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DEPARTMENT OF ECONOMICS | https://business.fullerton.edu/academics/ECONOMICS | 657-278-2228

Department of Economics
Working Paper Series

2022/001R

The Determinants of Fed Policy: The Great Recession vs the Great Inflation

Gabriela Best and Joonyoung Hur

January 2026

800 N. State College Blvd., SGMH 3313, Fullerton, CA 92831
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The Determinants of Fed Policy: The Great Recession vs. the Great Inflation

Gabriela Best* Joonyoung Hur†

January 9, 2026

Abstract

We analyze the determinants of the Federal Reserve's monetary policy decisions since the 1960s justified by potentially evolving beliefs—through a real-time learning process—about the structure of the economy and Markov-switching shifts in policymakers' preferences between dove and hawk regimes. We argue that although central bank learning played an important role in the determination of Fed policy there were several shifts in policymakers' preferences in the post-war period. We find a dovish kind of monetary policy regime present in the 1970s and early 2000s, and before the onset of the Great Recession.

Keywords: Great Inflation; Policy Preferences; Policymakers' Beliefs; Constant Gain Learning; Markov-switching DSGE Models
JEL Classifications: C11; D83; E31; E50; E52; E58; E32; E44

*Corresponding author, Department of Economics, College of Business and Economics, California State University Fullerton, Fullerton, CA 92834, USA. Tel: +1-657-278-2387, E-mail: gbest@fullerton.edu.

†Department of Economics, Sogang University, 35 Baekbeom-ro, Mapo-gu, Seoul, 04107, Republic of Korea. Tel: +82-2-705-8514, E-mail: joonyhur@gmail.com.

1 INTRODUCTION

The Federal Reserve (Fed) has conducted monetary policy to achieve its dual mandate of stable prices and maximum sustainable employment. Although this mandate has remained unchanged since the Fed's inception in 1913, there is ample evidence that monetary policy responses to prices and output, as well as policy objectives, have evolved considerably over the decades since then.

The canonical workhorse in empirical approaches to understanding the evolution of Fed policy over time are Taylor rule models. Such rules capture the central banks' reaction functions in a reduced form setting. Numerous studies have documented significant time-variation in the Fed's reaction function using time-varying forward-looking Taylor rules (e.g., Ang et al. (2011), Boivin (2006), Kim and Nelson (2006)). A potential drawback of these Taylor-rule-based studies is their inability to distinguish between changes in policymakers' preferences and other factors affecting their behavior, such as policymakers' understanding of real-time macroeconomic developments. These studies often attribute "good policy management" to factors that may or may not be related to central bank preferences. Spotting these differences is crucial for monetary policy design due to its implications for macroeconomic dynamics as we show in this paper.[1]

One strand of literature attempts to explain the evolution of Fed policy over time focusing exclusively on policymakers' preferences, structurally modeling these preferences using a simple model of optimizing central bank behavior. The common finding among the many studies adopting this approach is the identification of one important shift in monetary policy objectives—-the appointment of Paul Volcker as the chairman of the Fed in August 1979 [see Dennis (2006), Favero and Rovelli (2003), Ozlale (2003), Salemi (2006), Ilbas (2012), Givens (2012), and Best (2016)]. However, it is entirely possible that preference parameters may have experienced more than one structural break, an issue potentially overlooked by previous works. Meltzer (2006), Romer and Romer (1989) and Owyang and Ramey (2004) have documented several shifts in policy objectives from the late 1960s to the onset of the Great Recession.

To address these concerns, Lakdawala (2016) estimates time-varying preference parameters for the Fed using a backward-looking model, concluding that there were numerous preference changes in the post-war period. Complementarily, Debortoli and Nunes (2014) analyze regime switches in policy preferences between dovish and hawkish regimes. They find that an increased likelihood of a future dovish regime raises inflation expectations and intensifies inflation responses during hawkish regimes.

A second strand of literature attributes monetary policy evolution entirely to policymakers learning about the behavior of the economy in real time. According to this thinking, stabilization

[1] Good policy management has been characterized as monetary policy aiming for inflation targeting consistent with the Taylor principle, as seen during Volcker's tenure. Previous studies found that interest rates accommodated inflation prior to Volcker's tenure. See Taylor (1993), Clarida et al. (1999),Woodford (2003). Further analysis and extensions can be found in works by Orphanides (2001) Orphanides (2002), Levin et al. (2003), and Nikolsko-Rzhevskyy et al. (2014).

policy is set optimally, conditional on current beliefs as in Primiceri (2006) and Lubik and Matthes (2016) among others. As such, the Great Inflation period is attributed by this line of research to misperceptions about the standard features of the U.S. economy (Romer and Romer (2002), Hartnett et al. (2006), Carboni and Ellison (2009)). These studies typically assume stable policy-makers' preferences postwar— with the exception of Best and Hur (2019) which allow for a break at the date of Chairman Volcker's appointment.

Clearly, in focusing on one factor to the exclusion of the other, both research strands miss important time-varying features that may manifest in both, central bank preferences and learning. The first strand of literature overemphasizes evolving central bank objectives, neglecting the role played by policymakers' understanding about the structure of the economy. Additionally, by assuming that the structural parameters of the economy are fixed, these studies may potentially deliver biased estimates of central bank preferences. The second strand explains time variation in policy coefficients solely through the central bank's learning process, ignoring switches between dove and hawk regimes well-documented in the Federal Reserve's history and existing literature (Bianchi (2013)).

Recently, textual analysis has been increasingly utilized to measure the tone of central bank communications, such as speeches and minutes, to assess how this tone predicts monetary policy decisions (e.g., Apel and Blix Grimaldi (2014); Istrefi (2019); Malemendier et al. (2021)). Apel and Blix Grimaldi (2014) developed indices that classify language as hawkish or dovish, providing insights into the Swedish central bank's policy stance and intentions. Malemendier et al. (2021) highlight the nuanced nature of central bank decision-making and emphasize the importance of understanding the factors that shape policy preferences. They underscore the challenge of mapping policy preferences, particularly in identifying central bankers as "hawks" or "doves," within the context of central bank decision-making. This paper addresses this issue by mapping policy preferences and identifying switches between dove and hawk regimes using a Markov-switching approach and objective data.[2]

This paper aims to fill the gap in existing literature by merging features of both strands to account for time variation in central bank preferences and learning providing a comprehensive understanding of Fed policy evolution. We estimate a model incorporating central bank learning about the structure of the economy à la Primiceri (2006) and a Markov-switching process between dove and hawk regimes for the preference parameter in the optimal policy function. This broader setup allows us to disentangle the role that each factor (shifts in policymakers' preferences and the Fed's learning about the economy's structure) played in the evolution of U.S. policy post-war. Additionally, the study analyzes the implications that each policy regime had on the evolution of U.S. macroeconomic dynamics in the post war period.

[2]Future research could extend this model to consider Federal Reserve members' personal experiences in the policy preference identification strategy.

Our findings reveal several regime shifts in monetary policy regarding preferences (dovish and hawkish regimes) and beliefs from the late 1960s to the onset of the Great Recession. Hawkish regimes appeared in the mid-1960s, during the Great Moderation (1980-2000), and early and mid-2000s. Dovish regimes prevailed from 1970-1978, in 1987 (before the stock market crash), between 2001-2004 and before the Great Recession. We find strong evidence of high shock volatility throughout the 1970s until the mid-80s, late 1960s, and early 1990s. However, we do not find high shock volatility before the Great Recession, indicating adverse macroeconomic shocks ("bad luck") were not the crisis's cause.

This study demonstrates that accounting for policy regime shifts has significant implications for macroeconomic dynamics. Marginal efficiency of investment (MEI) shocks, which serve as proxies for the functioning of the financial system, have been documented as the leading candidate explanation for postwar business cycle fluctuations (see Fisher (2006), Smets and Wouters (2007), Justiniano and Primiceri (2008),Justiniano et al. (2011), Papanikolaou (2011), Gust et al. (2017)). Interestingly, we find that MEI shocks predominantly explain business cycle fluctuations only during hawkish regimes.[3] The impact of other shocks is magnified during dovish regimes, such as those in the 1970s, before 1982, and the early and late 2000s. These periods are also associated with the Great Inflation and the lead-up to the Great Recession. Models that do not account for variations in monetary policy regimes fail to adequately explain the contribution and response of key macroeconomic variables—such as output, consumption, and investment—to both monetary and non-monetary shocks.

We contribute to the literature in several ways. First, methodologically, as this is the first paper accounting for time variation in central banks' preferences while simultaneously allowing for time variation in their understanding of the economy. Second, we focus on two challenging periods to study: the Great Inflation and the Great Moderation. There is a consensus that "bad monetary policy"—specifically, prolonged low interest rates—contributed to both the Great Inflation and, more recently, the Great Recession (see Bernanke (2010), Taylor (2007), Taylor (2014), Stiglitz (2009b)). Such "bad policy" leads to indeterminacy and multiple equilibria, complicating model estimations. Existing methods to address indeterminacy, like those described by Lubik and Schorfheide (2004) and Farmer et al. (2015), are complex and not easily implementable with standard software packages. We tackle this issue by utilizing the methodology proposed by Bianchi and Nicolò (2021) to estimate a model that accounts for "bad policy" and indeterminacy.

Third, our model characterizes a broad spectrum of causes for the Great Inflation and potentially the Great Recession, such as financial market instability, productivity slowdown, and fiscal policy mistakes. We capture these factors by incorporating heteroskedastic non-policy shocks following a Markov-switching process, extending previous works.

[3] Gust et al. (2017) estimate a nonlinear DSGE model with an occasionally binding zero lower bound. According to their analysis, shocks to the demand for risk-free bonds and, to a lesser extent, the marginal efficiency of investment proxying for financial frictions, played a critical role in the Great Recession.

Fourth, we present novel findings regarding the causes of both the Great Inflation and the Great Recession. Our analysis indicates that learning about the economy's structure, a prolonged dovish monetary policy during the 1970s, and heightened shock volatility were significant contributors to the Great Inflation. The shift to a hawkish regime under Chairman Volcker's leadership brought about economic and financial stability, positioning the financial system as the main driver of the business cycle. In contrast, during the early 2000s a clear dovish turn in monetary policy appears to have been a key factor in the Great Recession. According to Romer (2022), the Fed adopted timid responses to adverse shocks during this period, affecting interest rates and leaving the economy vulnerable to further disruptions. This dovish stance contributed to speculative investments and a credit boom that culminated in the housing crisis and the Great Recession. Unlike the 1970s, the early 2000s did not exhibit increased shock volatility. However, the extended period of dovishness fueled unsustainable growth dynamics. Therefore, discretionary deviations to a dovish regime contributed to both the Great Inflation and the economic crisis in the 2000s.

2 THE PRIVATE SECTOR

In order to draw a parallel between previous models that considered potential regime switches in monetary policy and shocks evolving over time according to a Markov-switching (MS) process, we estimated a model closer to Bianchi (2013). Moreover, it includes two types of investment shocks akin to Justiniano et al. (2011, JPT hereafter) as in Best and Hur (2019). It is essential to keep this two investment shock structure because one of the shocks, the marginal efficiency of investment (MEI) shock, has been found to be a key driver of business cycle fluctuations and the functioning of the financial sector. It explains how savings are transformed into future capital input, specifically how installed capital is produced from investment goods. In the present regime switching structure, we investigate how its contribution to the variables fluctuates overtime and through monetary regimes. The second investment shock considered, is an investment-specific technology shock (IST) that explains how consumption goods are transformed into investment goods.

The additional consideration of the present paper is that the central bank has time-varying beliefs about the structure of the economy as well as monetary policy preferences subject to potential MS switches between dove and hawk regimes. This is a medium scale DSGE model that has been proven to fit the data well and has been reproduced here for convenience.[4]

Consumption, investment and capital goods are decentralized into separate sectors. A chain of intermediate and final good producers makes the final consumption good using the following

[4] As in Bianchi (2013) we abstract from the household's labor supply decisions, which are similar to those of Erceg et al. (2000). They are monopolistic suppliers of specialized labor with wage setting behavior that evolves à la Calvo (1983). For details on the derivation of the model and the system of log-linearized equations refer to Bianchi (2013) and Justiniano et al. (2011) technical appendix. The private sector model presented here is the same as in Best and Hur (2019).

technology

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{1}{1+\lambda_{p,t}}} di \right]^{1+\lambda_{p,t}} \tag{1}$$

where $\lambda_{p,t}$ is the desired markup of price over marginal cost for intermediate goods firms.

The final good is purchased at a unit price P_t and is used for consumption by households and as an input in production for the investment good by firms. Profit maximization and the zero profit condition leads to the following demand function for intermediate good i:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\frac{1+\lambda_{p,t}}{\lambda_{p,t}}} Y_t. \tag{2}$$

The price P_t is a CES aggregate of the prices of the intermediate goods $P_t(i)$.

