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ABSTRACT

We estimate a model in which fiscal and monetary policy behavior arise from the optimizing behavior of distinct policy authorities, with potentially different welfare functions. Optimal time-consistent policy behavior fits U.S. time series at least as well as rules-based behavior. American policies often do not conform to the conventional mix of conservative monetary policy and debt-stabilizing fiscal policy. Even after the Volcker disinflation, policies did not achieve that conventional mix, as fiscal policy did not act to stabilize debt until the mid 1990s. A credible conservative central bank that follows a time-consistent fiscal policy leader would come close to mimicking the cooperative Ramsey policy. Had that strategic policy mix been in place, American might have avoided the Great Inflation. Enhancing cooperation between policy makers without an ability to commit may be detrimental to welfare.

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A data appendix is available at http://www.nber.org/data-appendix/w27540

STRATEGIC INTERACTIONS IN U.S. MONETARY AND FISCAL POLICIES[*]

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1 INTRODUCTION

A large literature analyzes shifts in monetary policy regime. One important branch assesses how much of the "Great Moderation" in output and inflation volatility was simply "good luck"—a favorable shift in shock volatilities—or "good policy"—a desirable change in monetary policy rule parameters [Sims and Zha (2006)]. Many researchers date the improvement in policy making to the Volcker disinflation in 1979 or shortly after. Very little work examines the role fiscal policy played in altering inflation trends. This neglect is surprising in light of the co-movements in inflation, real interest rates, and fiscal variables including the government debt. The upward trend in inflation before the 1980s is associated with a downward trend in the debt-GDP ratio, while the moderation in inflation coincided with a step increase in the real interest rate and a rising debt-GDP ratio, at least until 1995 [figure 1].

Bianchi (2012) and Bianchi and Ilut (2017) are notable exceptions. They build on the policy interactions in Leeper (1991) to allow for switches in the combinations of monetary and fiscal policy rules over time.[1,2] Bianchi and Ilut find that a combination of passive monetary policy and active fiscal policy produced higher inflation and lower debt during the Great Inflation from 1965 to 1982. A period of policy conflicts follows with both monetary

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[1] Leeper (1991) characterizes monetary policy as active (AM) or passive (PM) depending on whether or not it satisfies the Taylor principle. A fiscal policy that adjusts taxes to ensure fiscal sustainability is passive (PF), while failing to do is an active policy (AF).

[2] Related papers include Davig (2004) and Davig and Leeper (2006, 2011), which allow for regime switching in estimated fiscal policy. Traum and Yang (2011) and Leeper, Traum, and Walker (2017) implicitly consider switches in monetary and fiscal policy by estimating a DSGE model with fixed policy rules over sub-samples.

and fiscal policy following active rules. Eventually, fiscal policy turns passive to stabilize debt in the face of the Fed's anti-inflationary actions. This conventional policy mix—active money/passive fiscal—explains the steady decline in inflation and rise in debt in the 1980s.

This paper builds on that analysis in several ways. First, we consider other types of policy making in addition to simple policy rules. Monetary policy is conducted optimally, but under time-consistent policy with fluctuations in the degree of inflation conservatism, as in Chen, Kirsanova, and Leith (2017). We permit fiscal policy to choose among active, passive, and optimal time-consistent fiscal rules, where the fiscal authority acts as a Stackelberg leader in a game with the optimizing monetary authority. This strategic policy specification, which resembles actual policy arrangements, fit data surprisingly well, yielding a fit comparable to the usual rules-based menu. To solve the strategic policy game between the monetary and fiscal policy makers in the face of regime switching, the paper develops a new algorithm.

Second, optimal policy's fit to data introduces a fresh narrative of how policies have evolved in the post-war period. Under time-consistent optimal policy the movement between regimes is more nuanced and it is rare that policy combinations conform to something akin to the theoretical active/passive pairings. We do not find that the Volcker disinflation was followed by a permanent shift to a debt-stabilizing fiscal policy, as conventional rules-based estimates do. We reconcile these findings with narrative evidence on the evolution of policy making.

Third, a counterfactual exercise points to *joint* monetary-fiscal behavior as the source of the Great Inflation. Optimal fiscal policy with conservative monetary policy, even when behavior is strategic and time-consistent, could have avoided the Great Inflation. This new result carries important practical implications. First, estimates find at least some periods when the policy mix prevailed, making the result non-vacuous. Second, the specification is a natural description of optimal policy behavior, as it requires neither cooperation nor commitment. Third, it points to the potency of good fiscal choices in inflation outcomes, something largely neglected in studies of inflation dynamics.

Finally, we assess the welfare implications of alternative policy regimes. The mix of a conservative central bank that follows an optimizing fiscal authority who acts as Stackelberg leader comes close to mimicking cooperative Ramsey policies. It turns out that merely enhancing cooperation between policy makers without also inducing commitment can reduce welfare relative to the estimated strategic interactions equilibrium. But the Stackelberg leadership regime must be credible, and not expected to shift to another potential policy regime. Credibility is important because there can be substantial spillovers across regimes, with a fiscal authority behaving optimally, taking into account possible future switches to a passive fiscal rule. And the inflationary impacts of an active fiscal regime are affected by the possibility of switching to a passive fiscal policy that raises distorting tax rates to stabilize debt. This latter phenomenon arises from the inflationary impacts of alternative distorting tax policies, a fiscal consideration missing in Bianchi (2012) and Bianchi and Ilut (2017).

2 The Model

Households, a monopolistically competitive production sector, and the government populate the economy. A continuum of goods enters the households' consumption basket. Households form external consumption habits at the level of the consumption basket as a whole, what

Ravn, Schmitt-Gróhe, and Uribe (2006) call "superficial" habits.[3] The economy is subject to both price and inflation inertia, which help to capture the hump-shaped responses of output and inflation to shocks evident in VAR-based studies, and are often employed in empirical applications of the New Keynesian model [Smets and Wouters (2003) and Christiano, Eichenbaum, and Evans (2005)].

On the fiscal side, the government levies a tax on firms' sales revenue, which is equivalent to a tax on all labor and profit income in this model. These revenues finance government consumption, pay for transfers to households, and service the outstanding stock of government debt. Government issues a portfolio of bonds of different maturities subject to a geometrically declining maturity structure.

2.1 Households

A continuum of households indexed by k and of measure one derive utility from consumption of a composite good, $C_t^k = \left(\int_0^1 \left(C_{it}^k\right)^{\frac{\eta-1}{\eta}} di\right)^{\frac{\eta}{\eta-1}}$, where η is the elasticity of substitution between the goods in this basket. Households suffer disutility from hours spent working, N_t^k. Habits are formed at the level of the aggregate consumption good and households fail to take account of the impact of their consumption decisions on the utility of others. To facilitate data-consistent detrending around a balanced growth path without restricting preferences to be logarithmic, we assume that consumption enters the utility function scaled by the economy-wide technology trend [Lubik and Schorfheide (2006) and An and Schorfheide (2007)]. This implies that the household's consumption norms rise with technology and are affected by habits externalities. Households maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(X_t^k\right)^{1-\sigma} (\xi_t)^{-\sigma}}{1-\sigma} - \frac{\left(N_t^k\right)^{1+\varphi} (\xi_t)^{-\sigma}}{1+\varphi} \right] \tag{1}$$

where $X_t^k \equiv \frac{C_t^k}{A_t} - \theta \frac{C_{t-1}}{A_{t-1}}$ is the habit-adjusted consumption aggregate, θ is the habit persistence parameter $(0 < \theta < 1)$, and $C_{t-1} \equiv \int_0^1 C_{t-1}^k dk$ is the cross-sectional average of consumption. Households gain utility from consuming more than other households and are disappointed if their consumption doesn't grow in line with technical progress. Preferences are subject to a taste shock, $\ln \xi_t = \rho_\xi \ln \xi_{t-1} + \sigma_\xi \varepsilon_{\xi,t}$. β is the discount factor $(0 < \beta < 1)$, and σ and φ are the inverses of the intertemporal elasticities of habit-adjusted consumption and work $(\sigma, \varphi > 0;\ \sigma \neq 1)$.

The process for technology is non-stationary

$$\begin{aligned} \ln A_t &= \ln \gamma + \ln A_{t-1} + \ln q_t \\ \ln q_t &= \rho_q \ln q_{t-1} + \sigma_q \varepsilon_{q,t} \end{aligned}$$

Households choose the composition of the consumption basket to minimize expenditure, so demand for individual good i is

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

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[3] For a comparison of the implications for optimal policy of alternative forms of habits see Amato and Laubach (2004) and Leith, Moldovan, and Rossi (2012).

where P_{it} is the price of good i, and $P_t = \left(\int_0^1 (P_{it})^{1-\eta} di\right)^{1-\eta}$ is the CES aggregate price index associated with the composite good consumed by households. Aggregating across households, we obtain the overall demand for good i as

$$C_{it} = \int_0^1 C_{it}^k dk = \left(\frac{P_{it}}{P_t}\right)^{-\eta} C_t \tag{2}$$

Households choose the habit-adjusted consumption aggregate, X_t^k, hours worked, N_t^k, and the portfolio allocation, $B_t^{S,k}$ and $B_t^{M,k}$, to maximize expected lifetime utility (1), subject to the budget constraint

$$\int_0^1 P_{it}C_{it}^k di + P_t^S B_t^{S,k} + P_t^M B_t^{M,k} = B_{t-1}^{S,k} + (1 + \rho P_t^M) B_{t-1}^{M,k} + W_t N_t^k + \Gamma_t + P_t Z_t \tag{3}$$

and a no-Ponzi scheme condition. Period t income includes: wage income from providing labor services to goods producing firms, $W_t N_t^k$, a lump-sum transfer from the government, Z_t, dividends from the monopolistically competitive firms, Γ_t, and payoffs from the portfolio of assets, $B_t^{S,k}$ and $B_t^{M,k}$. Households hold two forms of government bonds. The first is the familiar one-period debt, B_t^S, whose price equals the inverse of the gross nominal interest rate, $P_t^S = R_t^{-1}$. The second type of bond is actually a portfolio of many bonds, which pays a declining premium of ρ^{j-1}, j periods after being issued where $0 < \rho < \beta^{-1}$ [Woodford (2001)]. The duration of the bond is $\frac{1}{1-\beta\rho}$, which means that ρ can be varied to capture changes in the maturity structure of debt. By using this simple structure we need to price only a single bond, since any existing bond issued j periods ago is worth ρ^{j-1} new bonds. When $\rho = 1$ these bonds become infinitely lived consols.

