots & \ddots & \vdots \\ \phi_{1,N,p} & \cdots & \phi_{G,N,p} \end{bmatrix},\ \boldsymbol{\Gamma} = \begin{bmatrix} \gamma_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \gamma_G \end{bmatrix},$$

$$\boldsymbol{\Theta}_q = \begin{bmatrix} \theta_{1,1,q} & \cdots & \theta_{H,1,q} \\ \vdots & \ddots & \vdots \\ \theta_{1,N,q} & \cdots & \theta_{H,N,q} \end{bmatrix},\ \boldsymbol{\Psi} = \begin{bmatrix} \psi_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \psi_H \end{bmatrix},$$

while ordinary difference operator matrix $\boldsymbol{\Delta}^{d} = \prod_{i=1}^{d}\left(\begin{bmatrix}\boldsymbol{0} & \boldsymbol{I}_{T-i}\end{bmatrix} - \begin{bmatrix}\boldsymbol{I}_{T-i} & \boldsymbol{0}\end{bmatrix}\right)$, and lag operator matrices $\boldsymbol{L}_{\boldsymbol{P}}^{p} = \begin{bmatrix}\boldsymbol{I}_{T-P_1-P_2} & \boldsymbol{0}\end{bmatrix}\begin{bmatrix}\boldsymbol{0} & \boldsymbol{I}_{T-P_1}\end{bmatrix}\begin{bmatrix}\boldsymbol{I}_{T-p} & \boldsymbol{0}\end{bmatrix}$ if $p \le 0$ and $\boldsymbol{L}_{\boldsymbol{P}}^{p} = \begin{bmatrix}\boldsymbol{0} & \boldsymbol{I}_{T-P_1-P_2}\end{bmatrix}\begin{bmatrix}\boldsymbol{I}_{T-P_2} & \boldsymbol{0}\end{bmatrix}\begin{bmatrix}\boldsymbol{0} & \boldsymbol{I}_{T-p}\end{bmatrix}$ otherwise, and $\boldsymbol{L}_{\boldsymbol{Q}}^{q} = \begin{bmatrix}\boldsymbol{I}_{T-Q_1-Q_2} & \boldsymbol{0}\end{bmatrix}\begin{bmatrix}\boldsymbol{0} & \boldsymbol{I}_{T-Q_1}\end{bmatrix}\begin{bmatrix}\boldsymbol{I}_{T-q} & \boldsymbol{0}\end{bmatrix}$ if $q \le 0$ and $\boldsymbol{L}_{\boldsymbol{Q}}^{q} = \begin{bmatrix}\boldsymbol{0} & \boldsymbol{I}_{T-Q_1-Q_2}\end{bmatrix}\begin{bmatrix}\boldsymbol{I}_{T-Q_2} & \boldsymbol{0}\end{bmatrix}\begin{bmatrix}\boldsymbol{0} & \boldsymbol{I}_{T-q}\end{bmatrix}$ otherwise. The unique global minimum $\bar{\boldsymbol{Y}}_{|T}$ of objective function (42) exists and satisfies:

