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Abstract

Is inflation 'always and everywhere a monetary phenomenon' or is it fundamentally a fiscal phenomenon? This article augments a standard monetary model to incorporate fiscal details and credit market frictions. These ingredients allow for both interpretations of the inflation process in a financially constrained environment. We find that adding financial frictions to the model generates important identifying restrictions on the observed pattern between inflation and measures of financial and fiscal stress, to the extent that it can overturn existing findings about which monetary-fiscal policy regime produced the pre-crisis U.S. data.

Keywords: monetary and fiscal policy; financial frictions; marginal likelihood.

JEL Classification: C52, E44, E62, E63, H63

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1 Introduction

In any dynamic model with nominal government debt, there are two regions of the policy parameter space in which monetary and fiscal policy can *jointly* determine inflation and stabilize debt [Leeper (1991), Sims (1994), Woodford (1995)]. One region produces active monetary and passive fiscal policy or regime-M, yielding the conventional paradigm of inflation determination. Regime-M assigns monetary policy to control inflation by raising nominal interest rate aggressively with inflation and fiscal policy to stabilize debt by adjusting taxes or spending. A second region consists of passive monetary and active fiscal policy or regime-F, producing the fiscal theory of the price level. Under regime-F, policy roles are reversed with monetary policy responding weakly to inflation and fiscal instruments adjusting weakly to government debt. Because these two policy regimes imply completely different mechanisms for price level determination and therefore starkly different policy advice, identifying the prevailing regime is a prerequisite to understanding the macroeconomy and to making good policy choices.

While the popular surplus-debt regressions are subject to potential simultaneity bias that may produce misleading inferences about the nature of fiscal behavior, testing endeavors based on general equilibrium models, on the other hand, find nearly uniform statistical support for regime-M in the pre-crisis U.S. data [Traum and Yang (2011), Leeper and Li (2017)].[1] This consensus emerged even from periods of fiscal stress during which monetary policy appears to lose control over inflation. Scant attention, however, has been paid to the empirical relevance of financial frictions in discerning the underlying regime despite the strong comovement between measures of financial and fiscal stress shown in Figure 1. A natural question is then what are the effects of credit risk on inflation. The answer hinges on the policy regime.

This article assesses the identification role of credit market imperfections. To that end, we extend a standard medium-scale dynamic stochastic general equilibrium (DSGE) model in two aspects. In particular, we follow Leeper, Traum and Walker (2017) (henceforth, LTW) to fill in details of the fiscal policy and incorporate credit market frictions as in Christiano, Motto and Rostagno (2014) (henceforth, CMR). These ingredients allow for a comprehensive study of monetary and fiscal policy interactions in a financially constrained environment.

Our key findings are twofold. First, adding financial frictions to the model improves the relative statistical fit of regime-F, to the extent that it can fundamentally alter the regime ranking found in the literature. Second, the two regimes produce strikingly different inflation dynamics following a credit crunch. Contrary to regime-M that underlies CMR's analysis, elevated credit risk brings forth heightened fiscal uncertainty and inflation through the mechanism that regime-F emphasizes. The implied pattern between inflation and measures of financial and fiscal stress is consistent with the empirical evidence in the 1970s and the recent Great Recession.

[1] The literature on regime-switching monetary and fiscal policy constitutes an exception.