Household optimization yields the optimal allocation of consumption across time, based on the pricing of one-period bonds

$$\begin{aligned} 1 &= \beta E_t \left[\left(\frac{X_{t+1}^k \xi_{t+1}}{X_t^k \xi_t} \right)^{-\sigma} \frac{A_t}{A_{t+1}} \frac{P_t}{P_{t+1}} \right] R_t \\ &= E_t Q_{t,t+1} R_t \end{aligned}$$

where we have defined the stochastic discount factor as

$$Q_{t,t+s} \equiv \beta \left(\frac{X_{t+s}^k \xi_{t+s}}{X_t^k \xi_t} \right)^{-\sigma} \frac{A_t}{A_{t+s}} \frac{P_t}{P_{t+s}}$$

and the geometrically declining consols

$$\begin{aligned} P_t^M &= \beta E_t \left[\left(\frac{X_{t+1}^k \xi_{t+1}}{X_t^k \xi_t} \right)^{-\sigma} \frac{A_t}{A_{t+1}} \frac{P_t}{P_{t+1}} (1 + \rho P_{t+1}^M) \right] \\ &= E_t Q_{t,t+1} (1 + \rho P_{t+1}^M) \end{aligned}$$

When all bonds have one-period duration, $\rho = 0$, the price of these bonds is $P_t^M = R_t^{-1}$. Outside of this special case, the longer term bonds introduce a term structure of interest rates. The first-order condition for labor is

$$\frac{W_t}{P_t A_t} = N_t^{k\varphi} X_t^{k\sigma}$$

There is an associated transversality condition. Define household financial wealth in period t as

$$D_t^k \equiv (1+\rho P_t^M) B_{t-1}^{M,k} + B_{t-1}^{S,k}$$

and impose the no-arbitrage conditions to rewrite the budget constraint as

$$\int_0^1 P_{it} C_{it}^k di + E_t Q_{t,t+1} D_{t+1}^k = D_t^k + W_t N_t^k + \Gamma_t + P_t Z_t$$

Household optimization implies a transversality condition that combined with the no-Ponzi condition yields

$$\lim_{T\to\infty} E_t Q_{t,T} D_T^k = 0$$

2.2 Firms

Individual goods producers are subject to the constraints of Calvo (1983) contracts. Each period a firm can reset its price with probability $1-\alpha$, while it retains the previous period price with probability α. That previous price is indexed to the steady-state rate of inflation, following Yun (1996). When a firm can choose a new price, it can do so either to maximize the present discounted value of after-tax profits, $E_t \sum_{s=0}^{\infty} \alpha^s Q_{t,t+s} \Gamma_{it+s}$, or to follow a simple rule of thumb as in Galí and Gertler (1999). Profits are discounted by the s-step ahead stochastic discount factor $Q_{t,t+s}$ and by the probability of not being able to set prices in future periods. The firm's revenues are taxed at rate, τ_t, which in aggregate, is equivalent to the ratio of taxes to GDP, which can be easily mapped to the data. This, obviously, greatly simplifies the complexities of the tax system which features of myriad of allowances and marginal tax rates, but allows us to adopt a simple measure of distortionary taxation rather than the common assumption in rule-based estimations that taxes are lump-sum [Bianchi (2012) and Bianchi and Ilut (2017)]. Forward-looking profit maximizers are constrained by the demand for their good, condition (2), and the condition that all demand must be satisfied at the chosen price. An autocorrelated shock affects the desired markup, $\ln \mu_t = \rho_\mu \ln \mu_{t-1} + \sigma_\mu \varepsilon_{\mu,t}$. Firm i's optimization problem is

$$\max_{\{P_{it},\ Y_{it}\}} E_t \sum_{s=0}^{\infty} \alpha^s Q_{t,t+s} \left[\left((1-\tau_{t+s}) P_{it} \pi^s - \mu_{t+s} MC_{t+s} \right) Y_{it+s} \right]$$

subject to the demand curve

$$Y_{it+s} = \left(\frac{P_{it}\pi^s}{P_{t+s}} \right)^{-\eta} Y_{t+s}$$

Optimizing firms that are able to reset price choose P_t^f, whose relative price satisfies

$$\frac{P_t^f}{P_t} = \left(\frac{\eta}{\eta-1} \right) \frac{E_t \sum_{s=0}^{\infty} (\alpha\beta)^s \left(X_{t+s}\xi_{t+s} \right)^{-\sigma} \mu_{t+s} mc_{t+s} \left(\frac{P_{t+s}\pi^{-s}}{P_t} \right)^{\eta} \frac{Y_{t+s}}{A_{t+s}}}{E_t \sum_{s=0}^{\infty} (\alpha\beta)^s \left(X_{t+s}\xi_{t+s} \right)^{-\sigma} (1-\tau_{t+s}) \left(\frac{P_{t+s}\pi^{-s}}{P_t} \right)^{\eta-1} \frac{Y_{t+s}}{A_{t+s}}}$$

where $mc_t = \frac{MC_t}{P_t} = \frac{W_t}{P_t A_t}$ is the real marginal cost, given the linear production function, $Y_{it} = A_t N_{it}$. Under flexible prices, $mc_t = (1-\tau_t)\frac{\eta-1}{\eta}$.

Inflation is inertial. Some firms use rules of thumb. When those firms are permitted to post a new price, they choose P_t^b to obey

$$P_t^b = P_{t-1}^* \pi_{t-1}$$

so they update their price using last period's rate of inflation rather than steady-state inflation. P_{t-1}^* denotes an index of the reset prices, defined by

$$\ln P_{t-1}^* = (1-\zeta) \ln P_{t-1}^f + \zeta P_{t-1}^b$$

where ζ is the proportion of firms that adopt rule-of-thumb pricing. With α share of firms keeping last period's price (but indexed to steady-state inflation) and $1-\alpha$ share of firms setting a new price, the law of motion of the aggregate price index is

$$(P_t)^{1-\eta} = \alpha \left(P_{t-1}\pi\right)^{1-\eta} + (1-\alpha)\left(P_t^*\right)^{1-\eta}$$

The setup delivers a hybrid New Keynesian Phillips curve, as Leith and Malley (2005) detail. Combine the rule-of-thumb pricing with the optimal price setting to produce

$$\widehat{\pi}_t = \chi_f \beta E_t \widehat{\pi}_{t+1} + \chi_b \widehat{\pi}_{t-1} + \kappa_c \left(\widehat{mc}_t + \frac{\tau}{1-\tau}\widehat{\tau}_t + \widehat{\mu}_t \right)$$

$\widehat{\pi}_t = \ln(P_t) - \ln(P_{t-1}) - \ln(\pi)$ is the deviation of inflation from its steady-state value, $\widehat{mc}_t + \frac{\tau}{1-\tau}\widehat{\tau}_t = \ln(W_t/P_t) - \ln A_t + \frac{\tau}{1-\tau}\widehat{\tau}_t - \ln((\eta-1)/\eta) + \ln(1-\tau)$, are log-linearized real marginal costs adjusted for the impact of the sales revenue tax, and the reduced-form parameters are defined as $\chi_f \equiv \frac{\alpha}{\Delta}$, $\chi_b \equiv \frac{\zeta}{\Delta}$, $\kappa_c \equiv \frac{(1-\alpha)(1-\zeta)(1-\alpha\beta)}{\Delta}$, with $\Delta \equiv \alpha(1+\beta\zeta) + (1-\alpha)\zeta$.

2.3 The Government

Government choices satisfy the flow budget identity

$$P_t^M B_t^M = (1 + \rho P_t^M) B_{t-1}^M - P_t Y_t \tau_t + P_t G_t + P_t Z_t + P_t Y_t \xi_{tp,t}$$

We assume short bonds are in zero net supply, so $B_t^S \equiv 0$. $P_t^M B_t^M$ is the market value of debt, $P_t G_t$ and $P_t Z_t$ are government spending and transfers and $P_t Y_t \xi_{tp,t}$ is an *i.i.d.* shock to the budget constraint that arises from random fluctuations in the debt maturity structure.[4] Government can use distorting taxes to service government debt and to stabilize the economy. We deliberately reduce the complexity of the tax system to a single measure of distortionary taxation. With a sufficiently wide array of fiscal instruments the policy maker could address the limited set of distortions that the model contains, in a manner that policy cannot achieve in the real world.[5] Divide through by nominal GDP, $P_t Y_t$, to rewrite the budget identity in terms of the ratio $b_t^M = \frac{P_t^M B_t^M}{P_t Y_t}$

$$b_t^M = \frac{(1 + \rho P_t^M)}{P_{t-1}^M} \frac{Y_{t-1}}{\pi_t Y_t} b_{t-1}^M - \tau_t + g_t + z_t + \xi_{tp,t}$$

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[4] This shock breaks a singularity that arises when all the other elements of the budget constraint are observables in estimation.

[5] For example, in a simple New Keynesian model optimal use of multiple tax instruments can replicate the first best allocation in the same way lump-sum taxes and a production subsidy can [Correia, Nicolini and Teles (2008)]. This would render our policy problem trivial.

where $\xi_{tp,t} = \sigma_{tp}\varepsilon_{tp,t}$ and we assume that the government spending-GDP ratio, g_t, evolves according to

$$\ln g_t = (1-\rho_g)\ln g + \rho_g \ln g_{t-1} + \sigma_g \varepsilon_{g,t}$$

and the transfers-GDP ratio, z_t, follows a similar process

$$\ln z_t = (1-\rho_z)\ln z + \rho_z \ln z_{t-1} + \sigma_z \varepsilon_{z,t}$$

The fiscal shocks, $\varepsilon_{tp,t}$, $\varepsilon_{g,t}$ and $\varepsilon_{z,t}$ are all standard normally distributed.

2.4 THE COMPLETE MODEL

The complete system of non-linear equations that describe the equilibrium appear in appendix A. After log-linearizing around the deterministic steady state, the model is summarized by[6]

$$\text{Labor Supply: } \sigma\widehat{X}_t + \varphi\widehat{N}_t = \widehat{w}_t \tag{4}$$

$$\text{Euler equation: } \widehat{X}_t = E_t\widehat{X}_{t+1} - \frac{1}{\sigma}\left(\widehat{R}_t - E_t\widehat{\pi}_{t+1} - E_t\widehat{q}_{t+1}\right) - \widehat{\xi}_t + E_t\widehat{\xi}_{t+1} \tag{5}$$

$$\text{Bond Prices: } \widehat{P}^M_t = \frac{\rho\beta}{\gamma\pi}E_t\widehat{P}^M_{t+1} - \widehat{R}_t \tag{6}$$

$$\text{Resource Constraint: } \widehat{y}_t = \widehat{N}_t = \widehat{c}_t + \frac{1}{1-g}\widetilde{g}_t \tag{7}$$

$$\text{Consumption Habits: } \widehat{X}_t = (1-\theta)^{-1}(\widehat{c}_t - \theta\widehat{c}_{t-1}) \tag{8}$$

$$\text{Phillips curve: } \widehat{\pi}_t = \chi_f\beta E_t\widehat{\pi}_{t+1} + \chi_b\widehat{\pi}_{t-1} + \kappa_c\left(\widehat{w}_t + \frac{1}{1-\tau}\widetilde{\tau}_t + \widehat{\mu}_t\right) \tag{9}$$

$$\begin{aligned}\text{Govt Budget: } \widetilde{b}^M_t \quad &= \quad \frac{1}{\beta}\widetilde{b}^M_{t-1} + \frac{b^M}{\beta}\left(\frac{\rho\beta}{\gamma\pi}\widehat{P}^M_t - \widehat{P}^M_{t-1} + \widehat{y}_{t-1} - \widehat{y}_t - \widehat{\pi}_t - \widehat{q}_t\right) \\ &\quad -\widetilde{\tau}_t + \widetilde{g}_t + \widetilde{z}_t + \sigma_{tp}\varepsilon_{tp,t}\end{aligned} \tag{10}$$

$$\text{Govt Spending: } \widetilde{g}_t = \rho_g\widetilde{g}_{t-1} + \sigma_g\varepsilon_{g,t} \tag{11}$$

$$\text{Transfers: } \widetilde{z}_t = \rho_z\widetilde{z}_{t-1} + \sigma_z\varepsilon_{z,t} \tag{12}$$

$$\text{Technology: } \widehat{q}_t = \rho_q\widehat{q}_{t-1} + \sigma_q\varepsilon_{q,t} \tag{13}$$

$$\text{Cost-Push/Markup: } \widehat{\mu}_t = \rho_\mu\widehat{\mu}_{t-1} + \sigma_\mu\varepsilon_{\mu,t} \tag{14}$$

$$\text{Preference: } \widehat{\xi}_t = \rho_\xi\widehat{\xi}_{t-1} + \sigma_\xi\varepsilon_{\xi,t} \tag{15}$$

To close the model we specify policy behavior.