$$\begin{aligned} \operatorname{Vec}(\bar{\boldsymbol{Y}}_{|T}) &= \left[\boldsymbol{I}_{NT} + \sum_{d=1}^{D}\left((\boldsymbol{\Lambda}_d\boldsymbol{\Lambda}_d^{\mathsf{T}})\otimes((\boldsymbol{\Delta}^{d})^{\mathsf{T}}(\boldsymbol{\Delta}^{d}))\right) + \sum_{p=-P_1}^{P_2}\left(((\boldsymbol{\Phi}_p\boldsymbol{\Gamma})(\boldsymbol{\Phi}_p\boldsymbol{\Gamma})^{\mathsf{T}})\otimes((\boldsymbol{L}_{\boldsymbol{P}}^{p})^{\mathsf{T}}(\boldsymbol{L}_{\boldsymbol{P}}^{p}))\right) + \sum_{q=-Q_1}^{Q_2}\left(((\boldsymbol{\Theta}_q\boldsymbol{\Psi})(\boldsymbol{\Theta}_q\boldsymbol{\Psi})^{\mathsf{T}})\otimes((\boldsymbol{L}_{\boldsymbol{Q}}^{q})^{\mathsf{T}}(\boldsymbol{L}_{\boldsymbol{Q}}^{q}))\right)\right]^{-1} \\ &\cdot\left[\boldsymbol{I}_{NT} + \sum_{p=-P_1}^{P_2}\left(((\boldsymbol{\Phi}_p\boldsymbol{\Gamma})(\boldsymbol{\Phi}_p\boldsymbol{\Gamma})^{\mathsf{T}})\otimes((\boldsymbol{L}_{\boldsymbol{P}}^{p})^{\mathsf{T}}(\boldsymbol{L}_{\boldsymbol{P}}^{p}))\right)\right]\operatorname{Vec}(\boldsymbol{Y}). \end{aligned} \tag{43}$$

Proof. See Vitek (2018). □

This GMLF nests well established closed form univariate linear filters, while selectively accounting for dynamic stochastic interrelationships among variables of the form incorporated into multivariate linear unobserved components models. Indeed, in the univariate case its associated minimization problem reduces to that considered by Hodrick and Prescott (1997) for $d_1 = 2$, and to that considered by Lucas (1980) for $d_1 = 1$, given that $\gamma_g = \psi_h = 0$ for all $g = 1,...,G$ and $h = 1,...,H$. Moreover, this GMLF does not depend on initial conditions, as it operates over the entire sample in one step, unlike recursive multivariate linear filters such as that due to Kalman (1960), which pass sequentially through the sample.

C. Identification

To jointly estimate the stances of monetary and fiscal policy, we use transformations of selected approximate linear equilibrium conditions from our New Keynesian model as identifying restrictions. In particular, we select only those approximate linear equilibrium conditions that are empirically plausible, and evaluate them under perfect foresight:

$$\hat{\hat{\pi}}_t = \frac{\gamma}{1+\gamma\beta}\hat{\hat{\pi}}_{t-1} + \frac{\beta}{1+\gamma\beta}\hat{\hat{\pi}}_{t+1} + \frac{(1-\omega)(1-\omega\beta)}{\omega(1+\gamma\beta)}\frac{1}{\phi^{Y}}\hat{\hat{y}}_t, \tag{44}$$

$$\hat{\hat{y}}_t = \frac{\alpha}{1+\alpha}\hat{\hat{y}}_{t-1} + \frac{1}{1+\alpha}\hat{\hat{y}}_{t+1} - \sigma\frac{1-\alpha}{1+\alpha}\left[(\hat{\hat{i}}_t - \hat{\hat{\pi}}_{t+1}) - \frac{1}{\sigma}\frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{(\phi^C\Delta\hat{\hat{\tau}}_{t+1} - \Delta\hat{\hat{g}}_{t+1}) - \alpha(\phi^C\Delta\hat{\hat{\tau}}_t - \Delta\hat{\hat{g}}_t)}{1-\alpha}\right], \tag{45}$$

$$\hat{\hat{u}}_t = -\frac{1}{\phi^Y}\hat{\hat{y}}_t, \tag{46}$$

$$\Delta\tilde{i}_t - \Delta\tilde{\pi}_{t+1} = \frac{1}{\sigma}\left[\frac{\Delta^2\tilde{y}_{t+1} - \alpha\Delta^2\tilde{y}_t}{1-\alpha} + \frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{(\phi^C\Delta^2\tilde{\tau}_{t+1} - \Delta^2\tilde{g}_{t+1}) - \alpha(\phi^C\Delta^2\tilde{\tau}_t - \Delta^2\tilde{g}_t)}{1-\alpha}\right]. \tag{47}$$