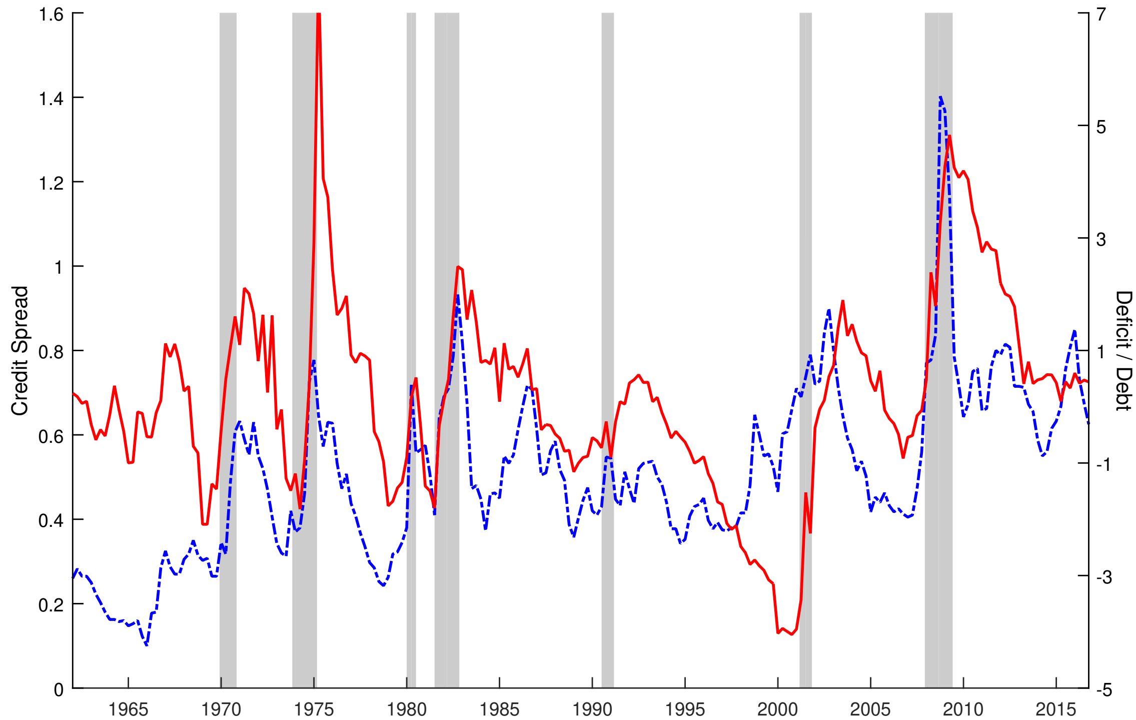

Figure 1: Financial stress and fiscal stress. Notes: The left and right vertical axes measure the credit spread (blue dashed line, measured by Baa Corporate Bond Yield over Ten-Year Treasury Constant Maturity Rate) and the deficit-to-debt ratio (red solid line, measured as in Sims (2011) by primary deficit as a proportion of lagged market value of privately held debt). Shaded bars indicate recessions as designated by the National Bureau of Economic Research.

2 The Models

This section briefly outlines the benchmark DSGE model for the subsequent empirical analysis. A detailed model description and its variants can be found in the Online Appendix. We denote $\hat{x}_t \equiv \ln(x_t) - \ln(x)$ the log-deviation of a variable x_t from its steady state x unless otherwise noted, and consider a log-linear approximation to the model's equilibrium conditions around the steady state.

2.1 Households and Firms

The economy is populated by a continuum of optimizing households indexed by $j \in [0, 1]$. Each household j derives utility from real consumption goods $C_t(j)$ relative to a habit stock, and suffers disutility from the aggregate quantity of a continuum of differentiated labor services $L_t(j)$. They have access to both nominal deposits D_t at banks that pay a non-contingent gross return R_t in period $t+1$ and a portfolio of long-term nominal government bonds B_t with price P_t^B. This general bond portfolio consists of perpetuities with coupons that decay at the constant rate $\rho \in [0, 1]$. Households receive deposit and bond earnings, labor income, profits from firms, and transfers from entrepreneurs, and pay lump-sum tax net of transfer $T_t(j)$ to the government. A perfectly competitive labor packer hires a continuum of differentiated labor $L_t(l)$ indexed by $l \in [0, 1]$, packs them to produce the aggregate labor L_t^d, and sells it to intermediate goods producers at price W_t. Each household can change the wages $W_t(l)$ of only a fraction of all labor services each period to maximize her expected lifetime utility; wages that cannot be reoptimized are partially indexed to past inflation.

The production sector consists of firms that produce intermediate and final goods. A perfectly competitive final goods producer combines the intermediate goods $Y_t(i)$ supplied by a continuum of intermediate goods producers indexed by $i \in [0, 1]$ to produce the final goods Y_t with price P_t. Intermediate goods producers are monopolistic competitors and choose the effective capital $K_t(i)$ at rental rate R_t^k and "packed" labor $L_t^d(i)$ at wage W_t in perfectly competitive factor markets. Their production function is subject to a labor-augmenting technological shock A_t that induces a stochastic trend to the model. Only a fraction of them can change the prices $P_t(i)$ each period to maximize their expected discounted future real profits; firms that cannot reoptimize partially index their prices to past inflation.