Each intermediate good $Y_t(i)$ is produced by a monopolist using the following production function:

$$Y_t(i) = \max\{A_t^{1-\alpha} K_t(i)^\alpha L_t(i)^{1-\alpha} - A_t \gamma_t^{\frac{\alpha}{1-\alpha}} F; 0\} \tag{3}$$

where F is a fixed cost, $K_t(i)$ and $L_t(i)$ are the services of capital and labor employed by firm i, while A_t is an exogenous labor-augmenting technological process or a neutral technology factor with a growth rate $z_t \equiv \Delta \log A_t$ which follows a stationary AR(1) process:

$$z_t = \overline{z} \left(z_{t-1}/\overline{z} \right)^{\rho_z} \exp \left[\sigma_z(\xi_t^Q) \epsilon_{z,t} \right], \quad \epsilon_{z,t} \sim N(0,1),$$

where ξ_t^Q is an unobservable state variable which governs the volatility regime at time t, and $\overline{z}$ is the steady-state technology growth. The variable γ_t is the investment-specific technological progress with properties that would be outlined below.

Every period a fraction $1 - \xi_p$ of intermediate firms can optimize their price à la Calvo (1983). The remaining firms reset their prices according to the indexation rule as follows:

$$P_t(i) = P_{t-1}(i) \pi_{t-1}^{\iota_p} \pi^{1-\iota_p},$$

where π_t is gross inflation and π is its steady state. ι_p denotes the degree of price indexation. The fraction of firms that choose their price $\tilde{P}_t(i)$ optimize the present discounted value of future profits subject to the demand function (2) and production function (3).

2.1 INVESTMENT GOOD PRODUCING SECTOR As previously noted, perfectly competitive firms purchase Y_t^I of the final good to transform it into the investment good in I_t units which are sold at a unit price P_{It} to the producers of capital. They maximize the profit function: $P_{It} I_t - P_t Y_t^I$, subject to the following production technology given by $I_t = \gamma_t Y_t^I$. The investment-specific technological (IST) progress γ_t, the slope of the production technology, increases with the quantity and quality of investment goods that can be produced with given inputs. The growth rate of the IST progress, defined by $\upsilon_t = \Delta \log \gamma_t$, evolves according to the following process

$$\upsilon_t = \overline{\upsilon} \left(\upsilon_{t-1}/\overline{\upsilon}\right)^{\rho_\upsilon} \exp\left[\sigma_\upsilon(\xi_t^Q)\epsilon_{\upsilon,t}\right], \quad \epsilon_{\upsilon,t} \sim N(0,1),$$

where $\overline{\upsilon}$ is the steady-state level of the IST progress growth.

2.2 CAPITAL GOOD PRODUCING SECTOR Perfectly competitive firms buy investment goods and convert them to installed capital which is then sold to households. The installed capital, $\bar{I}_t$ is produced using the following technology: $\bar{I}_t = \mu_t\big(1 - S\big(\frac{I_t}{I_{t-1}}\big)\big)I_t$, where the function S represent adjustment costs to investment and μ_t is the shock to the MEI or the disturbance to the process that transform investment goods into installed capital. The shock μ_t evolves according to the following process

$$\mu_t = \overline{\mu} \left(\mu_{t-1}/\overline{\mu}\right)^{\rho_\mu} \exp\left[\sigma_\mu(\xi_t^Q)\epsilon_{\mu,t}\right], \quad \epsilon_{\mu,t} \sim N(0,1),$$

where $\overline{\mu}$ is the steady-state level of the μ_t shock process. Producers of installed capital maximize the expected discounted value of future profits given by $E_t \sum_{s=0}^{\infty} \beta^s \hat{\lambda}_{t+s} \left(P_{kt+s}\bar{I}_{t+s} - P_{It+s} - P_{It+s}I_{t+s}\right)$, where P_{kt} is the price of installed capital per efficiency unit.

2.3 HOUSEHOLDS The representative household maximizes the following utility function:

$$E_t \sum_{s=0}^{\infty} \beta^s b_{t+s} \left[\log(C_{t+s} - h\bar{C}_{t+s-1}) - \frac{L_{t+s}^{1+\nu}}{1+\nu}\right],$$

where C_t denotes consumption, h is the external habit parameter, L_t denotes the household's labor supply and b_t is a shock to the discount factor that follows

$$b_t = \overline{b} \left(b_{t-1}/\overline{b}\right)^{\rho_b} \exp\left[\sigma_b(\xi_t^Q)\epsilon_{b,t}\right], \quad \epsilon_{b,t} \sim N(0,1),$$

where $\overline{b}$ is the steady-state level of the discount factor shock process.[5] The budget constraint of the household is

$$P_tC_t + P_{kt}\bar{I}_t + T_t + B_t \leq R_{t-1}B_{t-1} + W_tL_t + r_t^k u_t\bar{K}_{t-1} - P_t\frac{a(u_t)}{\gamma_t}\bar{K}_{t-1},$$

where T_t equal to net lump-sum taxes, B_t are government bond holdings, R_t is the gross nominal interest rate, and W_t is the wage rate.

Capital is owned by households that select the capital utilization rate u_t which transforms physical capital into effective capital following $K_t = u_t\bar{K}_{t-1}$. Firms rent effective capital at a

[5] The existence of state contingent securities ensures that in equilibrium consumption and asset holdings are the same across households.

rate r_t^k. The dollar cost of capital utilization per unit of physical capital is $P_t \frac{a(u_t)}{\gamma_t}$. The capital accumulation law of motion is given by $\bar{K}_t = (1-\delta)\bar{K}_{t-1} + \bar{I}_t$ with the depreciation rate δ.

As previously mentioned, the model separates final consumption goods, investment goods and newly installed capital, however it can be re-expressed as a one-sector model which proposes the following physical capital accumulation equation

$$\bar{K}_t = (1-\delta)\bar{K}_{t-1} + \mu_t \gamma_t (1 - S_t)\tilde{I}_t,$$

where S_t is the investment adjustment cost paid at time t and $\tilde{I}_t$ is real investment in consumption units.[6] As in Justiniano et al. (2011) physical capital accumulation is impacted by two shocks: the IST shock γ_t, that affects how consumption goods are transformed into investment goods, and the MEI shock μ_t that represents how investment goods are transformed into installed capital. These two shocks had been combined into one shock in previous estimations [see Smets and Wouters (2007) and Schmitt-Grohé and Uribe (2012)]; however, the distinction between these two shocks is important because it is the MEI shock—not the IST shock—that has been found to be the main driver of the business cycle.

2.4 GOVERNMENT

The government issues short-term bonds to finance its budget deficit. Government expenditures are determined as a time-varying factor of GDP as in $G_t = \left(1 - \frac{1}{g_t}\right)Y_t$, where g_t follows the stochastic process given by

$$g_t = \overline{g}\left(g_{t-1}/\overline{g}\right)^{\rho_g} \exp\left[\sigma_g(\xi_t^Q)\epsilon_{g,t}\right], \quad \epsilon_{g,t} \sim N(0,1),$$

where $\overline{g}$ is the steady-state level of government spending.

Finally, monetary policy is time-varying and is determined through a central bank loss function which is maximized subject to constraints that vary over time following an adaptive learning process. The details will be outlined in the next section.

2.5 MODEL SOLUTION

The levels of neutral *and* investment specific technology have a unit root therefore consumption, investment, capital, real wages, and output fluctuate around a stochastic balance growth path with the composite trend $A_t \gamma_t^{\frac{\alpha}{1-\alpha}}$. Its steady state growth rate is $\gamma* = \gamma_z + \frac{\alpha}{1-\alpha}\gamma_\upsilon$. The estimation involves writing the private sector model in detrended stationary variables, estimate its steady state, and log-linearize the model around its steady state.

3 THE CENTRAL BANK

In our framework, there are two potential sources of monetary policy time variation. First, using a vector autoregressive model of order two (VAR(2)), we capture the evolution of policymakers'

[6] For details on the procedure to obtain the one sector model see Justiniano et al. (2011).

understanding about the structure of the economy. Its parameter values are obtained recursively using a least-squares learning algorithm. Second, monetary policy preferences that change between dove and hawk regimes are represented by weights in the central bank loss function. The VAR model parameters will be used in the optimal control problem to minimize the central bank's welfare loss function.

3.1 THE POLICY OBJECTIVE FUNCTION UNDER IMPERFECT INFORMATION

The central bank's objective is to minimize the following quadratic welfare loss function that aims at stabilizing the output gap (x_t), and deviations of the nominal interest rate from its lagged value relative to inflation stabilization [see Dennis (2006) and Lubik and Matthes (2016)]:

$$E_t \left\{ \sum_{j=0}^{\infty} \beta^j \left[(\pi_{t+j})^2 + \lambda_{x,t}(x_{t+j})^2 + \lambda_{i,t}(i_{t+j} - i_{t+j-1})^2 \right] \right\}. \quad (4)$$

The focus of this paper is to estimate the **policy preference** parameters i.e., the weights assigned to the different stabilizing objectives represented by λ_t = $[\lambda_{x,t}, \lambda_{i,t}]$. As is customary in the literature, the weight assigned to inflation stabilization is normalized to *one*. Therefore, we estimate the FOMC output gap stabilization weights relative to inflation; consistent with the Fed dual mandate and the interest rate smoothing goal of the Fed. The later term provides the appropriate set-up to obtain an optimal monetary policy instrument (i_t) that embeds both, policymakers' beliefs and switches in policy preferences. The preference parameters λ_t experience Markov switches between dove and hawk regimes. In the dove regime, the central bank assigns more weight to the output gap stabilization, while the hawk regime is primarily concerned with inflation stabilization.

The literature provides overwhelming evidence of a potential break in 1979:Q3 with the appointment of Paul Volcker as chairman of the Federal Reserve [Boivin (2006), Duffy and Engle-Warnick (2006), Romer and Romer (1989)—RR henceforth—, and Meltzer (2006)], however, other papers suggest the existence of additional breaks in the late 1960s, early 1970s and a potential shift in the 2000s that led to the Great Recession. For example, based on narrative evidence, RR identify the following dates as regime switches: September 1955, December 1968, April 1974, August 1978, October 1979, and December 1988. At the Romer dates, the Fed declared an intent "to exert a contractionary influence on the economy in order to reduce inflation" (1989, p. 134). Our setup captures the possibility of multiple possible regime changes in the post-war period.

The central bank solves its optimal control problem (4) subject to a set of constraints. These constraints are expressed as a VAR(2) model of the economy containing information on inflation, the output gap, and past interest rates. Although the Fed's model could contain other variables as well, we decide to keep it simple and consistent with the Federal Reserve mandate.[7] The VAR(2)

[7] On a previous estimation we have included wage inflation, however the information seem redundant and the estimates with a parsimonious model are intuitive.

model has been extensively studied in the literature and is found to yield reasonable estimates of the time-varying Fed beliefs about the structure of the economy [Primiceri (2006), Slobodyan and Wouters (2012)].[8]

We estimate the following central bank VAR learning model

$$y_t = \hat{\mu}_s + \hat{\Gamma}_s(L)y_{t-1} + \hat{\Xi}_s(L)i^f_{t-1} + \epsilon_t, \tag{5}$$

for $t \geq s+1$ where $y_t = [x_t, \pi_t]'$ and i^f_t is the short-term interest rate.[9] The following matrices contain the coefficients that are time-varying and capture the policymakers evolving beliefs about the structure of the economy $\hat{\mu}_s = [\hat{c}_{y,s}, \hat{c}_{\pi,s}]'$, $\hat{\Gamma}_s = [\hat{b}_{1,s}, \hat{b}_{2,s}, \hat{b}_{4,s}, \hat{b}_{5,s}; \hat{c}_{1,s}, \hat{c}_{2,s}, \hat{c}_{4,s}, \hat{c}_{5,s}]$, and $\hat{\Xi}_s = [\hat{b}_{3,s}, \hat{c}_{3,s}, \hat{b}_{6,s}, \hat{c}_{6,s}]'$.

3.2 LEARNING For the recursive estimation of the central bank VAR model we use a constant gain learning algorithm (see Malemendier et al. (2021)).[10] The algorithm updates the model parameters using real time vintages of the output gap, inflation, and the lagged short term interest rates as more data becomes available. The crucial assumption of having access only to initial releases (no revisions) allows us to pin the down the time-varying *policymakers' beliefs* parameters and differentiate them from the *central bank preferences*. The updating rule for the central bank's beliefs is represented by (6), while (7) describes the updating formula for the precision matrix of the stacked regressors $R_{j,t}$,

$$\widehat{\phi}^j_t = \widehat{\phi}^j_{t-1} + \mathbf{g}R^{-1}_{j,t-1}\chi_t(\zeta^j_t - \chi'_t\widehat{\phi}^j_{t-1}), \tag{6}$$

$$R_{j,t} = R_{j,t-1} + \mathbf{g}(\chi_t\chi'_t - R_{j,t-1}), \tag{7}$$

where $j = \{x, \pi\}$, $\zeta_t \equiv [x_t, \pi_t]'$ is a vector of endogenous variables and $\chi_t \equiv [1, \zeta_{t-1}, \zeta_{t-2}, i_{t-1}, i_{t-2}]$ is a matrix of regressors. $\widehat{\phi}_t$ collects the reduce-form parameters of the central bank model and $\mathbf{g}$ is the gain parameter that governs how strongly past data are discounted.

3.3 OPTIMAL POLICY Every period, policymakers minimize their welfare loss function (4) subject to their constraints represented by the VAR model of the central bank, gathered in (5). The following is the solution to the optimal regulator problem [see Sargent (1987)],

$$i_t = F(\hat{\phi}_t, \lambda_t)z_t, \tag{8}$$

[8] Slobodyan and Wouters (2012) estimated and evaluated a VAR learning model to form agent's expectations and they found that it outperforming the rational expectations (RE) model.