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[6] The fiscal variables are normalized with respect to GDP, so $\widetilde{b}^M_t, \widetilde{\tau}_t$, $\widetilde{g}_t$, and $\widetilde{z}_t$ are defined as linear deviations from their steady states. Other variables are expressed as percentage deviations from steady state. Before linearizing, output, consumption and real wages are rendered stationary by scaling by technology, A_t.

3 Policy Making

Policy makers behave both optimally and strategically. We contrast the fit to data of this description of policy to a version of the model in which policy obeys the kinds of simple rules in existing literature. That rules-based benchmark appears in appendix C.

3.1 Optimal Policy

Now we describe our optimal policy specifications. Chen, Kirsanova, and Leith (2017) estimate monetary policy models of the U.S. economy to find that monetary policy is best described as optimal but time-consistent. The fit of that description dominates both rules-based and commitment Ramsey monetary policy. Extending this analysis to fiscal policy raises several considerations. First, the monetary and fiscal authorities are independent policy makers with potentially different policy objectives. This leads us to model strategic interactions between the two policy makers: they play a game where either authority may be the Stackelberg leader—making policy decisions anticipating the reaction of the other—or a Nash equilibrium where each policy maker takes the other's policies as given when formulating their own plans. Beetsma and Debrun (2004) argue that fiscal leadership is the best description of the interactions between monetary and fiscal authorities because in practice the monetary authority's response to shocks is well articulated and can be anticipated by the fiscal authorities.[7] Monetary policy is more nimble, able to react swiftly to news about economic conditions, including fiscal actions. We adopt this timing assumption in what follows. But we also estimated our model under the alternative assumptions of monetary leadership and the Nash solution. Changing the nature of the strategic interaction can have a material impact in simple models. This is not the case in our model, which features habits, inflation inertia and a desire to smooth instruments.[8]

Second, while Chen, Kirsanova, and Leith (2017) find strong evidence that monetary policy has been conducted optimally, albeit with switches in the degree of conservatism over time, it is not obvious that fiscal policy has been similarly optimal. This leads us to posit that monetary policy behaves optimally—with changes in degree of conservatism—while fiscal policy switches between rules-based and optimal time-consistent policy, as fit to data dictates.

An obvious approach to policy objectives would be to use the micro-founded welfare function based on the utility of the households that populate the economy.[9] But estimation with micro-founded weights is problematic. Because the micro-founded weights are functions of structural parameters, they place very tight cross-equation restrictions on the model, which are likely to deteriorate fit to data. With standard estimates of the degree of price stickiness, for example, the micro-founded weight attached to inflation can be over 100 times that attached to output [Woodford (2003, chapter 6)]. Optimal policy based on such a

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[7] Fiscal leadership is not fiscal dominance and does not imply that the fiscal authority forces the central bank to accommodate its actions. Leadership means that the central bank takes fiscal policy as given and it has a well-known reaction to the state of the economy, which the fiscal authority takes into account when setting policy. For example, the fiscal authority might anticipate that the central bank will act to stabilize inflation in the face of a fiscal stimulus.

[8] Results from alternative leadership assumptions are available upon request.

[9] See appendix B for the micro-founded welfare function.

strong anti-inflation objective would be wildly inconsistent with observed inflation volatility. Instead, we follow Chen, Kirsanova, and Leith (2017) and adopt a form of the objective function for each policy maker which is consistent with the representative agents' utility, but we freely estimate the weights within that objective function. The objective function for the monetary authority is

$$\Gamma_0^M = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \begin{array}{c} \omega_1 \left(\widehat{X}_t + \widehat{\xi}_t\right)^2 + \omega_2 \left(\widehat{y}_t - \frac{\sigma}{\varphi}\widehat{\xi}_t\right)^2 \\ +\omega_3 \left(\widehat{\pi}_t - \widehat{\pi}_{t-1}\right)^2 + \omega^M_{\pi,S_t}\widehat{\pi}_t^2 + \omega_R(\Delta \widehat{R}_t)^2 \end{array} \right\} \tag{16}$$

Under the optimal monetary policy specification, we consider potential switches in the weight attached to inflation stabilization, ω^M_{π,S_t}. That normalized weight can switch between $\omega^M_{\pi,S_t=1} = 1$ in the More-Conservative (MC) regime and $0 < \omega^M_{\pi,S_t=2} < 1$ in the Less-Conservative (LC) regime. We also allow monetary policy to value smooth interest rates.

Optimal fiscal policy minimizes

$$\Gamma_0^F = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \begin{array}{c} \omega_1 \left(\widehat{X}_t + \widehat{\xi}_t\right)^2 + \omega_2 \left(\widehat{y}_t - \frac{\sigma}{\varphi}\widehat{\xi}_t\right)^2 \\ +\omega_3 \left(\widehat{\pi}_t - \widehat{\pi}_{t-1}\right)^2 + \omega^F_{\pi}\widehat{\pi}_t^2 + \omega_\tau(\Delta \widetilde{\tau}_t)^2 \end{array} \right\} \tag{17}$$

The objective of the fiscal authority can differ from that of the monetary authority only in the weight attached to inflation, ω^F_π, the presence of a tax rate-smoothing term, and the absence of interest-rate smoothing. In essence, the two policy makers share the same conception of social welfare, but the government may appoint a monetary authority with an aversion to inflation that differs from that of society, to reflect Rogoff's (1985) arguments.

Habits externalities introduce the preference shock, $\widehat{\xi}_t$, into the objective functions. Habits confront policy makers with a trade off. When $\widehat{\xi}_t$ is high, utility of consumption and disutility of work are low. Policy makers will want to induce more labor, but any higher consumption from that labor produces a lower utility gain.

3.2 POLICY RULES

We adopt an agnostic view of fiscal behavior by not forcing it to be optimal at all times. When fiscal policy is not optimal and time-consistent—when it is not minimizing (17)—it obeys the tax rule

$$\widetilde{\tau}_t = \rho_{\tau,s_t}\widetilde{\tau}_{t-1} + (1-\rho_{\tau,s_t})\left(\delta_{\tau,s_t}\widetilde{b}^M_{t-1} + \delta_y \widehat{y}_t\right) + \sigma_\tau \varepsilon_{\tau,t} \tag{18}$$

The coefficient on debt, δ_{τ,s_t}, and the persistence of the tax rate, ρ_{τ,s_t} are subject to regime switching with $s_t = 2$ the Passive Fiscal (PF) regime and $s_t = 3$ the Active Fiscal (AF) regime. The value of the coefficient on debt determines fiscal regime, with $\delta_{\tau,s_t=2} > \frac{1}{\beta} - 1$ in the PF regime and $\delta_{\tau,s_t=3} = 0$ in the AF regime.

Transition matrices for monetary and fiscal policy regimes are

$$\Phi = \left[\begin{array}{cc} \phi_{11} & 1-\phi_{22} \\ 1-\phi_{11} & \phi_{22} \end{array} \right], \ \Psi = \left[\begin{array}{ccc} \psi_{11} & 1-\psi_{22}-\psi_{23} & \psi_{31} \\ \psi_{12} & \psi_{22} & 1-\psi_{13}-\psi_{33} \\ 1-\psi_{11}-\psi_{12} & \psi_{23} & \psi_{33} \end{array} \right]$$

where $\phi_{ii} = \Pr[S_t = i|S_{t-1} = i]$ and $\psi_{ii} = \Pr[s_t = i|s_{t-1} = i]$. The Optimal Fiscal (OF) regime corresponds to $s_t = 1$.

We also permit fundamental shock volatilities to change, a feature of existing explanations of the Great Moderation. Failure to do so can bias the identification of shifts in policy [Sims and Zha (2006)]. Standard deviations of technology (σ_{q,k_t}), preference (σ_{ξ,k_t}) and cost-push (σ_{μ,k_t}) shocks may switch independently, with $k_t = 1$ the low volatility regime and $k_t = 2$ the high volatility regime. The transition matrix for the shock volatilities is

$$H = \begin{bmatrix} h_{11} & 1 - h_{22} \\ 1 - h_{11} & h_{22} \end{bmatrix}$$

where $h_{ii} = \Pr[k_t = i|k_{t-1} = i]$.[10]

To solve the optimal policy problem, we develop a new algorithm that appendices D and E describe, with two policy makers under different structures of strategic interaction: when one policy maker can act as a Stackelberg leader in the policy game and when they move simultaneously as part of a Nash equilibrium. Our algorithm incorporates potential changes in policy makers' preferences over time.

3.3 Understanding Optimal Policy Behavior

To understand our results, it is helpful to review the Ramsey policy in which the two policy makers share a common objective and are able to credibly commit to future policy actions [see Leeper and Leith (2017) for an extensive discussion]. That policy setting delivers a variant of tax smoothing: the policy maker smooths the distortions associated with satisfying its budget constraint, using government debt as a shock absorber to do so. This doesn't mean that taxes themselves are smoothed, since tax rates will adjust to offset cost-push shocks; rather, policy smooths the distortions that would arise from not moving tax rates perfectly in line with cost-push shocks. This policy generates a random walk in debt: the short-run costs of reducing debt, once a given shock has dissipated, are exactly balanced by the long-run benefits of lower debt. In our model, the desire to reduce variations in the tax rate ensures that government debt is eventually retired back to its steady state even under commitment, but this is extremely gradual.[11] Another notable feature of outcomes under commitment is that although policy makers do utilize inflation surprises to help stabilize debt, reliance on such measures is limited.