These identifying restrictions are the Phillips curve, the Euler equation, the Okun's law relationship, and a transformation of the natural rate relationship. The Taylor rule is omitted as it is unlikely to provide an empirically adequate description of the conduct of monetary policy over a long sample period spanning multiple operating procedures. In parallel, the fiscal policy rules are omitted as they are unlikely to provide an empirically adequate description of the conduct of fiscal policy over a long sample period spanning many government administrations having different priorities. Furthermore, the government dynamic budget constraint is omitted as its derivation abstracts from long-term government debt, and assumes zero debt in steady state equilibrium. Finally, the natural rate relationship is differenced to eliminate additive constants, while recognizing that its derivation abstracts from asset risk premia which drive a wedge between the return on saving and the policy interest rate.

This partial information estimation approach bypasses the need to specify the entire structure of the economy empirically plausibly. However, abandoning the full information estimation approach prevents us from evaluating our identifying restrictions under rational expectations. Evaluating them under perfect foresight instead replaces rational expectations with future realizations. But this transformation makes our identifying restrictions excessively forward looking. To counteract this, we introduce a predictive discounting parameter μ which satisfies $0 \le \mu \le 1$, and use it to uniformly shrink the future realizations of all variables expressed as deviations from their underlying equilibrium values towards zero, motivated by Gabaix (2020).

The ordered set of observed endogenous variables under consideration consists of the inflation rate, output, the unemployment rate, the nominal policy interest rate, the government expenditure ratio, and the government revenue ratio. The sets of approximate linear equilibrium conditions under consideration restrict dynamic interrelationships among the unobserved components of these $N = 6$ observed endogenous variables. We treat the deviations of these observed endogenous variables from their flexible price equilibrium values as cyclical components, and these flexible price equilibrium values as trend components. Accordingly, the coefficient matrices associated with our $G = 3$ dynamic cyclical restrictions may be stated as

$$\mathbf{\Phi}_{+1} = \mu\begin{bmatrix} -\frac{\beta}{1+\gamma\beta} & -\sigma\frac{1-\alpha}{1+\alpha} & 0 \\ 0 & -\frac{1}{1+\alpha} & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & \frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{1}{1+\alpha} & 0 \\ 0 & -\frac{\phi^C}{1-\phi^C}\frac{1}{1-\tau}\frac{1}{1+\alpha} & 0 \end{bmatrix}, \quad \mathbf{\Phi}_0 = \begin{bmatrix} 1 & 0 & 0 \\ -\frac{(1-\omega)(1-\omega\beta)}{\omega(1+\gamma\beta)}\frac{1}{\phi^Y} & 1 & \frac{1}{\phi^Y} \\ 0 & 0 & 1 \\ 0 & \sigma\frac{1-\alpha}{1+\alpha} & 0 \\ 0 & -\frac{1}{1-\phi^C}\frac{1}{1-\tau} & 0 \\ 0 & \frac{\phi^C}{1-\phi^C}\frac{1}{1-\tau} & 0 \end{bmatrix}, \quad \mathbf{\Phi}_{-1} = \begin{bmatrix} -\frac{\gamma}{1+\gamma\beta} & 0 & 0 \\ 0 & -\frac{\alpha}{1+\alpha} & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & \frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{\alpha}{1+\alpha} & 0 \\ 0 & -\frac{\phi^C}{1-\phi^C}\frac{1}{1-\tau}\frac{\alpha}{1+\alpha} & 0 \end{bmatrix},$$

where maximum lag order $P_1 = 1$ and lead order $P_2 = 1$. These cyclical restrictions are nonredundant, as they are linearly independent. In parallel, the coefficient matrices associated with our $H = 1$ dynamic trend restriction may be stated as