[9] The estimation uses the lagged federal funds rate as a proxy for the previous short-term interest rate.

[10] Malemendier et al. (2021) offers further justification for policymakers to update their beliefs using a constant gain algorithm, in addition to considering structural changes in the stochastic processes that agents learn about. The study finds that data from the distant past holds little weight because policymakers tend to overweight personal experiences relative to objective historical data.

that results in the optimal monetary policy variable i_t which is a function of the time-varying beliefs $\hat{\phi}_t$, regime dependent policy preference parameters λ_t, and state variables z_t; The policy variable i_t is used in the estimation of the private sector model.

Specifically, the policy rule (8) can be rewritten as

$$i_t = F_{x1}x_t + F_{x2}x_{t-1} + F_{\pi 1}\pi_t + F_{\pi 2}\pi_{t-1} + F_{il}i^f_{t-1} + \sigma_i\epsilon_{i,t}, \tag{9}$$

where σ_i denotes the regime independent standard deviation of the monetary policy disturbance with $\epsilon_{i,t} \sim N(0,1)$.[11] One technical difficulty is that both beliefs and preferences vary over time, and so does $F(\hat{\phi}_t, \lambda_t)$; therefore the model must be solved every period to find the time-varying data generating process.

We follow the convention on the adaptive learning literature, where policymakers are "anticipated utility" decision makers [see Kreps (1998), Primiceri (2006), and Sargent (1999)] who estimate the parameter in their model and treat them as true values, neglecting the possibility of future updates.

4 Solution and Estimation of the MS-DSGE Model

We estimate three sets of the parameters in the model: (1) the structural parameters in the private sector of the model; (2) the monetary policy preference parameters, which are allowed to vary across the regimes; and (3) the regime-dependent standard deviations of the shock processes. We allow for two regimes for monetary policy preference as well as for the volatility of the shocks. The two monetary policy preference regimes are designed to capture potential switches between the hawkish and dovish policy stances [Dennis (2006) and Lakdawala (2016)], while the two shock volatility regimes reflect changes in the size of the shocks hitting the U.S. economy [Sims and Zha (2006)].

4.1 Estimation Procedure: Overview

This model is estimated in two steps. In the first stage, the parameters in the central bank model (beliefs part only) that evolve according to a learning process are obtained by using real time data on the output gap and inflation.

The estimation used two data sets. The first data set, which includes real time vintages of the output gap and inflation available to policymakers from 1960:Q2 to 2007:Q4 was used to estimate the central bank learning model. The output gap data includes the Fed's real time estimates of potential output used in Orphanides (2003). The main implication is that this allows us to capture the Fed understanding of the economy in real time by including the overestimation of potential output during the Great Inflation.[12] The real time inflation series come from two sources; from

[11] The monetary policy disturbance was added to aid with estimation of the model but is not part of the central bank's optimization problem.

[12] We are greatly indebted to Athanasios Orphanides for kindly providing us with the real-time data on inflation and

1960:Q2 to 1966:Q1 we use Orphanides (2003), and for the remaining period we use the Real Time Data Set for Macroeconomists available from the Federal Reserve Bank of Philadelphia. Lastly, we use ordinary least-squares estimates as initial beliefs for the central bank learning model using data from Orphanides (2003) for the pre-sample period (1954:Q2 and 1960:Q1).[13]

In the second stage, we estimate the parameters from the private sector DSGE model. For this purpose, we use ex-post macroeconomic data ranging from 1960:Q1 to 2007:Q4. The estimation utilizes six series: the growth rates of real per capita output, consumption and investment, and of the relative price of investment, together with inflation and the optimal policy variable obtained from the first stage of the estimation. Notice that these variables—except for the optimal policy rate—are identical to one used for the estimation of the model by Justiniano et al. (2011).

4.2 SOLUTION OF THE MS-DSGE MODEL After log-linearizing the private sector DSGE model depicted in Section 2, the system of equations in the model associated with the Markov-switching structure can be written as follows:

$$\Gamma_{0,t}(\xi_t^P, \Theta^P)S_t = \Gamma_{1,t}(\xi_t^P, \Theta^P)S_{t-1} + M(\xi_t^Q, \Theta^Q)\epsilon_t + \Pi\eta_t, \quad (10)$$

where S_t denotes the vector of variables. ξ_t^P and ξ_t^Q are the latent factors governing the monetary policy preference and non-policy shock volatility regimes, respectively. Θ^P and Θ^Q denote the vectors of structural parameters and stochastic volatilities, respectively. Lastly, ϵ_t is the vector containing all the exogenous shocks of unit variance and the vector η_t includes the expectation errors. Matrices $\Gamma_{0,t}$ and $\Gamma_{1,t}$ are time-varying because the central bank continually updates the Taylor rule coefficients to inflation and output by solving the optimal problem described in Section 3.

The state variables ξ_t^P and ξ_t^Q follow a first-order Markov chain with the following transition probability matrices:

$$H^P = \begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix} \quad \text{and} \quad H^Q = \begin{bmatrix} Q_{11} & Q_{12} \\ Q_{21} & Q_{22} \end{bmatrix},$$

where $P_{ij} = \text{Prob}(\xi_t^P = j|\xi_{t-1}^P = i)$ and $Q_{ij} = \text{Prob}(\xi_t^Q = j|\xi_{t-1}^Q = i)$. Following the previous studies on this topic, changes in ξ_t^P and ξ_t^Q are assumed to be independent [Bianchi (2013), Davig and Doh (2014)].

As discussed in Bianchi (2013), the model in (10) becomes linear once conditioning on a specific realization of ξ_t^P and ξ_t^Q. We solve the linear rational expectations model by using the solution algorithm proposed by Bianchi and Nicolò (2021). As it is now well understood, the

the output gap used in Orphanides (2003).

[13] Slobodyan and Wouters (2012) conclude that the data from the said pre-sample period provides a superior fit for the learning model.

post-World War II U.S. macroeconomic dynamics are associated with periods when the Taylor principle is violated—a central bank implements a stabilizing monetary policy when it raises the nominal policy rate by more than an increase in inflation. Since the principle is a necessary and sufficient condition for the existence of a determinate rational expectations equilibrium in conventional monetary models, the possibility of equilibrium indeterminacy makes standard solutions to rational expectation models, such as Blanchard and Kahn (1980) and Sims (2002), inapplicable for our study. In contrast, Bianchi and Nicolò's (2021) algorithm overcomes this limitation since it solves linear rational expectations models both for determinacy and indeterminacy.

Another useful algorithm that is frequently employed in the existing MS-DSGE literature, is the one developed by Farmer et al. (2011) , which also incorporates the possibility of indeterminate solutions. A notable characteristic of their solution algorithm is that it relies not only on the model's parameters but also on the probability of regime shifts as perceived by private agents in the model. In previous studies applying this method to monetary policy analyses, regime shifts are often characterized by changes in the Taylor rule coefficients, which tend to occur infrequently due to changing economic environments or Fed's chairmanships.

In our model, by contrast, the Taylor rule coefficients change every period as the central bank updates its understanding of the economy through learning. Therefore, in our case, the model solutions need to be obtained period by period, making it unsuitable for the Farmer et al. (2011) solution algorithm.

To implement Bianchi and Nicolò's (2021) solution algorithm, we introduce an auxiliary process to the expectation error of inflation as follows:[14]

$$\omega_t = \left(\frac{1}{\alpha}\right)\omega_{t-1} - \nu_t + \eta_t^{\pi}, \tag{11}$$

where ω_t is an independent autoregressive process, and ν_t is a mean-zero sunspot shock with standard deviation σ_ν, which is assumed to be uncorrelated with the model's exogenous shocks. η_t^{π} is the one-step ahead forecast error associated with inflation, defined as $\eta_t^{\pi} \equiv \pi_t - E_{t-1}(\pi_t)$. We set α to be contingent upon the model's determinacy as follows:

$$\text{Determinacy: } \alpha = 2,$$
$$\text{Indeterminacy: } \alpha = 0.5.$$

If there exists a solution to (10), the output of the solution algorithm can be expressed in a

[14] It is worth noting that the implementation of Bianchi and Nicolò's (2021) solution algorithm requires the maximum degree of indeterminacy—the number of auxiliary expectational variables needed for the solution of an indeterminate model to be uniquely determined—set by the practitioner. Based on the model as in Smets and Wouters (2007), Bianchi and Nicolò (2021) demonstrate that the maximum degree of indeterminacy to be one and add an auxiliary process to the expectation error of inflation. We also confirm the identical degree of indeterminacy in the model employed in this article and augment it with an auxiliary process onto the expectation error of inflation.

regime-switching vector autoregressive form:

$$S_t = T_t(\xi_t^P, \Theta^P)S_{t-1} + M(\xi_t^Q, \Theta^Q)\epsilon_t. \tag{12}$$

Notice again that the solution matrix T_t varies over time due to the time-varying monetary policy stance toward inflation and the output gap.

4.3 BAYESIAN ESTIMATION PROCEDURE

Let X_t denote the observable data used for the second stage of the estimation procedure delineated in Section 4.1. Then the measurement equation is given by

$$X_t = ZS_t \tag{13}$$

where Z is a matrix that maps the DSGE model's law of motion in (12) into the observable variables.

Once the solution to the model is obtained, the next step of estimation is to maximize the log posterior function, which combines the priors and the likelihood of the data, by using the Sims's optimization routine *csminwel*. Evaluating the likelihood for the Markov-switching model employs the Kalman filter developed by Kim and Nelson (1999). Unlike to the standard Kalman filter which utilizes information only in the current period, inferences associated with Kim and Nelson's (1999) algorithm are conditional in both on current and past states ξ_t^P and ξ_t^Q's. Finally, the random walk Metropolis-Hastings algorithm simulates 300,000 draws with the first 100,000 used as a burn-in period and every 20th thinned, leaving a final sample size of 10,000.

4.4 BAYESIAN ESTIMATION: PRIORS

Following Justiniano et al. (2011), we calibrate some of the parameters that are difficult to identify from data. The quarterly depreciation rate for capital, δ, is set to 0.025, implying that the annual depreciation rate is 10 percent. The steady state government spending to GDP ratio $(1 - 1/g)$ is computed from the sample mean, which is 0.22. We also fix the gain parameter for the learning algorithm, **g**, which is drawn from the estimates of Best and Hur (2019). They allow for a potential break in the speed of policymakers' learning in 1979:Q3 and obtain the median gain coefficients for the pre- and post-79 samples of 0.01 and 0.003, respectively. Following Best and Hur (2019), we set $\mathbf{g}_{pre-79} = 0.01$ and $\mathbf{g}_{post-79} = 0.003$, postulating that policymakers assign a relatively larger weight to new information for the pre-79 period, compared to the post-79 one [Marcet and Nicolini (2003), and Milani (2014)].

We estimate the rest of the model's parameters. The third and fourth columns of Table 1 present prior distributions along with their means and standard deviations for the estimated parameters. The prior distributions for the structural parameters of the private sector model are largely drawn from Justiniano et al. (2011) and Bianchi (2013). In addition, the priors for the regime switching probability are similar to those in Bianchi (2013), and they are assumed to follow Dirichlet distributions—see Bianchi (2013) and Hur (2017) for details.

The priors for the weights in the policymakers' loss function are informative and follow beta distributions. They are chosen to be asymmetric across the policy preference regimes, centered at the values consistent with the microfounded estimates in Giannoni and Woodford (2003), Debortoli and Nunes (2014) as well as with the DSGE estimates reported in Best and Hur (2019). The priors for the weight on the output gap have mean values of 0.005 for the hawkish regime with a standard deviation of 0.005, and a value of 0.45 for the dovish regime with a larger standard deviation of 0.18. These values are similar to the calibrated parameters in Debortoli and Nunes (2014) where the assigned parameter on the output weight assumes a value of 0.5 during the dovish regime and 0.02 in the hawkish regime. Their interpretation is that the dovish regime assigns to output gap stabilization half of the weight assigned to price stabilization. It is also important to note that in our setup, the weight on inflation stabilization has been normalized to one, so that the output gap loss function parameter captures the weight of the output gap response relative to the inflation response. As considered in Debortoli and Nunes (2014) the changes in the relative weights act as movements along a policy frontier, where targeting a reduction in the volatility of one variable increased the volatility in the other variable. The prior for the interest rate-smoothing parameter assumes *a priori* that monetary policy decisions tend to be more persistent for the dovish regime than the hawkish one. Best and Hur (2019) find that the interest-rate-smoothing parameter for the 1970s, when a dovish policy regime was in place, is estimated to be consistently higher than for the pre- and post-70s decade samples.