When we relax the assumption that the policy maker can commit, outcomes change radically [Leeper and Leith (2017) and Leeper, Leith, and Liu (2020)]. Our economy possesses an efficient steady state in which the distortions that make output suboptimally low (monopolistic competition and distortionary taxation) balance the impact of the habits externality that makes output too high. This eliminates the inflationary bias problem in steady state. But any level of debt outside of this steady-state value creates an incentive for the policy maker to use inflation surprises. Those surprises would bring the decentralized equilibrium closer to the efficient allocation, both by influencing output in the sticky-price economy and

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[10] The joint transition matrix governing the monetary-fiscal-shock regime is $\Phi \otimes \Psi \otimes H$, to yield 12 regimes under optimal policy.

[11] Counterfactual outcomes under commitment and other forms of benchmark optimal policy are presented in figure 4 and described in subsection 5.1.

by reducing debt. The incentive to inflate generates an inflationary bias problem outside of the steady state because economic agents understand the policy maker's incentives. The policy maker can eliminate this bias by returning debt to steady state. But the rapid return of debt to steady state produces a "debt stabilization bias," as Leeper, Leith, and Liu (2020) label it, so policy makers stabilize debt more rapidly than they would under commitment. This explains why welfare outcomes under discretion are so much worse than commitment: the policy makers return debt to steady state far too rapidly, failing to use debt as a shock absorber, a phenomenon frequently observed in actual economies.

Optimal policy in our model also deviates from the Ramsey outcome by assuming that policy makers do not cooperate: they control their respective policy instruments and have different objectives. As discussed above, our policy makers act strategically with the fiscal authority the Stackelberg leader and the monetary authority the follower.[12] The separation of policy makers is actually beneficial from a societal perspective. The fiscal authority knows that if they aggressively try to reduce debt through taxation, the inflation-averse monetary authority will tighten monetary policy to reduce inflation. This moderates the use of taxes to stabilize debt, reducing the inflationary consequences of such a policy. Lower inflation prompts the monetary authority to refrain from tightening monetary policy. Looser monetary policy feeds back to encourage the fiscal authority to further delay fiscal stabilization because debt service costs are not as high. The net outcome from a lack of cooperation is that inflation is closer to target and debt gets stabilized more gradually.

The final complication in our description of optimal policy relative to the Ramsey is that economic agents in our model expect there to be switches in policy regimes. This is reasonable given the frequency of observed policy switches within our sample and the evolution of policy that Romer and Romer (2002b, 2010) describe. The main channel through which these effects manifest themselves is the impact of a potential switch to passive fiscal behavior on the optimizing regime. In the passive regime, distortionary taxes adjust to return debt to steady state. The more that debt deviates from target, the more strongly taxes adjust. Suppose debt is above target and fiscal policy is being conducted by an optimizing Stackelberg leader. Since policy can potentially switch to a passive regime, debt growth creates the expectation that a future change to passive behavior will raise the tax rate substantially, which drives up inflation. The optimizing fiscal authority responds to higher expected and current inflation by cutting current taxes.[13] This worsens debt dynamics, raising inflation expectations still more to encourage further tax cuts, and so on. If the economy stayed permanently in the non-cooperative optimal regime, while economic agents continue to expect a switch to one of passive fiscal policy regimes, this would ultimately be destabilizing. During specific sample periods, though, this policy behavior can describe data.

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[12] We considered alternative timing assumptions—simultaneous moves and the monetary authority acting as leader. This does not materially affect outcomes and there is no clear preference for one approach over another in terms of the marginal data density.

[13] The policy maker is not playing a game against future policy makers. But economic agents factor possible changes in policy regime into their expectations and the current policy maker responds to that behavior.

4 Estimation

The empirical analysis uses seven U.S. time series on real output growth (ΔGDP_t), annualized domestic inflation (INF_t), the federal funds rate (FFR_t), the annualized debt-GDP ratio (B_t/GDP_t), government spending ratio (G_t/GDP_t), transfers ratio (Z_t/GDP_t) and federal tax revenue ratio (T_t/GDP_t) from 1955Q1 to 2008Q3. All data are seasonally adjusted and at quarterly frequencies. Output growth is the log difference of real GDP, multiplied by 100. Inflation is the log difference of the GDP deflator, scaled by 400. The four fiscal variables—debt, government spending, transfers and taxes—are normalized with respect to GDP and multiplied by 100. Appendix F describes the dataset in detail.

The data are linked to the law of motion of states through the measurement equation

$$\begin{bmatrix} \Delta GDP_t \\ INF_t \\ FFR_t \\ G_t/GDP_t \\ T_t/GDP_t \\ Z_t/GDP_t \\ B_t/GDP_t \end{bmatrix} = \begin{bmatrix} \gamma^Q + \Delta\widehat{y}_t + \widehat{q}_t \\ \pi^A + 4\widehat{\pi}_t \\ r^A + \pi^A + 4\gamma^Q + 4\widehat{R}_t \\ 100g + \widetilde{g}_t \\ 100\tau + \widetilde{\tau}_t \\ 100z + \widetilde{z}_t \\ \frac{100}{4}b^M + \frac{1}{4}\widetilde{b}_t^M \end{bmatrix}$$

where parameters, γ^Q, π^A, r^A, g, τ, z and b^M represent the steady-state values of output growth, inflation, real interest rates the government spending-GDP ratio, transfers-GDP ratio, the tax rate, and debt-GDP on a quarterly basis.

Steady-state values of fiscal variables and output growth are fixed at their means over the sample period. The government spending-GDP ratio (g) is 8%, transfers (z) is 9.19%, the federal tax revenues to GDP ratio (τ) is 17.5%, the federal debt to annualized output ratio (b^M) is 31%, and quarterly output growth (γ^Q) is 0.46%. The steady-state real interest rate (r^A) is 1.8% and the inflation target (π^A) is 2%. The average real interest rate, r^A, is linked to the discount factor, $\beta = \left(1 + r^A/400\right)^{-1}$. Average maturity of outstanding government debt is 5 years [Leeper and Zhou (2020, table 1)]. The inverse of Frisch elasticity of labor supply, φ, is set to 2.[14]

We approximate the likelihood function using Kim's (1994) filter, and then combine it with the prior distribution to obtain the posterior distribution. A random walk Metropolis-Hastings algorithm generates four chains of 540,000 draws each, after discarding the first 240000 draws, and saving 1 in every 100 draws. Brooks-Gelman-Rubin potential reduction scale factors, reported in appendix G, are all below the 1.1 upper bound for convergence.

4.1 Prior Distributions

Table 1 reports the priors of the optimal policy model, which consists of priors that are common to the rules-based estimation in appendix C, as well as those for parameters specific to the optimal policy estimation, such as the weights on the objective function. Priors

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[14] It can be difficult to estimate the inverse of Frisch elasticity without using labor market data. The value $\varphi = 2$ is consistent with the estimate of Smets and Wouters (2007). This value is in line with microeconomic estimates using household level data as in MaCurdy (1981).

for most of the parameters are relatively loose and broadly consistent with the literature that estimates New Keynesian models. We choose the normal distribution for the inverse of the intertemporal elasticity of substitution, σ, with a prior mean of 2.5. Habits formation, indexation and the AR(1) parameters of the technology, cost-push, taste, transfers, government spending shocks follow a beta distribution with a mean of 0.5 and a standard deviation of 0.15. The Calvo parameter for the probability of no price change, α, is set so that the average length of the contract is around one year with a fairly tight prior around that value. Allowing a looser prior on this parameter tends to result in implausibly high estimates of the degree of price stickiness.

The parameters specific to optimal policy include the relative weights ($\omega_1, \omega_{2,}$ $\omega_{3,}$and ω_R) attached to the output, changes in inflation, and interest rate smoothing terms in the monetary policy objective function. Those follow beta distributions. The normalized weight on inflation, ω^M_{π,S_t}, is unity in the More Conservative (MC) regime and obeys a beta distribution in the Less Conservative (LC) regime. For the fiscal policy objective function, we restrict the relative weights attached to the output terms to be the same as those on the monetary policy objective function, while we estimate the weight on the inflation stabilization term, ω^F_π, placed by the fiscal authority. ω^F_π follows a Gamma distribution with prior mean of 1 and a standard deviation of 0.3, so we do not presume that the fiscal authority will be either more or less inflation conservative than the central bank. We assume that the fiscal authority wants to avoid large variations in tax rates and a beta distribution is used for ω_τ.

4.2 Posterior Estimates

Table 1 presents the posterior parameter estimates. These include when the monetary authority conducts optimal policy taking the policies of the fiscal authority as given, and where the monetary authority's objective function may switch in its degree of inflation conservatism over time—between More or Less Conservative. The fiscal authority acts as a Stackelberg leader in the game with the monetary authority, so the fiscal authority conducts policy anticipating the response of the Fed. Fiscal policy may switch between this leadership role—Optimal Fiscal (OF)—and simple passive or active fiscal rules, labeled PF and AF. Six alternative policy regimes may arise in the optimal policy model: MC/OF, MC/PF, MC/AF, LC/OF, LC/PF and LC/AF.

Monetary policy is always optimal, but time-consistent. The weight attached to inflation stabilization, ω^M_{π,S_t}, is 0.61 in the LC regime, relative to the normalized value of one in the MC regime. Despite a prior mean of $\omega^F_\pi = 1$, the posterior estimate under OF is 0.32, implying that the fiscal policy maker is substantially less averse to inflation than is the central bank, even when monetary policy is Less Conservative. These estimates are consistent with Rogoff's (1985) idea that the government should appoint a conservative central banker with a stronger dislike of inflation than the government, as measured by the fiscal authority's estimated objective function. When we compute the optimal degree of inflation conservatism for a delegated central bank given the estimated parameters, we find that the optimized weight of 1.4 lies above the normalized weight of one under the MC regime. These additional gains from conservatism, however, come from reducing inflation volatility below levels observed in data.

Estimates of the deep model parameters are similar to those under rules-based policy—

see appendix C—with a modest rise in the intertemporal elasticity of substitution, σ, to 3.2, indexation, ζ, to 0.37, and the degree of habits, θ, to 0.81. The other significant difference is that the estimated degree of persistence of the cost-push shock process, ρ_μ, rises from 0.21 to 0.93 as we move from the rules-based estimation to the optimal policy estimation, while the variance of *i.i.d.* innovations to the cost-push shock fall dramatically. The combined effect of these differences is that the standard deviation of the cost-push shock process is actually lower under the optimal policy estimation.[15] Although cost-push shocks generate a meaningful trade off for policy makers by raising inflation and reducing output, they do not rise to implausible levels in explaining the data when policy behaves optimally. Appendix H reports results from the Komunjer and Ng (2011) identification test, along with plots of the prior and posterior densities.