2.2 Financial Frictions A perfectly competitive capital goods producer accumulates physical capital with an investment adjustment cost and sells it to a continuum of entrepreneurs indexed by $e \in [0, 1]$ at price Q_t^k. Each entrepreneur e combines her net worth $N_{t-1}(e)$ with loans $B_{t-1}^d(e)$ from banks to acquire $\bar{K}_{t-1}(e)$ units of physical capital at the end of period $t-1$, which are converted into effective capital in period t but subject to an idiosyncratic shock $\omega_t(e) \geqslant 0$. Following CMR, we assume that $\omega_t(e)$ follows a log-normal distribution with mean unity and refer to $\sigma_{\omega,t-1}$, the cross-sectional standard deviation of $\ln \omega_t(e)$, as risk shock. Banks can observe the realization of $\omega_t(e)$ only by undertaking costly monitoring and will therefore include a premium in the interest rate on loans to protect themselves against the default risk. The entrepreneur then chooses a utilization rate of physical capital that incurs some real cost, rents it to intermediate goods producers at rate R_t^k, and sells the undepreciated capital to the capital goods producer. Her gross nominal return on capital $\tilde{R}_t^k$ is given by

$$\hat{\tilde{R}}_t^k = \frac{r^k}{r^k + 1 - \delta} \hat{r}_t^k + \frac{1 - \delta}{r^k + 1 - \delta} \hat{q}_t - \hat{q}_{t-1} + \hat{\pi}_t \tag{2.1}$$

where $r_t^k \equiv R_t^k / P_t$, $q_t^k \equiv Q_t^k / P_t$, δ is the capital depreciation rate, and $\pi_t \equiv P_t / P_{t-1}$ is the inflation rate. Moreover, the expected capital return premium, i.e., the credit spread, fluctuates with entrepreneurs' leverage and their riskiness according to

$$E_t[\hat{\tilde{R}}_{t+1}^k - \hat{R}_t] = \zeta_{sp,b}(\hat{q}_t^k + \hat{\bar{k}}_t - \hat{n}_t) + \zeta_{sp,\sigma_\omega} \hat{\sigma}_{\omega,t} \tag{2.2}$$

where $\bar{k}_t \equiv \bar{K}_t / A_t$, $n_t \equiv N_t / (P_t A_t)$, and $(\zeta_{sp,b}, \zeta_{sp,\sigma_\omega})$ are the elasticities with respect to leverage and risk. Note that if $\zeta_{sp,b} = 0$ and $\hat{\sigma}_{\omega,t} = 0$, financial frictions dissipate and (2.1)–(2.2) reduce to the familiar arbitrage condition between the return to capital and the risk-free rate.

2.3 Monetary and Fiscal Policy The central bank implements monetary policy according to an interest rate rule. It reacts to deviations of inflation and output from their steady states

$$\hat{R}_t = \rho_r \hat{R}_{t-1} + (1 - \rho_r)(\phi_\pi \hat{\pi}_t + \phi_y \hat{y}_t) + u_t^r \tag{2.3}$$

where ρ_r determines the degree of policy smoothing, (ϕ_π, ϕ_y) control the responsiveness to inflation and output deviations, $y_t \equiv Y_t/A_t$, and u_t^r is a monetary policy shock. The government collects revenues from net lump-sum tax and sells nominal bond portfolio to finance interest payments and expenditures. Its flow budget constraint is given by

$$b_t + \tau_t = \frac{1 + \rho P_t^B}{P_{t-1}^B} \frac{b_{t-1}}{\pi_t \Delta_t} + g_t \tag{2.4}$$

where $b_t \equiv P_t^B B_t/(P_t Y_t)$, $\tau_t \equiv T_t/Y_t$, and $g_t \equiv G_t/Y_t$ are expressed in terms of the ratio to output, and $\Delta_t \equiv Y_t/Y_{t-1}$ is the gross growth rate of output. In what follows, we denote $(\hat{b}_t, \hat{\tau}_t, \hat{g}_t)$ the level-deviations of these variables from their steady states, i.e., $\hat{x}_t \equiv x_t - x$ for $x \in \{b, \tau, g\}$, to avoid having the percentage change of a percentage.