		Prior		Posterior (MS Pref.)		Posterior (MS Taylor)	
Description	Parameter	Density	Mean (Std.)	Median	[5%, 95%]	Median	[5%, 95%]
Capital share	α	Normal	0.30 (0.05)	0.19	[0.18, 0.20]	0.16	[0.15, 0.18]
Price indexation	ι_p	Beta	0.50 (0.15)	0.19	[0.07, 0.38]	0.15	[0.05, 0.30]
SS composite tech. growth rate	γ_*	Normal	0.40 (0.01)	0.40	[0.38, 0.41]	0.40	[0.38, 0.42]
SS IST growth rate	γ_υ	Normal	0.29 (0.01)	0.29	[0.27, 0.30]	0.29	[0.27, 0.30]
Consumption habit	h	Beta	0.50 (0.10)	0.84	[0.80, 0.87]	0.89	[0.86, 0.91]
SS mark-up goods prices	λ_p	Normal	0.15 (0.05)	0.17	[0.08, 0.25]	0.17	[0.08, 0.25]
SS hours	$\log L^{ss}$	Normal	0.00 (0.50)	0.04	[−0.79, 0.86]	0.01	[−0.76, 0.79]
SS quarterly inflation	$100(\pi-1)$	Normal	0.50 (0.05)	0.50	[0.44, 0.57]	0.51	[0.44, 0.57]
Discount factor	$100(\beta^{-1}-1)$	Gamma	0.25 (0.05)	0.18	[0.14, 0.21]	0.18	[0.13, 0.23]
Inverse Frisch elasticity	ν	Gamma	2.00 (0.75)	2.02	[1.52, 2.71]	1.05	[0.79, 1.41]
Calvo prices	ξ_p	Beta	0.50 (0.10)	0.64	[0.58, 0.70]	0.57	[0.55, 0.63]
Capital utilization costs	χ	Gamma	5.00 (1.00)	5.39	[3.93, 7.18]	5.27	[3.74, 7.14]
Investment adjustment costs	S''	Gamma	4.00 (1.00)	0.76	[0.59, 0.95]	1.01	[0.75, 1.26]
Neutral tech. AR(1)	ρ_z	Beta	0.40 (0.20)	0.08	[0.02, 0.17]	0.04	[0.01, 0.09]
Gov't spending AR(1)	ρ_g	Beta	0.60 (0.20)	0.97	[0.96, 0.98]	0.99	[0.98, 0.99]
Invest. tech. AR(1)	ρ_υ	Beta	0.60 (0.20)	0.46	[0.36, 0.56]	0.46	[0.38, 0.56]
Preference AR(1)	ρ_b	Beta	0.60 (0.20)	0.27	[0.12, 0.46]	0.52	[0.41, 0.63]
MEI AR(1)	ρ_μ	Beta	0.60 (0.20)	0.28	[0.16, 0.39]	0.25	[0.16, 0.35]
Monetary policy std.	σ_i	Inv. Gamma	0.20 (0.20)	0.07	[0.05, 0.08]		
Monetary policy std., regime 1	σ_i (R1)	Inv. Gamma	0.20 (0.20)			0.04	[0.03, 0.05]
Monetary policy std., regime 2	σ_i (R2)	Inv. Gamma	0.20 (0.20)			0.22	[0.14, 0.40]
Neutral tech. std., regime 1	σ_z (R1)	Inv. Gamma	2.00 (2.00)	0.83	[0.60, 1.15]	1.57	[1.18, 2.08]
Neutral tech. std., regime 2	σ_z (R2)	Inv. Gamma	2.00 (2.00)	2.35	[1.55, 3.49]	5.24	[3.37, 8.36]
Gov't spending std., regime 1	σ_g (R1)	Inv. Gamma	1.00 (2.00)	0.09	[0.07, 0.12]	0.21	[0.18, 0.24]
Gov't spending std., regime 2	σ_g (R2)	Inv. Gamma	1.00 (2.00)	0.21	[0.15, 0.28]	0.44	[0.33, 0.64]
Invest. tech. std., regime 1	σ_υ (R1)	Inv. Gamma	0.50 (0.50)	0.93	[0.61, 1.43]	2.80	[1.72, 4.33]
Invest. tech. std., regime 2	σ_υ (R2)	Inv. Gamma	0.50 (0.50)	13.71	[10.32, 14.89]	12.60	[8.13, 14.74]
Preference std., regime 1	σ_b (R1)	Inv. Gamma	1.00 (1.00)	2.52	[1.58, 4.12]	9.95	[6.23, 13.97]
Preference std., regime 2	σ_b (R2)	Inv. Gamma	1.00 (1.00)	4.95	[2.52, 10.24]	13.18	[9.47, 14.81]
MEI std., regime 1	σ_μ (R1)	Inv. Gamma	2.00 (2.00)	0.17	[0.13, 0.21]	0.20	[0.16, 0.24]
MEI std., regime 2	σ_μ (R2)	Inv. Gamma	2.00 (2.00)	0.47	[0.36, 0.64]	0.70	[0.48, 1.14]
Sunspot std.	σ_ν	Inv. Gamma	2.00 (2.00)	1.00	[0.99, 1.01]		
Prob. of MP regime 1	P_{11} (R1)	Dirichlet	0.948 (0.063)	0.97	[0.95, 0.98]	0.99	[0.97, 1.00]
Prob. of MP regime 2	P_{22} (R2)	Dirichlet	0.948 (0.063)	0.86	[0.80, 0.92]	0.98	[0.96, 0.99]
Prob. of volatility regime 1	Q_{11} (R1)	Dirichlet	0.948 (0.063)	0.97	[0.93, 0.99]	0.97	[0.94, 0.99]
Prob. of volatility regime 2	Q_{22} (R2)	Dirichlet	0.948 (0.063)	0.95	[0.88, 0.98]	0.90	[0.80, 0.96]
MP weight on output gap, regime 1	λ_x (R1)	Beta	0.005 (0.005)	0.00	[0.00, 0.00]		
MP weight on output gap, regime 2	λ_x (R2)	Beta	0.45 (0.18)	0.11	[0.10, 0.15]		
MP weight on smoothing, regime 1	λ_i (R1)	Beta	0.35 (0.15)	0.22	[0.20, 0.26]		
MP weight on smoothing, regime 2	λ_i (R2)	Beta	0.75 (0.15)	0.94	[0.84, 0.99]		
MP resp. to inflation, regime 1	f_π (R1)	Gamma	1.8 (0.4)			1.71	[1.47, 2.01]
MP resp. to inflation, regime 2	f_π (R2)	Gamma	1 (0.4)			0.98	[0.93, 1.03]
MP resp. to output growth, regime 1	f_y (R1)	Gamma	0.25 (0.15)			0.16	[0.06, 0.32]
MP resp. to output growth, regime 2	f_y (R2)	Gamma	0.25 (0.15)			0.20	[0.07, 0.41]
MP rule AR(1), regime 1	f_i (R1)	Beta	0.6 (0.2)			0.73	[0.69, 0.78]
MP rule AR(1), regime 2	f_i (R2)	Beta	0.6 (0.2)			0.51	[0.42, 0.62]

Table 1: Prior and posterior distributions for the estimated parameters.

4.5 Estimation of the Model with MS in the Taylor Rule Coefficients For comparison, we additionally estimate a model with the Markov-switching structure in the Taylor rule coefficients analogous to Bianchi (2013) and Davig and Doh (2014). We follow Bianchi's (2013) specification—including the prior distributions selection, the solution algorithm by Farmer et al. (2011), and the Markov-switching structure both in monetary policy and shock volatility.

5 Results

5.1 Parameter Estimates The fifth and sixth columns of Table 1 report the posterior median and 90% interval estimates for the structural parameters in the benchmark specification. Overall, the data seem to be informative in identifying the parameters, as the 90% posterior intervals for most of the parameters are different from those implied by the prior distributions. Moreover, the regime-independent parameter estimates tend to be in line with those in the existing literature—including Smets and Wouters (2007), JPT and Bianchi (2013).

Focusing on the regime-dependent monetary policy preference parameters, regime 1 is associated with almost no weight on output gap stabilization as the parameter λ_x (R1) is quite tightly estimated around zero. Although the prior for this parameter allows for the possibility of a higher weight on the output gap, the data is informative and produces a posterior that is tightly centered around a value very close to zero. In contrast, a relatively higher weight is estimated for the stabilizing output gap parameter under regime 2 with λ_x's (R2) posterior median and [5%, 95%] estimates of 0.11 and [0.10, 0.15], respectively. This parameter estimate is high enough to produce intuitive responses to inflation stabilization consistent with the Taylor principle.[15] Due to these characteristics, we shall refer to regime 1 as the *hawk* regime, while regime 2 will be the *dove* regime. Our estimates also suggest that regime 1 is associated with a lower interest rate smoothing than regime 2, as the median estimates for λ_i (R1) and λ_i (R2) are 0.22 and 0.94, respectively.

Median probabilities for the current policy preference regimes taking place in the next period are 0.97 and 0.86 for regimes 1 and 2, respectively, with no overlap of their 90% posterior intervals. This finding indicates that the hawk regime is substantially more persistent than the dove regime.

Turning to the volatility of the non-policy shocks, the estimated standard deviations of the exogenous shocks are consistently higher under the volatility regime 2 than the first one. For this obvious reason, we refer to the first and second volatility regimes as the low and high volatility regimes, respectively. Finally, the persistence parameter estimates for each volatility regime, Q_{11} and Q_{22}, reveal that the low volatility regime is slightly more persistent than the high volatility one. This finding is consistent with Bianchi (2013).

We evaluate the data fit of the regime-switching models and compare them with the fixed-coefficient model using statistics such as Geweke's log marginal data density, the deviance infor-

[15] Woodford (2003) is that a welfare-maximizing central bank should be assigned only a small weight to measures of economic activity in its objective.

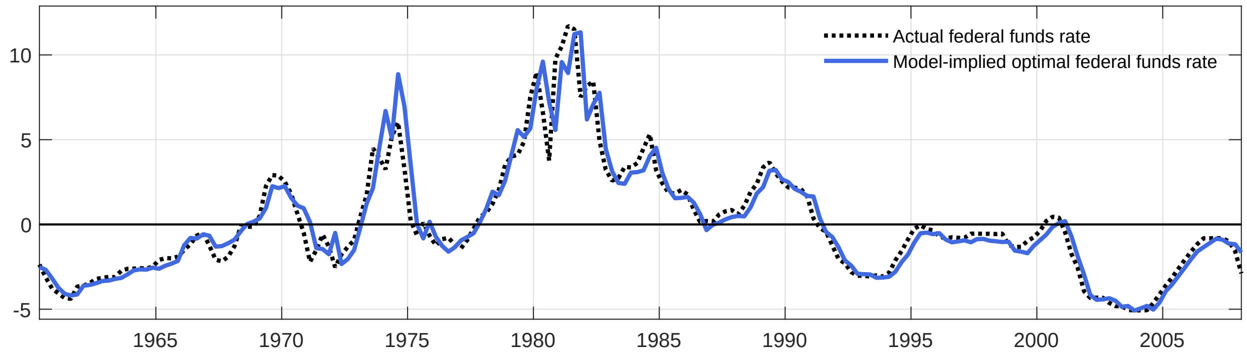

Figure 1: Actual federal funds rate (dotted line) and model-implied optimal federal funds rate associated with the benchmark specification (solid line). The model-implied series are evaluated at the median of posterior parameter estimates.

mation criterion (DIC), and the Bayesian predictive information criterion (BPIC). Our findings indicate that, regardless of the statistic used to assess data fit, the regime-switching model in monetary policy preferences outperforms the others.

5.2 MODEL-IMPLIED OPTIMAL POLICY VARIABLE

Figure 1 plots the actual federal funds rate and model-implied optimal monetary policy variable associated with the benchmark specification. We find that the policy variable resulting from the benchmark model estimation matches well the dynamic behavior of the fed funds rate during the period of study. In particular, it matches the upper bound of the target value during the Volcker disinflation period and follows closely the evolution of the funds rate during the 1990s and the pre-Great Recession period. In addition, the volatility of the policy instrument matches the federal funds rate's. Using a similar framework with central bank's learning, Best and Hur (2019) obtain the optimal federal funds rate in a model with *deterministic* shifts in policymakers' preferences in 1970 and 1979. The model-implied optimal policy variable in this paper outperforms theirs as it improves the fit in the mid-1970s, early 1980s, mid 1990s and in the pre-Great Recession period. This finding underscores the possibility of *stochastic* regime changes in monetary policy preference for applications as in this paper.

Next, we turn our attention to the dynamics that underpin the evolution of the optimal policy instrument. We first discuss the Markov-switching monetary policy preference estimation in which the central bank experiences shifts between a dove and hawk regime. Then we turn our attention to the beliefs part, which is motivated by our central bank learning structure.

5.3 SMOOTHED REGIME SWITCHING PROBABILITY

The top panel of Figure 2, plots the probabilities of the monetary policy preference regime 1, or hawk regime with the vertical lines indicating the Fed chairmanship. It is important to highlight that these are regime switches in preference parameters in the central bank loss function. Thus, they represent policy shifts, with the characteristic that a change in preferences should produce an increase in the volatility of one variable—i.e.

the output gap—, but a decrease in the volatility of the other [see Debortoli and Nunes (2014)]. This means that a direct comparison with Bianchi (2013) and Davig and Doh (2014) is not appropriate because in simple policy rules (as is the case in their studies) it is possible to drive the volatility of the output gap and inflation in the same direction. The probabilities in the top panel of Figure 2 follow a similar pattern as in Bianchi (2013) and Davig and Doh (2014). Specifically, a dovish episode with great preference for output gap stabilization in the 1970s under Burns' chairmanship. We also estimate a non-zero probability of switching to a dove regime in the late 1970s-to-early 1980s, 1987, early 2000s and at the onset of the Great Recession.