4.3 Model Comparison

Does modeling strategic interactions between optimizing policy makers deliver a reasonable statistical fit to data? Table 2 reports the log marginal likelihood values for models with rules-based and optimal strategic policies to provide a basis for comparison. We compute Geweke's (1999) modified harmonic mean estimator and the statistic that Sims, Waggoner, and Zha (2008) propose to draw similar conclusions. The latter method is designed for models with time-varying parameters, where the posterior density may be non-Gaussian. The two models fit data equally well.

We also present the marginal likelihood associated with an intermediate case in which we allow monetary policy to be time-consistent with switches in the degree of conservatism, while fiscal policy switches between active and passive rules, without the possibility of the fiscal authority behaving optimally.[16] The optimal policy model's fit is also comparable to the intermediate model's: episodes of fiscal Stackelberg leadership can help explain the data, even when those episodes occur relatively infrequently. Fiscal leadership is consistent with specific policy episodes. Fiscal leadership also affects fit because of the impact it has on other policy regimes through expectations. We discuss this issue below.

Model comparisons lead to a key finding that speaks to the bulk of the literature that estimates policy rules. Optimal policy fits data at least as well as policy rules or a combination of optimal monetary policy and fiscal rules. This is a surprising outcome in light of the additional restrictions that policy optimization imposes.

4.4 Regime Switching

We model monetary policy as optimal and fluctuating between the more (MC) and less (LC) conservative regimes. Fiscal policy can move among optimal policy (OF), a passive rule (PF), and an active rule (AF). Figure 2 reports probabilities of each policy–volatility regime over the sample. This section connects estimated policy shifts to narrative descriptions of the evolution of monetary and fiscal policies.

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[15] The unconditional standard deviation of the cost-push shock process under the rules-based estimation is 4.9% (13%) in the low (high) volatility regimes, but is only 1.5% (4.2%) under the optimal policy estimation. This compares to an unconditional standard deviation of the cost-push process in Smets and Wouters (2007) of 14.7%.

[16] Parameter estimates of this intermediate model are available upon request.

4.4.1 Monetary Policy Regimes

Looking at monetary policy alone, periods of the LC regime capture those identified as passive in the rules-based estimation [appendix C]. There are other periods in which monetary policy is less conservative. The late 1950s gave way to fluctuations in conservatism throughout the first half of the 1960s. Debate surrounds the anti-inflation stance of monetary policy in the 1950s: Romer and Romer (2002a) argue that policy makers appeared to recognize the need to fight inflation with monetary tightening, while Friedman (1960) was concerned that the policy of targeting free reserves implied a less conservative regime. Our switches in monetary policy regime in the late 1950s and early 1960s mirror this debate in the sense that relatively benign macroeconomic outcomes can be described as a mixture of more or less conservative monetary policy in this period.

By the mid 1960s, Romer and Romer (2002b) find that monetary policy makers seemed to believe that while rising inflation was driven by buoyant levels of output, inflation itself would soon stabilize without requiring a significant recession. This is consistent with the switch to the less conservative regime we see in the mid 1960s.

The Romers suggest that policy makers internalized the Friedman-Phelps accelerationist Phillips curve in the 1970s, but with an initially overoptimistic assessment of the natural rate of unemployment. That assessment evolved to a pessimistic view of the output costs of fighting inflation. This explains the loss of inflation conservatism throughout the 1970s.

The Volcker disinflation didn't really take hold until 1982 [Chen, Kirsanova, and Leith (2017)]. The switch to high conservatism in 1982 corresponds with an increasing acknowledgement of the costs of inflation on the part of monetary policy makers [Romer and Romer (2002b)] and Volcker's own assessment of when his deflation had finally achieved credibility.[17] Finally, the temporary loss of conservatism in 1987 reflects the operation of the "Greenspan put" as monetary policy responded to the Black Monday stock market crash of that year [Bornstein and Lorenzoni (2018)].

4.4.2 Fiscal Policy Regimes

Romer and Romer (2009, 2010) extensively analyze postwar tax changes. They distinguish among tax policies designed to reduce the budget deficit, attempts to affect aggregate demand, actions intended to pay for specific spending initiatives, and tax reforms aimed at enhancing long-run growth.

Throughout the 1950s and 1960s fiscal authorities ran either fiscal surpluses or small deficits, so the debt-GDP ratio gradually declined [figure 1]. In the brief period in the 1950s, which our estimates identify as optimal, Romer and Romer (2010) do not find any significant tax changes other than as a response to changes in spending. The stability of taxes, falling debt levels, and low and stable inflation observed in this period are all consistent with optimal fiscal policy. In the next decade, there are some limited tax measures designed to match additional spending commitments like the expansion of highways and social security, but without significant tax changes. The slower pace of debt reduction and rising inflation imply that policy is no longer optimal, switching to passive.

By the end of 1960s, the debt-GDP ratio has fallen below the implicit steady state and the Romers do not find instances of tax cuts designed to return debt back to steady state. Tax cuts at the time aimed to boost aggregate demand and reduce unemployment. Those

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[17] Silber (2012, chapters 11–13) details Volcker's belief that fiscal policy appeared to be beginning to pull in the same direction as monetary policy when the Reagan administration partially reversed their tax cuts in 1982 prompting him to write to the President suggesting that "we are turning the corner."

cuts were relatively small and were unable to overcome the fiscal drag generated by high inflation and a progressive tax system with non-indexed tax brackets. The upward trend in the tax burden, at a time of high inflation and low debt, explains why the estimates find that fiscal policy is predominantly active in the 1970s. Instances of non-active fiscal policy in this period are associated with the more sizeable tax cuts. The Nixon administration's tax reforms of 1970 appear as a passive policy, which then turned optimal as fiscal policy was further loosened before the 1972 election. Policy was optimal in the sense that reducing tax revenues as a share of GDP reduced the inflationary impact of distortionary taxation at a time when inflation was rising sharply, but debt levels were low. Ford's tax rebate in 1975 appears as a fleetingly passive fiscal policy when the debt-GDP ratio had fallen below its steady-state value.

The reason fiscal policy is identified as active in the 1970s differs from the reason in the 1980s to the mid-1990s. The former was a decade when fiscal authorities failed to cut taxes despite debt falling below steady state; in the latter period government did not generate sufficient tax revenues to prevent debt from rising rapidly. President Reagan introduced measures to mitigate the increase in the deficit in 1982 and enhance the sustainability of Social Security in 1983.[18] But these were dominated by the tax cuts contained in the earlier Economic Recovery Tax Act of 1981, which was phased in over three steps between 1982 and 1984. The Reagan administration also significantly reduced the progressivity of the tax system by eliminating tax brackets and indexing remaining brackets to inflation. The tax burden fell significantly and the debt-GDP ratio rose. There was no attempt to reduce the deficit under President George H. W. Bush either, until he broke his "no new taxes" pledge in budget negotiations with Congress in 1991. Dominance of large exogenous tax cuts over deficit targeting in the 1980s is consistent with finding that policy was active in this period.

Only with the passing of the Omnibus Budget Reconciliation Act of 1993 under President Clinton does fiscal policy emerge from the active regime to enter a sustained period of optimal or passive policy regimes. As in the 1950s, which our estimates label optimal, the second half of the 1990s is also marked by low and stable inflation and debt returning to steady state. These are the main features identified by our model as constituting optimal fiscal policy. Optimal fiscal behavior gives fiscal policy a prominent role in producing the observed stable inflation. Rules-based studies credit monetary policy fully with delivering those favorable inflation outcomes. In those studies, fiscal policy passively adjusts taxes to stabilize debt, playing no role in determining inflation.

The active fiscal regime re-emerges around President G. W. Bush's cuts taxes in 2001 and 2003, partly to promote long-term growth and partly to offset the macroeconomic shock associated with the 9/11 terrorist attacks. Finally, the switch to passive policy after 2005 is not obviously due to any observed discrete policy changes, but likely reflects the increase in revenues generated by the booming economy leading up to the financial crisis that began in 2007.

4.4.3 Welfare Gaps

To gain further insight into which features of the data drive the identification of the various policy regimes, we examine the welfare-relevant "gaps" policy makers aim to close. We consider four gaps: inflation, output, taxes, and debt, where

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[18] The Tax Equity and Fiscal Responsibility Act of 1982 and Social Security Amendments of 1983.

inflation and debt gaps measure the deviation of the variable from its steady state or target value. The output gap, $\widehat{y}_t - \widehat{y}_t^*$, computes the deviation of output from the level of output that would be chosen by the social planner, $\widehat{y}_t^*$ [appendix I]. This output gap captures the extent to which the policy maker is unable to achieve the desired level of output due to nominal inertia, the habits externality, fiscal constraints, and time-consistency problems. It reflects the welfare trade offs between inflation and the real economy embedded in the estimated objective function, but reduces those to a single measure. The tax gap, $\widetilde{\tau}_t - \widetilde{\tau}_t^*$, is the difference between the actual tax rate, $\widetilde{\tau}_t$, and the rate that a policy maker could choose to eliminate cost-push shocks, $\widetilde{\tau}_t^* = -(1-\tau)\widehat{\mu}_t$. This reflects the fact that distortionary taxation acts as a form a cost-push shock in the NKPC, so that tax cuts can, potentially, be used to offset realized cost push shocks driven by variations in the desired markup. For this reason, the inflation and tax gaps are often, to some extent, the mirror image of each other, as both are influenced by the estimated cost-push shocks.

The top two panels of figure 3 plot the inflation and output gaps alongside the probability that monetary policy is in the LC regime. This shows that the LC regime arises from periods of higher inflation for a given output gap. Although there is a sizeable negative output gap in the early 1970s, this was not as large relative to the levels of excess inflation found during the Volcker disinflation. This is why the Volcker period shows up as a switch to more conservative monetary policy. Similarly, a more conservative policy maker would not have suffered the modest rise in inflation which was associated with the loosening of monetary policy after the stock market crash of 1987.

The bottom two panels of figure 3 plot the tax and debt gaps, alongside the probabilities of being in the OF and PF fiscal regimes. The relatively rare optimal fiscal regime in the 1950s and in 1995 corresponds to periods when the tax, output, and inflation gaps are modest, with debt returning to steady state. Passive fiscal policy is associated with debt-stabilizing movements in taxation predominantly in the 1960s. Exit from the passive fiscal regime in the late 1960s corresponds to a period of rising tax gap that was not consistent with the negative debt gap in the 1970s; these gaps are then reversed from the 1980s to the mid 1990s. Seen in this way, the prolonged periods of active fiscal behavior—throughout the 1970s and then the 1980s until 1995—are due to tax policies that fail to stabilize debt in both directions.

5 Welfare

This section explores how different permutations of policies are ranked in terms of welfare, before turning to describe what drives these welfare differences. Table 3 reports the unconditional variances of key variables as well as the implied welfare cost of shocks under various policy regimes. To measure welfare, we use the fiscal authority's objective function, excluding the tax-rate smoothing term. This is a more natural measure of social welfare than is the monetary authority's objective function because central bank objectives reflect Rogoff's (1985) suggestion to appoint monetary policy makers with stronger aversion to inflation than society at large. The fiscal authority's dislike of inflation, by contrast, reflects society's. From this social welfare measure, we report the "welfare cost" as how much steady-state inflation the policy maker would be willing to accept to achieve the Ramsey allocations.