Fiscal variables, as evinced by Figure 1, are persistent and variable. To capture these features, we follow Sims (2012) and embed a 'long-run risk' type of component into a possibly countercyclical tax rule

$$\hat{\tau}_t = \gamma_b^\tau \hat{b}_{t-1} + \gamma_y^\tau \hat{y}_t + u_t^{\tau,l} + u_t^{\tau,s} \tag{2.5}$$

where $(\gamma_b^\tau, \gamma_y^\tau)$ control the responsiveness to deviations of lagged debt and current output. The tax shock contains both a very persistent long-run component $u_t^{\tau,l}$ with small variance to capture the low frequency movement in fiscal variables and a mildly persistent short-run component $u_t^{\tau,s}$. Moreover, government consumption follows the rule

$$\hat{g}_t = \rho_g \hat{g}_{t-1} - (1 - \rho_g)(\gamma_b^g \hat{b}_{t-1} + \gamma_y^g \hat{y}_t) + u_t^g \tag{2.6}$$

where ρ_g measures the degree of policy smoothing, (γ_b^g, γ_y^g) control the responsiveness to deviations of lagged debt and current output, and u_t^g is a fiscal policy shock. The presence of response to output deviations in (2.5)–(2.6) renders fiscal instruments automatic stabilizing, which plays a similar role as LTW's distorting steady-state taxes. Besides the benchmark specification above (model 1), we also consider the original model of LTW that allows government consumption to be valued as a public good (model 2) as well as its lump-sum tax version with automatic stabilizers (model 3).

The fundamental difference between the two policy regimes lies in their distinct fiscal financing schemes. We highlight all financing possibilities of government debt that can be gleaned from the linearized version of government budget constraint (2.4)

$$\hat{b}_t = -\underbrace{(\hat{\tau}_t - \hat{g}_t)}_{\text{primary surplus}} - \underbrace{\frac{b}{\beta}\hat{\pi}_t}_{\text{surprise inflation}} + \underbrace{\frac{b\rho}{\pi e^{\gamma}}\hat{P}_{B,t}}_{\text{bond price}} - \underbrace{\frac{b}{\beta}\hat{\Delta}_t}_{\text{output growth}} + \underbrace{\frac{1}{\beta}(\hat{b}_{t-1} - b\hat{P}_{B,t-1})}_{\text{predetermined term}} \tag{2.7}$$

where β is the household's discount factor and γ is the growth rate of A_t along the steady-state balanced growth path. (2.7) makes it clear that a fiscal consolidation can be accomplished through several channels—higher primary surplus, surprise inflation, lower bond price, and higher output growth—or any of their combinations, regardless of the policy regime in place. In particular, while regime-M relies primarily on direct taxation, regime-F hinges crucially on the debt revaluation effects of higher inflation and lower bond price.

3 Regime Comparison

We apply Bayesian methods to estimate each regime-dependent model over two subsamples: pre-Volcker era, 1962:Q1–1979:Q2; and post-Volcker era, 1984:Q1–2007:Q4.[2] The common set of quarterly observables includes: log differences of private consumption, investment, real wage, and GDP deflator; log hours worked; federal funds rate and credit spread. In addition, we add two fiscal variables, i.e., government consumption and real market value of debt, to the dataset: ratios to GDP for model 1; and log differences for models 2 and 3. See the Online Appendix for details on the data construction, measurement equations, prior distributions, and posterior estimates. For comparison purpose, we also remove the spread data and reestimate all models without financial frictions.

3.1 Marginal Likelihood In the Bayesian paradigm, formal regime comparison and selection can be made possible through marginal likelihoods and Bayes factors. We follow the multistage framework of Chib and Jeliazkov (2001) that, in conjunction with the tailored randomized block posterior sampler of Chib and Ramamurthy (2010), provides an efficient scheme for estimating marginal likelihoods in high-dimensional DSGE models, and is immune to the difficulties with harmonic mean based approaches. Two aspects of the implied Bayes factors reported in Table 1 are worth highlighting.[3]

First, in the absence of financial frictions, whereas the post-Vocker sample overwhelmingly favors regime-M in all models, the pre-Volcker sample remains inconclusive—small perturbations

[2]Our full sample begins when the spread data first becomes available and ends before the federal funds rate nearly hit its effective lower bound. To reflect the two policy regimes, we specify two sets of priors on the policy parameters, each of which places almost all probability mass on regions of the parameter space that deliver unique model solution consistent with a regime.

[3]For each case in Table 1, we estimate the marginal likelihood from a 6-stage parallel procedure based on 10,000 posterior draws for each stage. All computations are executed using the MATLAB toolbox developed by Chib and Tan (2017).