Our methodology which allows us to disentangle switches between dove and hawk regimes while simultaneously accounting for policymakers' understanding of the economy in real time, is a main contribution of this study. Traditionally, central bank members of the Federal Open Market Committee have been identified as hawks and doves by their expressed views on policy based on documents released with FOMC transcripts. The most recent literature measures perceived policy preferences of the FOMC based on newspaper and financial media coverage and concludes that the variations between regimes are largely explained by the composition of the FOMC members (see Istrefi (2019)). As this composition varies over time due to rotating voting rights, this leads to significant variation in hawkish and dovish regimes. Most importantly, a direct mapping of policy preferences (see Malemendier et al. (2021) and Istrefi (2019)) is not straightforward, an issue that this paper aims to resolve.

Our results for the hawkish/dovish regime corroborate other findings in the literature. For example, our model finds a hawkish regime for the 1960s-1970 period when William McChesney Martin was the chairman of the Federal Reserve (serving from 1951 to 1970). Chairman Martin was known for his active anti-inflationary policies throughout his tenure, a fact that was widely cited in the press which also conforms with Istrefi (2019) findings. We estimate a less hawkish regime change in 1966, which is partly attributed to the preponderance of dovish FOMC members in the voting committee during this time. In fact, in December of 1968, Romer and Romer (2024) identifies one of the few episodes with low commitment to disinflation due to monetary policymakers' unwillingness to accept output losses, specifically a downturn. [16]

Our results also indicate that there is a high probability of a dove regime between 1970 and 1978, particularly 1973-1978. This period coincides with the tenure of Arthur Burns as the Chairman of Federal Reserve. The Fed was not willing to make "discernible output sacrifices" to reduce inflation during this period (see Romer and Romer (2002)). However, as we discuss below, we attribute some of the "mistakes" of monetary during this period, which led to the Great Inflation, to the Fed's erroneous beliefs about the functioning of the economy, persistence of inflation, and

[16] Romer and Romer (2024) acknowledges that disinflations have been successful due to the motivation and decisions of policymakers. Using the narrative record, they identify and rank the Federal Reserve's contractionary actions to reduce inflation since World War II by their level of commitment to disinflation using their expressed desire to reduce inflation, concrete actions, and willingness to accept output losses for their policy.

trade-offs between inflation and potential output. Nonetheless, the reason why high inflation persisted for so long was because of the prolonged dovish stance of the monetary policy during this period, as captured by our model.[17]

Our estimates of the smoothed probability provide mixed evidence of a dovish/hawkish regime in late 70s, during the tenure of G. William Miller, which was appointed Fed chairman in 1978. After aiming for above-trend growth rates in early 1978, the FOMC expressed a desire to achieve a lower growth rate of output—sustainable over the long run—in the second half of the year. Our model captures this hawkish tilt (figure 2) consistent with the evidence provided by Romer and Romer (2002). Nonetheless, this tilt was soon abandoned as witnessed by accounts in the financial press which reported that the Fed expected a recession to start before the end of the year, followed by a dovish policy. This is also captured by our model, as reflected by the decrease in the probability of the hawkish regime at the tail end of Miller's tenure. Some signs of Miller's low commitment to monetary inflation policy were his desire to lower inflation slowly, "wringing it out" over a five-to-seven year period, and his belief that several other policies (i.e. fiscal, income, reduction in regulatory burden etc.) came first in an effort to bring inflation down (see Romer and Romer (2024)).[18]

There was a radical pivot towards a hawkish regime with the appointment of Paul Volcker as the chairman of the Fed in 1979, which prevailed until early 2000s, spanning the tenures of both Volcker and Greenspan (figure 2). Volcker was widely known for his aggressive stance in combating inflation, raising interest rates at the fastest pace in history (see Goodfriend and King (2005), Romer and Romer (1989), and more recently Romer and Romer (2024) and Istrefi (2019)). His 1981 deliberate and sustained effort to lower inflation has been classified as the of policy with the highest level of commitment to disinflation in the post-war period (see Romer and Romer (2024)). Goodfriend and King (2005) describes that there was a brief change in preferences in 1979 toward a hawkish regime to fight inflation that solely contained it. Shortly thereafter, there was a steadfast reversal of policies to fight the recession which ultimately hurt the credibility of the Fed captured by our smoothed probability estimates in figure 2.

The deliberate policy to bring inflation down started in 1981 even with the Fed's acknowledgment that it was going to be extremely costly in terms of output losses. Volcker's 1981 sustained effort to lower inflation has been classified as the policy with the highest level of commitment to disinflation in the post-war period (see Romer and Romer (2024)). Their aim was to restore credibility in the Fed's inflation fighting policy in the face of a very skeptical private sector. This ulti-

[17]These results contradict the findings in Istrefi's(2019) which regard Burns as a hawkish chairman even when pressured politically to follow expansionary policy. [Abrams (2006)]. In fact, Istrefi (2019) considers Burns as "overly concerned with inflation rather than fighting the recession" aiming for a moderately restrictive monetary policy until the existing inflation had been eliminated.

[18]Istrefi (2019) concludes that while Miller was not known as an inflation fighter, the FOMC was still perceived as hawkish during this period. This conforms with our findings of a mix of dovish and hawkish regimes during Miller's tenure.

mate policy preference shift to a hawkish regime lasted almost twenty years, (figure 2). Lastly, our estimates of the smoothed probability capture a distinctive short-lived switch to a dovish regime toward the end of Volcker's tenure (1986-1987), before the 1987 stock market crash or Black Monday. This dovish bias has been attributed to changes in the composition of the Fed, with a larger share of dovish board members appointed by President Reagan as counterweight to Volcker's hawkish policy preferences (see Istrefi (2019)).

While Greenspan was also regarded as an inflation hawk in the earlier part of his tenure, the Fed's stance turned dovish between 2001 and 2004 and from 2006 onward as captured by our smooth probability estimates. In the first half of the 2000s the federal funds rate was lower than expected and veered off the typical hawkish policy seen during the Great Moderation (Kahn (2005), Jarociński and Smets (2008), Stiglitz (2009a) and Taylor (2014). Following a counterfactual experiment, Taylor (2007) finds that the policy response to inflation between 2003 and 2005 shows a large downward shift, comparable to 1970s policy, fueling the extraordinary surge in demand for housing. This change in stance can be attributed to Greenspan's belief that the boost in productivity experienced during this period had increased the potential for non-inflationary growth (Blinder and Reis (2019). Greenspan's episodes of dovish policies reported by our smoothed probabilities were not captured by the Taylor rule regime switching estimates in Bianchi (2013) partly because our methodology allows us to perform a direct mapping to policy preferences.

Our sample includes only a few years in the tenure of Ben Bernanke as the Fed Chairman; the overall stance, as captured by our smooth probability is generally dovish, though there is a pivot towards tighter policy at the end of the 2007, right before the onset of the Great Recession. President George W. Bush nominated Ben Bernanke in 2002 as a board member of the Federal Reserve; consequently, he was appointed as the chairman in 2006. As a board member, he advocated aggressive stimulus policies such as a money-financed tax cuts and an inflation targets of 3% - 4% as recommendations for monetary policy at the zero bound on interest rates. As an advocate of inflation targeting one of his biggest concerns was preventing deflation. His policies preferences as the Federal Reserve chair, moreover, were influenced by the Fed staff in general, particularly after the FOMC meeting of June 2003, where more cautious Fed policies were discussed (see Ball (2016). In the press Bernanke was regarded as dovish, more so than Greenspan.

5.4 SMOOTHED PROBABILITY OF SHOCK VOLATILITY

Turning to the shock volatility regimes, the top panel of Figure 3 reports the smoothed probability of the high volatility regime for the non-policy shocks. Our estimates indicate that most of the 1970s and the first half of the 1980s were characterized by a high volatility regime, which is consistent with the finding in Bianchi (2013) and Davig and Doh (2014). In addition, we identify periods of high volatility in the early 1960s, the second half of the 1960s, and the early 1990s. Therefore, we find strong evidence of high volatility from the earlier stages of the Great Inflation until the beginning of the Great Moderation and after the Black Monday of 1987. Sizable adverse shocks (namely "bad luck") played a large

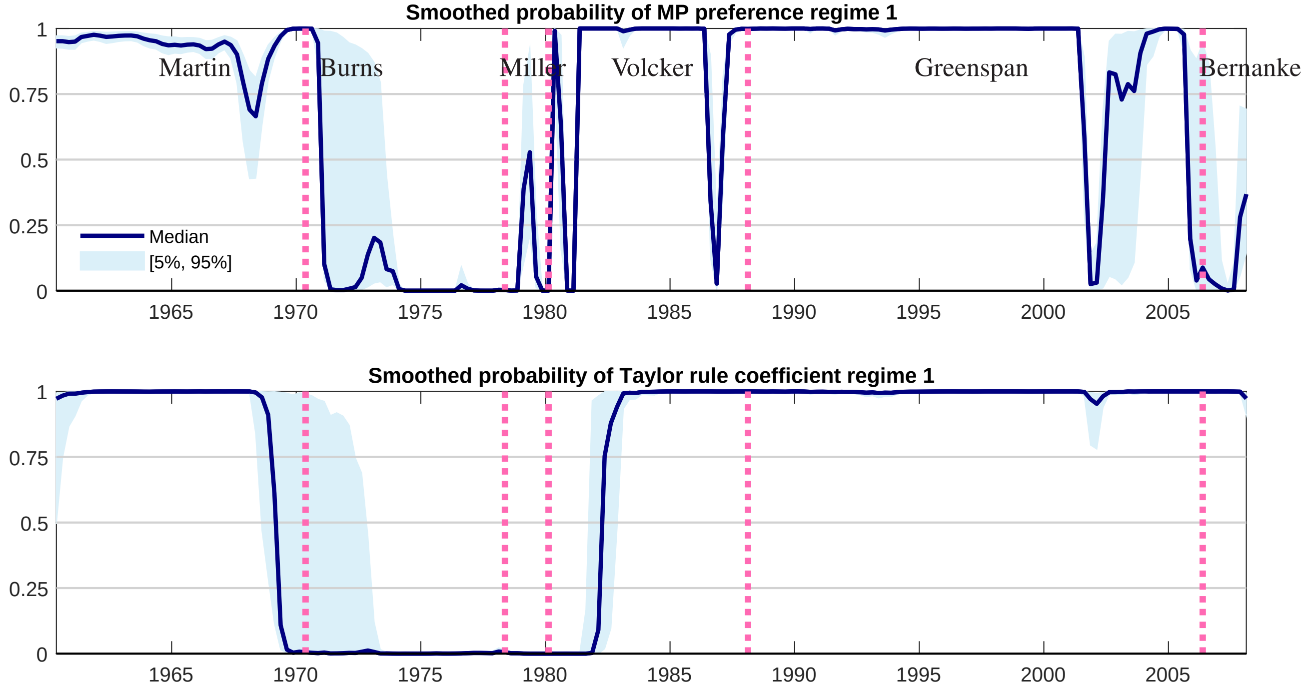

Figure 2: Probabilities of the monetary policy preference regime 1 (upper panel) and of Taylor rule coefficient regime 1 (lower panel). Posterior median and [5%, 95%] band estimates are reported. The vertical lines indicate Fed chairmanship.

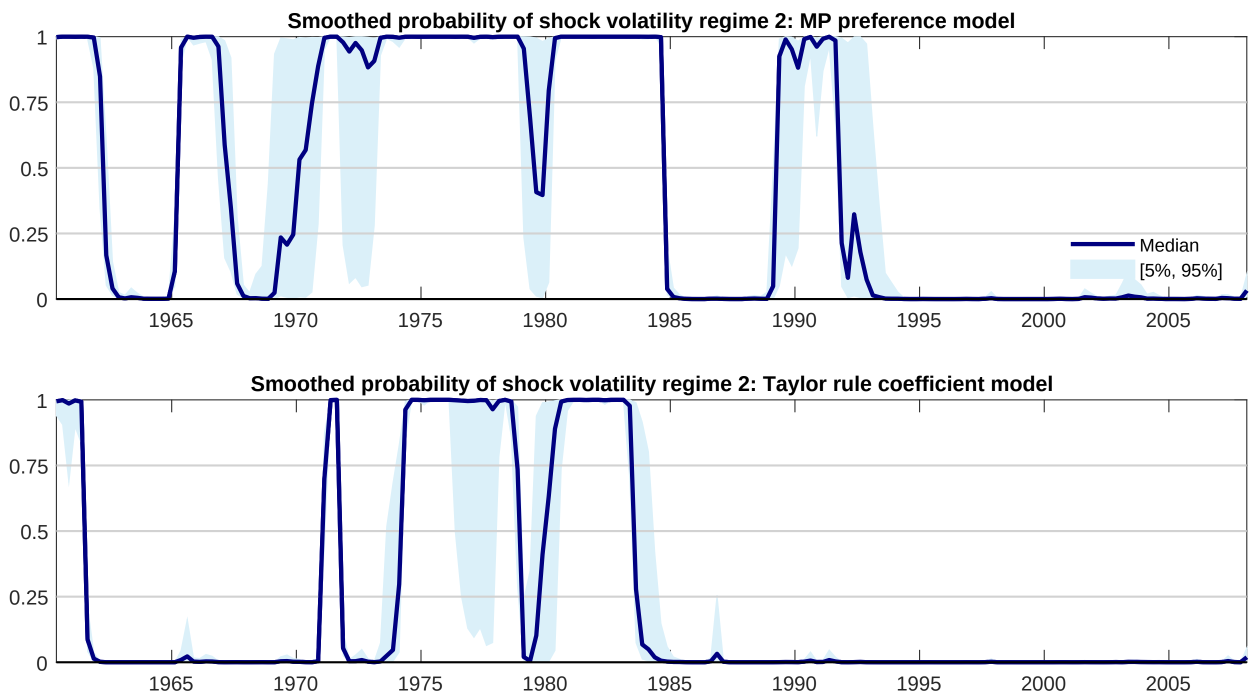

Figure 3: Probabilities of the shock volatility regime 2 associated with the monetary policy preference model (upper panel) and associated with the Taylor rule coefficient model (lower panel). Posterior median and [5%, 95%] band estimates are reported.