We collect results in two groups—no credibility and full credibility—and order equilibria by their welfare implications within each group; the far right column of the table reports the overall ranking across the two credibility groups. A credible regime is a once-for-all switch in policy, so economic agents do not anticipate any movement away from that regime. A non-credible regime is one where economic agents anticipate fluctuations in regime in line with the estimated transition probabilities.

The benchmark equilibrium—"Commitment/Ramsey"—appears in the first row of the Full Credibility panel of table 3. That policy regime uses tax rates extensively to almost completely stabilize inflation: fiscal actions are integral to inflation control.

Turn to the table's "No Credibility" group. The "Estimated" case ranks 8th overall, with an equivalent inflation cost of 1.17% relative to Ramsey. This case reflects an environment where policy regimes switch in line with the estimated transition probabilities. Any regime ranked higher than 8th improves on historical policies. The other two non-credible regimes combine a passive fiscal policy with either a more or less conservative monetary policy; regimes remain in place indefinitely, even though economic agents anticipate switches to other policy regimes according to the estimated transition probabilities. Adopting a passive fiscal rule, even if it lacks credibility, would lead to a marginal improvement over the estimated mix of regimes. Remaining permutations of policies create unstable debt dynamics if followed indefinitely, as the counterfactual assumes; a welfare ranking cannot be obtained for these regimes.

Results differ sharply when the policy regime is fully credible. A credible combination of a conservative central bank following a Stackelberg leading fiscal authority comes closest to achieving the Ramsey outcome. Its inflation-equivalent cost is only 0.6%. This is striking because without credibility the same regime cannot stabilize debt. There is a slight deterioration in welfare if the monetary authority is less conservative, but still combined with an optimal fiscal policy. Otherwise, the credible regimes that improve upon historical policies require that the monetary authority be more conservative. Any other credible regime with a less conservative monetary policy and either a passive or active fiscal rule deteriorates in welfare relative to the estimated policy mix. A mix of LC/AF produces the largest welfare losses.

The credible and cooperative, but time-consistent policy, labeled "Discretion," also performs poorly. With a rank of #10, it comes in below the estimated mix. Poor outcomes occur because the discretionary policy suffers from a "debt stabilization bias," which we discuss below.

5.1 Avoiding the Great Inflation with Optimal Fiscal Leadership

Figure 4 reports a set of counterfactuals that highlight the features of the best performing policy regimes. The left column plots equilibrium time paths from the #2 ranked regime in table 3—credible MC/OF—along with the same regime without credibility and actual data. The right column repeats the data beside paths under credible cooperative policies—Commitment and Discretion, ranked #1 and #10 in the table and discussed in section 3.3. Comparing outcomes within and across columns reveals how a credible policy of fiscal leadership comes close to achieving the welfare levels observed under a cooperative Ramsey policy.

Optimal fiscal policy improves welfare only under full credibility. When a regime is not credible, agents expect it will change eventually. That expectation creates spillovers across regimes that show up in the dotted lines in the first column of figure 4. When regime change is possible, even if current fiscal is optimal, economic agents anticipate the rise in taxes and, therefore, inflation that would occur whenever the economy switches to a passive fiscal rule in the future. Through the New Keynesian Phillips curve, the rise in expected inflation raises inflation today, inducing the fiscal authority to cut taxes today to offset those contemporary inflationary effects. This reduces inflation today, but raises debt accumulation and inflation volatility. If not credible, this regime would ultimately be unstable as progressively higher debt levels fuel inflation.

Credible optimal fiscal leadership—dashed lines in the left column—produces large sustained movements in debt that are ultimately stabilized. Inflation does not deviate significantly from target. Comparing dashed lines for inflation across the two columns reveals that credible strategic policies deliver nearly identical inflation outcomes as cooperative Ramsey policies.

Inflation outcomes in the left column point to a key finding in the paper. Optimal fiscal leadership could have avoided the Great Inflation. Actual inflation averaged 5.80% from 1965 to 1982. A credible mix of MC/OF would have reduced that average to 3.30%; if the mix were not credible, inflation would have averaged 3.48%.[19]

This is a new finding that places fiscal behavior at the center of understanding sources of the Great Inflation. Although the consensus view places the Great Inflation squarely at the feet of the Fed, this finding reveals optimal fiscal leadership to be a potentially powerful source of inflation stabilization, particularly when coupled with more conservative monetary policy.[20]

5.2 Is Cooperation Welfare Enhancing?

The second column of the figure plots outcomes under cooperative policies with and without commitment. Cooperative policies emerge when monetary and fiscal authorities share the same objective—the estimated objective function of the fiscal authority, which is assumed to represent social welfare. The Ramsey/Commitment policy dramatically stabilizes inflation, using substantial movements in debt to smooth tax distortions. Deviations from pure tax smoothing reflect the desire to offset cost-push shocks through variations in distortionary taxation. Substantial tax cuts in the 1970s largely offset the big cost-push shocks estimated to have hit the economy during that period. The increase in the tax rate in the mid-1980s reflects a reversal in persistent cost-push shocks from positive to negative, inducing a desirable offsetting rise in taxation.

Time-consistent discretionary policy, in contrast, poses very different incentives for cooperative policy makers. Consider a shock that raises government debt above target. Governments face a temptation to reduce the debt burden through inflation surprises. This temptation grows with the level of debt to create a state-dependent inflationary bias problem. Private agents understand those incentives, raising inflation and inflationary expectations until the government no longer wishes to generate such surprises. By raising taxes more

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[19] These compare to the commitment average of 2.02%. Steady-state inflation is 2% in the model.

[20] Bianchi and Ilut (2017) also give fiscal policy a prominent role in the Great Inflation, but they do not credit optimal fiscal behavior with the ability to avoid the inflation.

than tax-smoothing considerations alone would dictate, the government can return debt to steady state to mitigate the associated inflationary bias. This aggressive reduction in debt is called the "debt stabilization bias" [Leeper and Leith (2017) and Leeper, Leith, and Liu (2020)].[21]

The top right panel of figure 4 underscores that the debt stabilization bias can be sizable. In place of a Ramsey policy that would have allowed debt to reach 130% or more of GDP in the 1990s and 2000s, time-consistent discretionary policy and its associated stabilization bias would have kept debt well below 50%.

Contrasting the outcomes under cooperative policy—right column—with those under strategic interactions—left column—the credible regime of fiscal leadership combined with a conservative monetary follower closely mimics outcomes under commitment. Both would have offset inflation by reducing taxes and permitted a sustained increase in debt to support that fiscal policy.

The welfare rankings highlight the importance of credibility: a fiscal authority credibly acting as a Stackelberg leader in a game with the monetary authority results in outcomes closest to those achieved under a cooperative Ramsey policy. Without credibility, such a policy mix would lead to an unstable debt path if pursued indefinitely when economic agents expect the policy regime to switch. Finally, strategic interaction between the monetary and fiscal authorities is generally beneficial when the policy makers are unable to commit. Cooperative time-consistent policies, on the other hand, suffer from a debilitating debt stabilization bias. Cooperation can be detrimental for welfare.

6 Conclusions

The evolution of inflation dynamics in the United States, as seen through the lens of a conventional New Keynesian model, cannot be understood without explicitly modeling the stance of fiscal policy. A model that allows monetary policy to be optimal, but with potential switches between more- or less-conservative inflation aversion, and fiscal policy to switch among a passive and an active fiscal rule and time-consistent Stackelberg leadership fits post-war American data at least as well as purely rules-based policies.

This environment offers fresh interpretations of monetary and fiscal policy interactions than the rules-based model. The narrative that the switch in monetary policy at the time of the Volcker disinflation was associated with a similar switch in fiscal policy making from a regime where the fiscal authorities did not act to stabilize debt to one where they did, does not fit time series data. Instead, we find that the Volcker disinflation occurred around 1982, but wasn't supported by a debt stabilizing fiscal policy until 1995 and even then this policy was subject to further revisions. There are numerous switches between the various permutations of policies, with a passive fiscal policy still not clearly supporting the post-Volcker monetary conservatism observed in the data. The implicit assumption that allows fiscal policy to be safely ignored in monetary policy models is inconsistent with U.S. data.

Counterfactuals suggest that adopting an optimal fiscal policy can be welfare improving, but only if it is credible. The ideal time-consistent policy regime would couple Stackelberg

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[21] Under commitment the temptation remains, but governments are able to resist the temptation. Under discretion rational agents anticipate the temptation and inflationary expectations rise to eliminate the temptation. The debt stabilization bias reduces debt rather than letting it follow a random walk.

leader fiscal authority with a conservative monetary authority. That regime comes close to mimicking the outcomes that would have been observed under a cooperative Ramsey policy. This regime must be fully credible in the sense that there is no expectation that policy will switch to any alternative policy combination. Enhancing cooperation can actually reduce welfare relative to the case of strategic interactions between distinct monetary and fiscal authorities.