$$\boldsymbol{\Theta}_{+1} = \begin{bmatrix} -1 \\ -\frac{1}{\sigma}\frac{1}{1-\alpha} \\ 0 \\ 0 \\ \frac{1}{\sigma}\frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{1}{1-\alpha} \\ -\frac{1}{\sigma}\frac{\phi^C}{1-\phi^C}\frac{1}{1-\tau}\frac{1}{1-\alpha} \end{bmatrix}, \boldsymbol{\Theta}_{0} = \begin{bmatrix} 1 \\ \frac{1}{\sigma}\frac{2+\alpha}{1-\alpha} \\ 0 \\ 1 \\ -\frac{1}{\sigma}\frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{2+\alpha}{1-\alpha} \\ \frac{1}{\sigma}\frac{\phi^C}{1-\phi^C}\frac{1}{1-\tau}\frac{2+\alpha}{1-\alpha} \end{bmatrix}, \boldsymbol{\Theta}_{-1} = \begin{bmatrix} 0 \\ -\frac{1}{\sigma}\frac{1+2\alpha}{1-\alpha} \\ 0 \\ -1 \\ \frac{1}{\sigma}\frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{1+2\alpha}{1-\alpha} \\ -\frac{1}{\sigma}\frac{\phi^C}{1-\phi^C}\frac{1}{1-\tau}\frac{1+2\alpha}{1-\alpha} \end{bmatrix}, \boldsymbol{\Theta}_{-2} = \begin{bmatrix} 0 \\ \frac{1}{\sigma}\frac{\alpha}{1-\alpha} \\ 0 \\ 0 \\ -\frac{1}{\sigma}\frac{1}{1-\phi^C}\frac{1}{1-\tau}\frac{\alpha}{1-\alpha} \\ \frac{1}{\sigma}\frac{\phi^C}{1-\phi^C}\frac{1}{1-\tau}\frac{\alpha}{1-\alpha} \end{bmatrix},$$

where maximum lag order $Q_1 = 1$ and lead order $Q_2 = 2$. Note that coefficient matrix Φ_{+1} has been scaled by predictive discounting parameter μ.

We calibrate the structural parameters that enter into these restrictions to lie within the range of estimates reported in the existing empirical literature. In particular, the subjective discount factor parameter β is set to imply an annualized discount rate of 4.0 percent, while the habit persistence parameter α is set to 0.50, and the intertemporal elasticity of substitution parameter σ is set to 1.00. In addition, the credit constrained household share parameter ϕ^C is set to 0.50, while the production degree of homogeneity parameter ϕ^Y is set to imply an Okun's law coefficient of −0.50. Furthermore, the partial indexation parameter γ is set to 0.50, while the nominal rigidity parameter ω is set to imply an average reoptimization interval of 4.0 quarters. Finally, the steady state equilibrium output tax rate parameter τ is set to 0.20, while the predictive discounting parameter μ is set to 0.80.