Table 1: Log Marginal Likelihood Estimates

	1962:Q1–1979:Q2				1984:Q1–2007:Q4			
Model	No FF	ln BF	+ FF	ln BF	No FF	ln BF	+ FF	ln BF
Model 1: Benchmark								
Regime-M	-700.05	–	-621.62	–	-660.07	12.67*	-535.94	0.82
	(0.06)		(0.06)		(0.08)		(0.11)	
Regime-F	-685.13	14.92*	-602.82	18.80*	-672.74	–	-536.76	–
	(0.08)		(0.11)		(0.06)		(0.07)	
Model 2: LTW + distorting tax								
Regime-M	-815.49	11.71*	-735.32	6.96*	-861.51	24.92*	-732.56	21.86*
	(0.08)		(0.08)		(0.09)		(0.09)	
Regime-F	-827.20	–	-742.28	–	-886.43	–	-754.42	–
	(0.10)		(0.08)		(0.14)		(0.14)	
Model 3: LTW + lump-sum tax								
Regime-M	-839.68	8.95*	-756.70	0.88	-867.33	37.92*	-735.97	34.69*
	(0.10)		(0.08)		(0.09)		(0.11)	
Regime-F	-848.63	–	-757.58	–	-905.25	–	-770.66	–
	(0.10)		(0.08)		(0.13)		(0.12)	

NOTES: Marginal likelihood estimates with numerical standard errors in parentheses and Bayes factors (BF) are reported in logarithm scale for models 1–3 under each regime both with and without financial frictions (FF). Asterisk (*) signifies decisive evidence in favor of the regime with superior fit, corresponding to a log Bayes factor greater than 4.6 based on Jeffreys' (1961) criterion.

to the fiscal details of the model and data can lead to a reversal of the regime ranking. Importantly, only model 1, which features a persistent component in the tax rule, identifies the switch in monetary policy stance that aligns well with the narrative record of policymakers' beliefs: the passive stance of most of the 1970s under Federal Reserve chairmen Arthur Burns and G. William Miller; and the active stance of the early 1980s and beyond under Paul Volcker and Alan Greenspan. Second, adding financial frictions to the model uniformly improves the *relative* fit of regime-F in all cases, to the extent that it can fundamentally alter the regime ranking—regimes M and F become 'nearly' observationally equivalent in model 3 over the pre-Volcker era and, surprisingly or not, model 1 over the post-Volcker era for which the tenability of regime-M has rarely been challenged in the literature. This echoes the theoretical demonstration of Leeper and Walker (2013) that the two regimes can provide equally plausible interpretations of the data. Taken together, these findings point to a broader message that policymakers should routinely