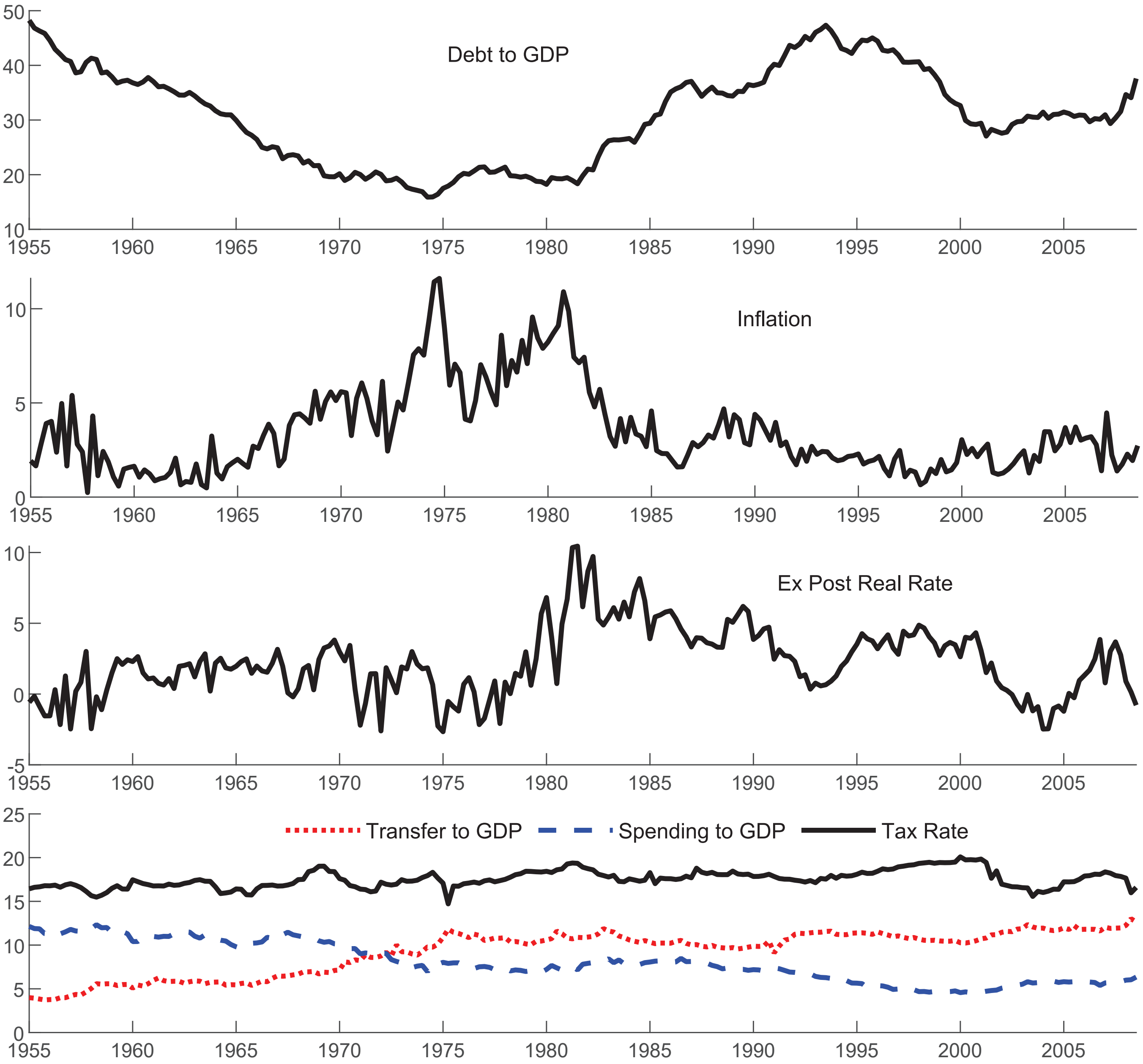

Figure 1: United States Data.

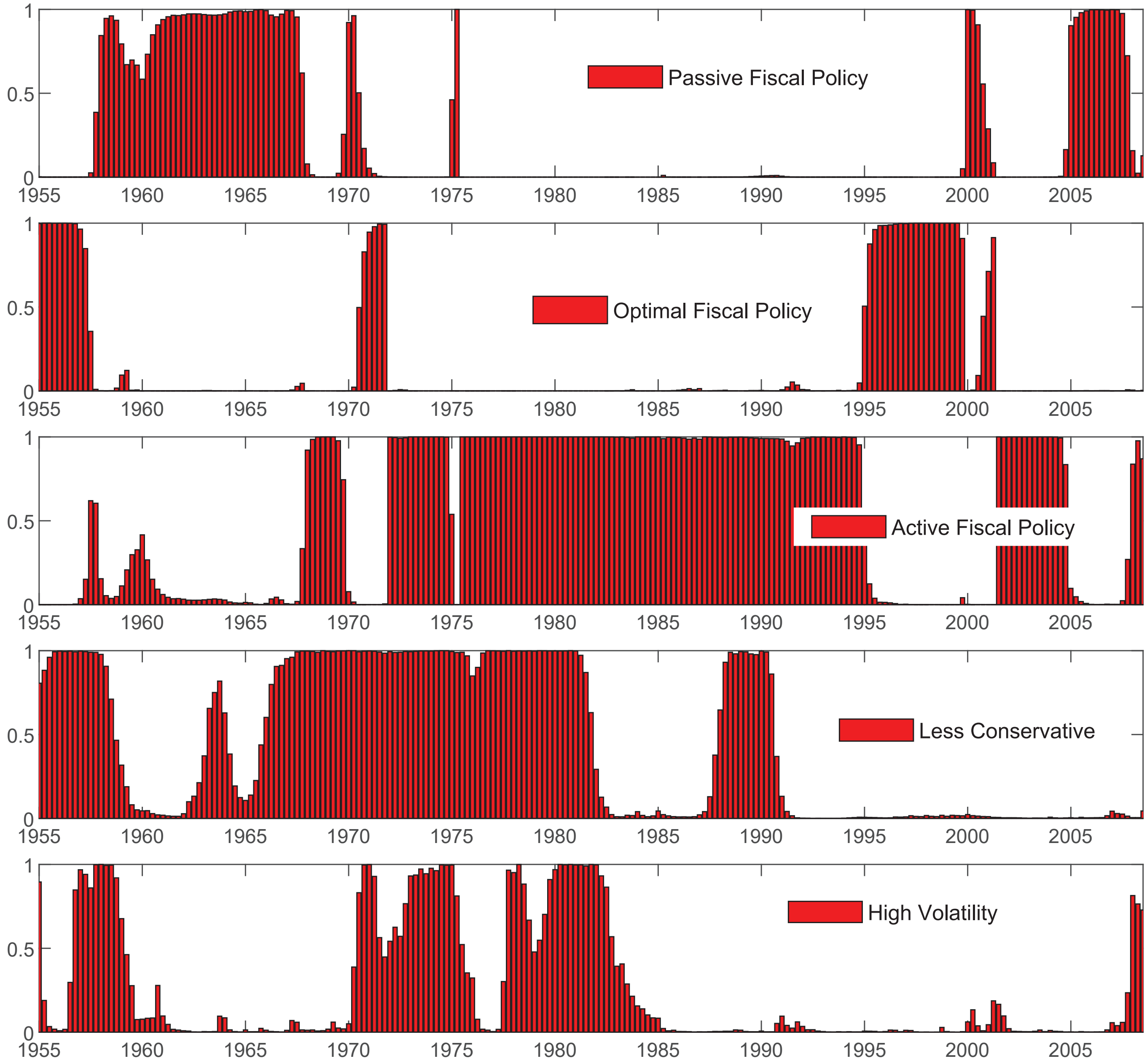

Figure 2: Markov Switching Probabilities: Policy and Volatility Switches under Optimal Strategic Policy

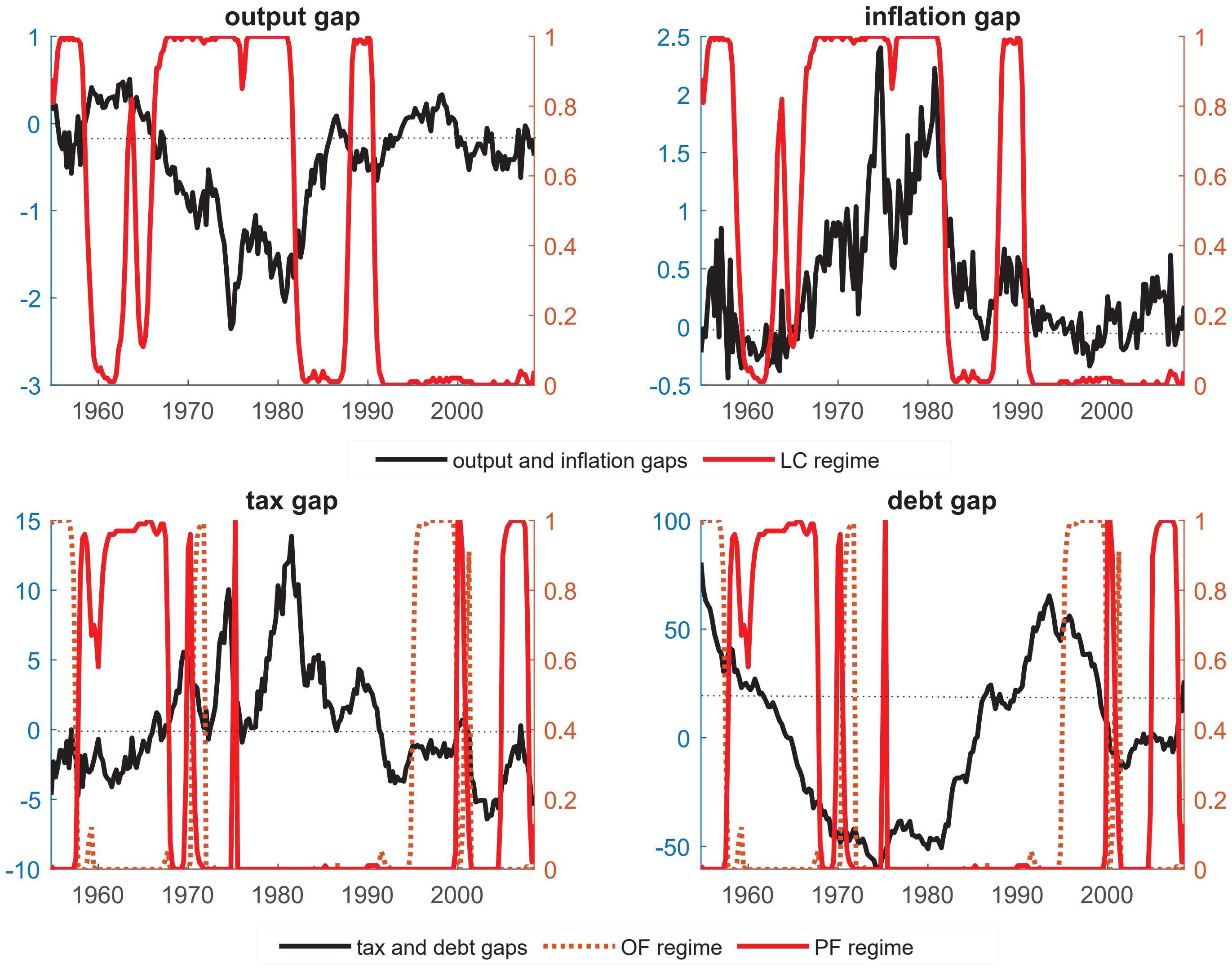

Figure 3: Output, Inflation, Tax, Debt and Policy Regimes. The output gap measures the difference between output and what would be chosen by a social planner given the estimated objective function as a percentage, as Appendix I describes. Inflation and debt gaps measure the deviation from steady state and the tax gap is the difference between the percentage tax rate and the tax rate that would perfectly offset the inflationary impact of cost push shocks. All gaps are measured on the left scale and the probability of policy regimes on the right scale.