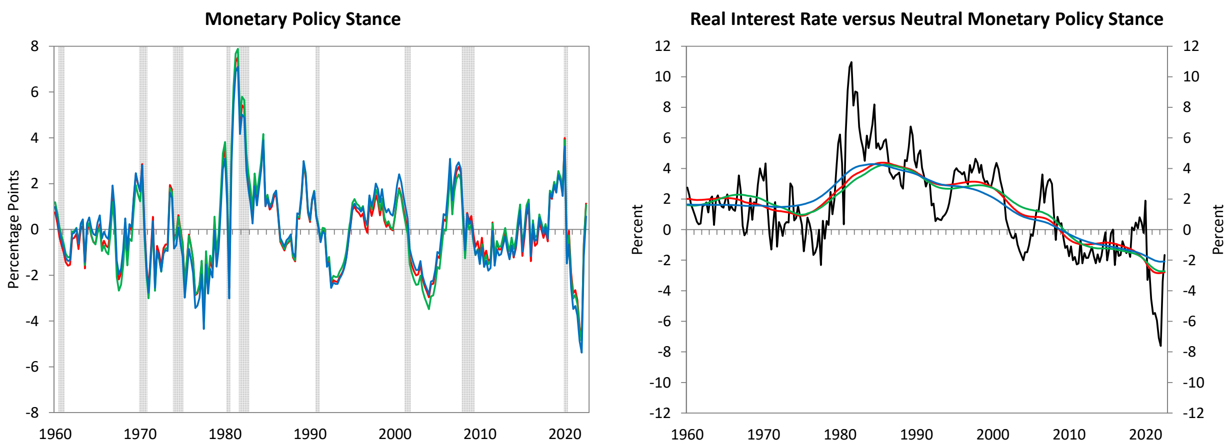
D. Results

We use the GMLF to jointly estimate the stances of monetary and fiscal policy for the United States, conditional on these approximate linear equilibrium conditions from our calibrated New Keynesian model, which we treat as stochastic restrictions. Measurement of the inflation rate is based on the seasonally adjusted gross domestic product price deflator, of output is based on seasonally adjusted real gross domestic product, of the unemployment rate is based on the seasonally adjusted civilian unemployment rate, and of the nominal policy interest rate is based on the effective federal funds rate expressed as a period average. Measurement of the government expenditure ratio is based on the ratio of consumption and investment expenditures for the general government to nominal output, and of the output tax rate is based on this plus the ratio of the primary fiscal balance for the general government to nominal output. These time series variables are transformed in line with our New Keynesian model, with the inflation and nominal policy interest rates expressed as quarterly percentage rates. They span the sample period 1960Q1 through 2022Q4, and were obtained from Haver Analytics.

Given this set of time series variables, and the sets of stochastic linear restrictions among their cyclical and trend components under consideration, using the GMLF requires assigning values to the tuning parameters that enter into the objective function that it minimizes. For all variables other than output — which do not exhibit long run trends — we set the difference orders d_i to 1 and the smoothing parameters $\lambda_{1,i}$ to 20. In contrast, for output — which does exhibit a long run trend — we set the difference order d_i to 2 and the smoothing parameter $\lambda_{2,i}$ to 400. For the cyclical restrictions we set the weight parameters γ_g to 1, thereby quadratically penalizing the deviations of these dynamic linear combinations of the cyclical components from zero as much as the deviations of the cyclical components from zero. Finally, for the trend restriction we set the weight parameter ψ_h to 0.001, as the deviations of this dynamic linear combination of the trend components from zero are much more persistent than those of the dynamic linear combinations of the cyclical components.

Our multivariate filter based estimate of the stance of monetary policy exhibits economically significant and interpretable deviations from that generated abstracting from fiscal policy, and from that generated using the corresponding univariate filters with matching smoothing parameter values, as shown in Figure 1. In absolute value, these deviations are up to 52 basis points when abstracting from fiscal policy, and up to 69 basis points when using the univariate filters. The cyclical restrictions under consideration pull the multivariate filter based estimates above or below the univariate filter based estimates at cyclical frequencies, to varying degrees depending on whether they account for fiscal policy. For example, the real natural rate of interest is estimated to have fallen more in the aftermath of the Global Financial Crisis when these cyclical restrictions are conditioned on, particularly when they account for fiscal policy. This reflects the abnormally slow increase in the output gap during the subsequent sluggish recovery, which the multivariate filter partially attributes to a tighter stance of monetary policy than the univariate filter estimates, particularly given the loose stance of fiscal policy and the operation of automatic fiscal stabilizers.[2] In contrast, the trend restriction under consideration shifts the multivariate filter based estimates above or below the univariate filter based estimates at trend frequencies.