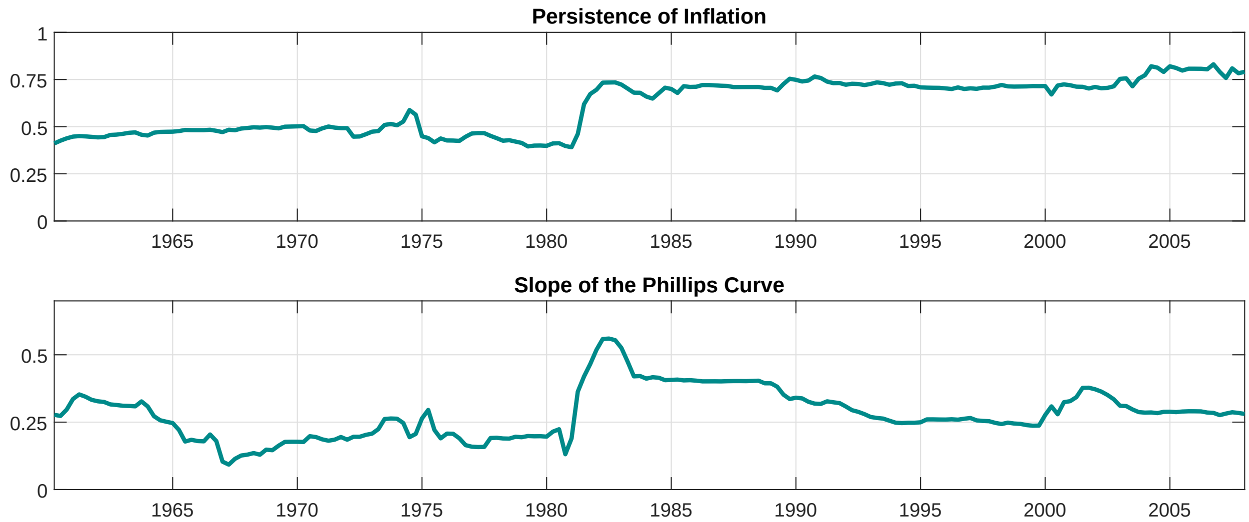

Figure 4: Persistence of inflation (upper panel) and slope (lower panel) of the Phillips curve, associated with the benchmark specification. The series are evaluated at the median of posterior parameter estimates.

role in the Great Inflation episode, as discussed by Sims and Zha (2006), among others. However, we do not detect, high volatility before the Great Recession, therefore we don't consider this as a main source of instability during this period. As much, we consider the dovish stance of monetary policy prior to the financial crisis documented in the previous section as a key contributor to the Great Recession.

5.5 POLICYMAKERS' BELIEFS Figure 4 plots the real time estimate of the persistence of inflation, parameter $\hat{c}_1$ as well as the slope of the Phillips curve, parameter $\hat{c}_2$. These parameters are crucial in the interpretation of the evolution of the monetary policy instrument in our period [see Orphanides and Williams (2005), Milani (2007), and Primiceri (2006)]. We estimate a low persistence of inflation in the beginning of the sample up to the mid-1970s when we estimate a jump in this time-varying parameter. Our results for the earlier part of the sample are consistent Primiceri (2006). The underestimation of the persistence of inflation in the early stages of the Great Inflation provides a justification for monetary policy authorities' passive behavior toward the threat of increasing inflation. Inflation persistence was even higher in mid-1980s.

The bottom panel of Figure 4 presents the perceived slope of the Phillips curve. In the beginning of the sample the slope was higher, then we observe a persistent decline on the output gap-inflation trade-off consistent with the recent perception of a flatter Phillips curve. The main implication is that from mid-1960s until early 80s the perceived effectiveness of monetary policy decreased, and the cost of bringing inflation down, in terms of the output gap, increased. During this period, policymakers reviewed their perceived output gap-inflation trade-off toward zero, finding it very unfavorable. Since the 1980s with anchored inflation expectations, the perceived worsening of the trade-off hasn't been an issue, but it was problematic when attempting to bring

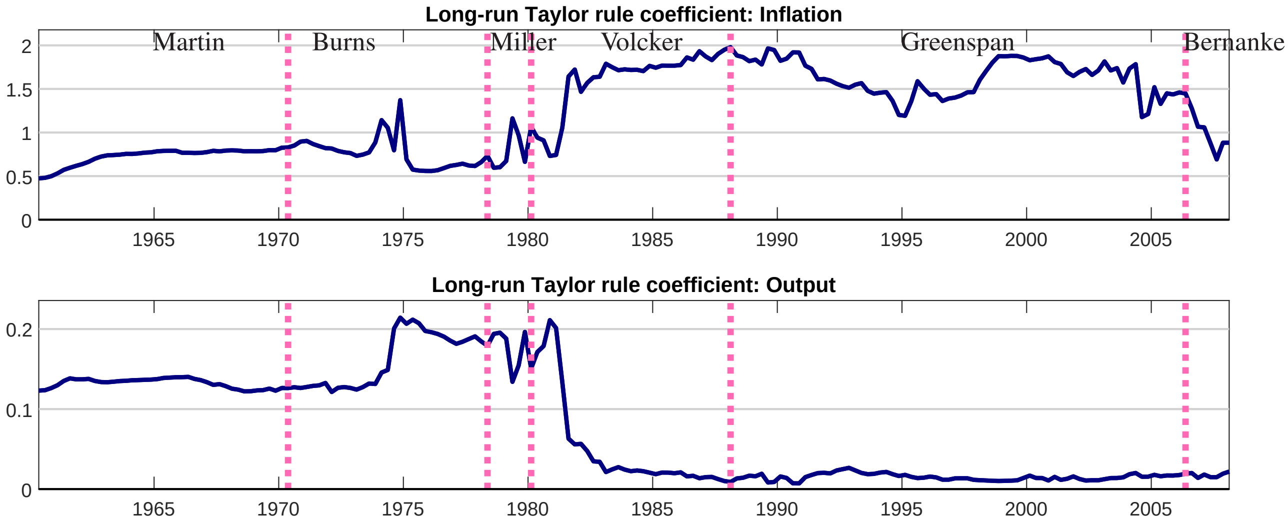

Figure 5: Model-implied long-run Taylor rule coefficients for inflation (upper panel) and output gap (lower panel), associated with the benchmark specification. The series are evaluated at the median of posterior parameter estimates. The vertical lines indicate Fed chairmanship.

inflation down during the Great Inflation. This belief leads to non-traditional responses of the variables to shocks in the 1960s and 1970s. It also partially explains why policymakers kept a dovish regime in place during the Great Inflation, even when the inflation rate had been on the rise since 1965 [see Primiceri (2006), Lubik and Matthes (2016)].[19]

5.6 MODE-IMPLIED TAYLOR RULE COEFFICIENTS Figure 5 presents the model-implied Taylor rule (TR) coefficients for inflation and output gap associated with the benchmark specification. These can replicate remarkably, the time-varying TR coefficients present in papers such as Boivin (2006), Kim and Nelson (2006), and Ang et al. (2011).

It is important to note that earlier in the sample, before the mid-1970s, we find policy preferences consistent with a "hawkish" central banker, as discussed in section 5.4. However, the TR coefficients presented here correspond to a low response to inflation——less than one for one——and a higher response to the output gap. This underscores the importance of modeling both time-varying preferences and learning: TR coefficients cannot be interpreted entirely as central bank stabilizing objectives, because they also mask beliefs about the structure of the economy.

During the mid-1970s, and up to the early 1980s the Taylor rule response to the output gap increases considerably, consistent with a dovish central banker, while the response to inflation decreases. We observe a spike in the inflation coefficient in the mid-1970s in response to the oil price shock and the increased inflation persistence. Importantly, while the change in preference to a hawkish regime started in the late 1970s the response to inflation did not increase until the early 1980, so the regime change for a Fed concerned with inflation was put in place in the late 1970s as

[19]Recently mentioned by Christina Romer on her keynote speech to the WEAI 2022 meeting entitled "The Timid Fed: Evidence and Explanations."

in Romer and Romer (2002).

In the early 1980s, the response to inflation increased, with dips right before the mid-1990s and the mid-2000s. As shown previously in Figure 2, there was a shift in policy preferences around 2001–2002 to a dovish regime which may have affected the response to inflation from the reaction function with a lag. In the episode leading to the Great Recession, we observe a lower response to inflation than in the late 1990s, comparable to the behavior of monetary policy during the Great Inflation.[20]

5.7 COMPARISON TO THE MODEL WITH MS IN THE TAYLOR RULE COEFFICIENTS The last two columns of Table 1 provide the posterior estimates obtained from the model with Markov-switching Taylor-rule coefficients. As shown in the table, regime 1 reacts more actively to inflation, but does less strongly to output, relative to regime 2. The degree of interest rate smoothing turns out to be higher under regime 1. Meanwhile, the standard deviations of the shocks are invariably higher under the volatility regime 2. All these properties are consistent with those observed in the existing MS literature using a similar framework [e.g., Bianchi (2013) and Davig and Doh (2014)].

The timing of the Taylor-rule regime 1 is plotted in the bottom panel of Figure 2. Based on the MS in the Taylor rule coefficients, we observe a regime switch in the late 1960s and early 1980s, earlier than under the benchmark model for the former, and later for the latter. This indicates that the estimation of a regime switching Taylor rule for monetary policy may be misleading in the sense that it would appear as if monetary policy preferences are shifting while the change may come from changes in the Fed's understanding about the dynamics of the economy. Romer's (2022) speech on the timid Fed, explains that timid policy changes are due to incorrect economic perceptions, such as the worsening of the output-gap inflation trade-off (1970–1971) or the belief that the Fed's role is to mitigate adverse economic conditions, rather than offset them (2000–2001 and 2007–2008).[21] The Taylor rule estimation also shows a consistent hawk regime until the end of the sample while in the top panel of Figure 2 we observe switches to dove regimes in 1987, but most importantly in the early 2000s. In a similar set-up, Bianchi (2013), records a switch to dovish policy at the onset of the Great Recession only, not in the early 2000s. We believe that this early 2000s switch to a dovish policy fueled the speculative credit and investment boom which led to the Great Recession and it is captured by our benchmark model.

In the bottom panel of Figure 3, we plot the smoothed probability of non-policy shock volatility in a model with the Taylor Rule. We find a high volatility shock regime present since the early-to-mid 1970s up to the onset of the Great Moderation. Results are generally similar to our benchmark model, however, unlike our benchmark, here we do not detect a high volatility regime in the earlier

[20] We checked determinacy properties of the benchmark model and we conclude that there exists a determinate equilibrium during the entire sample which is consistent with the use of the Bianchi and Nicolò algorithm.

[21] Fed timidity is defined as having monetary policymakers that see undesirable shocks to the variables they care about, but choose not to respond or to respond only partially.

states of the Great Inflation and after Black Monday.

6 TIME-VARYING VARIANCE DECOMPOSITION

In the following section we present the results of a time varying decomposition for the benchmark model (regime switching) and counterfactual scenarios where we assume either: 1) an all dove regime, or 2) an all hawk regime throughout the entire sample. The purpose is twofold. First, we study the time-varying contribution of each individual shock to the forecast error variance. We are particularly interested in the MEI shock, a proxy for the functioning of the financial system, which has been found to play a key role in the business cycle [see Justiniano et al. (2011), Fisher (2006), Smets and Wouters (2007), Justiniano and Primiceri (2008), Papanikolaou (2011), and Gust et al. (2017))]. As our results below indicate, our estimation shows that the contribution of said shock varies over time and through monetary policy regimes. In particular, we find that the main contributor to macroeconomic dynamics during hawkish regimes is the MEI shock that captures the behavior of the financial sector. In dovish episodes, however, we observe that the contribution of other shocks increases. consequently, we attempt to dissect and describe the contribution of the additional shocks to macroeconomic dynamics below.

Second, we are very interested in finding any potential commonalities (or differences) between the Great Inflation and the period leading to the Great Recession given that they are both consistent with dovish regimes. In particular, our focus is on identifying which shocks served as catalysts for the adverse macroeconomic environments that unfolded during both periods.