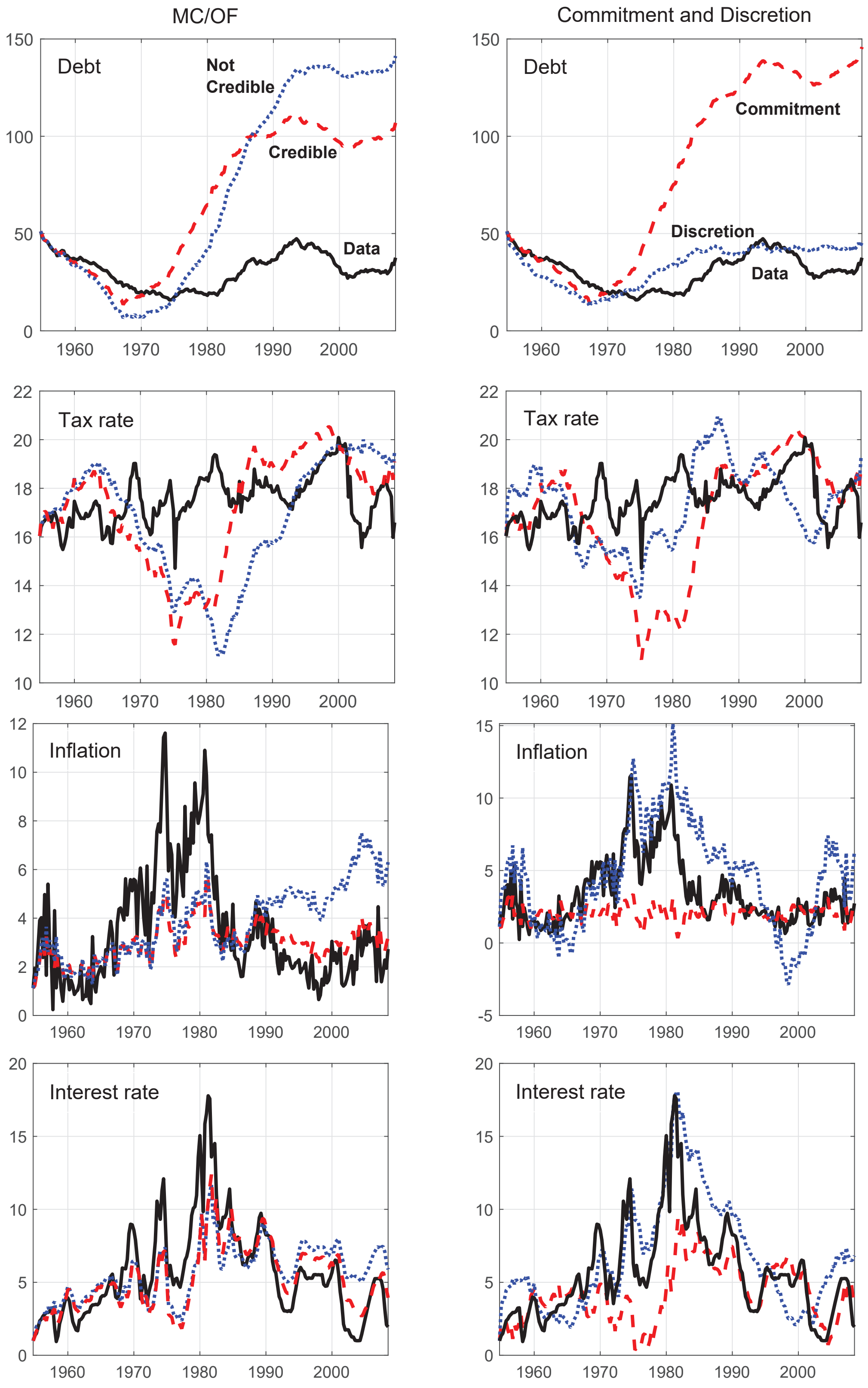

Figure 4: "Best" Policy Regimes: Optimal Strategic Policy and Cooperation. In the left column, policies interaction strategically; in the right column, policies cooperate by maximizing a shared welfare function.

	Posterior				Prior		
Parameters	Mode	Mean	5%	95%	Type	Mean	Std Dev
Optimal policy parameters							
ω_1, gap term, $\hat{X}_t - \hat{\xi}_t$,	0.221	0.208	0.135	0.280	B	0.50	0.10
ω_2, gap term, $\hat{y}_t - \frac{\sigma}{\varphi}\hat{\xi}_t$,	0.256	0.247	0.177	0.318	B	0.50	0.10
ω_3, change in inflation	0.422	0.420	0.271	0.588	B	0.50	0.10
$\omega^M_{\pi,S_t=1}$, inflation	1.00	1.00	-	-	Fixed	-	-
$\omega^M_{\pi,S_t=2}$, inflation	0.611	0.601	0.484	0.722	B	0.50	0.10
ω_R, change in interest	0.739	0.724	0.568	0.882	B	0.50	0.15
$\omega^F_{\pi,s_t=1}$, inflation	0.298	0.316	0.193	0.433	G	1.00	0.30
$\omega_{\tau,s_t=1}$, change in tax	0.699	0.659	0.491	0.812	B	0.50	0.15
$\rho_{\tau,s_t=2}$, lagged tax rate	0.964	0.950	0.924	0.971	B	0.70	0.15
$\rho_{\tau,s_t=3}$, lagged tax rate	0.932	0.935	0.914	0.960	B	0.50	0.15
$\delta_{\tau,s_t=2}$, tax rate resp. to debt	0.045	0.050	0.037	0.062	G	0.05	0.02
$\delta_{\tau,s_t=3}$, tax rate resp. to debt	0.00	0.00	-	-	Fixed	-	-
Deep parameters							
σ, Inverse of intertemp. elas. of subst.	3.102	3.208	2.759	3.631	N	2.50	0.25
α, Calvo parameter	0.780	0.774	0.751	0.797	B	0.75	0.02
ζ, inflation inertia	0.353	0.366	0.277	0.458	B	0.50	0.10
θ, habit persistence	0.802	0.810	0.736	0.885	B	0.50	0.10
φ, Inverse of Frisch elasticity	2.00	2.00	-	-	Fixed	-	-
Serial correlation of shocks							
ρ_ξ, AR coeff., taste shock	0.938	0.942	0.931	0.953	B	0.50	0.15
ρ_μ, AR coeff., cost-push shock	0.938	0.931	0.912	0.949	B	0.50	0.15
ρ_q, AR coeff., productivity shock	0.274	0.280	0.211	0.350	B	0.50	0.15
ρ_z, AR coeff., transfers	0.968	0.971	0.960	0.982	B	0.50	0.15
ρ_g, AR coeff., government spending	0.986	0.984	0.978	0.989	B	0.50	0.15

Table 1: Optimal Policy. Under optimal policy, we have six policy permutations: MC/OF, MC/PF, MC/AF, LC/OF, LC/PF, LC/AF. For monetary policy switches, $S_t = 1$ is the MC regime and $S_t = 2$ is the LC regime. For fiscal policy, the OF policy regime corresponds to $s_t = 1$, while the PF and AF regimes correspond to $s_t = 2$ and $s_t = 3$, respectively. Weights $\omega_1, \omega_2, \omega_3$ are constant across monetary and fiscal policy regimes.

	Posterior				Prior		
Parameters	Mode	Mean	5%	95%	Type	Mean	Std Dev
Standard deviation of shocks							
$\sigma_{\xi,k_t=1}$, taste shock	0.804	0.874	0.608	1.126	IG	0.50	2.00
$\sigma_{\xi,k_t=2,}$ taste shock	2.318	2.309	1.539	3.075	IG	0.50	2.00
$\sigma_{\mu,k_t=1,}$ cost-push shock	0.545	0.617	0.487	0.740	IG	0.50	2.00
$\sigma_{\mu,k_t=2,}$ cost-push shock	1.660	2.001	1.401	2.580	IG	0.50	2.00
$\sigma_{q,k_t=1,}$ productivity shock	0.684	0.680	0.605	0.759	IG	0.50	2.00
$\sigma_{q,k_t=2}$, productivity shock	1.218	1.286	1.055	1.507	IG	0.50	2.00
σ_{tp}, term premium shock	2.558	2.587	2.332	2.839	IG	2.00	2.00
σ_g, government shock	0.161	0.163	0.150	0.176	IG	0.50	2.00
σ_z, transfer shock	0.303	0.305	0.281	0.330	IG	0.50	2.00
σ_τ, tax rate shock	0.234	0.243	0.217	0.268	IG	0.50	2.00
Transition probabilities							
ϕ_{11}, monetary policy: remaining mc	0.962	0.962	0.942	0.983	B	0.95	0.05
ϕ_{22}, monetary policy: remaining lc	0.956	0.889	0.859	0.922	B	0.95	0.05
ψ_{11}, fiscal policy: remaining optimal	0.875	0.873	0.844	0.902	D	0.90	0.05
ψ_{12}, optimal to passive fiscal policy	0.004	0.008	0.000	0.016	D	0.05	0.05
ψ_{22}, fiscal policy: remaining passive	0.966	0.949	0.920	0.978	D	0.90	0.05
ψ_{23}, passive to active fiscal policy	0.007	0.013	0.000	0.025	D	0.05	0.05
ψ_{33}, fiscal policy: remaining active	0.916	0.912	0.889	0.936	D	0.90	0.05
ψ_{31}, active to optimal fiscal policy	0.001	0.005	0.000	0.010	D	0.05	0.05
h_{11}, volatility: remaining with lv	0.965	0.952	0.925	0.982	B	0.90	0.05
h_{22}, volatility: remaining with hv	0.894	0.943	0.906	0.979	B	0.90	0.05

Table 1: Optimal Policy (continued). For volatility, $k_t = 1$ is the low volatility regime and $k_t = 2$ is the high volatility regime.

	Log Marginal Data Density	
Model	Geweke	Sims, Waggoner, Zha
Optimal Policy	−1410.627	−1410.502
Intermediate Model	−1416.304	−1416.392
Rules-Based Policy	−1418.116	−1418.541

Table 2: Model Comparison. The intermediate model treats monetary policy as time-consistent optimal policy with changes in the degree of inflation conservatism, while fiscal policy switches between the PF and AF regimes. The optimal policy model adds to the intermediate model the possibility that fiscal policy may switch to an additional OF regime.

Regime	Output	Inflation	Interest	Tax	Welfare Cost	Ranking
No Credibility						
MC/PF	0.482	0.333	0.332	3.116	1.12	6
LC/PF	0.443	0.624	0.415	2.900	1.14	7
Estimated	0.458	0.468	0.367	2.546	1.17	8
Full Credibility						
Commitment/Ramsey	0.610	0.005	0.781	10.455	0.00	1
MC/OF	0.405	0.121	0.297	3.84	0.60	2
LC/OF	0.372	0.416	0.333	3.124	0.84	3
MC/AF	0.437	0.259	0.244	1.136	1.02	4
MC/PF	0.477	0.305	0.280	3.075	1.09	5
LC/PF	0.454	0.720	0.477	3.071	1.21	9
Discretion	0.596	0.910	2.426	192.075	1.41	10
LC/AF	1.522	11.076	8.295	0.403	3.80	11

Table 3: Unconditional Variances and Welfare With Regime Switching. Welfare cost is measured as the amount of steady-state inflation equivalent the policy maker would pay to move to the Ramsey outcome. Output is $\hat{y}_t$, inflation is $\hat{\pi}_t$, interest is $\hat{R}_t$, and tax is $\tilde{\tau}_t$.

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