Figure 1. Monetary Policy Stance Estimates



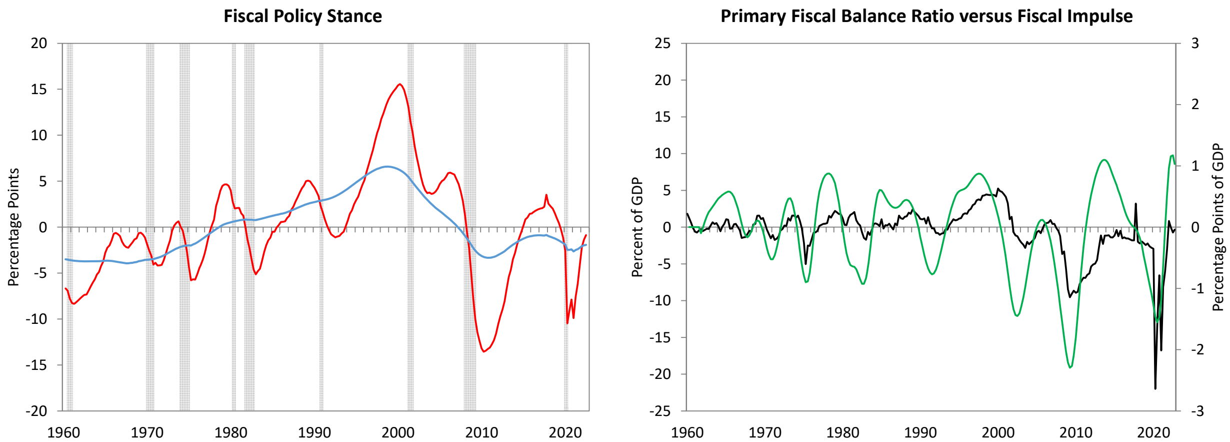
Note: The left graph depicts monetary policy stance estimates from the multivariate filter with fiscal policy ■, the multivariate filter without fiscal policy ■ and the univariate filter ■, where shaded regions indicate recessions as dated by the National Bureau of Economic Research. The right graph depicts the real interest rate ■ versus neutral monetary policy stance estimates from the multivariate filter with fiscal policy ■, the multivariate filter without fiscal policy ■, and the univariate filter ■.

Our multivariate filter based estimate of the stance of fiscal policy differs enormously from both the univariate filter based estimate, and from the multivariate filter based estimate of the fiscal impulse, as shown in Figure 2.[3] The multivariate filter based estimate of the stance of fiscal policy fluctuates at business cycle frequencies, generally indicating fiscal policy tightening before recessions and loosening during them. In contrast, the univariate filter based estimate of the stance of fiscal policy tracks the trend of the multivariate filter based estimate, but exhibits little or no variation at business cycle frequencies, limiting its informativeness. While the multivariate filter based estimate of the fiscal impulse does fluctuate at business cycle frequencies, it is a poor proxy for the stance of fiscal policy. This reflects the purely backward looking nature of the fiscal impulse, and its lack of differentiation between fiscal expenditure versus revenue multipliers. Indeed, the correlation between the multivariate filter based estimates of the stance of fiscal policy and the fiscal impulse is only 0.21.

[2] The real interest rate gap only measures the stance of conventional monetary policy, unless an estimated shadow nominal policy interest rate substitutes for the observed nominal policy interest rate when the latter was constrained by the effective lower bound and unconventional monetary policy measures were resorted to.

[3] Following conventional practice, the fiscal impulse is annualized by calculating the seasonal difference of the annual moving average of the estimated quarterly structural primary fiscal balance ratio.