6.1 TIME-VARYING VARIANCE DECOMPOSITION: DEFINITION

In order to examine the role of each exogenous shock in accounting for the variability of a macro variable at a specific period, we calculate time-varying variance decomposition defined as

$$\text{Time-varying variance decomposition } (X_t^s) = \frac{(X_t^s)^2}{\sum_{s \in S} (X_t^s)^2} \tag{14}$$

where $X = \{Y, C, I, \pi, R\}$ is the set of the aggregate variable of interest and $S = \{i, z, g, \upsilon, b, \mu, \nu\}$ is the set of exogenous shocks in the model. Accordingly, X_t^s denotes the value of the variable X at time t generated by a specific shock $s \in S$.

6.2 TIME-VARYING VARIANCE DECOMPOSITION

Figures 6 and 7 show the time-varying shares of forecasting error variances accounted for by each shock in the benchmark regime switching model (red line), and counterfactual experiments without regime switching (blue lines). Figure 6 depicts forecast error variances under a hawkish regime throughout the sample while Figure 7 assumes a counterfactual scenario of a dovish regime during the entire period .

As depicted in Figures 6 and 7 the MEI shock is the main determinants of output, consumption

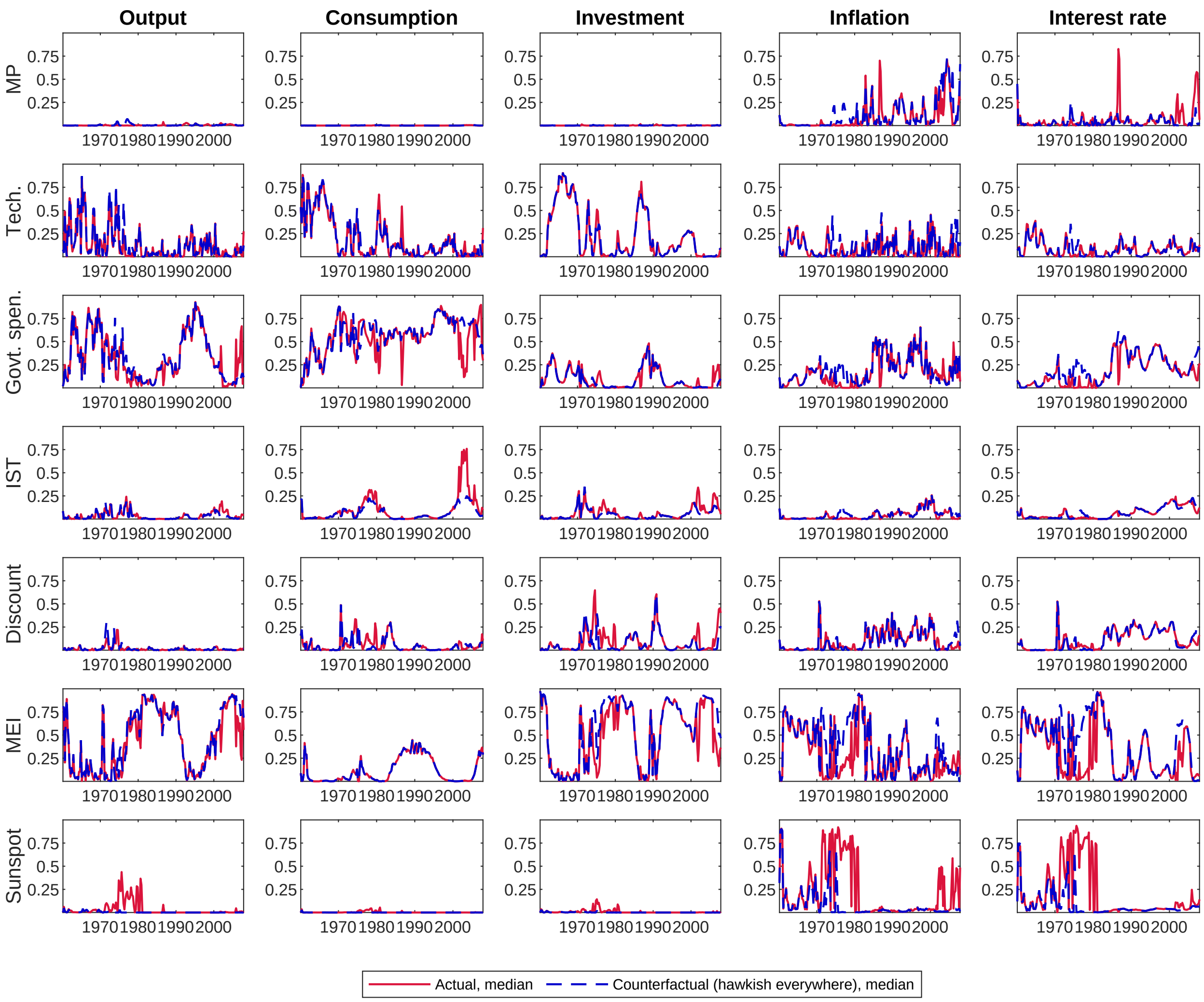

Figure 6: Share of forecasting error variances accounted for by each shock, associated with the counterfactual scenario. The counterfactual series are obtained under the assumption that the hawkish policy preference regime is maintained for the entire sample. In each figure, median (solid line) and 90% interval (dashed lines) estimates are reported.

and investment in the benchmark estimation (red lines) mainly during hawk regimes. However, differences arise in the 1970s, around 1987, and 2000s primarily during periods leading to a dovish regime and the regime itself, where government, technology shocks and IST shocks have higher contributions.

Our benchmark, regime switching model (Figures 6 and 7 red line) shows that interest rates and inflation have been primarily determined by government spending and MEI shocks during hawk regimes, and sunspots shocks during dove regimes. This result is corroborated by figure 6 (counterfactual experiment with a hawkish regime in place throughout the sample) where we observe a decreased response to sunspots shocks before the 1980s offset by an increase in the contribution of the MEI shock. The monetary policy shock is a key contributor to inflation during hawk regimes while it affects interest rates primarily during 1987 and the 2000s dove regimes.

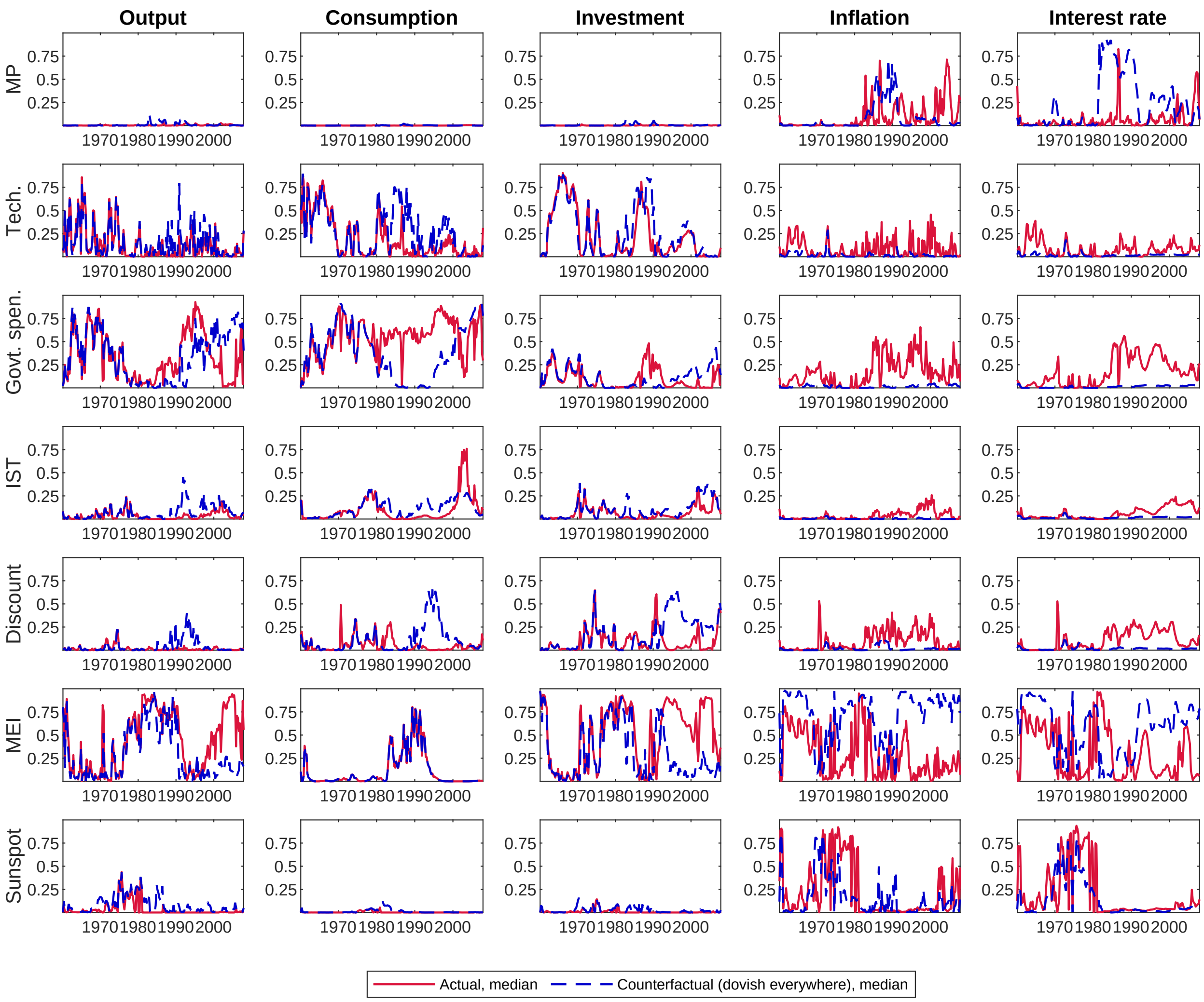

Figure 7: Share of forecasting error variances accounted for by each shock, associated with the counterfactual scenario. The counterfactual series are obtained under the assumption that the dovish policy preference regime is maintained for the entire sample. In each figure, median (solid line) and 90% interval (dashed lines) estimates are reported.

Therefore, the MEI shock's is still a main contributor to economic dynamics primarily during the hawkish episodes, however the importance of other shocks emerge in presence of dove regimes. Estimating models that do not allow for the possibility of variations in monetary policy regimes, moreover, fall short in explaining the contribution and response of relevant macroeconomic variables (i.e. output, consumption, investment etc.) to all shocks, monetary and non-monetary. In addition, sunspot only contributes to economic dynamics during the 1970s and slightly before the Great Recession during dove regimes.

6.3 Time-varying Variance Decomposition: Historical Periods In this section we will specifically focus on uncovering potential similarities between the Great Inflation and the period leading to the Great Recession given that they both emerged and were exacerbated by dovish

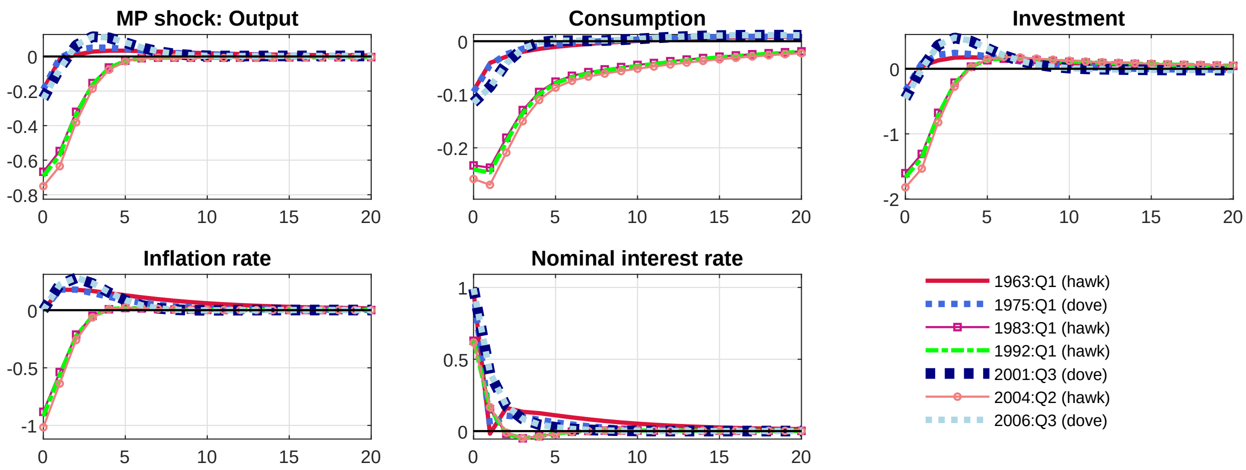

Figure 8: Impulse responses to monetary policy shocks for the selected periods. The impulse responses are evaluated at the median of posterior parameter estimates.

regimes. We observe that throughout the dovish monetary regime present during the Great Inflation, technology and government spending shocks were the main drivers of macroeconomic dynamics however, we also observe an important contribution of sunspots shocks to output, inflation and interest rate dynamics. At this time, the monetary policy and MEI shocks had minor contributions, only for specific years for the latter, i.e. we observe a spike in 1975. This is contrast with the hawkish regime present in the course of the Great Moderation where the MEI shock is the decisive factor driving economic dynamics. We see smaller average contributions of government, technology, and the discount factor shocks to the forecast error variances.

We observe that economic dynamics shift again with the emergence of a dovish regime in the early 2000s, where three notable differences arise with respect to the dovish regime present during the Great Inflation. One, technology shocks do not have significant contributions to macroeconomic dynamics. Two, monetary policy shocks increase their influence on the interest rate and inflation. Lastly, sunspot shocks only affect inflation.