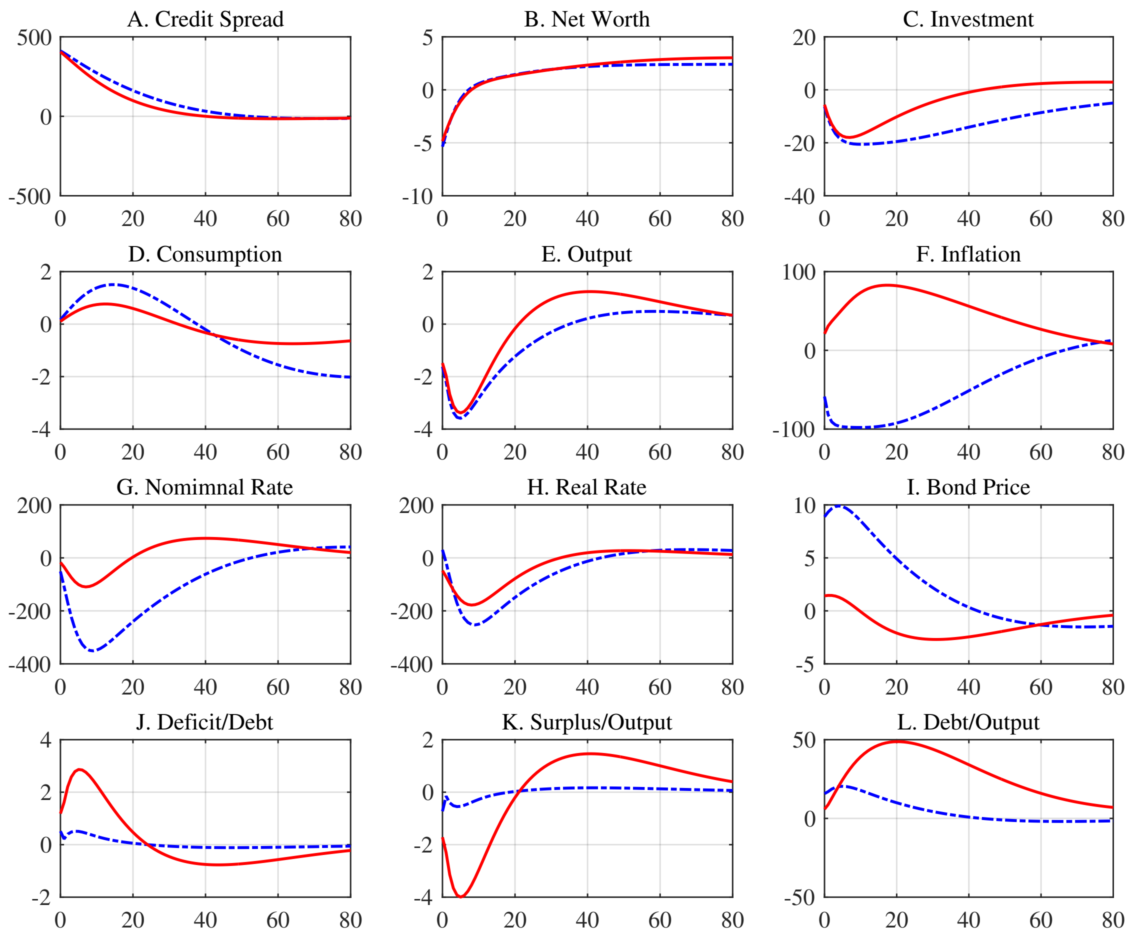

Figure 2: Dynamic responses to one percent positive risk shock. Notes: Responses are evaluated at the posterior modes of regime-M (blue dashed line) and regime-F (red solid line) based on the full sample. Credit spread, inflation, nominal and real rates are converted into annualized basis points; the remaining variables are in percentage deviations from steady state.

scrutinize alternative monetary-fiscal policy specifications in their policymaking process.

3.2 Inspecting the Mechanism Observational equivalence of the two regimes may obscure their strikingly different inflation dynamics following a credit crunch. Figure 2 displays the dynamic responses of key variables to an adverse risk shock in model 1. Since banks charge a higher interest rate on loans in response to a rise in risk, the credit extended to entrepreneurs falls. With fewer financial resources, entrepreneurs purchase less physical capital from the capital goods producer who in turn acquires fewer investment goods. Under both regimes, falling investment leads to a drop in output; it also pushes down the price of physical capital and hence the net worth of entrepreneurs, amplifying the impacts of credit market tensions on the macroeconomy through the standard financial accelerator.

Turning to the policy reactions to the economic contraction, the monetary authority responds by more aggressively cutting the policy rate in regime-M. With sticky prices, a lower nominal interest rate reduces the real interest rate. As a result, consumption rises by more than that in regime-F, tempering the short-run drop in output. The automatic stabilizing fiscal instruments, on the other hand, respond by cutting taxes and increasing expenditures financed by nominal bond sales. Together with lower output and higher bond price due to lower nominal rate, this fiscal expansion raises the market value of debt as a share of output in both regimes. Because higher deficits do not trigger expectations of sufficiently high surpluses to stabilize debt in regime-F, households feel wealthier and demand more consumption goods, which bids up the price level. The resulting higher inflation and lower bond price jointly ensure that the market value of debt is aligned with the expected present value of surpluses. Such wealth effect, if any, will almost be neutralized by the passive fiscal policy in regime-M so that the decline in economic activity results in a decline in the marginal cost of production and hence inflation.

Overall, including financial frictions in the model yields an important identifying restriction on the observed pattern between inflation (Panel F) and measures of financial (Panel A) and fiscal stress (Panel J). In particular, contrary to regime-M that underlies CMR's analysis, elevated credit risk can bring forth fiscal inflation through the debt revaluation channel that regime-F emphasizes. This pattern clearly accounts for the Great Inflation of the 1970s as well as the missing deflation during and following the recent Great Recession when the credit market tightened sharply and large fiscal stimulus plans were implemented, suggesting that regime-F has prevailed in those periods.

4 Concluding Remarks

This article studies monetary and fiscal policy interactions in a financially constrained environment. We estimate various versions of a standard medium-sized DSGE model augmented with fiscal details and credit market imperfections, and find that adding financial frictions to the model plays an important role in improving the relative fit of regime-F that embodies the fiscal theory. The improvement stems largely from regime-F's implications for the inflation dynamics following a credit crunch, which find empirical support in some historical periods. Further identifying restrictions from elsewhere, however, are necessary to break the near observational equivalence of the two regimes found in the present study.

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