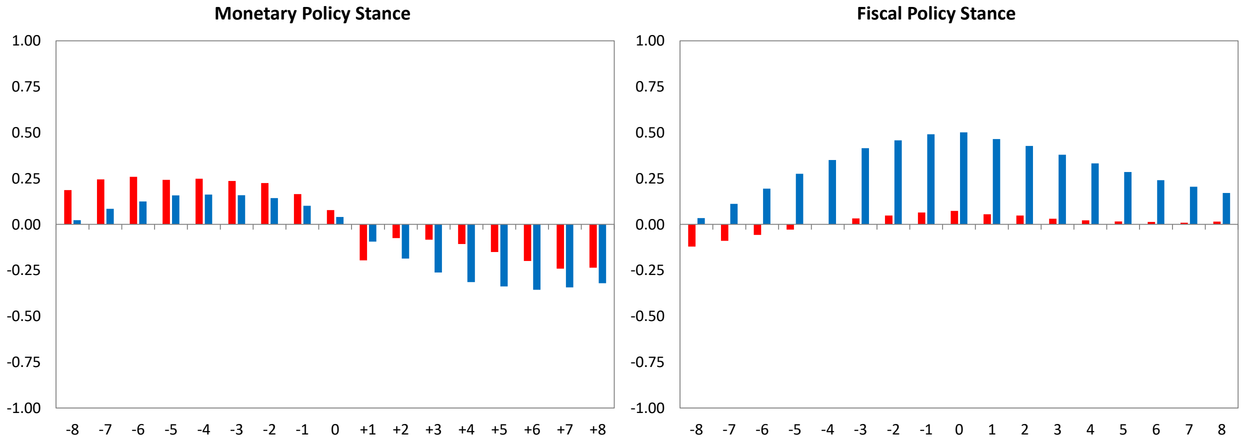
Figure 2. Fiscal Policy Stance Estimates



Note: The left graph depicts fiscal policy stance estimates from the multivariate filter ■ and the univariate filter ■, where shaded regions indicate recessions as dated by the National Bureau of Economic Research. The right graph depicts the primary fiscal balance ratio ■ versus the estimated fiscal impulse from the multivariate filter ■.

Our multivariate filter based estimates of the stances of monetary and fiscal policy are both countercyclical, but exhibit different intertemporal correlation patterns with the corresponding estimates of the inflation and output gaps, as shown in Figure 3. The stance of monetary policy is positively correlated with the contemporaneous and lagged inflation and output gaps, and is negatively correlated with their leads. This reflects the inflation and output stabilization objectives of monetary policy, which is systematically tightened in response to contemporaneous and past deviations of inflation above target and output above potential, subsequently reducing inflation and output, and vice versa. In contrast, the stance of fiscal policy is approximately uncorrelated with the inflation gap, but is positively correlated with the output gap, at all horizons. This reflects the countercyclical stabilization objective of fiscal policy, which is systematically tightened in response to contemporaneous and past deviations of output above potential, and vice versa. This fiscal consolidation or stimulus tends to be highly inertial, explaining the positive correlation of the stance of fiscal policy with leads of the output gap, and making fiscal policy unsuitable for fine-tuning the business cycle.

Figure 3. Intertemporal Correlations with the Inflation and Output Gaps



Note: Depicts the correlations of the multivariate filter based estimate of the stance of monetary or fiscal policy with lags and leads of the corresponding estimates of the inflation ■ and output ■ gaps.

E. Robustness

The dependence of the GMLF on multiple parameters — entering into both the objective function that it minimizes and the stochastic restrictions that it conditions on — has advantages and disadvantages. This parametric flexibility provides considerable scope to adjust the relative volatility and theoretical congruence of the cyclical and appropriately differenced trend component estimates. The cost of this flexibility is the potential sensitivity of these estimates to parameter perturbations. Fortunately, sensitivity analysis is computationally simple to conduct.

Table 1. Sensitivity of Multivariate Filter Estimation Results to Smoothing Parameter Perturbations

	$\lambda_{1,1}$		$\lambda_{2,2}$		$\lambda_{1,3}$		$\lambda_{1,4}$		$\lambda_{1,5}$		$\lambda_{1,6}$	
	10	40	100	1,600	10	40	10	40	10	40	10	40
mp_t	0.342	0.420	0.099	0.177	0.004	0.007	0.798	0.811	0.094	0.141	0.050	0.064
fp_t	0.012	0.020	1.354	2.203	0.054	0.089	0.049	0.061	2.464	1.653	1.041	0.479

Note: Reports root mean squared deviations from the central estimates in percentage points.