7 Impulse Responses

Impulse responses are presented in 8 – 11. Overall, we find that there is a distinct grouping in impulse responses which depends on the regime, with hawkish regimes eliciting similar reactions (with the exception of the hawkish regime of 1963) which generally differ from dovish regimes. For example, the impact of a contractionary policy shock on macro variables (output, consumption, investment and inflation) is distinctly more pronounced during the hawkish than dovish regimes. Output, consumption and investment decline as a result of tighter monetary policy, but the drop is much larger during hawkish regimes. Interestingly, we find no evidence of a price puzzle in hawkish regimes, but it is always present in dovish regimes.

The impact of a government spending shock is similar across hawkish/dovish regimes, with a

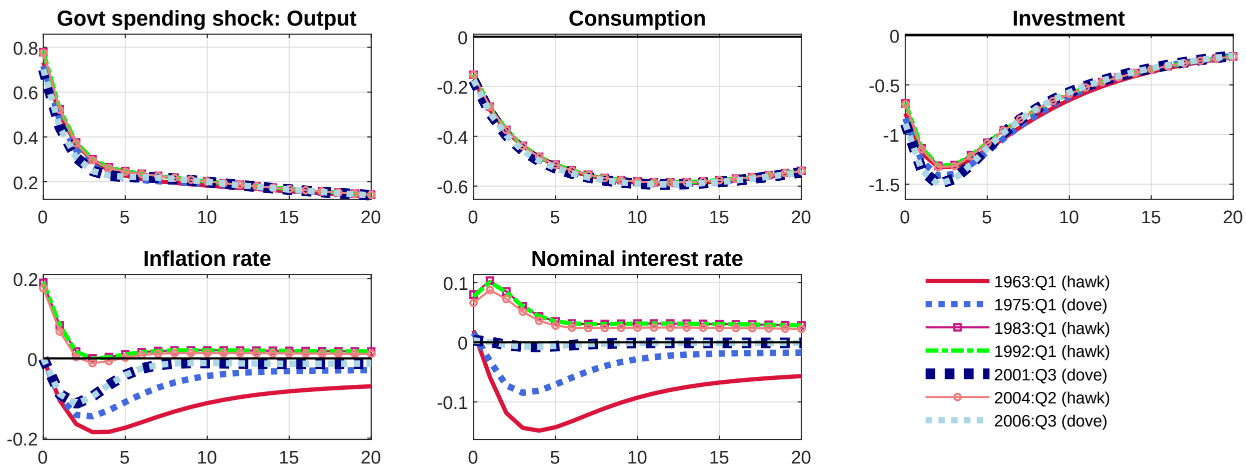

Figure 9: Impulse responses to government spending shocks for the selected periods. The impulse responses are evaluated at the median of posterior parameter estimates.

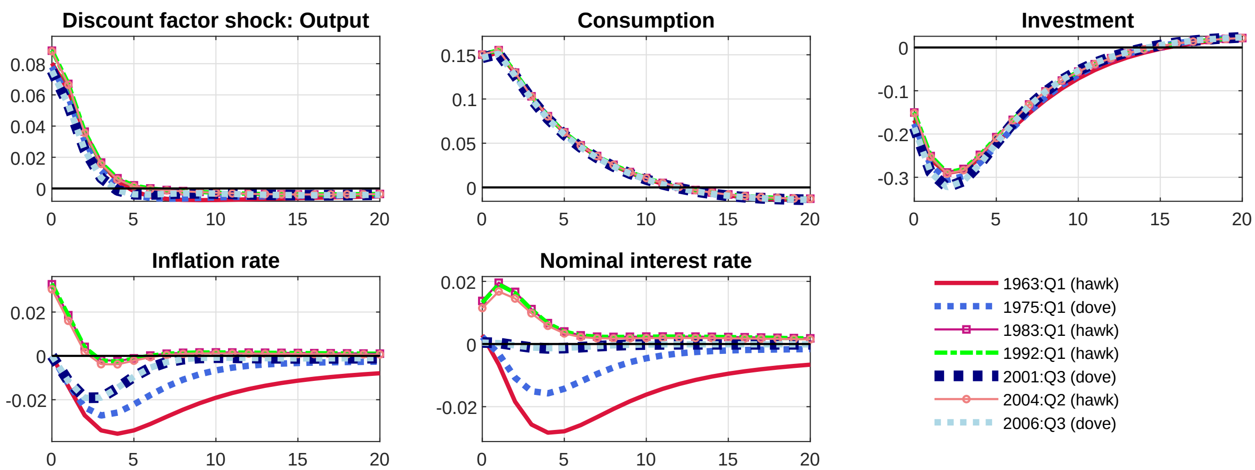

Figure 10: Impulse responses to discount factor shocks for the selected periods. The impulse responses are evaluated at the median of posterior parameter estimates.

rise in spending increasing output, decreasing consumption and crowding out investment 9. These findings partially corroborate those of Davig and Leeper (2011), with the exception that they document a decrease in consumption only under an active monetary/passive fiscal regime. Our results also show that the behavior of interest rates and inflation to a government spending shock is counter intuitive during dovish regimes, but conforms with economic theory in hawkish regimes: interest rates and inflation rise in hawkish regimes but decline in dovish regimes. These results contradict Davig and Leeper (2011) who document that nominal interest rate rise after a government spending shock under all regimes.

We find similar anomalous responses to discount rate and MEI shocks during dovish regimes. A positive shock to the discount rate (10 increases the nominal rate and inflation during hawkish regimes, but it has a negligible to negative effect on inflation and the interest rate during the dovish

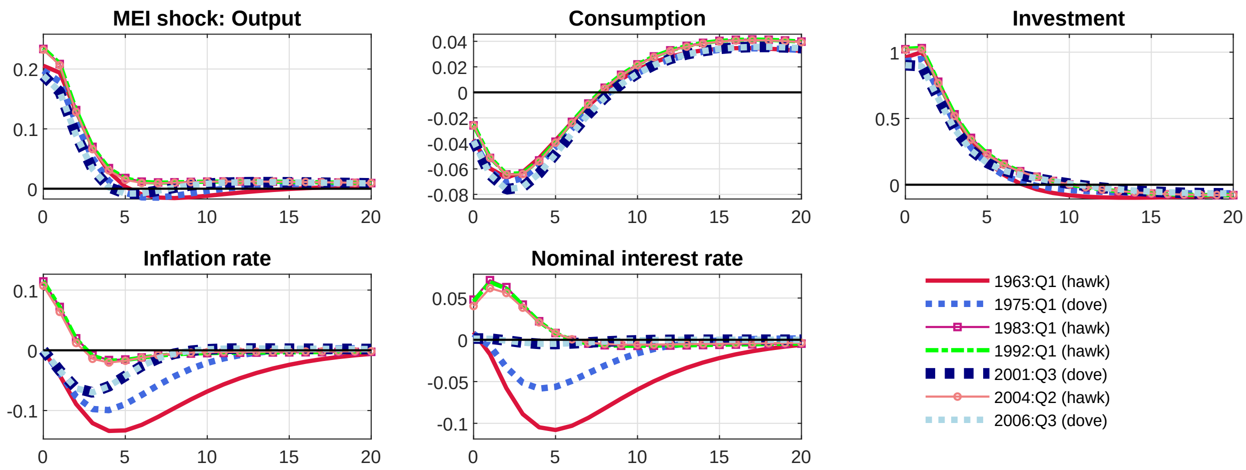

Figure 11: Impulse responses to marginal efficiency of investment shocks for the selected periods. The impulse responses are evaluated at the median of posterior parameter estimates.

regimes, with a pronounced negative effect during the Great Inflation.[22] Likewise, while the MEI shock produces similar impulse responses to Justiniano et al. (2011) under the hawkish regime (with inflation and interest rates rising), the opposite occurs during dovish regimes. This effect is distinctly more pronounced during the period of the Great Inflation.

In summary, our impulse responses under a hawkish regime are fairly standard and conform with economic theory and previous findings in the literature. However, the impulse responses are rather atypical during dovish regimes, especially as it relates to interest rates and inflation.[23] These atypical responses are the product of the Fed's erroneous beliefs about the structure of the economy as discussed in 5.5.

8 THE GREAT INFLATION AND THE GREAT RECESSION

In our benchmark model we observe that the combination of Fed beliefs about the structure and performance of the economy, "bad luck" due to the sequence of adverse shocks that hit the economy, as well as a prolonged dovish monetary policy regime during the 1960s and 1970s were the determinants of the Great Inflation. This means that that if a hawkish regime had been in place during the Great Inflation, it would have eliminated the contribution of sunspot shocks to the economy, increasing the influence of technology and government spending shocks. But since other factors, such as adverse shocks and erroneous beliefs also played a role, a change in the monetary regime alone may have been insufficient to prevent the occurrence of the Great Inflation.

[22]The discount factor shock impact on macro variables is fairly standard in our model: a positive shock increases output, consumption, and decreases investment for all regimes, similar to the findings presented in Smets and Wouters (2005).

[23]We have one exception, during the 1960s, a hawkish regime was in place however the responses are consistent with what we see during dovish regimes.

However, the appointment of chairman Volcker to the Federal Reserve in 1979 and the reported shift to a hawkish regime improved financial and economic stability, and decreased volatility of the shocks, resulting in the MEI (financial sector) the main driver of the business cycle (output, consumption and investment). Otherwise, as shown in the counterfactual under a dovish regime in Figure 7, the economy would have still been vulnerable to technology and monetary policy shocks. Therefore, the switch to a hawkish regime as a "fire extinguisher," citing Christopher Sims's kitchen fire analogy [Sims (2012)], is capable of limiting the adverse impact of even a major shock.

We observe two switches to a dovish regime in the early 2000s and after 2006; in the prelude to the Great Recession. These were identified in Romer (2022) as episodes when the Fed was behaving timidly, observing adverse shocks hitting the economy but choosing to respond partially or not at all and determining the behavior of interest rates. This timidity is in line with recent changes (2000) in the Fed's monetary policy framework, where it would not raise interest rates if unemployment rate had fallen below the potential rate if inflation had not risen Romer (2022). The prevailing economic dynamics changed, decreasing the contribution of the MEI shock, and leaving the economy susceptible to other shocks such as government spending, IST, and discount shocks. In particular, the monetary policy shock drove the interest rate.

We believe that the 2000s were different from the 1970s in the sense that we do not detect an increased volatility of shocks or erroneous beliefs about the structure of the economy driving monetary policy. We argue that the recorded prolonged dovish episode in the earlier part of the 2000s, during the Fed's "timid" phase, fueled speculative investment and a credit boom that led to the housing crisis and eventually the Great Recession. Our estimates show that the functioning of the financial system, through the MEI shock, was not the main driver of investment during this time, as it had been previously. Investment was also influenced by other shocks (i.e. discount and IST shocks), and we observe a similar pattern followed by the interest rate with monetary policy becoming a main contributor. Meltzer (2012) argues that the Fed ushered in the economy's longest period of low inflation and relatively stable growth between 1985 and 2003 when it followed a Taylor rule. He also concludes that discretionary judgments, as we have observed in the current set-up through deviations to a dovish regime, brought about the Great Inflation, but in particular the current crisis by keeping interest rates too low for too long and changing macroeconomic dynamics and the contribution of certain, non-financial shocks to the economy.

9 CONCLUSION

Monetary policy has evolved considerably over the post war period. There are many factors that explain this evolution, and this study argues that it is important to distinguish between the causes. We find that a Taylor rule that switches between dove and hawk regimes is not able to identify the exact dates in which monetary policy objectives switched, because it is capturing also beliefs about the model of the economy in the central bank model.

However, when we allow for the possibility of regime switches in monetary policy explained by changes in policy preferences regarding inflation and output gap stabilization, we find that a "dove" regime was in place during the 1970s. Therefore, before the 1970s, a hawkish regime governed the conduction of monetary policy making it clear that erroneous beliefs about the structure of the economy led to the beginnings of the soaring inflation episode. We also find that the inflation stabilization efforts started with a switch to a hawkish regime in the late 1970s; when a hawkish monetary policy regime is put in place, the contribution of MEI shock that acts as a proxy for the functioning of the financial markets increases almost across the board thereafter.

We observe three additional switches to a dovish regime: one in the late 1980s, one in the early 2000s, and one just before the Great Recession. In these episodes we observe a decrease in the contribution of the MEI shock leaving the economy vulnerable to the effects of other shocks such as government spending, IST, monetary policy, and sunspot shocks. Some of these estimated switches to a dovish regimes coincide with periods where the Fed was timidly acting to offset adverse economic shocks (2000–01 and 2007–08) and we believe that in the former case, it fueled speculative investment that led to the Great Recession.

10 ACKNOWLEDGMENTS

We are greatly indebted to Mira Farka fo her help and support with many aspects of this project. We would also like to thank seminar participants at the 2022 NBER-NSF SBIES Conference, the 2022 WEAI Annual Conference, the Korea Macroeconomics Research Group, Korea University, Sogang University, Sungkyunkwan University, Athanasios Orphanides, and Francesco Bianchi, Siddhartha Chib, Sylverie Herbert, Jinill Kim, and Wade Martin for helpful comments.

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