The sensitivity of our multivariate filter based estimates of the stances of monetary and fiscal policy to parameter perturbations varies widely, measured in terms of root mean squared deviations from the central estimates. Focusing on material root mean squared deviations exceeding 10 basis points, the sensitivity analysis with respect to the smoothing parameters reported in Table 1 reveals that the monetary policy stance estimates vary with the smoothness of trend inflation and the nominal natural rate of interest, whereas the fiscal policy stance estimates vary with the smoothness of potential output, the structural government expenditure ratio and the structural government revenue ratio. Furthermore, the sensitivity analysis with respect to the weight parameters reported in Table 2 reveals that the monetary policy stance estimates vary with the degree to which the Phillips curve and Euler equation are conditioned on, while the fiscal policy stance estimates vary with the degree to which the Euler equation is conditioned on. Finally, the sensitivity analysis with respect to the structural parameters reported in Table 3 reveals that the calibration of those parameters that only enter into the Phillips curve or Okun's law relationship affects neither of the stance estimates, whereas the calibration of all of the other parameters affects at least one of them. These sensitivity analysis results highlight the importance of the Euler equation and its implications for the output gap for estimating the stances of monetary and fiscal policy.

Table 2. Sensitivity of Multivariate Filter Estimation Results to Weight Parameter Perturbations

	γ_1		γ_2		γ_3		ψ_1	
	0.000	2.000	0.000	2.000	0.000	2.000	0.000	0.002
mp_t	0.242	0.233	0.205	0.132	0.008	0.007	0.007	0.021
fp_t	0.008	0.007	3.982	2.916	0.101	0.089	0.002	0.007

Note: Reports root mean squared deviations from the central estimates in percentage points.

Table 3. Sensitivity of Multivariate Filter Estimation Results to Structural Parameter Perturbations

	β		α		σ		ϕ^C		ϕ^Y		γ		ω		τ		μ	
	1/1.005	1/1.015	0.250	0.750	0.500	1.500	0.250	0.750	1/0.250	1/0.750	0.250	0.750	(2-1)/2	(6-1)/6	0.100	0.300	0.600	1.000
mp_t	0.001	0.001	0.137	0.115	0.104	0.103	0.084	0.097	0.013	0.010	0.007	0.004	0.145	0.018	0.020	0.021	0.254	0.250
fp_t	0.000	0.000	1.983	5.982	5.966	1.996	3.716	14.138	0.066	0.095	0.000	0.000	0.011	0.001	0.885	1.174	5.426	5.616

Note: Reports root mean squared deviations from the central estimates in percentage points.

IV. Conclusion

Accurately measuring the stances of monetary and fiscal policy helps achieve their objectives. Within the framework of an empirically plausible extension of the basic New Keynesian model, we find that measures of the stances of monetary and fiscal policy are closely interrelated. This theoretical result calls for estimating the stances of monetary and fiscal policy jointly, to avoid biases from conditioning on misspecified identifying restrictions. Indeed, our empirical application shows that accounting for fiscal policy can significantly alter the estimated stance of monetary policy. These theoretical and empirical results call into question the common practice of estimating the stances of monetary and fiscal policy separately.

The inflation and output stabilization objectives of monetary policy under a flexible inflation targeting regime are both cyclical in nature, and tend to be mutually reinforcing. In contrast, the countercyclical stabilization and debt sustainability objectives of fiscal policy operate at different frequencies, and are often in conflict with one another. It follows that the stance of monetary policy may be summarized with a single measure, whereas the stance of fiscal policy is not amenable to a parallel treatment without abstracting from one of its objectives. Our focus on the countercyclical stabilization objective when measuring the stance of fiscal policy assumes that fiscal space is adequate to abstract from the debt sustainability objective. For some economies at some times, this assumption is violated to some degree, limiting the applicability of our approach.

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